Prepared Statement of
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Senate Finance Subcommittee on Energy, Natural Resources, and Infrastructure
"Tax Reform and Federal Energy Policy: Incentives to Promote Energy Efficiency"
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Chairman Bingaman, Ranking Member Cornyn, and members of the Subcommittee, thank you for this opportunity to discuss the importance of energy efficiency to our nation now and in the future. Before I begin my opening statement, I want to commend Chairman Bingaman on his outstanding leadership, his valuable service to the nation, and his strong dedication to advancing science, technology, and energy policies to meet the challenges facing our nation.

I'm Director of the National Renewable Energy Laboratory, commonly known as NREL. We are the U.S. Department of Energy's (DOE) primary laboratory for research and development (R&D) of energy efficiency and renewable energy technologies. Although we do not take positions on legislation or policy, I will speak to how federal investments in energy efficiency initiatives and technologies can benefit our energy security and environment, and become a driver of economic growth for our nation.

NREL plays a significant role in developing and demonstrating new, more efficient ways to construct, modernize, and operate homes and commercial buildings, and we are leading by example. Our energy-efficient activities on our campus—such as new construction that maximizes energy efficiency, energy retrofits, and energy-management control systems—are helping us exceed the administration's goal for Federal buildings to reduce energy use by 3 percent each year or by a total of 30 percent by the end of Fiscal Year 2015 (relative to a Fiscal Year 2003 energy-use baseline). I should note that in a separate research area we additionally are working to increase the energy efficiency of our cars, trucks, and the rest of our nation's transportation system. Because this hearing is focusing on legislation related to tax incentives for homes, commercial buildings, and industry, I will limit my testimony today to those areas.

This year, I also have had the honor of serving as a member of the Alliance to Save Energy's Commission on National Energy Efficiency Policy. The Commission has been looking at a full range of energy efficiency issues, and I'm confident the release of the Commission's final recommendations early next year will be welcomed as a roadmap for future efforts to achieve our important energy efficiency goals.

Although NREL's research on solar, wind, biofuels, and other renewable energy technologies frequently gets more attention, we know well that energy efficiency is fundamental and essential to all else we do. The guiding strategy that we've evolved over the years emphasizes doing everything that can be done to reduce the overall need for energy before employing new energy production systems. We've learned that by cutting energy consumption first, you can maximize the efficiency and reduce the cost of whatever new clean energy option is chosen. The reality is that the "nega-watts" that aren't used can be just as important as the megawatts that are.

Energy Efficiency Research Confirms Significant Savings

Three years ago, McKinsey & Co. produced a landmark analysis of potential energy savings in economic sectors other than transportation. The magnitude of the energy efficiency potential found by the study was astounding. That report characterized energy efficiency as a "vast low-cost energy resource for the U.S. economy," and it showed the United States could reduce non-transportation energy consumption by nearly a quarter by the end of this decade. Although that would require an investment of $520 billion, it would yield $1.2 trillion in energy cost savings. Notably, the effort would also cut 1.1 gigatons of greenhouse gas emissions, an effect equal to eliminating the emissions from all passenger vehicles and light trucks in the United States.

A year later, the National Academies of Science and Engineering released another comprehensive assessment of energy efficiency potential in the United States. It found the nation could save money while producing the same amount of goods and services and still cut energy consumption by 30 percent.

And, in August of this year, my research institution, NREL, took the next step by assessing the impact that some 400 laboratory-tested and peer-reviewed energy efficiency measures could have if deployed in the United States ["A Tool to Prioritize Energy Efficiency Investments"; Philip Farese, Rachel Gelman, and Robert Hendron; NREL TP-6A20-54799]. This work showed there are multiple pathways for the nation to reduce energy use in buildings by one-half by 2030. And if we do so, the energy cost savings would equal twice the dollar amount invested.

R&D Investments in Energy Efficiency Produce Economic Benefits

Perhaps the most compelling evidence that energy efficiency measures can have dramatic effects in the future is the often overlooked fact that they already have produced so many benefits for our nation. The Alliance to Save Energy's National Energy Efficiency Policy Commission has shown that the nation would be using 50 percent more energy than we currently use today if we had not taken advantage of all the energy efficiency opportunities developed and deployed during the past three decades.

Even so, experts who have examined this issue most often conclude that our nation has seriously underinvested in energy efficiency during those same decades. Although that lapse has cost us in many ways, it also represents a huge opportunity for the nation today. There is much that can be done to improve the efficiency of our built environment, with positive returns on investment and spurring broader economic benefits.

The R&D achievements for high-performance buildings in recent years provide more evidence that energy efficiency initiatives can deliver significant results. Strategies that consider the performance of a building as a whole, rather than the performance of individual components, have proven to be most successful to maximize energy savings and encourage market adoption. We've found that this whole-building, integrated-systems approach minimizes the potential for unintended consequences when changes are made in one component that can influence performance in other areas. We've also learned that we can accelerate the market adoption and overall transformation of the building stock wherever we can clearly demonstrate that efficiency

upgrades are low risk, and deliver high performance and fit within existing building codes and energy incentive programs.

A leading example of R&D success is the Commercial Building Partnership (CBP), a public-private, cost-shared program. Sponsored by DOE, it partners building owners and operators, National Laboratories like NREL, and technical experts from the private sector. The CBP has examined scores of different energy efficiency measures spanning a full range of building components—from more efficient sales floor lighting to use of reflective roof coatings. Researchers used advanced modeling tools to find the right mix of concepts for whole-building design that maximizes energy efficiency gains at the lowest possible cost. Over time, the program has encompassed both new buildings and retrofits, and the real-world results have been impressive. For example, NREL worked with the retrofit of a SuperTarget store in Thornton, Colorado, resulting in savings of 35% compared to current energy codes. Based on NREL analyses of retrofit impacts across the nation, Target now intends to replicate this success across its entire portfolio.

CBP has developed purpose-specific models that capture the best strategies for five different commercial sectors: general merchandise, higher education, commercial lodging, offices, and restaurants. Each of the recommended strategies is paired with project-specific case studies that detail decision criteria and lessons learned from each of the field projects. Because each of the building pilot projects includes ongoing monitoring of performance, the building sector models are based on verified results—not projections—which makes them all the more valuable and relevant to the industry.

The partnership has included some of the biggest names in the retail business, including Wal-Mart, Target, Best Buy, JCPenny, Home Depot, and Kohl's. And by virtue of these players alone, the program can have impact: Total floor space operated by these retailers is 1.7 billion square feet.

Grocery stores comprise another key category. Because of the need for both large refrigeration systems and oftentimes commercial-scale bakeries and kitchens, the grocery segment has some of the highest per-square-foot energy costs of any retail business. Grocery represents 2 percent of the nation's commercial floor space, but consumes 5 percent of total commercial building energy consumption. The slim margins of a modern-day grocery chain—about 2 percent on average—on one hand demand that energy improvements be cost-efficient. On the other hand, the substantial energy needs of these stores means big opportunities for savings, and equally large returns on investment. One assessment showed that $1,000 saved in utility bills can have the same bottom-line impact as $50,000 in new grocery sales.

The CBP is providing important technical information that supports the DOEs Better Buildings Initiative, which works with leading private-sector organizations and cities across the country to implement energy efficiency at scale in buildings and communities.

Although the mix of specific design and operational concepts for each building category is what makes the program so effective, a number of broader, generic lessons have been gleaned. These lessons include making energy savings part of the corporate culture, setting quantifiable whole-

building energy goals, investing in expert resources and analysis, verifying and maintaining energy savings, and committing to continuous improvement. Taken individually or collectively, such strategies can help meet the nation's energy savings goals, and at the same time reduce expenses and improve profit margins of individual businesses.

One key lesson from the CBP is that energy efficiency and other retail priorities can go hand in hand. More efficient use of energy can work in tandem with other market drivers, including improved shopping experience for customers, greater employee productivity, lower equipment operations cost, as well as marketing and brand-building. By adopting energy efficiency as a corporate-wide value, companies can help solidify their broader image as a low-cost and high-value option for consumers. In short, our experience shows that for business, energy efficiency should be cast in an entirely new light—as a customer-friendly and profit-producing corporate strategy, free at last of the harsh and spartan image that has too often colored it in the past.

Progress is also being made on revolutionary energy efficiency technologies not yet in the marketplace. An example is a novel air-conditioning system invented by NREL that recently won an R&D 100 award. The Desiccant-Enhanced Evaporative air conditioner, or DEVAP as it's known, is a new technology that can deliver superior occupant comfort for commercial building applications, while cutting electricity use by as much as 90 percent, compared to conventional air-conditioning systems. Developed by NREL and two private-sector partners, AIL Research and Synapse Development, the DEVAP technology in coming years holds promise to revolutionize how the nation cools its buildings—a not inconsequential feat, as air conditioning uses 15 percent of the electricity generated in the United States.

NREL's Research Support Facility

Building sustainability programs, like the Green Building Council's LEED program for Leadership in Energy and Environmental Design, put a spotlight on energy savings. But energy considerations many times get short shrift when pitted against conventional design criteria, aesthetic concerns, and first-cost construction issues. At my own institution, NREL, our Research Support Facility (RSF) provides an example of how much can be accomplished when energy efficiency becomes a primary and essential priority of a building's design, and every practical energy-saving concept is given full consideration. The RSF is a LEED Platinum, 360,000-square-foot, 1,300-occupant, modern office building that also happens to be a showcase of and living laboratory for high-performance building technology. Coupled with adjacent solar photovoltaic systems and a renewable biofuels heating plant, the RSF is the world's largest net-zero-energy office building, and it has won numerous awards for its sustainability, innovative design, and energy-saving features.

Energy efficiency begins with how the building wings are oriented toward the sun, and also determined the 60-foot width of each wing, an interior breadth that enables thorough day-lighting and natural ventilation for all occupants. Windows are optimally sized, placed, and shaded to maximize daylight while minimizing unwanted heat losses and excessive gains. A below-building labyrinth of massive concrete structures stores thermal energy. Precast concrete insulated panels provide significant thermal mass to moderate the building's internal temperature.

The RSF's rating of 34.4 kBtu/square foot/year is fully 50 percent better than the industry standard, ASHRAE 90. And the RSF manages to achieve this feat in cost-competitive ways. The RSF's cost of $254/square foot compares favorably to the average cost of $335/square foot for newly constructed commercial buildings designed to LEED levels.

State-of-the-Art Efficiency for Residential Buildings

Private residences, which comprise a little more than half of energy use by buildings in the United States, provide equally large opportunities for energy savings. NREL's residential buildings research focuses on developing reliable, comprehensive system-based approaches to cost-effective residential energy savings, then validating and field-testing the improvements that are developed.

DOE's Building America program, www.buildingamerica.gov, works to develop market-ready solutions through partnerships with new building and remodeling industry leaders, building design professionals, and the National Laboratories, including NREL, while allowing for the considerable differences in regional climatic conditions and architectural vernacular seen across the nation.

For new homes, the Building America program has demonstrated that cost-neutral energy savings of 40 percent more than existing codes is possible at a production scale for new home builders in every climate zone in the United States. Building America has worked with nearly three dozen builders, constructing thousands of new homes, using a whole-house and trade-off analysis process developed by NREL to find the most cost-effective solutions. Each concept home reduced energy costs to the point where utility bill savings would more than make up for any initial cost increase. In every field study, new homeowners made a net profit in the first year alone.

Although energy improvements in new homes are critical, more than 70 percent of the U.S. housing stock was built before 1990, before the most energy-efficient building codes were put in place. For retrofits, NREL has worked with Building Performance Institute to develop four Home Energy Professional Certifications, including Quality Control Inspector. These certifications were developed in conjunction with industry, and we currently have a pilot program to certify individuals with a national rollout planned for the summer of 2013. We've worked with Habitat for Humanity affiliates in several cities. And in areas with constrained energy generation capacity, we've helped utilities develop market-based incentives that encourage builders to adopt measures that limit real-time peak energy demand, as well as the total energy used.

Simulation Models and Other Tools

In that the energy efficiency legislation under consideration by the committee would use simulation-based methods to design and qualify energy savings for its incentive programs, it is worth noting that NREL developed a computerized calculator for DOE to facilitate easy access to the commercial buildings 179D tax deduction. This allows owners, architects, and engineers to almost instantaneously determine the appropriate efficiency strategies for their buildings to

qualify for the incentive. Simple tools like this depend on the development of sophisticated simulation models. NREL has been working to improve the completeness and accuracy of such models for both commercial and residential buildings. Businesses, consumers, utilities, government agencies, and policy makers are most interested in location-specific recommendations for optimal new building and retrofit packages, with accurate energy- and cost-savings data. Today, we continue to learn from real-world experience and are improving the methodology we use in our simulation tools, and thus improving the overall accuracy of our whole-building analysis. A comprehensive clearinghouse, the Building America Solutions Center, documents research results, http://www1.eere.energy.gov/library. Key results are also incorporated into public analysis tools and databases, widely available and widely used by the building community. These include the National Residential Efficiency Measures Database and the BEopt optimization tool: http://www1.eere.energy.gov/buildings/residential/ba_retrofits.html and http://www1.eere.energy.gov/buildings/residential/ba_beopt.html, respectively.

We've researched and published the most cost-effective Energy Savings Measure Packages for existing homes, optimized for the local climate and prevalent building characteristics (i.e., foundation types). Energy savings are typically between 30 percent and 50 percent more than a local reference home.

Just as architecture and design software has progressed from seeing the world as flat to seeing it as a living, three-dimensional virtual space, energy software is becoming more complex, increasingly allowing design teams to assess dozens, even hundreds of different energy options for new buildings and retrofits. The advent of whole-building simulation and building information modeling (BIM) now allows for complete energy modeling of a structure, from computational fluid dynamics to daylight analysis—so everything from window glare to thermal comfort can be forecast and assessed, individually and collectively, with a bottom line estimate for a resulting building's overall energy savings. NREL has developed the Open Studio interface with DOE's EnergyPlus building Energy simulation package, making it quick and easy for architects and engineers to facilitate optimized energy efficiency decisions throughout the design or retrofit process. Modeling capability like this enabled NREL to design and build the RSF (the largest zero-energy office building in the world) at no additional cost.

DOE's EnergyPlus software additionally models a full range of building energy and sustainability issues, including water usage and carbon emissions, in an integrated evaluation of building energy flow. It allows architects and builders to research energy-smart design options before construction. The program includes many innovative simulation capabilities, such as multi-zone air flow, thermal comfort, natural ventilation, and photovoltaic systems, www.energyplus.gov .

Even though energy increasingly is a consideration in building design, it too often is relegated to the back end of the process. Our challenge going forward is to create new and better tools to ensure energy efficiency is accurately represented and gets the attention it deserves in the broader building design process.

Industrial Energy Efficiency

Industry represents 31 percent of U.S. energy consumption, and there exists huge potential for energy savings in the U.S. industrial and manufacturing sector. Industrial energy efficiency is an area where new equipment technology can dramatically improve performance. Let me cite two examples.

The burgeoning number of energy-intensive computer data centers in the United States is another business sector where opportunities abound for efficiency improvements. Set to open next year, NREL's new peta-scale high-performance computer system will be the fastest computer anywhere dedicated to clean energy technology development, and will add major new capabilities for researchers across the Laboratory. In partnership with HP and NREL, we're designing it to be the world's most energy-efficient high-performance computing center. Heat generated by the computer center will become the primary source for heating NREL's new Energy Systems Integration Facility (ESIF), the building in which the data center is housed. By comparison, an average data center today requires 13 times as much energy as the new NREL system will for the same computing power.

ESIF itself will help create important new strategies for integrating various energy systems in the most efficient ways possible. ESIF's megawatt-scale test facilities will allow manufacturers and system operators to maximize the efficiencies of a range of energy equipment, operating both individually and within a real-world energy system, with greater certainty and confidence than previously was possible. With its high-performance computing capabilities, the ESIF additionally will be able to mine real-time operating data to produce empirically grounded grid energy system modeling, and validate system interfaces and control algorithms that can significantly increase efficiencies in both new and existing energy systems. Specifically for buildings, research tools available within ESIF will help to develop energy management systems that will monitor building functions, and adjust heating and ventilation systems to increase efficiencies. Then, as these local systems can be integrated into the broader, grid-linked energy systems, the same local controls can be used to balance various types of generation sources on the grid, further increasing efficiencies and maximizing use of renewable wind and solar energy resources as well. In fact, our researchers foresee a day when smart energy systems—using the back-and-forth flow of energy information—may be just as critical to increasing overall system efficiency as any production or end-use technology is today.

One major ancillary benefit from energy efficiency initiatives by industry is the tendency of energy-inspired modernization investments to also yield improvements in equipment, processes, and operations, which in turn mean significant gains in overall plant productivity. The Alliance to Save Energy's Commission report concludes that "higher industrial energy productivity can lead to stronger businesses, with higher paying jobs in the U.S."

Disaster Recovery and Energy Efficiency

This year's devastating super-storm Sandy underscores the susceptibility of our residential and commercial buildings, and our energy delivery systems, like the electric transmission grid, to natural disasters. I was recently appointed to serve on New York Governor Cuomo's NYS2100

Infrastructure Commission, which will explore methods to strengthen the state's infrastructure in the face of natural disasters and other emergencies. Along with Ms. Patricia Hoffman, DOE Assistant Secretary in the Office of Electricity Delivery and Energy Reliability, I intend to draw upon the work we are doing at NREL to demonstrate how energy efficiency measures—such as doors, windows, structural systems and insulation—can strengthen a residential or commercial building's resiliency against violent storms. Additionally, rebuilding efforts following a disaster offer great opportunity to reconstruct damaged buildings to meet the highest energy efficiency standards, frequently, at little or no additional cost. And in the event of future storms that disrupt power supplies, energy-efficient buildings will need fewer or smaller generators. This both reduces the cost of backup generation and frees up their supply.

In conclusion, I commend the subcommittee for considering initiatives to promote and improve energy efficiency. NREL will continue to serve as a valuable asset to the nation and promises to build upon the thirty-five years of successful innovation from fundamental research through commercializing and deploying energy efficiency solutions. Our laboratory continues to pave the way toward a stronger clean energy economy, and I appreciate this opportunity to highlight the important work NREL and others are doing to advance these objectives.