United States Senate Committee on Environment and Public Works

Testimony for the September 25, 2007 Hearing on:

Green Jobs Created by Global Warming Initiatives

by

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Introduction & Summary

Chairman Barbara Boxer, Hearing Chair Barrie Sanders, and other members of the Senate Environment and Public Works Committee, I appreciate your invitation to appear before you today. I am particularly appreciative your inspiring efforts to develop a comprehensive approach to environmental quality, human health protection, and economic development for the nation. I am grateful for the opportunity today to speak with you on the energy, climate, and security issues that face our nation and the planet.

In this testimony I highlight the key finding that while a continuation of business as usual energy choices will result in socially, politically, and environmentally costly and destructive climate change, the motivation to invest in solutions to climate change can be simply that a green economy can also be exceedingly vibrant. In fact, an economy built around a suite of low-carbon technologies can be resistant to price shocks as well as secure against supply disruptions as well as inclusive of diverse socioeconomic groups. A new wave of job growth – both 'high technology' and ones that transform 'blue collar labor' into 'green collar' opportunities. The combination of economic competitiveness and environmental protection is a clear result from a systematic approach to investing in *climate solutions*.

Clean energy systems and energy efficiency investments also contribute directly to energy security and to domestic job growth versus off-shore migration. Renewable energy systems are more often local than imported due to the weight of biomass resources and the need for operations and maintenance.

A growing number of state, regional, and national economies are assuming leadership positions for a clean, low carbon, energy economy. These 'early actors' are reaping the economic benefits of their actions. Among the global leaders are Brazil, Denmark, Iceland Germany, Japan, Spain, all of which have made significant commitments to a green economy, and all are seeing job growth and rapidly expanding export opportunities. In the United States several states have embarked on significant climate protection efforts, and half of U. S. states have taken the vital step of adopting minimum levels of renewable energy requirements.

On the vitally important issue of transportation a set of European nations have shared, along with California, Illinois, and now a number of additional states in developing and adopting versions of the Low Carbon Fuel Standard (Kammen, 2007; Kammen, *et al.*, 2007). The goal of a Low Carbon Fuel Standard is to reduce the greenhouse impact of fossil fuel emissions, and to begin to move toward a diverse set of economically and environmentally sustainable transportation choices.

Job Growth in a Green Economy – Empirical Lessons and Strong Prospects

Expanding the use of renewable energy is not only good for our energy self-sufficiency and the environment; it also has a significant positive impact on employment. My students and I have examined the *observed* job growth in a number of technology sectors (Kammen, Kapadia and Fripp, 2004).

We reviewed 13 independent reports and studies that analyzed the economic and employment impacts of the clean energy industry in the United States and Europe. These studies employ a wide range of methods, which adds credence to the findings. In addition to reviewing and comparing these studies, we have examined the assumptions used in each case, and developed a job creation model which shows their implications for employment under several future energy scenarios.

Energy Technology	Source of Estimate	Average Employment Over Life of Facility (jobs/MWa)		
		Construction, Manufacturing, Installation	O&M and fuel processing	Total Employment
PV 1	REPP, 2001	6.21	1.20	7.41
PV 2	Greenpeace, 2001	5.76	4.80	10.56
Wind 1	REPP, 2001	0.43	0.27	0.71
Wind 2	EWEA/Greenpeace, 2003	2.51	0.27	2.79
Biomass – high estimate	REPP, 2001	0.40	2.44	2.84
Biomass – low estimate	REPP, 2001	0.40	0.38	0.78
Coal	REPP, 2001	0.27	0.74	1.01
Gas	Kammen, from REPP, 2001; CALPIRG, 2003; BLS, 2004	0.25	0.70	0.95

Table 1: Average employment for different energy technologies. "MWa" refers to average installed megawatts de-rated by the capacity factor of the technology; thus, for a 1 MW solar facility operating on average 21% of the time, the power output would be 0.21 MWa. References in parentheses and sources refer to the studies reviewed in the text. The biomass energy studies are a proxy for jobs that could derive from an expansion of biofuels (e.g. ethanol use) in regional or the national energy mix.

Economic Benefits – focus on biofuels

Forecasts of job creation can, in fact be *far* higher that our assessment. The Apollo Alliance has concluded that even stronger job growth is possible, and a recent U. S. Department of Energy report *Breaking the Barriers to Cellulosic Ethanol* concluded that:

> A biofuel industry would create jobs and ensure growing energy supplies to support national and global prosperity. In 2004, the ethanol industry created 147,000 jobs in all sectors of the economy and provided more than $2 billion of additional tax revenue to federal, state, and local governments (RFA 2005). Conservative projections of future growth estimate the addition of 10,000 to 20,000 jobs for every billion gallons of ethanol production (Petrulis 1993). In 2005 the United States spent more than $250 billion on oil imports, and the total trade deficit has grown to more than $725 billion (U.S. Commerce Dept. 2006). Oil imports, which make up 35% of the total, could rise to 70% over the next 20 years (Ethanol Across America 2005). Among national economic benefits, a biofuel industry could revitalize struggling rural economies. Bioenergy crops and agricultural residues can provide farmers with an important new source of revenue and reduce reliance on government funds for agricultural support. An economic analysis jointly sponsored by USDA and DOE found that the conversion of some cropland to bioenergy crops could raise depressed traditional crop prices by up to 14%. Higher prices for traditional crops and new revenue from bioenergy crops could increase net farm income by $6 billion annually (De La Torre Ugarte 2003)

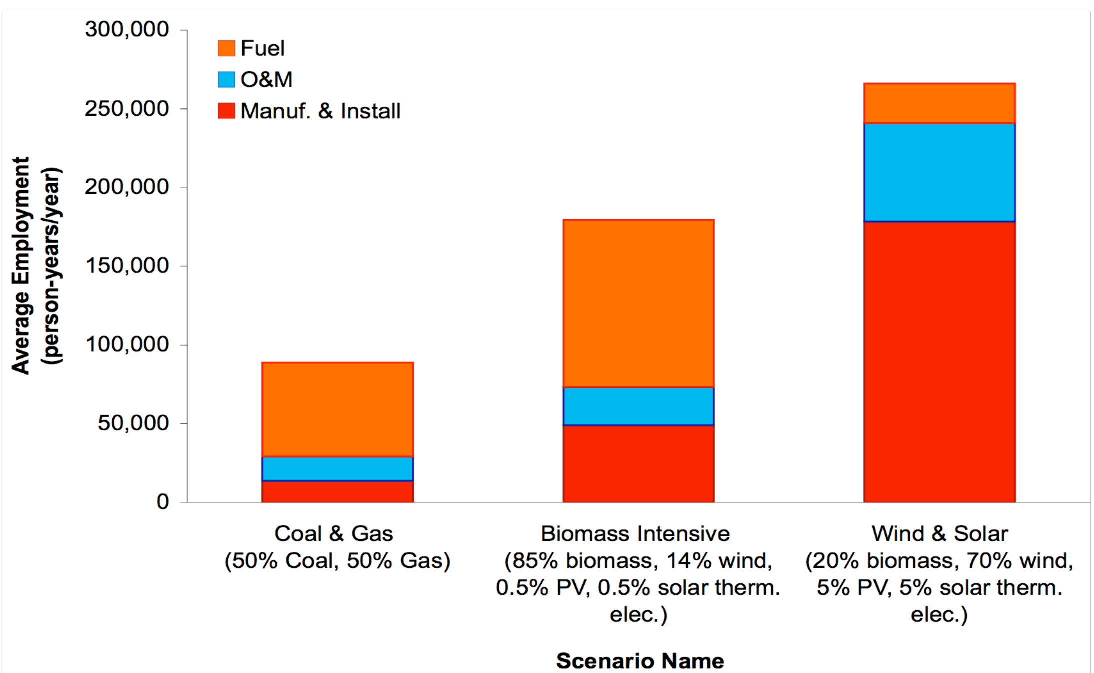

Figure 1: Comparison of the estimated employment created by meeting the equivalent of 20 percent of current U.S. electricity demand via and expansion of fossil or renewables-based electricity generation. These totals use the jobs per megawatt numbers from Table 1. These scenarios are for different fuel mixtures that could comprise a federal Renewable Energy Portfolio Standard.

A key result emerges from our work, and can be seen in Table 1. Across a broad 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. Further, generating local employment – including that in inner-cities, rural communities, and in areas in need of economic stimulus -- through the deployment of local and sustainable energy technologies is an important and underutilized way to enhance national security and international stability. Conversely, we find that the employment rate in fossil fuel-related industries has been declining steadily for reasons that have little to do with environmental regulation.

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.

Moving to Federal Action – A Green Jobs/Renewable Energy Portfolio

Twenty-three states and the District of Columbia have now enacted Renewable Energy Portfolio Standards, which each call for a specific percentage of electricity generated to come from renewable energy. Federal legislation should, *at minimum*, solidify state action with federal support. A great deal would be achieved if Congress took the logical step and instituted a federal standard. A 20% federal RPS enacted today and required by 2020 is reasonable and achievable, and should be a focal point of congressional action.

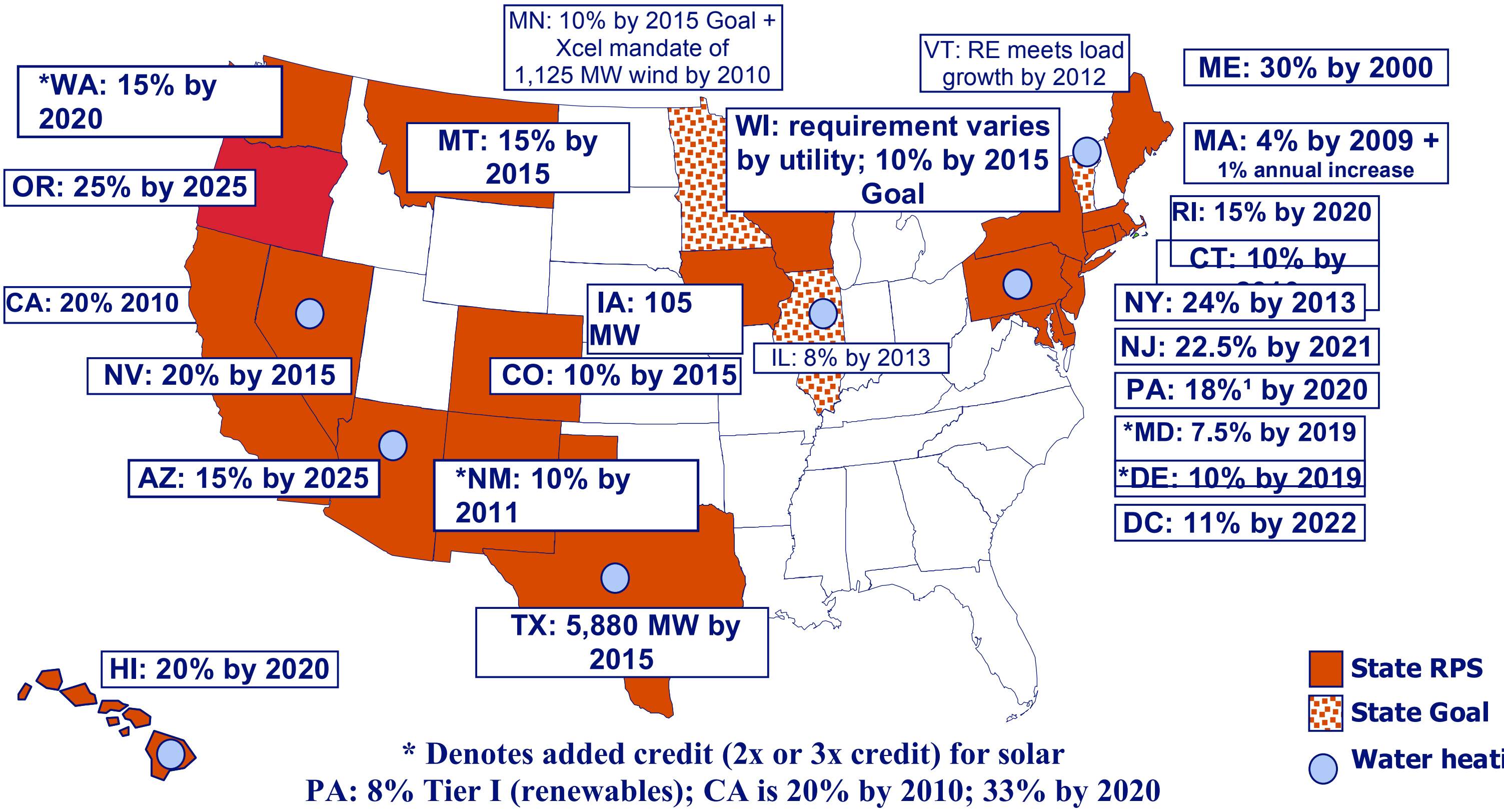

Figure 2. Map of States with Renewable Energy Portfolio Standards As of January 2007, 23 states and the District of Columbia have enacted or voted to adopt renewable energy standards. These plans represent a diversity of approaches and levels, but each reflect a commitment to clean and secure energy 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.

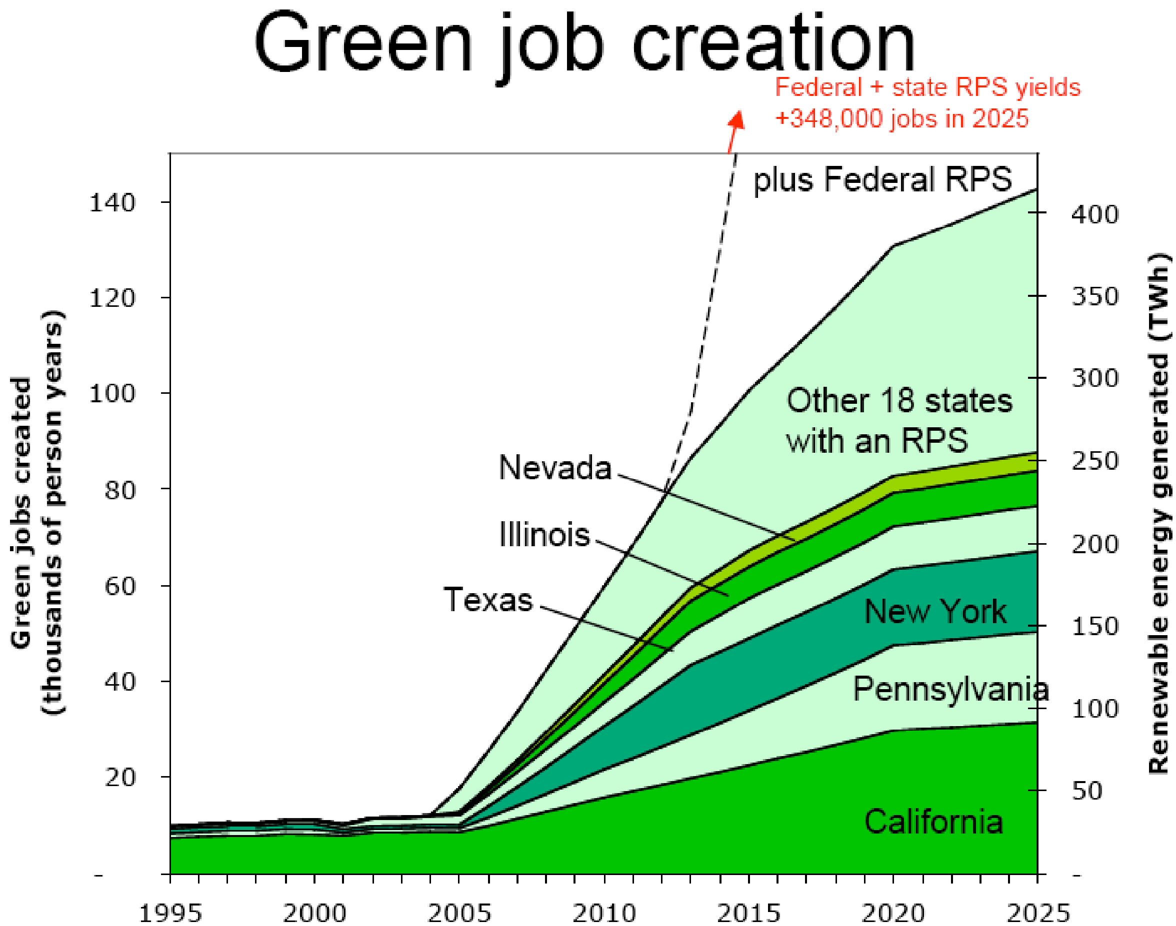

Figure 3: Green job creation totals for selected states, *and* for the nation as a whole if a 20% RPS were adopted for 2020.

It is clear that developing a clean energy economy is not only good for the environment, but it is good for job creation as well.

Recommendations

There are a number of measures that the committee should consider, and the nation as a whole would be well-served to include in a clearly articulated plan for the development of a national energy vision and green jobs strategy. These include:

Raise Clean Energy Research, Development, and Deployment Spending to Reasonable Levels

The U. S. has under-invested in energy research, development, and deployment for decades (Kammen and Nemet, 2005), and sadly the FY2008 budget request is no exception. Federal energy research and development investment is today back at *pre-OPEC* levels – despite a panoply of reasons why energy dependence and *in-security,* and climatic impact from our energy economy are dominating local economics, geopolitics, and environmental degradation.

At $2.7 billion, the overall energy RD&D FY08 request is $685 million higher than the FY06 appropriated budget. Half of that increased request is accounted for by increases in fission, and the rest is in moderate increases in funding for biofuels, solar, FutureGen, and $147 million increase for fusion research. However, the National Renewable Energy Laboratory's (NREL) budget is to be cut precisely at a time when concerns over energy security and climate change are at their highest level, and level of need. The fact that a plan exists to cut assistance to low-income families by 41% from FY06 levels for weatherization to improve the energy efficiency of their homes is startling.

The larger issue, however, is that as a nation we invest *less* in energy research, development, and deployment than do a few large biotechnology firms in their own, private R&D budgets. This is unacceptable on many fronts. The least of which is that we *know* that investments in energy research pay off at both the national and private sector levels.

In a series of papers (Margolis and Kammen, 1999; Kammen and Nemet, 2005; Nemet and Kammen, 2007) my students and I have documented a disturbing trend away from investment in energy technology—both by the federal government and the private sector, which largely follows the federal lead. The U.S. invests about $1 billion less in energy R&D today than it did a decade ago. This trend is remarkable, first because the levels in the mid-1990s had already been identified as dangerously low, and second because, as our analysis indicates, the decline is pervasive—across almost every energy technology category, in both the public and private sectors, and at multiple stages in the innovation process. In each of these areas investment has been either been stagnant or declining. Moreover, the decline in investment in energy has occurred while overall U.S. R&D has grown by 6% per year, and federal R&D investments in health and defense have grown by 10 to 15% per year, respectively.

One of the clearest findings from tracking actual investment histories, is that there is a direct and strong correlation between investment in innovation and demonstrated changes in performance and cost of technologies available in the market.

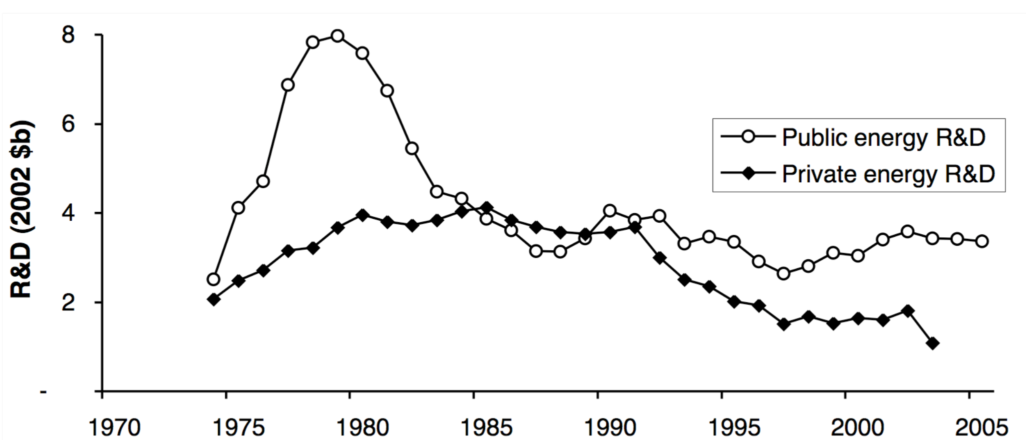

Figure 4. The history of declining energy R&D investment by both public and private sectors. Both 2006 and 2007 were years of budget upturn, and there is significant hope that 2008 will continue that trend. It is vital that a significant, steady, and sustained, increase takes place. Public sector investment in energy R&D is vital to 'prime the pump' and enable private efforts. Source: Kammen and Nemet (2005) *Issues in Science and Technology.*

In the case of solar photovoltaics, a 50% increase in PV efficiency occurred immediately after unprecedented $1 billion global investment in PV R&D (1978-85). From there, we observed significant efficiency improvements, which accounts for fully 30% of the cost reductions in PV over the past two decades. (Increased plant size, also related to the economic viability of PV accounts for the largest segment, 40% of the cost decline over the same period of time.)

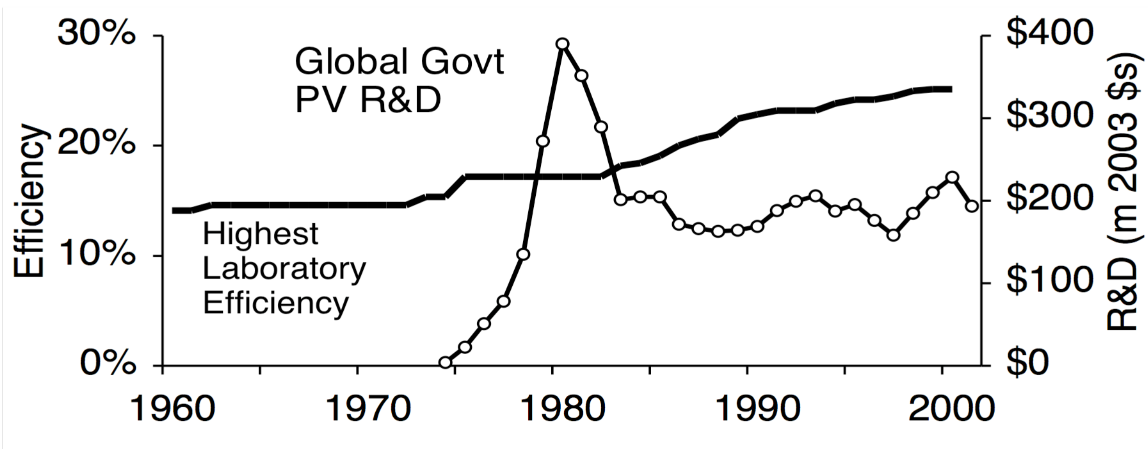

Figure 5: Benefits of R&D Investments in Improving Products in the Market. Directly after a significant increase in federal funding for solar photovoltaics, a 50% rise in cell efficiency occurred. This increase in efficiency has been shown to be the second largest single contributor to the cost effectiveness of solar cells. Source: Nemet, G. F. (2006). "Beyond the learning curve: factors influencing cost reductions in photovoltaics, *Energy Policy* **34(17),** 3218 - 3232.

The U. S. experience is not at all unique. A world-leading solar energy program was initiated in Japan almost 20 years ago. The results have been dramatic.

The Japanese program integrated *both* research and development efforts. The result of the Japanese program was striking: the cost of installed solar PV systems *fell* by over 8% per year for a decade. A smaller effort in California, but without significant R&D spending, resulted in *one-half* that level of innovation and cost improvement. California has now embarked on a much larger (10 years, $320 million/year) commercialization

The case of solar photovoltaics is not at all unique. By looking at individual energy technologies, we have found that in case after case, R&D investment spurs invention and job creation. In a set of recent reports we (Kammen and Nemet, 2005) report on the strong correlation between investment and innovation and job creation for the solar, wind, biomas, and nuclear industries.

We also see steady cost declines in solar and wind technologies, although a significant amount of the manufacturing for each technology has been outside the U. S. for many years.

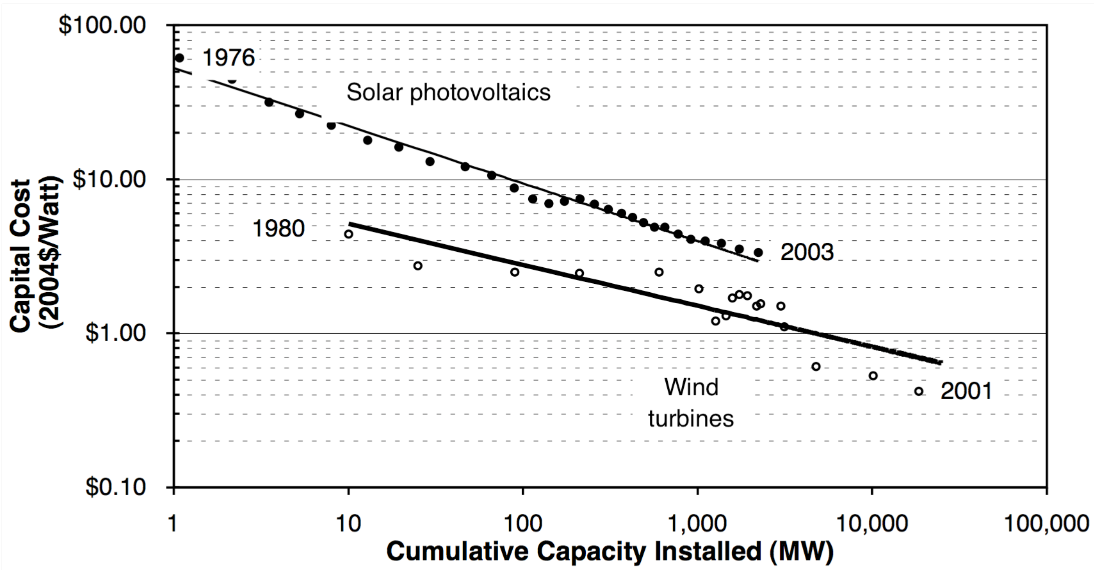

Figure 6: Capital costs of photovoltaics and wind turbines (constant 2004$/Watt.) The horizontal axis shows cumulative worldwide installations of each technology (Duke and Kammen, 1999). Expanding production, driven by research, development, and deployment directly pays off in cost declines for the technology, and larger domestic markets further result in greater economic activity and job creation (Kammen, Kapadia, and Fripp, 2004).

Provide Research Support Jointly to the Departments of Energy and Agriculture, and the Environmental Protection Agency to Study a Federal Low Carbon Fuel Standard

The recent explosion of interest in biofuels, including ethanol and biodiesel, has been a major advance in diversifying our transportation fuels markets. On January 27, 2006, our research group at the University of California, Berkeley, published a paper in *Science*, the magazine of the American Association for the Advancement of Science, and an accompanying website (http://rael.berkeley.edu/ebamm) that provided a calculator to compare the greenhouse gas benefits of ethanol derived from a range of input biofuels, and produced in distilleries powered by different fuels (e.g. coal, natural, gas, or through the use of renewables).

The conclusion of that work was simple: not all biofuels are created equal in terms of their carbon content. The next logical step was to rank, and then regulate fuels, based on their carbon content.

In January 2007 California Governor Arnold Schwarzenegger signed Executive Order 1-07 to establish a greenhouse gas standard for fuels sold in the state. The new Low Carbon Fuel Standard (LCFS) requires a 10 percent decrease in the carbon intensity of California's transportation fuels by 2020. The state expects the standard to more than triple the size of the state's renewable fuels market while placing an additional seven million hybrid and alternative fuel vehicles on the road. The standard will help the state meet its greenhouse gas reduction goals set by state Assembly Bill 32, which the governor signed last year.

On February 21, 2007 California Governor Schwarzenegger and Senator McCain called for a federal LCFS. An important piece of the LCFS should be the inclusion of electricity as a fuel to support the development and use of plug-in hybrid vehicles in areas where the average grid power is sufficiently low-carbon to result in a net reduction in greenhouse gas emissions. A low carbon fuel standard will promote the development of at least two important industries: a sustainable biofuels sector; and the evolution of the plug-in hybrid sector. Both of these are area of potentially strong and sustained job growth. At present, however, Detroit automakers have expressed concerns about the job benefits of a clean energy economy. A study conducted by the University of Michigan found, in fact, that job *losses* could occur if Detroit does not become more innovative and competitive. Integration of bioenergy/ethanol resources *and* work to develop the commercially successful plug-in hybrid industries could both become major areas of new job growth.

Significantly, bioenergy work – agriculture and distilling – and battery construction and vehicle construction are areas where high wages can be expected.

Build Jobs Across Socioeconomic Groups – the Green Jobs Program in the U. S. and Overseas

Green jobs can accrue across the entire economy, from laboratory research and development positions, to traditionally unionized work in plumbing, electrical wiring, and civil engineering. Following the critically important Green Jobs initiative Senator Sanders spearheaded in the Senate, the House Green Jobs Act (initially sponsored by Solis and Tierny, HR 2847, now part of the HR 3221, the Renewable Energy and Energy Conservation Act of 2007) invests in worker training and career opportunities for low-income Americans. These efforts are to be applauded, and could be the model for expanded job access and development efforts in a wide range of energy related industries.

In addition to supporting domestic job creation, clean energy is an important and fastest growing international sector, and one where overseas policy can be used to support poor developing regions – such as Africa (Jacobsen and Kammen, 2007) and Central America – as well as regaining market share in solar, fuel cell and wind technologies, where European nations and Japan have invested heavily and are reaping the benefits of month to *year* backlogs in clean energy orders. Some of those orders are for U. S. installations, but many more could be if we choose to make clean and green energy a national priority for both domestic installation and overseas export.

Technology exports have impacts well beyond domestic job creation. In fact, if properly managed, the development of a thriving 'cleantech' sector can address a vital global issues, namely the emissions trajectories of major developing nations. China and India are often singled out for attention as major, emerging global emitters. China, in fact, will become the world's largest greenhouse emitter in the near future, if it has not already. This fact, is often used – mistakenly in my view – to argue against unilateral climate protection efforts by nations such as the United States. This view is shortsighted in two vital respects. First, China is demonstrably already suffering from the impacts of fossil fuel use. Crop yields in many parts of China are significantly lower than they would be without the significant sulfur and particulate burden that results from domestic coal combustion. (In fact, coal combustions emissions from China have significant air quality impacts on Japan, and can be measured in the U. S. as well.) Crop losses of over 20% have been reported in part of China, with the decrease unambiguously linked to air pollution. China also experiences significant *human* health impacts from this pollution burden as well.

Second, China has committed, on paper, to a 'circular economy' where waste is reduced and overall productivity is enhanced. *If* the United States were to become a major exporter, or even a partner, in the production of low-emissions technologies – from truly carbon-capture coal-fired power plants, to increased numbers of solar, wind, and biofuel technologies – China would be an eager trading partner, so that they could install increasing numbers of low-emissions technologies. This would directly help the Chinese economy and their environmental and public health situation.

On both of these grounds, U. S. domestic expansion of the clean energy sector will likely positively impact the ability and the actions of a number of emerging economies to 'go green'.

Brief Biography – Daniel M. Kammen

I hold the Class of 1935 Distinguished Chair 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 Intergovernmental Panel on Climate Change (IPCC), and have testified before both U. S. 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.

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