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Renewable Energy in United States Foreign Policy

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RENEWABLE ENERGY IN UNITED STATES FOREIGN POLICY

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INTRODUCTION AND MOTIVATION

After years of neglect, concerns over energy security have become *de rigueur* in every discussion of United States foreign policy. The causes of this newly discovered, or if the presidency of Jimmy Carter is used as a not-too-distant point of reference, re-discovered attention are largely obvious: two Gulf wars in a little over a decade fought, at least in part, over oil access and security; oil prices that have hovered at the historic peaks of about $60/barrel (in inflation adjusted dollars),[1] highly-visible instabilities in nations key to the United States' supply, and the emergence on international buying markets of major competitors for oil, notably China. At a time when the "cleantech" energy sector is

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[1] U.S. Department of Energy Petroleum Reference Data, http://www.eia.doe.gov/emeu/aer/eh/frame.html.

dramatically expanding, even within the United States, the potential of a vigorous domestic renewable policy to become a central component of United States foreign policy still remains largely overlooked at the federal level.

While "energy security" is evoked regularly to justify United States military and economic policies, federal strategies and efforts remain almost exclusively fixated on fossil-fuel supply security. This position is paradoxical, and ultimately self-defeating, given the universal recognition that feeding an addiction, as President Bush amongst others, have termed the United States' demand for oil (and response), is the worst response possible in terms of the long-term health of the patient.[2] In this case, the patient being both the United States economy and the global environment subject to climate change. Multiple options exist to actually reduce United States oil dependence by increasing the use of renewable energy sources, as efforts in a number of states as well as foreign governmental policies demonstrate.

This article examines the root-causes of the United States' oil-induced myopia, and highlights the synergies that could exist between a low-carbon and a high-security national energy policy and how such synergies might reshape foreign policy dynamics and options.[3]

I. BACKGROUND RECENT NATIONAL ENERGY POLICY ACTIONS

There is no industry more important to the economy of the United States, California, and the world than energy.[4] It is by far the largest business on the planet and has the greatest impact on job growth, as well as on the quality of the environment.[5] But this nation has been treating energy policy as an afterthought.

In this context, faced with record-high oil prices and an oil-relevant, if not oil-driven, war in Iraq, United States President Bush unveiled during the summer of 2005 several new energy initiatives as solutions to national energy, security and economic ills.[6] The President's plan called

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[2] President George Bush, 2006 State of the Union Address, http://www.whitehouse.gov/news/releases/2006/01/20060131-10.html

[3] Nebojsa Nakicenovic et al, *Long-term Strategies for Mitigating Global Warming*, 18 ENERGY 401 – 609 (1993).

[4] INTERNATIONAL ENERGY AGENCY, *IEA* ENERGY TECHNOLOGY R&D STATISTICS, 1974-1995 (Int'l Energy Agency, Org. for Econ. Cooperation & Dev., Paris 1997).

[5] DANIEL M. KAMMEN, KAMAL KAPADIA, & MATTHIAS FRIPP, PUTTING RENEWABLES TO WORK: HOW MANY JOBS CAN THE CLEAN ENERGY INDUSTRY GENERATE? A REPORT OF THE RENEWABLE AND APPROPRIATE ENERGY LABORATORY, UNIVERSITY OF CALIFORNIA, BERKELEY (2004).

[6] President George Bush, 2006 State of the Union Address,

for importing of liquefied natural gas, the construction of added refineries, and support for improved diesel fuels.[7] At best, these measures should be seen as short-term, stopgap measures that might be adopted as part of a long-range energy package. In fact, they only serve to expand our dependence on oil, widen the trade deficit, and put American troops needlessly in harms way.[8]

In addition, the President proposed streamlining the licensing of new nuclear power plants, which at best may be good for a very few companies hoping to sell today's technology.[9] This package overall failed to address the problematic economics of the nuclear industry today, the management of nuclear waste, or the long-term issue that unless we are prepared to build *hundreds* of nuclear plants, there will be no significant impact on global warming, which is the real threat facing our economy and lifestyle.

One widely cited component of the bill's strength was the call for daylight saving time to be extended two months a year.[10] When asked about the rising cost of gasoline and policy instruments to curb the increase, David Garman, Under Secretary of Energy for President Bush, commented that perhaps Americans should "drive less."[11]

In fact, and perhaps most interestingly, the traditional strength of the Republican Party, big business, was left asking for added certainty and direction on energy and climate issues.

In a widely cited interview, Paul Anderson, Chairman and Chief Executive Officer of Duke Energy Corporation said that a carbon tax would be the best United States policy to encourage the inevitable requirements to reduce greenhouse gas emission.[12] "If we don't speak, regulators will make rules and we will have to live with them," he said.[13] "It's better to be part of the process. A carbon tax, for example, makes a

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http://www.whitehouse.gov/news/releases/2006/01/20060131-10.html.

[7] President George Bush, President Signs Energy Policy Act (August 8, 2005) http://www.whitehouse.gov/news/releases/2005/08/20050808-6.html.

[8] Daniel M. Kammen, Lack of Vision on Policy Clouds Energy Future, S.F. CHRON., May 13, 2005, at B9.

[9] President George Bush, President Signs Energy Policy Act (August 8, 2005) http://www.whitehouse.gov/news/releases/2005/08/20050808-6.html.

[10] As if this measure was not insignificant enough, serious debate and disagreement even exists over what energy savings, if any, this change would accomplish.

[11] Roger Metzger, Want Trumps Need in '05 Energy Crisis (July 3, 2005), EnergyBulletin.net, http://www.energybulletin.net/7379.html.

[12] William Schlesinger, Duke University, News & Communications, Carbon Tax Provides Fairest Incentive For Curbing Global Warming, (May 16, 2005), http://www.dukenews.duke.edu/2005/05/carbontax_print.htm.

[13] *Id.*

lot of sense. It's a no-regrets approach to global warming."[14]

Similarly, General Electric Chairman and Chief Executive Officer Jeffrey Immelt announced in the spring of 2006 that he supports federal requirements for utilities to produce a certain percentage of electricity from renewable sources.[15] The announcement came out of GE's new 'ecomagination' initiative that could transform the company into an even more profitable green giant.[16]

The real issue, in fact, is that today our energy economy lacks the diversity it needs to respond to the inevitable economic, political, and environmental shocks that history has demonstrated will frequently occur.[17] By contrast, the initiatives presented by the President send the signal to American industry that investment in truly innovative new technologies and economic leadership are not a national priority.[18]

II. USEFULLY DEFINING "ENERGY INDEPENDENCE"

What does *energy independence* really mean? More importantly, what does it do for the nation and the world? Does *energy independence* mean that no imported energy can or should be used? Does it mean that any and all domestic fossil fuels *should* be used? The answer is a resounding 'no' on both counts, and on both economic and environmental grounds. What is clear is that our foreign policy and our domestic economy have been shaped - arguably to our detriment - by the need to secure an ever-increasing amount of overseas oil. Energy is the largest component of our – and the world's - economy and has for far too long been an area we in the United States have either taken for granted, undervalued, or assumed would be available with little economic, social, or environmental cost. All three of these assumptions, or operating principles, have proven incorrect, often tragically. For example, the effect of high oil prices on our economy during the OPEC crises of the 1970s, and during Gulf War I, and Gulf War II, as well as in the wider Middle East geopolitics surrounding the 9/11 bombing and the United States response. Moreover, political upheavals in Nigeria, Venezuela and other oil producing countries have had their share of influence on the price of oil.

What *energy independence* more accurately and usefully means is

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[14] *Id.*

[15] A Change in the Wind, Another Conservative Opinion Leader Endorses Carbon Tax (Jan. 13, 2006), http://achangeinthewind.typepad.com/achangeinthewind/*2006/01*/another_conserv.html.

[16] *Id.*

[17] Kammen, *supra* note 8.

[18] *Id.*

the ability to make foreign and domestic policy decisions without being hostage to a resource addiction - in this case oil, and all of the irrationalities that come with decisions made in the throes of an addiction. To date the United States has not been able to break that addiction - a reality reflected plainly in our foreign relations. This is why, even while at war in Iraq in the name of democracy, the United States nonetheless remains supportive of autocratic, oppressive regimes, such as Saudi Arabia, to ensure that oil supplies to the United States are not unduly interrupted. This is why, even while diplomatically condemning Iran's recent pronouncement of its nuclear intentions, the United States is unlikely to take any action that will jeopardize the flow of Iranian oil to the United States. Such dynamics reveal some of the more obvious ways in which our lack of energy independence limits and shapes our foreign policy options.

Can we go fossil fuel cold turkey? The answer, of course, is 'no.' As dire as the ever-mounting body of evidence about global warming is, the reality is that it will take time, several decades, for the United States to make the transition to a low or no-carbon economy. One problem impeding this transition, however, is the fact that we are running out of atmosphere faster than we are running out of oil.[19] As a result of this alarming situation, high fossil fuel prices alone are probably not going to generate the sort of transition away from fossil fuels that we need. High fossil fuel prices may open the door for clean energy options, but without a strong technology base and a policy push, high prices won't do it by themselves.

The encouraging news is that we have a great many tools and options now available if the political will and leadership can be found. Wind power is in many areas cheaper than natural gas fired electric plants, solar photovoltaics are becoming cost-competitive, and solar thermal power plants can beat fossil fuel competitors today. Hybrid cars are now available, and plug-in hybrids running on corn-based, or ideally cellulosic ethanol could get us to the 100 to 200 mile per gallon range with current or near-term technology.[20] The success stories of wind in Denmark and Germany, ethanol in Brazil, and the policy leadership that California, New York and the New England states have shown, all point

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[19] Ann P. Kinzig & Daniel M. Kammen, *National Trajectories of Carbon Emissions: Analysis of Proposals to Foster the Transition to Low-Carbon Economies*, 8 GLOBAL ENVTL. CHANGE 177, 183-208 (1998); NEBOJSA NAKICENOVIC ET AL., SPECIAL REPORT ON EMISSIONS SCENARIOS, A SPECIAL REPORT OF WORKING GROUP III OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Cambridge University Press 2000).

[20] Alexander E. Farrell et al., *Ethanol Can Contribute to Energy and Environmental Goals*, SCIENCE MAGAZINE 311, 506-08 (2006).

the way to a clean energy future.[21]

Beyond that, Sweden has committed to significantly reducing its dependence on oil by 2020.[22] Germany has committed to a forty percent greenhouse gas reduction goal by 2020,[23] and a diverse network of cities is planning considerable green energy efforts.[24] We also know from a large body of individual and methodologically distinct studies that investments in clean energy come at a bonus of increased job creation relative to what similar investments in fossil fuel technology would deliver.[25]

Taken in sum, these are overwhelming reasons to push hard and fast for a clean energy economy, and one with increased job creation, international energy security, and strong environmental benefits.

In recent research projects, the Renewable and Appropriate Energy Laboratory at University of California at Berkeley (which I co-direct) has examined scenarios to wean the United States off of oil by 2025, the super-aggressive path, and by 2050, the less aggressive, but still revolutionary future-changing strategy.[26] In both cases we found that the technologies exist today to begin the transition, and that the benefits of embarking on this path are tremendously positive, both locally and globally.[27]

What is holding us back? Lack of investment in clean energy research, for one, as well as lack of appreciation of the benefits – in terms of jobs, geopolitical security, and environmental protection.[28]

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[21] Daniel M. Kammen, *An Energy Policy For The 21st Century*, 2 POLICY MATTERS 1, 14-19 (2005).

[22] Government Offices of Sweden, http://www.Sweden.gov.se/sb/d/2058/a/57732 (follow "The Commission on Oil Independence" hyperlink).

[23] See The Climate Group, http://www.theclimategroup.org/index.php?pid=422.

[24] Katrina C. Arabe, *The World's Greenest Cities* (June 9, 2004), http://news.thomasnet.com/IMT/archives/2004/06/the_worlds_gree.html.

[25] KAMMEN, *supra* note 5.

[26] Daniel M. Kammen, *The Renewable Energy Sector and U.S. Decarbonization*, SCIENTIFIC AMERICAN (forthcoming Special September 2006 Issue).

[27] *Id.*

[28] Robert Margolis & Daniel M. Kammen, *Underinvestment: The Energy Technology and R&D Policy Challenge*, SCIENCE 285, 690-92 (1999); Robert Margolis & Daniel M. Kammen, *Evidence of Under-Investment in Energy R&D in the United States and the Impact of Federal Policy*, 27 ENERGY POLICY 575-584 (1999); Gregory F. Nemet & Daniel M. Kammen, *Reversing the Incredible Shrinking Energy R&D Budget*, ISSUES IN SCIENCE & TECHNOLOGY (Fall 2005) 84-88.

III. OPPORTUNITY FOR ACTION: THE UNITED STATES CLIMATE CHANGE TECHNOLOGY PLAN

The United States Department of Energy released in September 2005 "a plan for accelerating the development and reducing the cost of new and advanced technologies that avoid, reduce, or capture and store greenhouse gas emissions."[29] In the words of the Director of the Climate Change Technology Program, David Conover, "This *Strategic Plan* is the first of its kind and will provide a comprehensive, long-term look at the role for advanced technology in addressing [climate change]."[30] The technologies developed under the Climate Change Technology program will be used and deployed among the United States' partners in the Asia-Pacific Partnership for Clean Development that was announced earlier this year.

As described in the United States Climate Change Technology Plan ("CCTP"), climate change presents our nation with a serious, long-term challenge.[31] Central to the difficulty of this challenge is that reducing the risks posed by climate change will require us to transform the largest industry on the planet - the energy industry. Energy is important, not only for its direct contribution to ten percent of economic output by our nation's private sector, but also as the fundamental enabling infrastructure for an array of economic activities, from manufacturing to agriculture to healthcare.[32] The availability of reliable and affordable energy should not be taken for granted. The challenges of renewing the United States energy infrastructure to enhance economic and geopolitical security and prevent global climate change are particularly acute, and depend on the improvement of existing technologies, as well as the invention, development, and commercial adoption of emerging ones. Recent trends in the energy sector - which show declining levels of technology investment and innovation - heighten the need for an

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[29] U.S. Climate Change Technology Program, U.S. Climate Change Technology Program Strategic Plan Draft for Public Comment (September 2005), http://www.climatetechnology.gov/stratplan/draft/invitation.htm.

[30] DOE Releases Draft Strategic Plan for Reducing Greenhouse Gas Emissions Through Deployment of Advanced Technology, http://www.climatetechnology.gov/library/2005/pr21sep2005.htm.

[31] United States Climate Change Technology Strategic Plan ("CCTP"), ch. 2, http://www.climatetechnology.gov/stratplan/draft/index.htm.

[32] *See, e.g.*, LINDA R. COHEN & ROGER G. NOLL, THE TECHNOLOGY PORK BARREL (Brookings Institution Press 1991); CTR FOR BLDG SCI. ENERGY AND ENV'T DIV., LAWRENCE BERKELEY NAT'L LAB., U.S. DEP'T OF ENERGY, FROM THE LAB TO THE MARKETPLACE: MAKING AMERICA'S BUILDINGS MORE ENERGY EFFICIENT (1995) (providing good examples of energy sector case studies).

aggressive response.[33] The CCTP provides a tremendous opportunity to reverse this trend, open up new technological options, and stimulate economic growth through the development of a new clean energy-based sector of the economy. Key strengths of the CCTP Strategic Plan are its call for strong leadership by the United States President, the acknowledgement of the long-term nature of the problem, and the breadth of its technology portfolio.[34]

The CCTP Strategic Plan in its current draft, nevertheless, is seriously flawed. The goal that it seeks to reach, and the basis on which we are here to evaluate it today, is far too modest. It is not commensurate with the magnitude of the challenges we face and not reflective of our nation's capacity for innovation. The most significant shortcoming of the CCTP strategic plan is that the goal it seeks to reach is not commensurate with the magnitude of the challenges posed by climate change and other energy-related problems. In evaluating the CCTP strategic plan one must first seriously consider what goal it is trying to achieve. To avoid the adverse impacts of climate change we will need to stabilize concentrations of greenhouse gases in the atmosphere. This will require real reductions in the amount of carbon dioxide and other greenhouse gases that we emit.[35] As the strategic plan itself asserts:

> Stabilizing GHG [greenhouse gas] concentrations, at any atmospheric concentration level, implies that global *additions* of GHGs to the atmosphere and global *withdrawals* of GHGs from the atmosphere must come into a net balance. This means that growth of *net* emissions of GHGs would need to slow, eventually stop, and then reverse, so that, ultimately, *net* emissions would approach levels that are low or near zero.[36]

The CCTP then, however, goes on to adopt the Bush Administration's emissions intensity target of an eighteen percent reduction in GHG intensity by 2012, pointing to a major flaw in the

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[33] The chart showing all U.S. federal R&D programs since 1955 demonstrates how small the energy R&D program is relative to the other R&D budgets. The current budgets for energy R&D would continue this situation, or even reduce R&D investment. Nemet & Kammen, *supra* note 28.

[34] CCTP, *supra* note 30 at ch. 3.

[35] Intergovernmental Panel on Climate Change, The Scientific Basis (Cambridge University Press 2001).

[36] Energy End-Use Forecasting, Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond, http://enduse.lbl.gov/index.html (highlight "Projects" hyperlink; then highlight "Policy Analysis" hyperlink; then follow "Five Lab Study" hyperlink).

CCTP plan; it is designed to meet a goal that is wholly inadequate to the challenge we face (Figure 1).[37] Only when we take the challenge of global climate change seriously will we be able to meaningfully mobilize our nation's scientific, technological, and economic resources to meet it, as well as to reap the benefits of international leadership in the clean and sustainable energy sector.

The need to reduce uncertainties in current climate science around climate sensitivity and expected impacts is often cited as a reason for delaying commitments to emissions reductions. Yet, the CCTP is correct in pointing out that scientific uncertainty is neither a valid justification nor a wise strategy for choosing to delay.[38] In fact, there is not much uncertainty about the basic problem and its magnitude. Figure 1 demonstrates estimates of carbon emissions done at the Lawrence Berkeley National Laboratory; this graph assumes we find a way to reduce emissions.

Figure 1: Carbon Intensity of the US Economy: Historical trend since 1975 and projection to 2025, with selected scenarios.

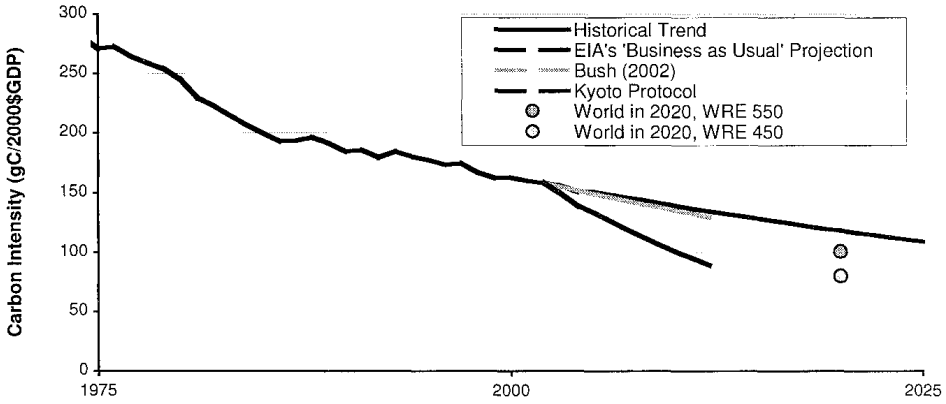

Figure 1 shows the carbon intensity of the United States economy (in gC-equivalent/2000$GDP). The historical trend is shown from 1975 to 2002, with the Energy Information Agency's ("EIA") "business as usual' ("BAU") projection to 2025. Also shown is the President's 2002 goal of an eighteen percent reduction in carbon intensity below the 2002 level by 2012, and the Kyoto Protocol's goal of a seven percent reduction in carbon emissions below 1990 levels by 2012. Additionally,

[37] Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2003 (2005).

[38] Scenarios of U.S. Carbon Reductions, *supra* note 35 at ch. 1.

the world "WRE stabilization pathways," named for the authors of a paper (Wigley, Richels, Edmonds) that has become a frequently used basis for carbon stabilization concentrations,[39] are used to calculate projected world average carbon intensity in 2020 for the 450 ppm and 550 ppm stabilization levels.[40]

In order to achieve Bush's goal, a reduction of 3.6%, or 66 million tons of carbon equivalent, would be required below the BAU projection.[41] By contrast, in order to achieve the Kyoto Protocol's goal, a reduction of thirty-three percent, or 613 million tons of carbon equivalent, would be required.[42] Note also that the WRE projections are world averages, which means that if a sufficient number of other countries had carbon intensities higher than these values, it is possible that the United States would have to reduce carbon intensity to below these values emissions to zero by 2050 while meeting energy service demands – i.e. very conservative estimates – will still almost certainly result in CO_2 levels exceeding 550 ppm in the atmosphere, if not more.

Given that the CO_2 level is now 380 ppm - thirty percent higher than it has been at any point in the last 650,000 years - we are essentially conducting an unprecedented experiment with the Earth.[43] Despite the long time horizons of the climate change problem, the availability of carbon-free energy technologies is a relatively urgent matter because the 100-year residence time of CO_2 in the atmosphere, the thirty to fifty-year lifetime of capital stock in the energy industry, and the typical decades-long diffusion curve for infrastructure-related technologies are to varying extents outside of our control.[44] The response to this combination of uncertainty and urgency should be a commitment to the creation of a multitude of new technological options, not a timid approach that narrows the range of possibilities at our disposal in the future.

In contrast, meeting the Bush Administration's current target will require only a slight change from the business as usual case.[45] More

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[39] T.M.L. Wigley, R. Richels & J.A. Edmonds, *Economic and Environmental Choices in the Stabilization of Atmospheric CO2 Concentrations,* 379 NATURE 191, 240-243 (1996).

[40] *Id.*

[41] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 1995: IMPACTS, ADAPTATION, AND MITIGATION OF CLIMATE CHANGE: SCIENTIFIC-TECHNICAL ANALYSIS. THE CONTRIBUTION OF WORKING GROUP II TO THE SECOND ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. (R.T. Watson et al. eds., Cambridge University Press 1996).

[42] Kinzig & Kammen, *supra* note 19, at 183-208.

[43] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 41.

[44] Kinzig & Kammen, *supra* note 19, at 183-208.

[45] *See infra* Figure 2. T.M.L. Wigley, R. Richels & J.A. Edmonds, *Economic and Environmental Choices in the Stabilization of Atmospheric CO_2 Concentrations*, 379 NATURE 191,

relevant to the climate problem, reaching this target would actually allow emissions to grow by twelve to sixteen percent. This target would thus represent a larger increase than the ten percent increase that occurred in the previous decade. If we are to be serious about meeting the climate challenge we need to set a goal consistent with the CCTP's objective of moving toward zero net emissions.

While the Kyoto Protocol - the current international climate change regime - has its flaws, its targets do represent a substantial shift toward reducing emissions.[46] Similarly, the Governor of California's GHG emissions targets announced last summer include both near-term and longer-term goals that delineate a path of emissions reductions toward climate stabilization (Figure 2).[47] The Bush Administration should also set a series of targets that show a clear path to emissions reductions.

Figure 2: Historical U.S. GHG emissions and targets

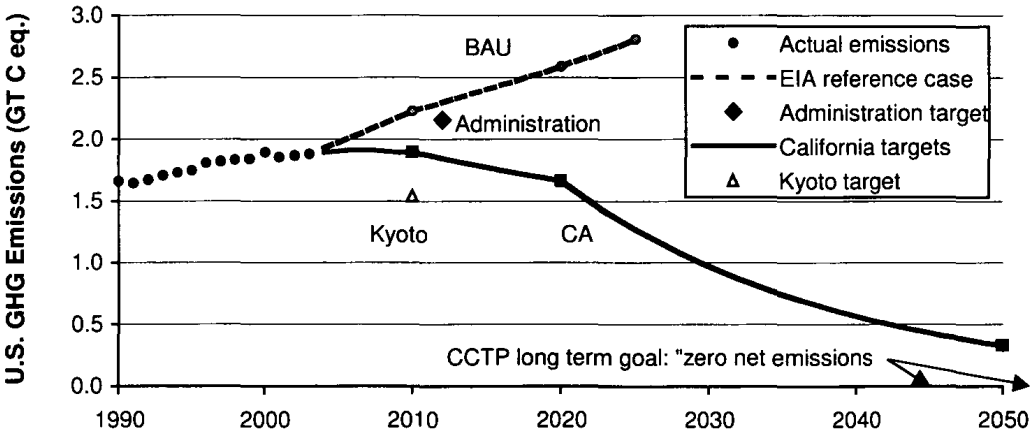

Figure 2 shows actual United States GHG emissions from 1990 through 2003 in giga-tons of carbon equivalent.[48] Four paths for future United States emissions are shown; circles show the business-as-usual (BAU), or "reference case," as calculated by the EIA. The diamond shows the Administration's GHG intensity target for 2012 of eighteen percent below 2002 level in tons of carbon per unit of GDP, or a 3.6% reduction in emissions from BAU. The squares show United

240 – 243 (1996).

[46] *See* United Nations Framework Convention on Climate Change, http://unfccc.int/essential_background/kyoto_protocol/items/2830.php (explaining that the Kyoto Protocol strengthens the Convention by committing Parties to the Protocol to individual targets of reduced greenhouse gas emissions that total a cut of emissions of at least 5% from 1990 levels). *Id.*

[47] Climate Action Team & Climate Action Initiative, http://www.climatechange.ca.gov/climate_action_team/index.html.

[48] Environmental Protection Agency, *supra* note 37.

States emissions if the nation were to meet the percentage reductions that have been announced in California for 2010, 2020, and 2050 (California Executive Order 3-05). The triangle shows the United States's target for 2010 under the Kyoto Protocol. Arrows indicate the levels required to meet the CCTP's long-term goal of "levels that are low or near zero."

What is needed is a serious and sustained commitment to emissions reductions and a time scale that conveys to the country the urgency of the need to open future options. Much as President Nixon's announcement of a program in the early-1970s to reduce reliance on foreign oil stimulated efforts by the private sector to invest in alternative energy sources, the articulation of a bold and clear target for emissions reductions would send a signal to the private sector that would leverage the federal government's direct investments in new technologies.

In recent work, my colleagues and I at Berkeley's Renewable and Appropriate Energy Laboratory calculated the investment in research and development ("R&D") required to reach a climate stabilization level of 550 ppm, a level that would double the amount of GHG in the atmosphere relative to that at the beginning of industrialization in the eighteenth century. Using emissions scenarios from the Intergovernmental Panel on Climate Change and a previous framework for estimating the climate-related savings from energy R&D programs, we calculate that United States energy R&D spending of $15-30 billion/year would be sufficient to stabilize CO_2 at double pre-industrial levels.[49] A strategy that employs a diversified portfolio approach to manage technological uncertainty is diluted quickly when funding levels are five to ten times below their socially optimal levels.

The CCTP plan itself states, "successful development of advanced technologies could result in potentially large economic benefits."[50] As an example of the effect of policy on abatement costs, we can observe how a combination of R&D and demand-side policy has stimulated cost reductions in energy technologies.[51] For example, solar cells, known as photovoltaics, have declined in cost by more than a factor of twenty and wind turbines by a factor of ten (Figure 3). Accelerating future cost reductions in these and other technologies will require further investments in technology development and market creation.

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[49] R. N. Schock, W. Fulkerson et al., *How Much is Energy Research and Development Worth as Insurance?* 24 ANNUAL REVIEW OF ENERGY AND ENVIRONMENT 487 – 512 (1999).

[50] CCTP, supra note 30 at 3-28.

[51] R.D. Duke & D.M. Kammen, *The Economics of Energy Market Transformation Initiatives*, 20 THE ENERGY JOURNAL 15 – 64 (1999); R. Margolis & D.M. Kammen, *Underinvestment: The Energy Technology and R&D Policy Challenge*, SCIENCE 285, 690 – 692 (1999).

Figure 3. Cost reductions in carbon-free energy technologies

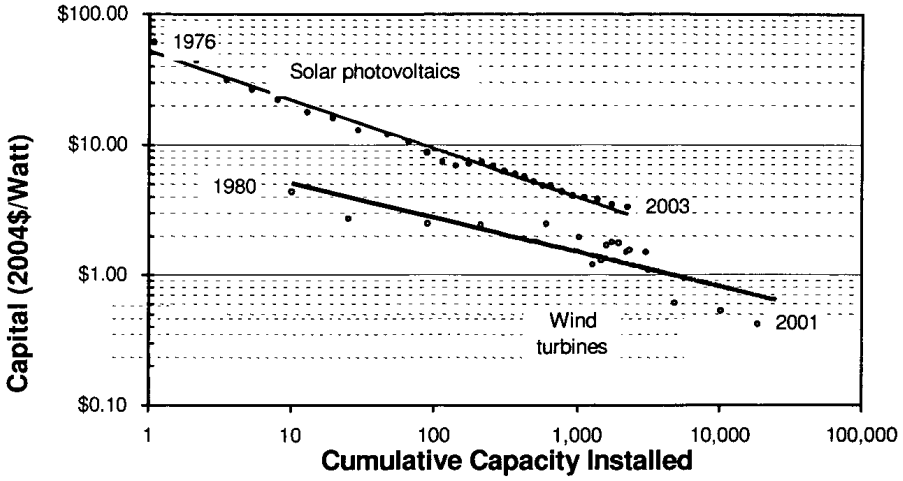

Figure 3. shows the capital costs of photovoltaics and wind turbines in constant 2004 $ per Watt. The horizontal axis shows cumulative worldwide installations of each technology.[52]

An important additional finding of the work on energy R&D conducted by Berkeley's Renewable and Appropriate Energy Laboratory is that many of the same programs that would help abate the climate problem would address other societal problems too.[53] Adoption of improved zero emissions energy production and end-use technologies would offset the adverse environmental and health effects associated with emissions of mercury, sulfur dioxide, and oxides of nitrogen.[54] Increased use of renewables-based power and fuels would reduce our sensitivity to energy production in politically unstable regions.[55] A more distributed power generation system, based on smaller scale production closer to the end user, would enhance the robustness and resilience of the electricity system, reduce the danger of costly power outages and thereby minimize vulnerability to potential terrorist sabotage of the grid.[56] Finally, a more diverse mix of technologies and fuels would diffuse the

[52] R.D. Duke & D.M. Kammen, *The Economics of Energy Market Transformation Initiatives*, 20 THE ENERGY JOURNAL 15 – 64 (1999).

[53] *Supra* note 47.

[54] Kammen, *supra* note 8.

[55] *Id.*

[56] M. Moner-Girona, R. Ghanadan, A. Jacobson & D.M. Kammen, *Decreasing PV costs in Africa*, REFOCUS: THE INTERNATIONAL RENEWABLE ENERGY MAGAZINE 40 – 45 (2006).

macro-economic effects of the volatility of energy prices.[57]

In our recent work at the Renewable and Appropriate Energy Laboratory, we have asked how feasible it would be to raise investment to levels commensurate with the energy-related challenges we face. One way to consider the viability of such a project is to set the magnitude of such a program in the context of previous programs that this committee has participated in launching and monitoring. Scaling up R&D by five or ten times from current levels is not a 'pie in the sky' proposal; in fact it is consistent with the scale of several previous federal programs, each of which took place in response to a clearly articulated national need.[58] While expanding energy R&D to five or ten times today's level would be a significant initiative, the fiscal magnitude of such a program is well within the range of previous programs, each of which have produced demonstrable economic benefits beyond the direct program objectives.

Table 1: Comparison of energy R&D scenarios and major federal government R&D initiatives

Program	Sector	Years	Additional spending over program duration (2002$ Billions)
Manhattan Project	Defense	1942-45	$25.0
Apollo Program	Space	1963-72	$127.4
Project Independence	Energy	1975-82	$25.6
Reagan defense	Defense	1981-89	$100.3
Doubling NIH	Health	1999-04	$32.6
War on Terror	Defense	2002-04	$29.6
5x energy scenario	*Energy*	*2005-15*	*$47.9*
10x energy scenario	*Energy*	*2005-15*	*$105.4*

"Major R&D initiatives" in this study are federal programs in which annual spending either doubled or increased by more than $10 billion during the

[57] http://www.cnn.com/2006/POLITICS/04/25/bush.ap/index.html.

[58] Nemet & Kammen, *supra* note 28.

program lifetime.[59] For each of these eight programs we calculate a "baseline" level of spending based on the 50-year historical growth rate of U.S. R&D, 4.3% per year.[60] The difference between the actual spending and the baseline during the program we call additional program spending.[61]

IV. EMERGING ACTION AGENDAS

A range of options exists to frame a new energy policy for the United States, at both the state and federal levels. In order to frame a coherent policy, a number of observations about the potential for a clean energy policy warrant attention.

First, the United States needs to recapture the mantle of leadership in innovative renewable energy technology and policy.[62] Today, orders for wind turbines are flooding Danish and German factories.[63] Germany, in fact, also has almost three times the total installed wind capacity as the United States, with a resource less than that of North Dakota alone.[64] "The global market for photovoltaic - solar cells - has, like the wind industry, grown by more than 20 percent a year for the past decade, and yet the United States lags behind Japan and Germany in producing and installing this local and secure source of power.[65] Hybrid vehicles, the hottest selling cars on the market today, are almost entirely imported from Japan."[66] This industry produces high-quality jobs that could be based in the United States but increasingly go overseas.

The United States President could instead make raising the average fuel efficiency of our vehicle fleet a national priority. More oil can be saved, and far more cheaply, through this mechanism than any other action.[67]

Individual states are getting the message, even if the federal government is not. Important innovations taking place at the state level would, moreover, be made far more efficient with federal support. Eighteen states have adopted renewable energy portfolio standards that

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[59] *Id.*

[60] *Id.*

[61] *Id.*

[62] Goldman School of Public Policy e-Digest, June 2005, http://violet.berkeley.edu/~gspp/news-events/eDigests/GSPP%20June%202005%20eDigest.pdf.

[63] *Id.*

[64] National Wind Technology Center, Wind Resource, http://www.nrel.gov/wind/wind_map.html.

[65] Goldman School of Public Policy e-Digest, *supra* note 62.

[66] *Id.*

[67] *Id.*

require a percentage of electricity to come from renewable energy sources.[68] Adopting a federal standard, or providing benefits to states that do, sends a critical signal to industry: If you build it, a market awaits.

California stands to benefit significantly if the country were to invest in our energy future - not simply subsidize our past. Californians have already shown what is possible with the adoption of a strong energy portfolio: the Vehicle Greenhouse Gas Reduction Bill[69] (passed in 2002, but facing challenges from the automotive industry) will reduce greenhouse gas emissions from vehicles thirty percent by 2016, and the California Public Utilities Commission Solar Initiative will provide demand for clean solar energy technologies. Federal leadership would expand these sorts of programs to our mutual benefit.[70]

Finally, instead of denying and impeding international treaties such as the Kyoto Protocol to limit the emissions of greenhouse gases, the federal government needs to recognize the business potential in leading the fight to safeguard the planet. Business opportunities abound in developing and selling solar panels, wind turbines and gasifiers that turn agricultural waste and crops into a truly natural gas, as well as developing a new generation of energy-efficient appliances, to name just a few.[71]

In terms of specific recommendations based on this analysis, a number of concrete actions would be possible. In particular, an integrated energy policy could focus on the items noted below.

A. MAKE ENERGY AND THE ENVIRONMENT A CORE AREA OF EDUCATION IN THE UNITED STATES

Public interest and action on energy and environmental themes requires attention to make us 'eco-literate and economically savvy.' We must develop in both K-12 and college education a core of instruction in the linkages between energy and both our social and natural environment. The Upward Bound Math-Science Program and the Summer Science Program each serve as highly successful models that could be adapted to the theme of energy for a sustainable society at all

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[68] R.Wiser, K. Porter & R. Grace, *Evaluating Experience with Renewable Portfolio Standards in the United States*, Proceedings of Global Windpower 2004, 28-31 March. Chicago, Illinois.

[69] *The Climate Change Crisis . . . Can California Create a Way Out?: Hearing Before the Cal. Select Comm. On Air & Water Quality*, (Cal. 2005) (testimony of Daniel M. Kammen).

[70] Goldman School of Public Policy e-Digest, *supra* note 62.

[71] *Id.*

educational levels.[72] The launch of Sputnik in 1957 mobilized United States science and technology to an unprecedented extent, and should serve as a lesson in how powerful a use-inspired drive to educate and innovate can become. The Spring 2005 Yale Environment Survey found overwhelming interest in energy and environmental sustainability.[73] Contrast that interest with the results of the Third International Mathematics and Science Study ("TIMSS") where American secondary school students ranked nineteenth out of twenty-one countries surveyed in both math and science general knowledge.[74] The United States can and should reverse this trend, and sustaining our natural heritage and greening the global energy system is the right place to begin.

B. ESTABLISH A SET OF ENERGY CHALLENGES WORTHY OF FEDERAL ACTION

Establish *Sustainable Energy USA* awards – modeled after the successful efforts of the Ashoka Innovators awards for social entrepreneurs and the Ansari X Prize initially given for space vehicle launch - that inspire and mobilize our remarkable resources of academia, industry, civil society, and government.[75] These initiatives would support and encourage groups to take action on pressing challenges. An initial set of challenges include: Buildings that cleanly generate significant portions of their own energy needs ('zero energy buildings'); Commercial production of 100 mile per gallon vehicles, as can be achieved today with prototype plug-in hybrids using low-carbon generation technologies accessed over the power grid, or direct charging by renewably generated electricity, and efficient biofuel vehicles operating on ethanol derived from cellulosic feedstocks; Zero Energy Appliances (appliances that generate their own power); 'Distributed Utilities,' challenges and milestones for utilities to act as markets for clean power generated at residences, businesses, and industries.

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[72] The Summer Science Program, http://www.summerscience.org/home/index.php

[73] Yale School of Forestry and Environmental Studies Climate Change Project, http://environment.yale.edu/climate/.

[74] Trends in International Mathematics and Science Study, http://nces.ed.gov/timss/.

[75] *See* Leonard David, *SpaceShipOne Wins $10 Million Ansari X Prize in Historic 2nd Trip to Space*, http://www.space.com/missionlaunches/xprize2_success_041004.html. "The Ansari X Prize is a $10 million purse for the first privately built vehicle that could safely haul a pilot and the equivalent weight of two passengers to the edge of space- - then repeat the feat within two weeks." *Id.*

C. MAKE THE NATION THE DRIVER OF CLEAN VEHICLE DEPLOYMENT

As the Zero Emission Vehicle Mandate and the Pavley Bill (AB 1493)[76] have shown in California, dramatic improvements in vehicle energy efficiency and reductions in carbon emissions are eminently achievable, given political leadership. A clear message, as well as dramatic carbon and financial savings, would derive from a decision to only purchase for state transportation needs vehicles meeting a *high* energy efficiency target, such as 40 miles per gallon for sedans and 30 miles per gallon for utility vehicles. These standards are now possible thanks to improvements in vehicle efficiencies and the wider range of hybrids (including SUV models) now available. A key aspect of such a policy is to announce from the outset that the standards will rise over time, and to issue a challenge to industry that a partnership to meet these targets will benefit their bottom line and our nation.

D. EXPAND INTERNATIONAL COLLABORATIONS THAT BENEFIT DEVELOPING NATIONS AT A CARBON BENEFIT

The goals of many developing nations are largely shaped by the challenge of balancing fundamental economic and environmental needs of their people. At the same time, these are our goals as well, both as a nation that must lead the charge to a sustainable and equitable world, and as citizens of a world where we share the rights and responsibilities to protect the atmosphere. Greenhouse gases emitted anywhere impact us all, not only today but for decades to come. In many cases, tremendous opportunities exist to offset future greenhouse gas emissions and to protect local ecosystems both at very low cost, but also to directly address critical development needs such as sustainable fuel sources, the provision of affordable electricity, health, and clean water. My colleagues and I at Berkeley's Renewable and Appropriate Energy Laboratory recently detailed the local development, health, and the global carbon benefits of research programs and partnerships on improved stoves and forestry practices across Africa.[77] Far from an isolated example, such opportunities exist everywhere. With the recent wave of interest in "sustainability science," this is a resource, aid, and business opportunity that the United States should embrace.[78]

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[76] http://www.arb.ca.gov/cc/cc.htm.

[77] R. Bailis, M. Ezzati, & D. Kammen, *Mortality and Greenhouse Gas Impacts of Biomass and Petroleum Energy Futures in Africa*, 308 SCIENCE, 98 – 103 (2005).

[78] A. Jacobson & D. Kammen, *Science and Engineering Research That Values The Planet*, 35 THE BRIDGE: JOURNAL OF THE NATIONAL ACADEMY OF ENGINEERING 1, 11 – 17 (Winter 2005).

E. RECOGNIZE AND REFLECT ECONOMICALLY THE VALUE OF ENERGY INVESTMENT TO THE ECONOMY

Clean energy production – through investments in energy efficiency and renewable energy generation – has been shown to be a winner in terms of spurring innovation and job creation. This should be reflected in federal economic assessments of energy and infrastructure investment. Grants to states, particularly those taking the lead on clean energy systems, should be at the heart of the federal role in fostering a new wave of 'cleantech' innovation in the energy sector.

F. BEGIN A SERIOUS FEDERAL DISCUSSION OF MARKET-BASED SCHEMES TO MAKE THE PRICE OF CARBON EMISSIONS REFLECT THEIR SOCIAL COST

A carbon tax and a tradable permit program both provide simple, logical, and transparent methods to permit industries and households to reward clean energy systems and tax that which harms our economy and the environment. Cap and trade schemes have been used with great success in the United States to reduce other pollutants and several northeastern states are experimenting with greenhouse gas emissions trading. Taxing carbon emissions to compensate for negative social and environmental impacts would offer the opportunity to simplify the national tax code while remaining, if so desired, essentially revenue neutral. A portion of the revenues from a carbon tax could also be used to offset any regressive aspects of the tax, for example by helping to compensate low-income individuals and communities reliant on jobs in fossil fuel extraction and production.

V. CONCLUSION

Taken together, the federal advances proposed above could help evolve our economy from one of energy "hunter-gatherers" to one of "energy farmers" - from a reliance on a precarious and tremendously expensive and environmentally-damaging traditional energy supply to meet a steadily growing demand, to one that emphasizes a full range of energy supply, efficiency and demand-management technologies.[79]

Moreover, this shift away from fossil fuels to renewables will help liberate the United States' foreign policy from the constraints imposed on it by our present economic dependence on short-term oil supplies. If we

[79] Goldman School of Public Policy e-Digest, *supra* note 62.

succeed in this transition, the United States will be in a position to lead rather than undermine international climate change efforts such as the Kyoto Protocol, and will not be forced to align itself with oil-producing Middle-East regimes with anti-democratic domestic policies (our support of which may only sow the seeds for future anti-American terrorism down the line). This shift is within our reach if there is leadership to seize the opportunity, and accomplishing this change – more than any other action that could be undertaken at the federal level – will help to preserve the United States' long-term national security.