United States House of Representatives
Committee on Oversight and Government Reform
Testimony for the November 8, 2007 Hearing on:

Opportunities for Greenhouse Gas Emissions Reductions

by

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The Low-Carbon Imperative and Economic Opportunity

Congressman Henry Waxman, Committee Chairman, Ranking Minority Member Tom Davis, and the rest of the Committee on Oversight and Government Reform, I am very pleased to have the opportunity to appear before you again. I appreciate the attention your committee is giving to the vital issues of greenhouse gas emissions reduction and climate protection.

I am particularly pleased to appear before this committee so soon after the Intergovernmental Panel on Climate Change (IPCC) was awarded the 2007 Nobel Peace Prize. I have served as a Coordinating Lead Author of IPCC investigations and reports, in particular focusing on the science and engineering of climate-friendly innovations, technologies, and policies (IPCC, 2000). Along with several thousand other climate and energy scientists, economic and policy analysts, I am tremendously pleased to share in the honor and the continuing responsibility to provide our collective best assessments on the state of climate science, and of both the need and the opportunities to effectively and efficiently address this national and global challenge. My laboratory group at the University of California, Berkeley, is focused on energy efficiency and renewable energy science, technology, and implementation. In addition, I also serve on the Executive Committee of the $500 million Energy Biosciences Institute funded by BP.

The United States is today faced with both a challenge to reduce our greenhouse gas emissions, and an opportunity to invent and re-invigorate several key industrial sectors. A key finding of my research is that by investing in, and deploying, low-carbon technologies we can add significantly to our economic and geopolitical health and security, while moving states and the nation to a position of global leadership in the emerging clean energy economy

My comments today will be focused on the availability and cost-effectiveness of *advanced control technologies and clean energy alternatives such as energy efficiency and renewable technologies* that the Environmental Protection Agency and state and local energy planners can consider as they strive to met growing energy demands in an environmentally responsible way.

While a great deal of research, development, and deployment will be needed to meet the long-term goals of climate stabilization, we currently have a diverse, cost-effective, and powerful array of highly efficient energy use technologies and management practices, and a growing range of low-carbon power generation technologies for both our stationary and mobile energy needs.

An expanding body of research, including a series of scientific, technological, and economic studies from my research team, the Renewable and Appropriate Energy Laboratory at the University of California, Berkeley, all indicate that a low-carbon economy can be achieved while expanding the economy and, in fact, reinvesting significantly in our industrial base.

Energy Efficiency Options to Meet Energy Service Needs

We now have over three decades of active research, investment, and deployment of energy efficiency technologies, practices, management strategies, and market mechanisms. The overwhelming conclusion from this work is that the most cost-effective form of energy is the energy that we did not need to design, build, deploy, or manage. This knowledge exists as a major resource of shared experience and expertise that is currently in the hands of Investor-Owned Utilities, Municipal Utility Districts, state Public Utility Commissions, the United States Department of Energy, the Environmental Protection Agency, and a number of other institutions and individuals.

The lists of individual energy efficiency innovations is tremendously long, and includes: efficient water heaters; improved refrigerators and freezers; advanced building control technologies and advances in heating, ventilation, and cooling (HVAC); smart windows that adapt to maintain a comfortable interior environment; a steady stream of new building codes to reduce needless energy use, compact fluorescent lights; the emerging wave of even lower energy solid state ("light-emitting diode") lights so forth. Improvements in buildings alone, where we use over sixty-percent of all energy, have come at savings of *tens of billions of dollars* each year.

Several states, including California, New York, Rhode Island, Wisconsin, and others, that have consistently deployed energy efficiency innovations. Their state planners officials, citizens, and industry leaders, have found these to be tremendously cost-effective, often providing greater service at *lower personal and social cost than the 'conventional'* route of simply adding more fossil-fuel based supply technologies. This is the case for several reasons. First, energy efficient technologies often represent upgrades in service through superior performance (e.g. higher quality lighting, heating and cooling with greater controls, or improved reliability of service through greater ability of utilities to respond to time of peak demand). These innovations can provide better, less expensive, service.

Second, a wide range of energy efficient technologies have ancillary benefits of improved quality of life, such as advanced windows that not only save on heating and cooling expenses, but also make the work-place or home more comfortable. More efficient vehicles, for example, not only save immediately on fuel purchases, but also emit less pollutants, improving health and saving on medical costs to the individual and to society.

The integrated benefits of energy efficiency have been so striking that those states and nations that have invested significantly in these technologies have saved significantly on energy costs and on greenhouse gas emissions.

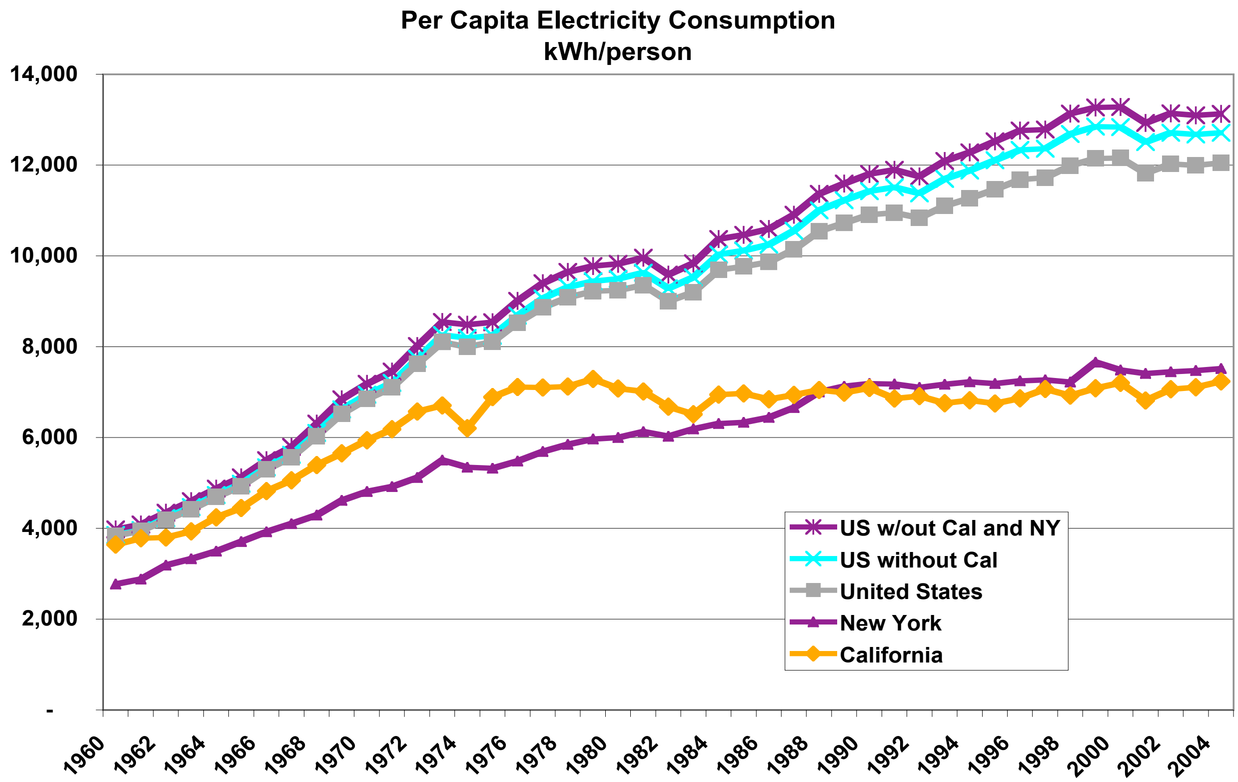

Figure 1: Per capita energy consumption in California, New York, and the United States as a whole. Energy consumption in the most efficient states is fully 40% lower than the national average. A number of nations, such as Denmark, are even far more efficient than the leading U. S. states, indicating strongly that a wealth of further innovations are possible if we invest in, and deploy, these technologies. Source: California Energy Commission.

The adoption rate of energy efficient technologies and energy management practices varies widely around the nation, with some states *more than 40% more efficient than the national average* on a per capita basis (Figure 1). According to statistics provided by the California Utilities Commission and the California Energy Commission, savings in California in 2007, relative to the national average amounted to more than $400/per person per year.

The United States, through the long-standing efforts of the EPA and the Department of Energy, have developed and facilitated in the adoption of a number of energy efficiency practices. The *Green Light*, *EnergyStar* programs, and much of the U. S. housing codes are derived from this experience. In Germany, a similar effort, *GreenFreeze* is credited with similar savings that are financial as well as in greenhouse gas emissions. In total, energy efficiency investments save the nation *over $170 billion* annually, an amount that is rising with increasing energy costs. While these savings are impressive, a wealth of data indicates that far greater savings could be realized if these programs were expanded to a greater number of appliances, lighting systems, and if the standards in place were to be made more stringent. *The most efficient technologies consistently provide remarkable levels of savings*, often repaying their added cost in mere weeks or months, and then providing those savings year after year.

These energy savings are *not* simply local benefit, providing much-needed savings for individuals and businesses. In regions with aggressive energy efficiency programs, the need for new power plants has been significantly reduced, in some locations permitting the *removal* of poorly functioning, or expensive fossil-fuel supply options.

Taking the Next Step in Energy Efficiency - Reducing Carbon Emissions at a Savings

Energy efficiency has been, and continues to provide, a tremendously cost-effective opportunity to reduce the need for new power generation and greenhouse gas generation. In many cases investments in energy efficiency can be made at near zero or even *negative* cost, when health, adder worker productivity, or security or other 'co-benefits' are taken into account (Kammen and Pacca, 2004).

Opportunities for energy efficiency come in a great many technologies and practices. California has been a consistent leader in developing and deploying energy efficiency and in the early 1980s took the innovative step to *decouple* revenues and total sales from its investor owned utilities. As a result, revenues are determined by a process of matching predicted and observed energy sales, with the effective price of electricity adjusted to meet an expected revenue target. This innovation has put energy efficiency and conservation on an 'even footing' with new generation, and has, in fact, institutionalized energy conservation and efficiency. The reason is that the value of efficiency is now equivalent to new generation on a kilowatt-to-kilowatt comparison, and in fact energy savings is generally superior due to the avoided costs of added power generation, operation and maintenance.

New energy efficiency innovations are taking place all the time, and should be featured prominently in the technical and economic assessments conducted by the EPA. On September 27, 2007, for example, the California Public Utilities Commission[1] voted to enhance energy efficiency performance standards by adding a new incentive program. This program returns a portion of the financial savings form deploying energy efficiency (e.g. compact fluorescent lighting, improved efficiency water heating and space conditioning) innovations as a monetary incentive to the Investor Owned Utilities based on the level of end-user (ratepayer) efficiency.

The opportunities to continue and expand the deployment of energy efficient technologies is vast. The evolution of solid state lighting, for example, has been sufficiently promising that the Office of Energy Efficiency and Renewable at the U. S. Department of Energy has now set a technology-based goal of lights that are fully 50% more efficient that what we have today, and result in a *decrease in total electricity consumption of ten percent*[2]. Sandia National Laboratory projects that advances in solid state lighting will save the nation over 70 GW of supply capacity, more than 100 million tons of carbon emissions annually, and save more than $42 billion/year.

[1] http://www.cpuc.ca.gov/static/news/index.htm
[2] http://www.netl.doe.gov/ssl

A vigorous energy efficiency research program will is needed to spur these advances, but as we have seen over the past decades, will pay for itself many times over in energy savings, avoided supply and greenhouse gas emissions.

Renewable Energy Technologies

The last few years have seen a tremendous expansion in interest in renewable energy supply technologies. Technological and cost advances in solar, wind, biofuel, geothermal, and ocean energy systems have made renewable energy supply options competitive with fossil fuel technologies in an increasing number of locations.

Wind energy in particular is now often directly cost competitive, and at times is a least-cost supply option. Prices for delivered wind energy range as low as 3.2 cents/kWh for the 120 MW San Juan Mesa wind farm in New Mexico[3]. Ownership and financial structures are particularly important for wind projects, with those privately owned averaging 4.95 cents/kWh including the federal production tax credit (PTC), 6.56 cents/kWh without the PTC. Investor Owned Utility projects with corporate financing averaged 3.53 cents/kWh including PTC, 5.9 cents/kWh without. Projects with public utility ownership, and project financing are inexpensive as 3.43 cents/kWh including renewable energy production incentives, and 4.89 cents/kWh without (Wiser and Bollinger, et al, 2007). The recent volatility in natural gas prices makes renewables an even better relative deal.

The performance of renewable energy technologies, including not limited to wind, has encouraged twenty-nine states and the District of Columbia to enact Renewable Energy Portfolio Standards, which each call for a specific percentage of electricity generated to come from renewable energy (Figure 2). Some of the most aggressive state standards call for over 20% of total electricity generation to come from renewable sources by 2020, and in 2007 these technologies generated almost 150 TWh of electricity. States that have seen that they will likely meet their RPS goals, including Texas, California, and Colorado, have in turn increased their call for renewable installations based on the performance, cost-effectiveness, and the benefits of supply diversity that renewables provide.

[3] http://www.awea.org/projects/newmexico.html

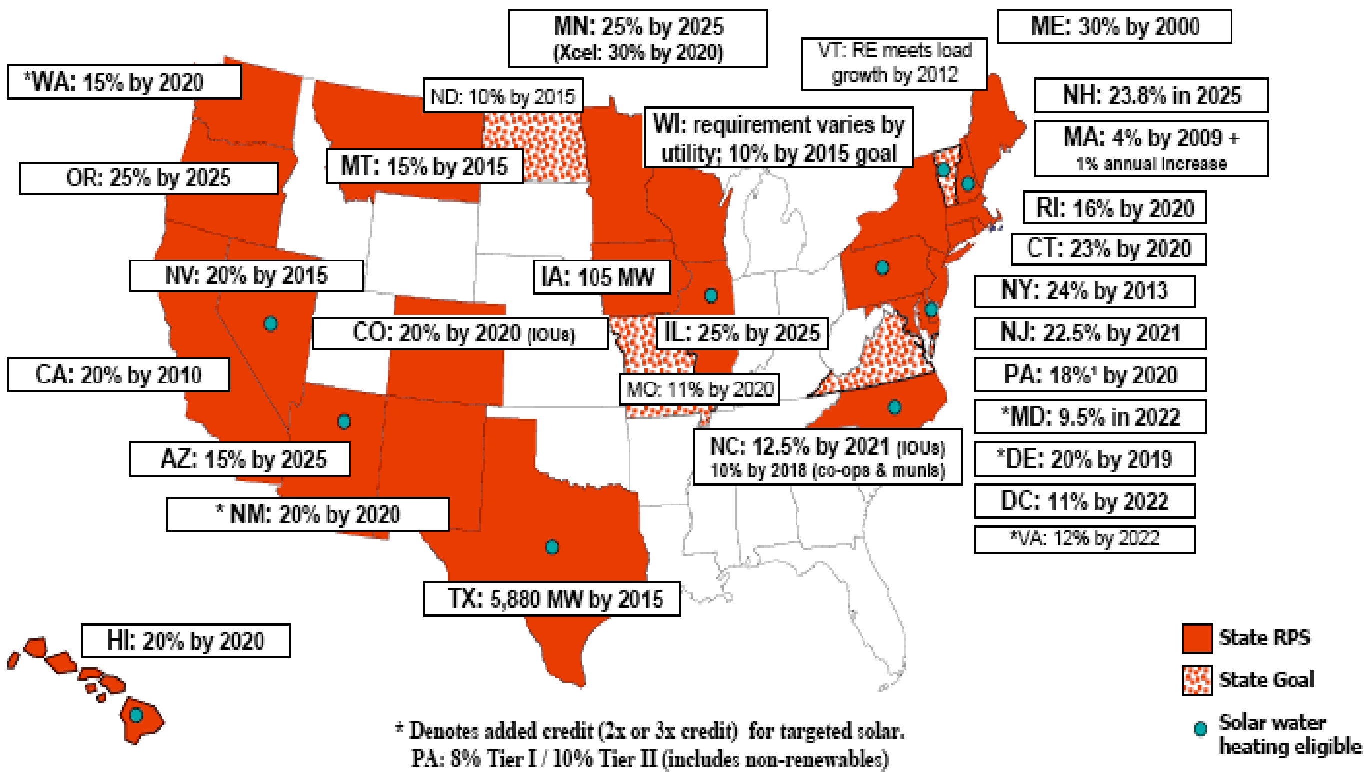

Figure 2. Map of States with Renewable Energy Portfolio Standards As of September 2007, 29 states and the District of Columbia have enacted or voted to adopt either an RPS or a state goal. These plans represent a diversity of approaches and levels, but each reflect a commitment to clean and secure energy that could be emulated at the federal level. In addition 13 states have specific measures to increase the amount of solar photovoltaic power in use. These range from specific solar energy targets, to double (MD) or up to triple credit (DE, MN, & NV) for solar. Electricity rates *fell* in portions of Colorado after voters approved Proposition 37, a 20% RPS limited to the Investor Owned Utilities.

An important feedback effect exists in the call for, and installation of clean energy supply and pollution control technologies. As more and more solar, wind, biofuel, and trace-gas emissions control technologies (e.g. NOx) and constructed and deployed, the price has consistently fallen by 10 – 20% per doubling of the total number of units ordered (Figure 3). This effect, termed the 'learning curve' has held remarkably constant over a wide range of technologies for many years of technology experience (Duke and Kammen, 1999). An outcome of this process of industrial learning is that as we invest more in the clean energy sector, the products we desire have become increasingly affordable, further increasing their significance in the market. This effect has been seen to occur for technologies than can be mass-produced. Our investment and deployment of energy efficiency, renewable energy, and of pollution control technologies are important drivers of future innovation.

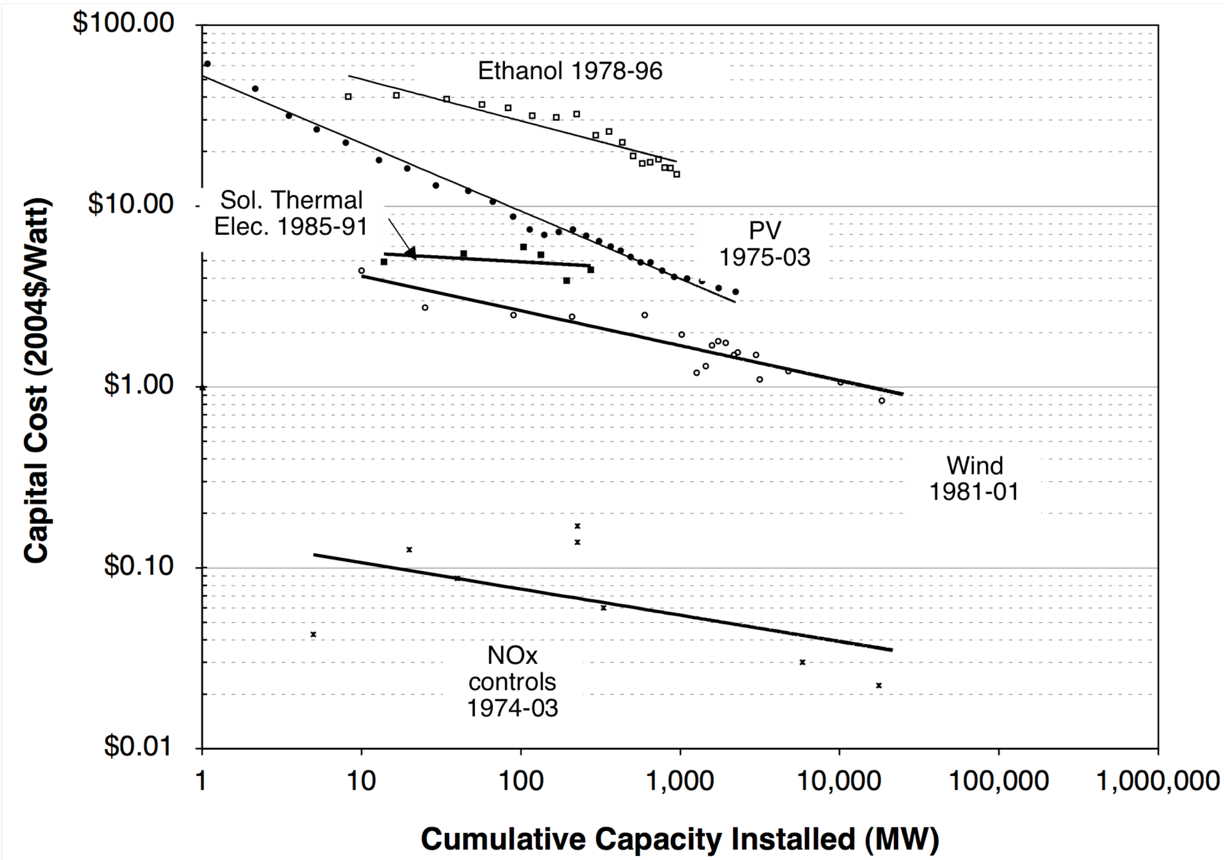

Figure 3: The 'learning curve', showing the cost declines in clean energy and pollution control technologies than accompanies expanded commercial production. A 10 – 20% decrease in per unit cost typically accompanies each doubling of cumulative production.

A diverse range of low-carbon energy supply, and energy efficiency options exist around the nation. Table 1 lists a range of current policies, and potential resources for two states, Utah and Kansas that currently do not currently have RPS policies in place. These states illustrate an added level of diversity in the efficiency and supply options, and policy measures, that can reduce greenhouse gas emissions and obviate the need for added fossil-fuel capacity.

Support and Opportunities for Efficient and Clean Energy Systems in Utah and Kansas

Current Utah Policies:

- Utah Renewable Energy Systems Tax Credit: 25% residential, 10% commercial
- Utah Renewable Energy Sales and Use Tax Exemption
- Utilize the Federal Renewable Energy Production Tax Credit of 1.9 cents/kWh
- Utah Solar and Geothermal Business Tax Credit of 10%

Opportunities for Utah:

- Utah has an exceptional solar resource, for both solar thermal (~ $0.1/kWh) and solar photovoltaic (~ $0.2/kWh) installations.
- Utah has a significant wind resource in the southwest and northwest areas of the state, and could meet a significant portion of total demand. An even more impressive wind resource exists in neighboring Colorado, where over 360 MW of wind has been installed, and where ratepayers in many parts of the state have seen *electricity rates fall since the adoption, by popular vote*, of a renewable energy portfolio standard (Proposition 37).

Current Kansas Policies:

- Renewable Energy Property Tax Exemption (100%)
- The Renewable Energy Electric Generation Cooperative Act (which provides for creation of non-profit cooperatives to generate electricity from renewables)
- Kansas Energy Efficiency Program (Zero interest on state loans for energy efficient appliances for low-income residential customers)
- Kansas City Power & Light Commercial / Industrial Energy Efficiency Rebate Program (which provides varying incentives for pre-approved projects)

Opportunities for Kansas:

- Kansas has an exceptional wind resource, estimated to be roughly 122,000 MW, third largest in the nation. According to the U.S. Energy Information Administration, it is also one of the four states with the most land near existing transmission lines which is suitable for wind energy development, making the state a leading candidate for utility-scale wind energy development. Kansas could thus become a low-cost *national* supplier of wind energy.

Table 1: The Utah and Kansas portfolios as examples of efficient and clean energy investment drivers and a number of opportunities for carbon savings, CO_2 mitigation, and economic growth.

The Job Creation Dividend from Greenhouse Gas Abatement

A number of analysts have charted an additional benefit of developing the clean energy options of efficiency and renewable energy technologies: job creation. My laboratory conducted a study of job growth in the clean energy industry across the nation relative to that seen in the fossil-fuel sector. We found (Kammen, Kapadia and Fripp, 2004) that on average, three to five times as many jobs were created by a similar investment in renewable energy versus that when the same investment was made in fossil-fuel energy systems.

In addition, an important aspect of the job growth is that a large percentage of the jobs will be local, community based. Van Jones of the Ella Baker Center for Human Rights in Oakland California has noted that not only can these jobs become drivers of re-development, but that they afford a chance to turn augment 'Blue Collar' with 'Green Collar' in poor communities, and in communities of color.

One way to sum up the job growth potential of an efficient and clean energy economy is to compare employment totals under fossil-based and clean energy-based supply scenarios. Using U. S. Department of Energy forecasts for new generation mixes, we provide a comparison in Figure 4.

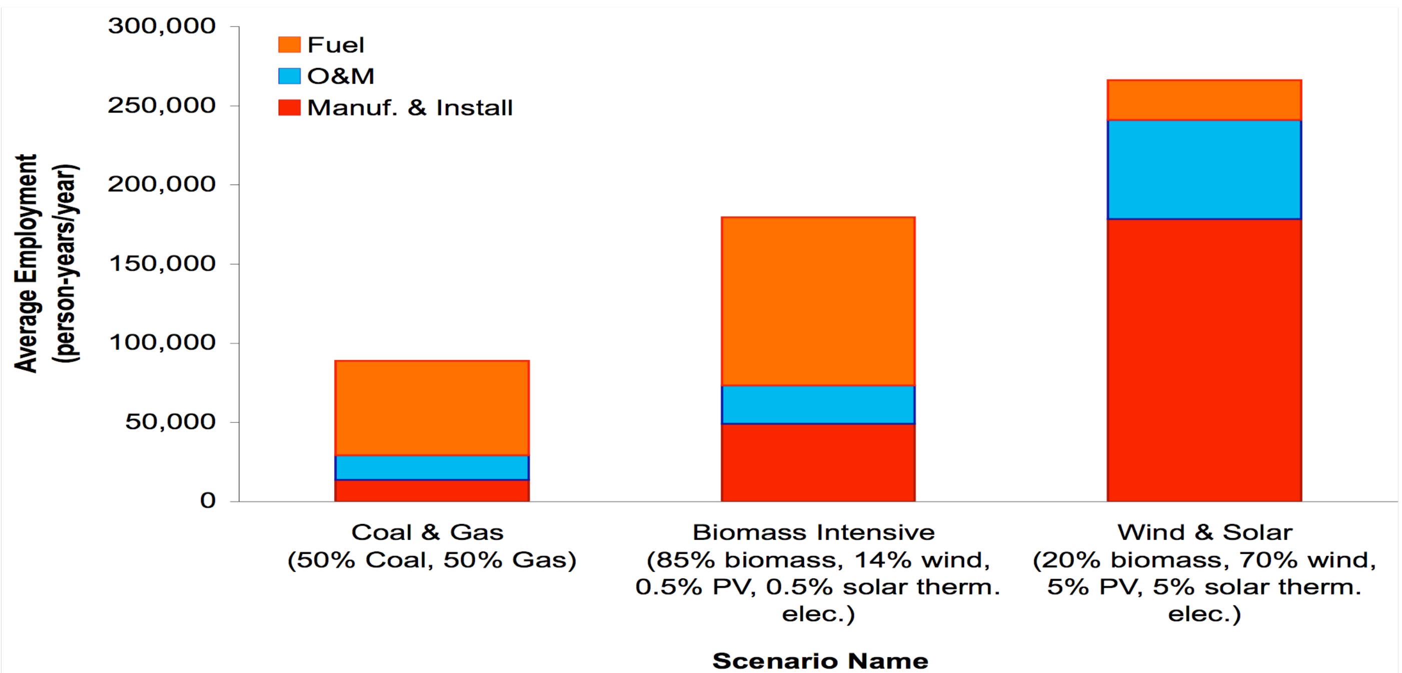

Figure 4: Comparison of the estimated employment created by meeting the equivalent of 20 percent of current U.S. electricity demand via and expansion of fossil or renewables-based electricity generation. These totals use the jobs per megawatt numbers from Kammen, Kapadia, and Fripp, 2004. These scenarios are for different fuel mixtures that could comprise state or federal Renewable Energy Portfolio Standards. The use of biofuel assumes that a range of biomass sources are either mixed with coal and combused as a solid fuel, or as a gasified feedstock that is combined with natural gas. In either case, the net greenhouse gas emissions is reduced over the coal-only or gas-only case because of the amount of biomass that is regrown in subsequent years (based on U. S. Department of Energy work in *The Billion Ton Feedstock Supply*, 2004).

A key result emerges from our work, and can be seen in Figure 4. Across a range of scenarios, the renewable energy sector generates more jobs than the fossil fuel-based energy sector per unit of energy delivered (i.e., per average megawatt). In addition, we find that supporting renewables within a comprehensive and coordinated energy policy that also supports energy efficiency and sustainable transportation will yield far greater employment benefits than supporting one or two of these sectors separately. Work by the German Potsdam Institute for Climate Change and the Ministry of the Environment comes to similar conclusions.

The U. S. Government Accounting Office conducted its own study of the job creation potential of a clean energy economy (GAO, 2004). In an important assessment of rural employment and income opportunities, they found that:

> … a farmer who leases land for a wind project can expect to receive $2,000 to $5,000 per turbine per year in lease payments. In addition, large wind power projects in some of the nation's poorest rural counties have added much needed tax revenues and employment opportunities.

Combining Technology and Financial Innovation – the Next Wave of Greenhouse Gas Abatement

As states and cities explore greenhouse gas emission reduction opportunities, new and important financial models are also emerging. The City of Berkeley, California provides one recent example that has already attracted international attention.

A Sustainable Energy Financing District is being developed as part of the City of Berkeley's implementation of Measure G – a successful 2006 ballot measure setting greenhouse gas reduction targets of a full 80% reduction in emissions by 2050.

The financing mechanism is loosely based on existing "underground utility districts" where the City serves as the financing agent for a neighborhood when they move utility poles and wires underground. In this case, individual property owners would contract directly with qualified private solar installers and contractors for energy efficiency and solar projects on their building. The City provides the funding for the project from a bond or loan fund that it repays through assessments on participating property owners' tax bills for 20 years. Cities may also be able to aggregate bonds, and states governments can facilitate this program in a number of ways.

No property owner would pay an assessment unless they had work done on their property as part of the program. Those who choose to pay for energy efficiency first, and then solar and energy installations through this program would pay only for the cost of their project, interest, and a small administrative fee.

The Financing District solves many of the financial hurdles facing property owners. First, there would be little upfront cost to the property owner. Second, the total cost of the solar system and energy improvements may be less when compared to financing through a traditional equity line or mortgage refinancing because the well-secured bond will provide lower interest rates than is commercially available. Third, the tax assessment is transferable between owners. Therefore, if an individual sells their property prior to the end of the 20-year repayment period, the next owner takes over the assessment as part of their property tax bill.

This mechanism, announced publicly on October 23, 2007, has attracted statewide attention as other cities, and now the state government, looks to find ways to expand the Financing District model statewide. Further, the U. S. Department of Energy has expressed its willingness to facilitate the dissemination of the program to other cities, states, and regions.

A Roadmap to Low Carbon Energy Efficiency and Clean Energy Supply Options

A particularly useful view of low carbon energy options has been developed by the Vattenfall Utility Cooperative in Sweden and can be done in the U.S. Such a roadmap can focus and contextualize EPA considerations of alternative power generation proposals and their related costs. This presentation, seen in Figure 5 shows:

- Estimated costs (some of which are negative, implying overall *savings* to the economy through the adoption of clean energy options) of potential climate solutions, *and* the amount of carbon they may be able to offset, or avoid, by a specific time (in this case 2030)
- The potential for a wide range of energy options to play a significant role in CO_2 reduction, which in turn leads to distinct technology and management strategies that individual states may pursue
- A clear conclusion that we will need to adopt policies that support and encourage development and deployment of a *diversity* of clean energy options.

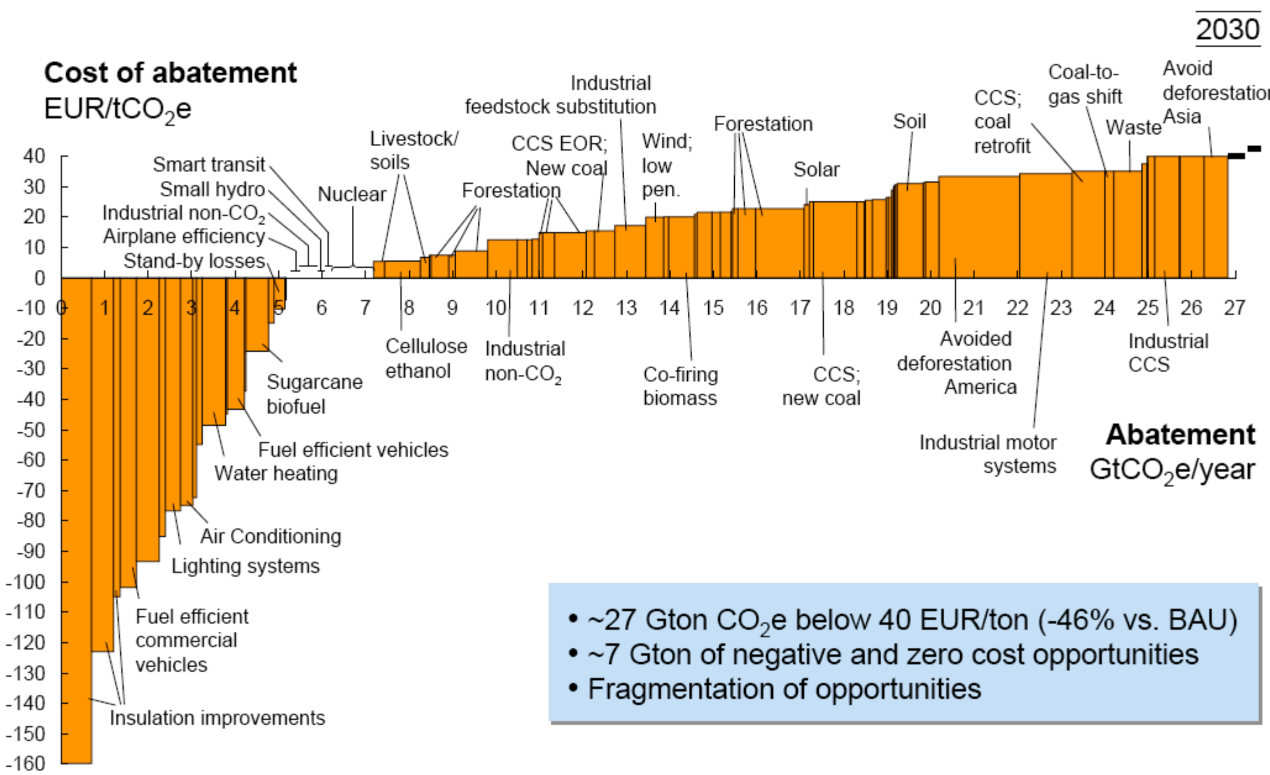

Figure 5: Estimate carbon reduction possibilities in Euros per ton of carbon dioxide equivalent (EUR/tCO_2e). The vertical axis shows the cost (or benefit) of the specific mitigation option, while the horizontal axis shows the estimated amount of savings (in giga-tons of carbon) by 2030.

The key insight from this analysis is that a portfolio of low-carbon opportunities exists, and that state and local governments, if supported by analysis and policies at the federal level, can enact a wide range of cost-effective dissemination programs. While these will require a combination of research and deployment to become major components of our economy, the tools to begin this process exist today. The abundance of cost-effective energy efficiency options, and of low-carbon sources in the U. S. is a rich resource from which we can draw.

The critical first step in achieving the benefits of a low-carbon economy is conduct systematic reviews of our options, and to build supply portfolios that protect the economy and the environment. My testimony highlights the degree to which this task, while significant, can be accomplished through actions by the EPA and other federal agencies.

Thank you for the opportunity to appear before your committee.

Brief Biography – Daniel M. Kammen

I hold the Class of 1935 Distinguished Professorship in Energy at the University of California, Berkeley, where I am a professor in the Energy and Resources Group, the Goldman School of Public Policy, and the Department of Nuclear Engineering. I am the founding director of the Renewable and Appropriate Energy Laboratory (http://rael.berkeley.edu), an interdisciplinary research unit that explores a diverse set of energy technologies through scientific, engineering, economic and policy issues. I am also the Co-Director of the University of California, Berkeley Institute of the Environment. I have served on the Nobel Peace Prize winning Intergovernmental Panel on Climate Change (IPCC) as a Coordinating Lead Author. I have testified before both United States House and Senate Committees on the science of regional and global climate change, and on the technical and economic status and the potential of a wide range of energy systems, notably renewable and energy efficiency technologies for use in both developed and developing nations. I am the author of over 200 research papers, and five books, most of which can be found online at http://rael.berkeley.edu

In July of last year the Honorable R. John Efford, the then Minister of Natural Resources Canada, announced my appointment, as the only U. S. citizen, to serve on the Canadian National Advisory Panel on the Sustainable Energy Science and Technology (S&T) Strategy.

I played a leadership role in developing, and now in managing, the successful $500 million Energy Biosciences Institute award from BP, won by our team from the University of California, Berkeley, the University of Illinois at Urbana Champaign, and Lawrence Berkeley National Laboratory.

Acknowledgments

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University of California Class of 1935. I am delighted to thank Carla Peterman, graduate students in the Energy and Resources Group at the University of California, Berkeley, for her assistance in developing this testimony.

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