THE POWER PRODUCTION PARADOX:

REVEALING THE SOCIO-TECHNICAL IMPEDIMENTS TO DISTRIBUTED GENERATION TECHNOLOGIES

by

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ABSTRACT

Dramatic improvements in renewable energy and small-scale distributed generation (DG) technologies have been made in the last twenty years. Nevertheless, they remain underutilized in the American electric utility system. Despite the immense environmental, technical, and financial promise of renewable energy systems and DG technologies, such generators still constitute a very small percentage of electricity generation capacity in the United States. This relative neglect occurs despite remarkable gains in their technical performance and reductions in their cost of producing power—the result (in part) of dramatic government support for several decades. Moreover, the technologies often demonstrate great environmental benefits that appeal to policymakers and consumers. At the same time, they offer ways to enhance strained distribution and transmission networks.

This project attempts to answer the paradoxical question: why do new energy technologies that offer such impressive benefits also find the least use? The dissertation emphasizes how the history and culture of the community of electricity producers and users helps explain why the new technologies have seen little use. Going beyond technical explanations of alleged low capacity factors and high capital costs, it focuses on the social nature of decision making among participants in the electric utility system. The approach not only helps us understand the glossing over of renewable energy and distributed generation technologies, but also suggests ways of overcoming the barriers faced by their advocates.

IMPORTANT RESEARCH NOTE

The views expressed in the research interviews conducted for this project do not represent the official policy of any particular company, institution, or agency. Individuals are speaking entirely—and only—on their own behalf.

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Chapter 1—Introduction

"To draw attention today to technological affairs is to focus on a concern that is as central now as nation building and constitution making were a century ago. Technological affairs contain a rich texture of technical matters, scientific laws, economic principles, political forces, and social concerns."

--Thomas P. Hughes, historian at MIT, 1983

1.1 Introduction

During the past three decades, the American electric utility system has faced immense challenges. Once viewed as a stable and secure consortium of publicly-regulated monopolies that produce and distribute electricity, the system has weathered market restructuring only to face the ever-present risk of natural disasters, price fluctuations, terrorist attacks, and blackouts. Despite the conventional wisdom learned by policymakers during the energy crises of the 1970s, the modern electricity sector continues to face many of the same problems that existed thirty years ago: increasing levels of pollution, growing vulnerability and inefficiency of transmission and distribution networks, and rising electricity prices related to disruptions and interruptions in fuel supply.

Distributed generation (DG) and renewable energy technologies offer policymakers a way to respond to these challenges. Distributed generation technologies produce decentralized and modular power close to its point of consumption. Renewable energy technologies consist of generators that create electricity from sunlight, wind, falling water, sustainable biomass, waste, and geothermal sources (and can sometimes be classified as DG systems). Both sets of technologies often are portrayed by their advocates as serving the needs of society better than technologies that consume coal, natural gas, oil, or nuclear fuels, largely because they produce fewer harmful byproducts. As the following chapters will explain, wind turbines and photovoltaic panels have the benefit of producing electricity without the release of carbon dioxide or other greenhouse gases, and they avoid discharging other pollutants that accompany combustion of organic chemicals. Some system operators have begun to deploy DG and renewable energy systems to relieve congestion on the transmission grid, and DG technologies minimize normal transmission losses because they generate electricity close to the end-user. Meanwhile, most renewable energy systems require less maintenance than fossil-fueled

generators, reducing the risk of interruptions in traditional fuel supplies and minimizing fuel price volatility. Some of these new technologies even produce power at lower prices than do conventional technologies. Advocates argue, in short, that DG and renewable energy technologies should make up a larger portion of the generation technology portfolio. They enhance the environment; they reduce dependence on fossil fuels, especially those obtained from insecure sources abroad; they help overcome problems with transmission and distribution; and they help stabilize or even lower prices to customers. The greater use of the technologies could therefore play an important role in the nation's overall energy and foreign policies.

This dissertation attempts to answer the apparently paradoxical question: why do new technologies that offer immense promise for the electric utility industry also find the least use? An examination of the history, culture, and social interests facing the community of electricity producers and users helps explain why the new technologies have seen little use. Instead of emphasizing the technical aspects of energy systems, the project focuses on how utility managers, system operators, business owners, and ordinary consumers view distributed generation and renewable energy technologies. The study's approach not only helps us understand the reluctance to employ renewable energy and distributed generation technologies; it also suggests ways of overcoming the barriers faced by their advocates.

1.2 Defining Technologies and Asking Questions

In many cases, renewable energy technologies can be considered a subset of a class of power systems known collectively as distributed generation (DG) technologies.[1] Consisting of small-scale generators that produce electricity on-site and close to the end user, DG technologies can help reduce peak-time demand and congestion on the transmission network. In contrast to the traditional use of a few large-scale generators distantly located from load centers (often having capacities of several thousand

[1] Because the concept of "distributed generation" refers to a wide variety of technologies and approaches toward energy management, it is associated with a diverse array of terms. "Distributed generation" is frequently used synonymously with "distributed resources," "distributed energy resources," "distributed energy," "distributed power," "dispersed power," "dispersed resources," "embedded resources," "inside the fence generation," "micro-power," "mini-generation," "modular resources," "on-site generation," and "self generation." Because distributed generation technologies generate electricity in close proximity to its use, the term is also often used interchangeably with "cogeneration," "trigeneration," and "combined heat and power."

megawatts [MW]), employment of numerous, but small (from multi-kilowatt [kW] to about 100 MW) plants can provide power onsite with little reliance on the distribution and transmission grid. DG technologies can therefore help defer costly transmission upgrades and expansions. Perhaps most significant in the post-September 11, 2001 era, DG technologies can also be used to improve the grid's security. Because of their dispersed nature, DG technologies may appear less attractive to terrorists than nuclear plants, natural gas refineries, and large transmission facilities, where one well-placed interruption can cause widespread damage to the electrical grid. The use of decentralized power plants may even help insulate parts of the grid from failure if terrorists (or even squirrels, hurricanes, utility maintenance inspections, and untrimmed trees) take down a critical component.

In recent years, the design of renewable energy and DG technologies has significantly improved. Many renewable systems now constitute modular technologies and can be sized at almost any capacity (or stacked to achieve large capacities).[2] Such technologies can also work in conjunction with other energy systems—such as fuel cells or micro-turbines—to create hybrid applications that maximize efficiency and extend the life-cycle of operation.[3] Spurred largely by improvements in turbine and engine design, DG technologies such as micro-turbines and reciprocating gas engines have lowered the cost and increased the efficiency of small scale generation technologies (which can be up to three times more efficient than traditional generators).[4] Advances in net metering, fuel

[2] For an excellent summary of the modular advantages of these technologies, Amory Lovins et al., *Small is Profitable: The Hidden Benefits of Making Electrical Resources the Right Size* (Snowmass, CO: Rocky Mountain Institute, 2002).

[3] For a brief summation of these advantages, see Marilyn Brown et al., "Solutions Towards a Climate Friendly Built Environment," *Oak Ridge National Laboratory Report* (June, 2005); David Garman, "National Energy Policy: Conservation and Energy Efficiency," *Hearing Before the Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce* (June 22, 2001); United States Department of Energy, "Homeland Security: Safeguarding America's Future With Energy Efficiency and Renewable Energy Technologies," *Tenth Annual Report of the State Energy Advisory Board* (August, 2002), available at http://steab.org/docs/STEAB_Report_2002.pdf; Interlaboratory Working Group on Energy-Efficient and Clean Energy Technologies, *Scenarios for a Clean Energy Future* (Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory, 2000); and National Commission on Energy Policy, *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges* (2004).

[4] See Howard A. Learner, "Cleaning, Greening, and Modernizing the Electric Power Sector in the Twenty-First Century," *Tulane Environmental Law Journal* 14 (2001): 277-314; Joseph Iannucci, "Electricity Competition: Volume 1," *Hearing Before the Subcommittee on Energy and Power of the Committee on Commerce, House of Representatives* (Washington, DC: Government Printing Office, March 18-May 6, 1999), pp. 214-221; Lovins et al. 2002, pp. 4-6.

conversion technology, and thermal engineering have followed developments in automation and control, improving the economy of small units and reducing the need for periodic maintenance and inspection.[5] Small system technology can also be mass-produced at a much lower unit cost than larger, fossil-fueled and nuclear generators, which are often custom built and unique to each site. This lower unit cost translates into lower initial capital investment.[6]

As an example of these benefits, consider combined heat and power (CHP) systems, which produce thermal energy and electricity from a single fuel source. CHP systems recycle normally wasted heat through cogeneration (where heat and electricity are both used) and tri-generation (where heat, electricity, and cooling are produced). Recycled thermal energy can be used directly for air preheating, industrial processes that require large amounts of heat, space cooling, and refrigeration. As a result, CHP technologies consistently double the efficiency (compared to traditional utility power plants that vent heat into the environment as a waste product) from combined cycle gas turbines and often have lower labor and capital costs. For example, Primary Energy Incorporated manages a CHP plant in East Chicago, Indiana, that generates 94 MW of electric power along with 930 thousand pounds per hour (kpph) of steam. By recycling waste heat recovered from coke batteries, the plant supplies one-fourth of Mittal Steel's total electric requirements and 85 percent of its process steam needs. In addition, Primary Energy claims that the plant displaces an average 13,000 tons of NOx, 15,500 tons of SO2, and 5 million tons of CO2 emissions per year.[7]

Finally—and perhaps most amazingly—renewable energy systems and DG technologies achieve their social and technical advantages while sometimes producing *cheaper* electricity, especially as fossil fuel prices have escalated since 1999. When levelized costs (the total cost over a life divided by the numbers of kWh produced)) are taken into consideration, wind and landfill-gas electricity generation turn out to be the

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[5] H. Lee Willis and Walter G. Scott, *Distributed Power Generation: Planning and Evaluation* (New York: Marcel Dekker, 2000), p. 4-6.

[6] Barney L. Capehart, Paul Mehta & Wayne Turner, "Distributed Generation and Your Energy Future," *Cogeneration and Distributed Generation Journal* 18(4) (2003): 17-33; Joel Blustein et al., "The Impact of Air Quality Regulations on Distributed Generation," *National Renewable Energy Laboratory Technical Monitor* (October, 2002), p. iii.

[7] See Primary Energy Incorporated, "Projects—Cokeenrgy LLC," January, 2006, available at http://www.primaryenergy.com/facilities/cokenergy.htm.

cheapest forms of electricity (compared to all other generators including advanced coal, natural gas, and nuclear plants) (Table 1.1).[8]

Table 1.1: Levelized Cost of Electricity (LCOE) for Fossil, Nuclear, and Renewable Technologies[9]

Technology	**LCOE, in 2005 $/kWh**
Wind	$.028
MSW-Landfill Gas	$.030
Advanced Nuclear	$.035
Scrubbed Coal	$.044
Integrated Gasification Combined Cycle (IGCC)	$.044
Advanced Combined Cycle Gas/Oil	$.047
Conventional Combined Cycle (CC) Gas/Oil	$.050
Biomass	$.050
IGCC with Carbon Sequestration	$.059
Advanced Combustion Turbine	$.067
Advanced CC with Carbon Sequestration	$.069
Conventional Combustion Turbine	$.077
Solar, PV (30%)	$.235
Solar, PV (10%)	$.310

[8] The capital cost of a technology only tells part of the story. Traditional technologies may have lower up-front capital costs, but over time the savings are eaten away by the cost of the fuel that they consume. Renewable technologies, in contrast, don't consume expensive fuels, but cost more up-front to install. In addition, not all traditional plants have low capital costs. The costs of some nuclear plants completed in the 1980s cost up to $5,000 per kW due to poor construction, high interest rates, and licensing and permitting obstacles. Analysts have begun to use the levelized cost of electricity (LCOE) as a more accurate method of predicting the costs of electricity generation over the entire life-cycle of a given technology. In other words, the LCOE is a lifecycle estimate of the cost to generate power with a particular generation source including capital and operations costs, fuel costs, financing, taxes and incentives. To quote from a recent Congressional Budget Office report on distributed generation, "Although consideration of a technology's capital costs can be important when choosing to invest in distributed generation, estimates of what economists refer to as long-run average costs—costs per unit of output that reflect capital and operating expenses—are generally the more important for investment decisions. Perhaps more relevant for comparing distributed generation technologies with one another and with utility costs and residential prices is a commonly used index of long-run costs known as the "levelized" cost. Levelized cost is a summary measure of the average cost of electricity per kilowatt-hour, expressed in current dollars. It is defined as the net present value of all direct costs (for capital, fuel, and O&M) over the expected lifetime of the system, divided by the system's total lifetime output of electricity." Using a "levelized" approach to estimate the costs of renewable electricity reveals that many wind technologies compete favorably with fossil-fueled power, especially when the recent price spikes involved with natural gas are taken into consideration. The question, however, is whether a customer wants to spend more money earlier in the life of a project and save money later, or conserve cash up-front and spend more down the road.

[9] Source: National Renewable Energy Laboratory, Energy Information Administration; Assumptions: Prices are in real (inflation adjusted) LCOE with federal tax credits, and assume high capacity factors. LCOE costs include fixed overnight construction costs, variable operations and maintenance charges, and fuel pries. Table is used courtesy of the Virginia Center for Coal and Energy Research, with permission.

While still comparatively high, the cost of power produced by photovoltaic (solar) panels, for example, has dropped by about 70 percent between 1980 and 1995, with further price reductions since.[10] Photovoltaic electrical systems cost more than $60 per watt in 1976, but cost only around $3 per watt in 2004—a decline of 95 percent.[11] Improvements in turbine design have also lowered the cost of wind-produced electricity from for most areas of the United States.[12] According to the California Independent System Operator (ISO) and California Energy Commission (CEC), in 1993 the average cost of wind energy throughout the United States was 7.5 cents per kilowatt hour (kWh), less than one-fifth the 1980s average price of 39 cents per kWh. In 2005, the California ISO and CEC estimated that the average price of wind energy in California was 3.5 cents per kWh (levelized costs).[13] These costs compare to around 6 cents per kWh (levelized costs) for popular gas-turbine plants built from 2000 to 2004.

Despite the immense environmental, technical, and financial promise of renewable energy systems, such generators still constitute a very small percentage of electricity generation capacity in the United States. Throughout the 1970s, some policy experts expected renewable energy systems to be used for much more generation capacity than they have. Dr. Arthur Rosenfeld, one of the five CEC commissioners serving from 2002 until the present, noted that President Carter had told him (during his presidency in the late 1970s) that he expected renewable energy systems to reach 10 percent of national electricity capacity by 1985.[14] However, Carter's expectation went unfulfilled: excluding large hydroelectric generators, renewable energy technologies in 2003 comprised only about 2 percent of the U.S. electricity generation mix (Figures 1.1 and 1.2 and Table 1.2).

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[10] Hermann Sheer, *A Solar Manifesto: The Need for a Total Energy Supply and How to Achieve It* (New York: Earthscan Publications, 2001).
[11] Rhone Resch and Colin Murchie, *State of Solar 2004* (Washington, DC: Solar Energy Industries Association, 2004), p. 2.
[12] Rebecca Smith, "Not Just Tilting Anymore." *Wall Street Journal* (October 14, 2004), p. C1.
[13] Yuri Makarov et al, "California ISO Wind Generation Forecasting Service Design and Experience," *Report from the California ISO* (December, 2005), p. 3-4.
[14] See Art Rosenfeld, Personal Interview; full transcript available in Appendix 2.

Figure 1.1: U.S. Electricity Generation by Source, 2003[15]

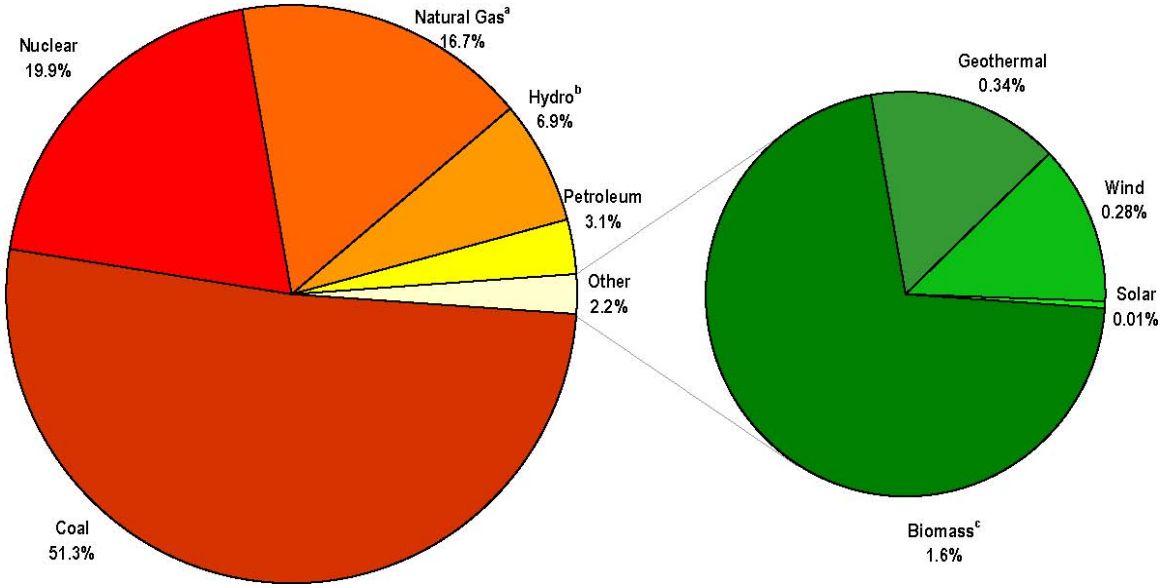
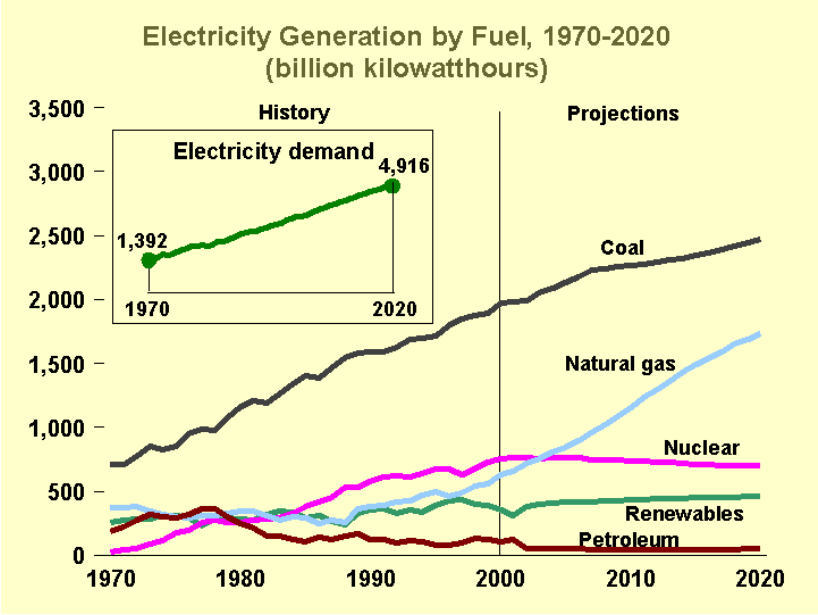


Figure 1.2: Electricity Generation by Fuel, 1970-2020 (billion kWh)[16]



[15] Source: Energy Information Administration, National Renewable Energy Laboratory, and the Virginia Center for Coal and Energy Research. Figure courtesy of the Virginia Center for Coal and Energy Research, used with permission.

[16] Source: Energy Information Administration, "The Role of Distributed Generation in U.S. Electricity Markets," 2002, Available at http://www.eia.doe.gov/oiaf/speeches/figure_8.html. Figure courtesy of the U.S. EIA, used under "Educational Fair Use Guidelines."

Table 1.2: Existing Capacity by Energy Source, 2004 (MW)[17]

Energy Source	Number of Generators	Generator Nameplate Capacity	Net Summer Capacity	Net Winter Capacity
Coal[1]	1,526	335,243	313,020	315,364
Petroleum[2]	3,175	37,970	33,702	37,339
Natural Gas	3,048	256,627	224,257	241,391
Dual Fired	3,003	193,115	172,170	184,399
Other Gases[3]	119	2,535	2,296	2,259
Nuclear	104	105,560	99,628	101,377
Hydroelectric Conventional[4]	3,995	77,130	77,641	77,227
Other Renewables[5]	1,608	21,113	18,763	19,000
Pumped Storage	150	19,569	20,764	20,676
Other[6]	42	754	700	716
Total	**16,770**	**1,049,615**	**962,942**	**999,749**

[1] Anthracite, bituminous coal, subbituminous coal, lignite, waste coal, and synthetic coal.

[2] Distillate fuel oil (all diesel and No. 1, No. 2, and No. 4 fuel oils), residual fuel oil (No. 5 and No. 6 fuel oils and bunker C fuel oil), jet fuel, kerosene, petroleum coke (converted to liquid petroleum, see Technical Notes for conversion methodology), and waste oil.

[3] Blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels.

[4] The net summer capacity and/or the net winter capacity may exceed nameplate capacity due to upgrades and overload capability of hydroelectric generators.

[5] Wood, black liquor, other wood waste, municipal solid waste, landfill gas, sludge waste, tires, agriculture byproducts, other biomass, geothermal, solar thermal, photovoltaic energy, and wind.

[6] Batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.

Notes: Where there is more than one energy source associated with a generator, the predominant energy source is reported here. Totals may not equal sum of components because of independent rounding.

The relatively minor use of renewable energy systems has created a general attitude among energy analysts, scholars, and laboratory directors that the technologies are not viable sources of electricity supply. For example, Rodey Sobin, former Innovative Technology Manager for the Virginia Department of Environmental Quality, argues that "in many ways, renewable energy systems were the technology of the future, and today they still are."[18] Ralph D. Badinelli, a professor of Business Information Technology at Virginia Tech, explains that renewable energy technologies do not contribute significantly to U.S. generation capacity because " such sources have not yet proven themselves … Until they do, they will be considered scientific experiments as opposed to

[17] Source: U.S. Energy Information Administration, Form EIA-860, "Annual Electric Generator Report," 2003. Figure courtesy of the U.S. EIA, used under "Educational Fair Use Guidelines."
[18] See Rodney Sobin, Personal Interview, September 15, 2005; full transcript available in Appendix 2.

new technologies."[19] Similarly, Mark Levine, the Environmental Energy Technologies Division Director at the Lawrence Berkeley National Laboratory, comments that despite all of the hype surrounding renewable energy, such systems are still only "excellent for niche applications, but the niches aren't large."[20]

DG/CHP technologies have an only slightly better record. In 2004, the Energy Information Administration characterized only 3.1 percent of electricity generation capacity as commercial or industrial combined heat and power (33,217 MW out of 1.49 terrawatts [TW]).[21] The EIA also estimated that in 2002 only 0.9 gigawatts (GW) of distributed generation capacity existed in the United States.[22] Similarly, the EIA's 2005 *Annual Energy Outlook* projected that CHP systems are not widely used in the electric power sector, amounting to 0.053% of utility generation (197 billion kWh out of 3,700 billion kWh).[23] Tom Casten, the Chair and Chief Executive Officer of Primary Energy, a manufacturer of fuel processing cogeneration steam plants, notes that even though CHP plants can reduce energy costs for industrial firms by over 40 percent, such plants remain "the exception instead of the rule."[24]

The astonishingly low percentage of distributed and renewable energy resources in the United States raises serious questions about American energy policy for at least three reasons. First, it suggests that major legislative mandates of the last thirty years designed to spur work on renewable energy technologies have resulted in only limited success. Second, the lower use of DG and renewable systems implies that the $6 billion worth of subsidies, energy research and development programs, and tax preferences spent on such systems has not catalyzed their wider use.[25] And third, the relatively small use of DG and renewable energy technologies defies international trends. In Europe, for example, renewable energy makes up a substantial part of electricity generation capacity,

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[19] See Ralph Badinelli, Personal Interview; March 15, 2006; full transcript available in Appendix 2.
[20] See Mark Levine, Personal Interview, October 25, 2005; Full transcript available in Appendix 2.
[21] See Energy Information Administration, "Existing Capacity by Producer Type," 2005, available at http://www.eia.doe.gov/cneaf/electricity/epa/epat2p3.html.
[22] Source: Energy Information Administration, "The Role of Distributed Generation in U.S. Electricity Markets," 2002, Available at http://www.eia.doe.gov/oiaf/speeches/figure_8.html.
[23] U.S. Energy Information Administration, *Annual Energy Outlook 2005*, p. 152 (Table A8).
[24] Tom Casten, Personal Interview, October 25, 2005; Full transcript available in Appendix 2.
[25] See Government Accountability Office, "National Energy Policy: Inventory of Major Federal Energy Programs and Status of Policy Recommendations," *United States GAO Report to Congress*, June, 2005 (GAO-05-379), p. 1-5.

and that amount continues to grow. Globally, the production of power from distributed generation and renewable energy systems surpassed all of the power produced by all nuclear plants in the world combined.[26]

1.3 Review of the Literature

In questioning why distributed and renewable energy technologies fail to gain wider acceptance among American consumers, business owners, and utility operators, this project differs from current scholarship in at least three ways. First, it contrasts energy reports such as those from the U.S. Energy Information Administration (EIA), Environmental Protection Agency (EPA), and International Energy Agency (IEA), which focus primarily on estimating generation capacities, projecting fuel costs, and predicting the environmental impacts of particular energy technologies. For example, the paragon of excellence among these types of reports, the EIA's *Annual Energy Outlook*, predicts the current and future technical potential for energy technologies, but does not connect consumption patterns to historical trends, nor does it anticipate future policy changes or provide policy recommendations. As Amory Lovins, director of the Rocky Mountain Institute, recently explained before the U.S. Senate Committee on Energy and Natural Resources, "the *Annual Energy Outlook* is not fate; it is not a mandate that one must fulfill; and it absolutely does not illuminate the true range of national choice."[27] In other words, the report assumes the existing configuration of the industry, and thus restricts consideration to a very narrow range of alternatives.

Second, those studies that do attempt to provide a rich, contextualized approach tracing social, historical, and technical factors in the acceptance of energy technologies have thus far failed to focus on distributed and renewable energy technologies. Two of the best investigations of the socio-technical nature of electricity technologies—Thomas Hughes' *Networks of Power* and David Nye's *Electrifying America*—limit their analysis from the 1880s to the 1940s, and focus exclusively on either generation (Hughes) or consumption (Nye).[28] David Nye's other influential book, *Consuming Power: A Social*

[26] Vijay V. Vaitheeswaran, Personal Interview; Full transcript available in Appendix 2.
[27] Amory Lovins, "Statement Submitted for the Record: EIA 2005 Annual Energy Outlook," *Hearing Before the Senate Committee on Energy and Natural Resources* (February 3, 2005), pp. 93-96.
[28] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore, MD: Johns Hopkins University Press, 1983); David E. Nye, *Electrifying America: Social Meanings of a New Technology, 1880-1940* (London: MIT Press, 1990).

History of American Energy Technologies, dedicates only a chapter to electricity and only a few paragraphs on renewable energy systems and DG technologies.[29] The work of historian Richard F. Hirsh on the managerial practices and technological choices facing the American electric utility industry provides excellent insight into how large-scale and centralized fossil-fuel generators lost both technical and social momentum throughout the 1960s, 1970s, and 1980s. However, Hirsh does not emphasize the importance of social choice and its relationship to dispersed energy technologies.[30] Martin V. Melosi and Vaclav Smil provide well written and thorough cultural histories of energy systems in the United States and the world, but conclude their investigation with the oil crises of the 1970s.[31] In other words, none of these excellent works focus on changes affecting renewables, DG, and the energy sector in the past ten to twenty years.

When such studies investigate particular energy technologies, they tend to focus on fossil fuels (especially since such fuels and generators have historically dominated American electricity generation) and cover either one aspect of supply or demand (rather than both). Additionally, the majority of these works was written well before the creation of the Energy Policy Act of 1992, consequent restructuring throughout most of the 1990s, occurrence of the California electricity crisis of 2000-2001, subsequent blackouts in the northeast (New York) and south (Hurricane Katrina), and enactment of the Energy Policy Act of 2005. Each of these events drastically altered the trajectory of the American electric utility system.

Third and finally, one cannot fully understand the reasons for non-adoption of DG technologies without studying electricity as a heterogeneous system. Instead, most of the recent policy briefs and books that focus on electricity in America attack the problem within narrow and disciplinarily boundaries. The Edison Electric Institute (EEI) and Electric Power Research Institute (EPRI) tend to center purely on the economics of electricity generation, transmission, and distribution, while reports from groups like the

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[29] David E. Nye, *Consuming Power: A Social History of American Energies* (London: MIT Press, 1999).
[30] Richard F. Hirsh, *Technology and Transformation in the American Electric Utility Industry* (Cambridge: Cambridge University Press, 1989; Richard F. Hirsh, *Power Loss: The Origins of Deregulation and Restructuring in the American Electric Utility System* (Cambridge: MIT Press, 1999). However, Hirsh discusses (in *Power Loss)* the unintended consequences of a 1978 law that provided huge incentives for research, development, and deployment of small-scale renewable generation technologies.
[31] Vaclav Smil, *Energy in World History* (New York: Westview, 1994); Martin V. Melosi, *Coping With Abundance: Energy and Environment in Industrial America* (New York: Knopf, 1985).

Pew Center and Natural Resource Defense Council emphasize the environmental dimensions of electricity generation and consumption. The National Academies of Science and Union of Concerned Scientists have produced insightful analysis of the security and infrastructure challenges facing the sector, while groups like the Alliance to Save Energy and the American Council for an Energy Efficient Economy remain only concerned with conservation and industrial efficiency. Those that even attempt a social analysis of the impediments facing particular technologies—such as the American Wind Energy Association, the American Solar Energy Society, or the Combined Heat and Power Association—limit their analyses to individual technologies, rather than how such technologies operate in the electric utility system as a whole. Put concisely, none of these organizations produces an interdisciplinary or holistic analysis of DG technologies that takes into account *all* of these factors under the concept of the "social." None connect research on cultural and social attitudes with patterns of electricity generation and consumption. And none focus on how DG and renewable energy systems can be considered a class of technologies (rather than individual artifacts) that emerge within a socio-technical system.

1.4 Research Methods: Textual Analysis, Interviews, and Field Observation

To explore the relative neglect of renewables and DG systems in greater detail, this project employs an ecumenical methodology that looks at wider socio-technical issues. Unlike the analyses produced by the above-mentioned institutions, this dissertation draws from textual analysis, interviews of energy experts, and field observation, as well as recent advances in the historiography and sociology of technology. The author conducted 62 formal, semi-structured interviews at 45 different institutions (including electric utilities, regulatory agencies, interest groups, energy systems manufacturers, nonprofit organizations, energy consulting firms, universities, national laboratories, and state institutions). For a full list of those interviewed, see Appendix 1; for transcripts, Appendix 2. In addition, those interviewed possessed exceptionally diverse educational backgrounds in various fields, such as environmental engineering, business, business administration, economics, engineering and public policy, history, geography, political science, public policy, electrical engineering, law, chemistry, biology, public administration, environmental science, environmental science and public

policy, and energy resource management. Thus, the interviews represent a broad overview of the interests and academic training of those connected to the electric utility sector. The author also spent three months as a graduate fellow working at the Oak Ridge National Laboratory in Oak Ridge, TN, and four months as a Senior Research Fellow at the Virginia Center for Coal and Energy Research. These experiences enabled countless hours of intensive field-observation of energy researchers, analysts, and policymakers.

1.5 Theoretical Methods: the Technological Systems Approach

To help understand why renewable energy systems and distributed generation technologies are so rarely used to generate electricity in the United States, this project views the electric utility industry as a technological system, drawing on work done by Thomas P. Hughes. In his seminal *Networks of Power: Electrification in Western Society* and other works, Hughes argues that the generation, transmission and distribution of electricity occurs within a technological system that extends beyond the engineering realm.[32] Such a system is understood to include a "seamless web" of considerations that can be categorized as economic, educational, legal, administrative, and technical. Large modern systems integrate these elements into one piece, with system-builders striving to "construct or ... force unity from diversity, centralization in the face of pluralism, and coherence from chaos."[33] If the managers succeed, the system expands and thrives while, simultaneously, closing itself. In other words, the influence of the outside environment on a technological system may gradually recede as the system expands its reach to encompass factors that might otherwise alter it.

Thus, the systems approach helps reveal that technological artifacts must be understood in their societal context, and that the different values expressed by inventors, utility managers, and energy consumers shape technological change.[34] The systems

[32] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1983).
[33] Thomas P. Hughes, "The Evolution of Large Technological Systems," In Wiebe E. Bijker, Hughes and Trevor J. Pinch (Eds.) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987), p. 52.
[34] See Ronald N. Giere, "Science and Technology Studies: Prospects for an Enlightened Postmodern Synthesis," *Science, Technology, and Human Values* 18(1) (Winter, 1993), p. 108; Ruth Schwarz Cowan, "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology," In Wiebe Bijker, Thomas P. Hughes, and Trevor Pinch (Eds.) *The Social Construction of Technological*

approach also suggests that successful systems are constructed out of chaos, conflict, diversity, and negotiation. System builders, it follows, must overcome a complex milieu of socio-technical obstacles. The approach highlights that, in the words of sociologist Donald MacKenzie, "systems or networks should not be taken simply as given, as unproblematic features of the world; nor should the use of the term 'system' be taken to imply stability or lack of conflict. Systems are constructs and hold together only so long as the correct conditions prevail."[35]

Hughes's systems approach also employs the notion of momentum, which *Networks of Power* describes as an accumulation of "machines, devices, structures" and "business concerns, government agencies, professional societies, educational institutions and other organizations" that "have a perceptible rate of growth or velocity."[36] The system's ability to continue along a given path results from the actions of numerous stakeholders, such as educational and regulatory institutions, the investment of billions of dollars in equipment, and the work and culture of people working within an industry. In concert, these elements promote business as usual and the outward show of a large degree of momentum. Furthermore, Hughes explains that system momentum can be aided through the use of "conservative" inventions, i.e., new technologies that preserve the existing system. Managers of the system obviously prefer to maintain their control of affairs and, while they may seek increased efficiencies and profits, they do not want to see introduction of new and disruptive "radical" technologies that may alter momentum and their control of the system.

1.6 The Importance of the Socio-technical Impediments to Energy Systems

The continuing contest between fossil fueled technologies and distributed or renewable resources offers an ideal situation to study the ways that technological systems acquire momentum and reshape society. Yet a discussion about the impediments facing renewable energy and distributed generation is not just important at an abstract and theoretical level. It has at least two serious real-world implications.

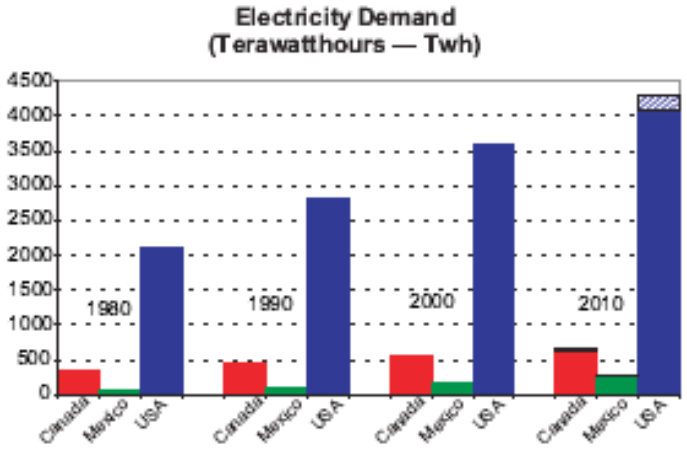
Systems: New Directions in the Sociology and History of Technology (London: MIT Press, 1987), pp. 261-280.

[35] Donald MacKenzie, "Missile Accuracy: A Case Study in the Social Process of Technological Change," In Wiebe Bijker, Thomas P. Hughes, and Trevor Pinch (Eds.) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (London: MIT Press, 1987), p. 197.

[36] Hughes 1983, p. 15.

First, the United States and the world face an impending energy crisis. The demand for electricity will perpetually increase, outpacing even noteworthy gains in efficiency, while supply threatens to stagnate. The EIA estimated in 2003 that, by 2010, the consumption of electricity in the United States will exceed 40,000 TWh (growing at a rate of close to 2 percent every year) (See Figure 1.4).

Figure 1.4: Projections for North American Electricity Demand, 1980-2010[37]



Thus, policymakers will need to obtain more generating capacity—fossil fueled or not—in the near future.

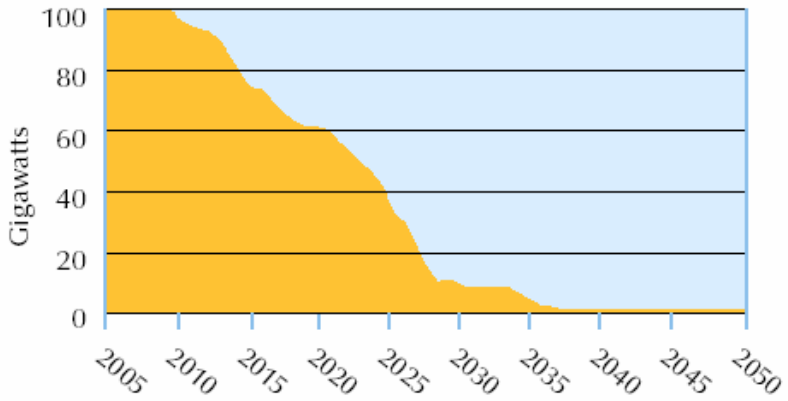
Understanding the impediments to small and decentralized energy units will become more important as large electricity plants are forced into retirement. Such retirement seems likely to occur in two instances: in which large plants are simply getting too old to operate any more, and in pollution non-attainment areas (locations where the government will ban the addition of any pollution-emitting technology). For example, many large, American hydroelectric facilities face license expiration. Through 2017, more than half of all non-federal hydroelectric capacity (more than 32,000 MW of power) will be forced to go through a federal re-licensing process. Many of the plants—which are already aging and provoking protest from environmental groups in the Pacific Northwest—are not likely to receive such licenses. Moreover, it will cost more than $2.7 billion (in 2001 dollars) to process license applications for 307 hydropower projects in 39 states. Even if every plant were to receive federal approval for a new license, the re-

[37] Source: EIA's Annual Energy Outlook, 2003. Figure courtesy of the EIA, available at http://www.eia.doe.gov/emeu/northamerica/engecon.htm, and used under "Educational Fair Use Guidelines."

licensing process typically takes between eight and ten years per project. Since most plants cannot operate without a license, utilities will desperately need to dispatch new generation supplies in hydroelectric regions.[38]

Additionally, forty percent of the U.S. nuclear power plant capacity, which in 2005 contributed about one-fifth of the country's electrical energy, is scheduled to retire by 2020 (See Figure 1.5). To fill the void left by expiring nuclear plants (along with more conventional coal-burning plants), business and policymakers need to choose replacement generation technologies. Of course, energy-efficiency technologies remain a solid, first choice (as a way to reduce overall demand), though (as other chapters point out) such practices have never been a popular choice among politicians and consumers. On the supply side, nuclear power may become more attractive, especially with inducements provided by the recently passed Energy Policy Act of 2005. However, obstacles such as the inability to find waste repositories, large up-front capital costs, and growing scarcity of uranium will likely continue to impede a significant transition to nuclear future.

Figure 1.5: Total U.S. Nuclear Power Plant Capacity (by License Expiration Date)[39]



Data Source: Energy Information Administration, 2003

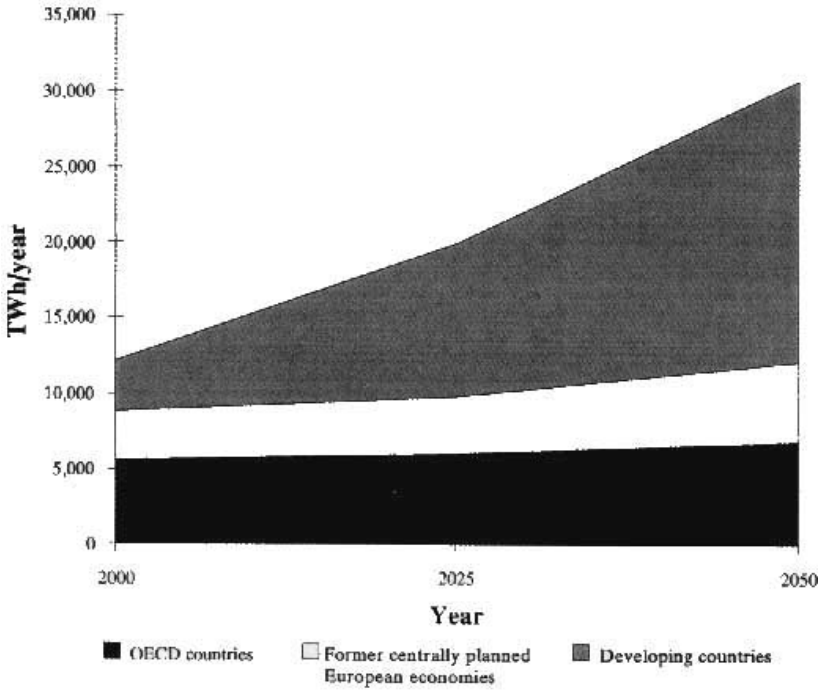
The demand for electricity (and the magnitude of crisis) will grow even more quickly throughout other parts of the world. Many studies have noted that energy sectors in developing countries need significant investment in electricity generation, transmission, and distribution. In 2004, 1.64 billion people still required electricity, with

[38] Scott Sklar and Todd R. Burns, *Hydroelectric Energy: An Overview* (Washington, DC: The Stella Group, 2003), p. 5.
[39] Figure courtesy of Oak Ridge National Laboratory, used with permission from Dr. Marilyn Brown.

ninety-nine percent of these people located in developing countries.[40] In India, for example, only 44 percent of rural residents have access to electricity.[41] One study undertaken by two energy economists noted that electric power systems in Africa alone need more than $18 billion of immediate investment just to provide the base-load power to electrify 2 million customers.[42] Despite the size of the continent, in 1998 Africa accounted for less than 3 percent of the world's electricity production. Even some European countries need drastic infrastructure improvement. Albania, for instance, is estimated to need at least $15 billion to update their electricity infrastructure to prevent weekly blackouts.[43] The International Energy Agency predicts that more than $17 trillion will be required in the next twenty-five years just to maintain currently levels of energy production.[44] Perhaps incongruously, emerging economies represent the areas where most population growth—and thus rising electricity demand—is expected to occur. For example, the U.S. Energy Information Administration's 2005 *International Energy Outlook* estimates that world energy consumption will increase by 57 percent from 2002 to 2025. Much of the growth in worldwide energy use is expected to occur in non-industrialized countries.[45] (See Figure 1.6).

[40] See Richard L. Ottinger and Rebecca Williams, "2002 Energy Law Symposium: Renewable Energy Sources for Development." *Environmental Law* 32 (2002), pp. 331-362; Richard L. Ottinger and and Mindy Jayne, "Global Climate Change Kyoto Protocol Implementation: Legal Frameworks for Implementing Clean Energy Solutions."*Pace Environmental Law Review* 18 (Winter, 2000), pp. 19-50.
[41] Akanksha Chaurey, Malini Ranganathan, and Parimita Mohanty, "ElectricityAccess for Geographically Disadvantaged Rural Communities – Technology and Policy Insights." *Energy Policy* 32 (2004), p. 1693.
[42] John Turkson and Norbert Wohlgemuth, "Power Sector Reform and Distributed Generation in sub-Saharan Africa." *Energy Policy* 29 (2001), p. 135.
[43] *The Economist*, January 7, 2006, "Albania's Electricity Shortages: Lights Out," p. 43.
[44] In Daniel Yergin, "Ensuring Energy Security," *Foreign Affairs* 85(2) (March/April, 2006), pp. 63-81.
[45] U.S. Energy Information Administration, *International Energy Outlook*, July 2005, Available at http://www.eia.doe.gov/oiaf/ieo/electricity.html.

Figure 1.6: Projections of Global Demand for Electricity, 2000-2050 (in TWh)[46]



Yet, to meet this demand, international actors continue to rely on centralized, fossil-fueled plants. More than 90 percent of the $90 billion spent from 1994-2001 on public and private capital flows towards new power plants was directed towards large scale coal and natural gas projects.[47] As of 2003, fossil fuels represented 86 percent of the World Bank's energy portfolio spending. Moreover, a study undertaken by the Sustainable Energy and Economy Network found that 81 percent of all oil energy the World Bank invests in are for export back to Western Europe, Canada, the United States, Australia, New Zealand, and Japan.[48] Globally, the promotion of renewable energy and DG technologies could be an important step towards breaking this dependency and promoting a more socially and economically sustainable form of global energy development.

Second, since the United States remains the world leader in the extraction, consumption, and use of coal and natural gas, the decisions that it makes affect the global

[46] Figure courtesy of National Renewable Energy Laboratory, used under "Educational Fair Use Guidelines."
[47] Andrew Simms, *The Price of Power: Poverty, Climate Change, the Coming Energy Crisis, and the Renewable Revolution* (London: New Economics Foundation, 2004), pp. 13-14.
[48] Jim Vallette and Steve Kretzmann, "World Bank Group Support for Fossil fuels." *Sustainable Energy and Economy* (Geneva: IPS Publishing, 1998), p. 2.

energy marketplace. By any standard, America is the largest consumer of energy. The U.S. thus constitutes the world's largest market for power equipment. In 1969, the country contained 43 percent of the noncommunist world's installed capacity. The U.S. Energy Information Administration estimated in 2005 that demand for electricity in the United States (3,561 billion kWh) equaled more than that for all of Western Europe (2,566 billion kWh). Americans consume a huge amount—roughly 17 percent—of the world's electricity.[49] The U.S. also possesses the world's largest electricity market and utility sector, with the greatest number of independent power producers and consumers. Leonardo Maugeri, Senior Vice President for the Italian energy company ENI, commented that because the United States consumes so much energy, "its problems spill over into the global market."[50] The size of the American electricity sector suggests that trends occurring in the United States may occur elsewhere, and that an understanding of the impediments preventing the wider use of DG technologies in America can help policymakers all over the world better understand how to promote dispersed energy resources, at least in other industrialized countries.

1.7 Preview of Chapters

To explain the "power production paradox," or why DG technologies offer so many benefits yet find the least use, the dissertation moves beyond typical explanations for the failure of distributed and renewable energy generators. Instead, the following chapters examine the more diffuse, subtle, and cultural reasons for the apparent failure of these technologies. In laying out the following chapters, it is not the author's intent to suppose that demarcations between "utility and business," "political and regulatory," "social and behavioral," and "environmental and aesthetic" impediments really exist in distinct, separate classes. The entire point of systems approaches is that such impediments are seamlessly interconnected; dividing the "social" from the "technical," or even the "economic" from the "political" is counterproductive and dangerous, since it misses the point that such impediments exist in a commutual and interdependent network. In other words, it is a heterogeneous combination of socio-technical factors that

[49] U.S. EIA, *International Energy Outlook*,
[50] Leonardo Maugeri, "Two Cheers for Expensive Oil," *Foreign Affairs* 85(2) (March/April, 2006), p. 156.

determine whether energy technologies achieve widespread acceptance, or face consumer rejection.

Chapter 2 begins with an exploration of how energy technologies should be viewed as parts of a technological system, rather than a collection of individual artifacts. It argues that technologies that promote the existing system have a much better chance of becoming widely adopted, whereas those challenging the technical, economic, political, or cultural structure of the system face obstacles. Chapter 2 also explores the contingent nature of technological development in the energy realm and investigates how energy technologies can be read as forms of congealed culture and social and political ordering.

Chapter 3 assesses four significant challenges facing the American electric utility sector: meeting demand projections, finding clean and abundant sources of energy supply, maintaining the infrastructure needed to distribute electricity, and minimizing the destruction of the environment. It argues that distributed and renewable energy systems can respond effectively to each of these challenges. Renewable and DG systems can meet growth in demand in ways that give communities greater control over energy technologies. Moreover, they often use fuel that is widely (and cheaply) available, and they can improve the stability of the grid and minimize transmission losses. Finally, DG technologies often operate more efficiently and emit less pollution than fossil-fueled generators.

Chapter 4 looks at how some businesses and utilities perceive renewable energy and DG systems. The chapter shows that most business leaders and utility managers believe that the high capital cost for DG technologies makes them too expensive for residential consumers, and too risky for businesses and industries. Moreover, many utility managers perceive that the intermittent nature of solar, wind, hydro, and ocean energy technologies make them a poor alternative. Furthermore, system operators continue to claim that DG technologies are difficult to dispatch and standardize.

Chapter 5 investigates the political and regulatory barriers to DG technologies. Beginning with an assessment at the energy policies of the 1970s, the chapter holds that many of the inflated projections and expectations regarding renewable energy turned advocates away from the technologies in the 1980s. Moreover, the chapter argues that variable and inconsistent political incentives for DG technologies—as well as lingering

utility monopoly rules that have become entrenched in federal and state legislation—convince public utility commissioners and system operators to rely on fossil fueled generation.

Chapter 6 analyzes the cultural and behavioral impediments to DG technologies. The chapter argues that utility operators reject distributed resources because they have become accustomed to think in terms of large, centralized plants. Furthermore, it notes that consumers ignore renewable energy systems because they are unfamiliar with them. Additionally, the chapter explores how intentional and unintentional market distortions (such as subsidies and split incentives, respectively) prevent consumers from becoming more interested in their energy decisions.

Chapter 7 explores the aesthetic and environmental impediments to renewable energy systems. After briefly tracing the genesis of the modern-day environmental movement, the chapter explores how some Americans have come to prize the preservation of wilderness and the protection of biodiversity. Such environmental advocates resist fossil fuel and nuclear technologies, but they also object to wind turbines, solar panels, and hydroelectric facilities because they are believed to require large amounts of land and because they may threaten birds, bats, and fish.

Chapter 8 offers the conclusions of the study. Since the demand for electricity will continue to grow significantly for both the United States and the world, understanding the relationship between energy technologies and society will become even more important as policymakers attempt to build more electricity generators. Furthermore, because the United States plans to phase out a number of itsw large hydroelectric and nuclear generators in the next thirty years, assessing the obstacles to smaller, more distributed energy resources may become even more vital as policymakers scramble to meet demand projections. And, finally, if it is true that for the past thirty years policymakers have tended to focus exclusively on supporting the *technical* components of renewable energy and DG systems, then it comes as a sharp wakeup call that the remaining impediments are *social*, and they therefore require an entirely new set of policy mechanisms to be overcome.

In essence, the sheer magnitude of the electric utility sector places it at a nexus of important concerns related to progress, modernity, nationalism, agriculture, industry, human needs and the environment. As David Nye notes:

> It is therefore fundamentally mistaken to think of "the home" or "the factory" or "the city" as passive, solid objects that undergo an abstract transformation called "electrification." Rather, every institution is a terrain, a social space that incorporates electricity at a certain historical juncture as part of its ongoing development. Electrification is a series of choices based only partly on technical considerations, and its meaning must be looked for in the contexts in which [people decide] how to use it.[51]

While it is true that Nye is writing about the historical process of electrification, his work suggests that social interests and attitudes greatly influence the trajectory that electricity technologies take. As such, looking at the social aspects of energy systems is not a matter of tracing predictable relationships. Instead, this project will tell a more complicated story in which social choices interact with energy technologies, markets, and political interests at any given time, and in which energy systems are chosen for both their technical *and* social compatibility. A clear, predictable and linear picture of fossil-fuel and DG technologies is replaced by a more complicated historical unfolding, in which goals, barriers, resources, and social attitudes constantly change over time. It is a story that shows how technological systems evolve, shift, and rearrange both technical artifacts and social power. In this way, negotiating technology is also a way of negotiating identity and social order.

[51] David E. Nye, *Electrifying America: Social Meanings of a New Technology, 1880-1940* (London: MIT Press, 1990), p. xi.

Chapter 2—Viewing Energy Technologies as a Technological System

> "Purely social relations are to be found only in the imaginations of sociologists, among baboons, or possibly on nudist beaches; and purely technical relations are to be found only in the sophisticated reaches of science fiction. The technical is socially constructed, and the social is technically constructed—all stable ensembles are bound together as much by the technical as by the social. Where there was purity, there is now heterogeneity. Social classes, occupational groups, firms, professions, machines—all are held in place by intimately linked social and technical means …. Society is not determined by technology, nor is technology determined by society. Both emerge as two sides of the socio-technical coin."
>
> Wiebe Bijker, sociologist of technology, 1993

2.1 Introduction

To say that renewable energy systems and DG technologies operate as part of a system seems obvious: these technologies clearly rely on a complex network of utility operators, transmission stations, and distribution facilities, to deliver their electricity to consumers. However, to argue that renewable energy and DG technologies operate within a "technological system" is slightly different. To study "technological systems" is to focus on the socio-technical nature of energy technologies, or how such systems both influence (and are influenced by) social and technical factors. Additionally, looking at the social dimensions of energy technologies counters the dominant notion that such technologies are solely the end product of logical, rational and technical discussion. Instead, as suggested in this chapter, energy technologies are deeply shaped by the culture, history, and the social interests of designers, manufacturers, users, and consumers of power.

The systems approach offers one of the best analytical tools for revealing the social aspects of technologies. This chapter describes its genesis, key concepts, limitations, use by other scholars, and its value for exposing things about DG and renewable energy technologies that might otherwise remain hidden. When applied to DG technologies, the systems approach helps explain both the emergence of alternative electrical generators as well as their failure to capture more of the electric utility market. The concept of *reverse salient*—an integral part of the systems approach—for example, is useful in depicting how the efficiency of traditional, fossil-fueled generators reached a plateau in the 1960s and 1970s, when engineers encountered insurmountable problems in

turbine and material design. In light of these problems, renewable and distributed energy technologies offered policymakers a hopeful alternative. Furthermore, the concepts of *momentum* and *interoperability* infer that renewable and distributed energy systems will never achieve widespread use as long as they lack the social, political, and cultural capital of traditional technologies.

2.2 Genesis of the Systems Approach

Before exploring these concepts, it is useful to examine what is meant by the term "technological system." In his highly synthetic *Networks of Power,* Thomas P. Hughes comments that human systems attempt to organize or consolidate disparate materials or functions to maximize the efficiency of a given technique, process, or goal.[1] Systems are "coherent structures comprised of interacting, interconnected components" that range from simple machines, such as a power generator or a telephone, to regional electric supply networks and the massive telecommunications complexes.[2] In other words, systems are comprised of related parts and components that become ordered, integrated, and coordinated. These components are connected by a network, or some type of structure, that allows each node to be centrally controlled. The limits to the system are established by this sense of hierarchical control. Controls are designed to optimize the system's overall performance and to direct the system to achieve its goals.[3] One primary goal of the electric supply system, for example, is to transform natural resources and raw materials into a usable form of energy.

Hughes notes that most operators choose to arrange their components either vertically or horizontally. Horizontally arranged systems interconnect components that have similar functions, whereas vertically arranged systems interconnect components joined in a functional chain. An electric supply system of the horizontal kind would govern a number of central power plants (though not necessarily of the same magnitude); an electric supply system of the vertical kind would control all of the components needed to generate electricity (including the coal mine that extracts fuel, the railway that distributes it, and the utility boiler that converts it into energy). Operators and managers

[1] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1983).
[2] Ibid, p. ix-x.
[3] Ibid, pp. 4-7.

often layer systems so that small systems yield their control to a larger, encompassing system. For instance, many electric supply networks have both vertical and horizontal elements: all of the coal mines, railways, trucks, fossil-fuel generators, and transmission lines are organized and managed separately by smaller, independent systems.

Hughes argues that large technological systems are simultaneously social and technical—or socio-technical—in at least two senses. First, systems require social institutions and technical artifacts to function. The electric utility system, for example, contains social institutions such as regulatory bodies and financing firms. At the same time, it encompasses technical artifacts such as electric generators, transmission substations, and cooling towers. Secondly, systems possess both physical and immaterial components. The electric utility system refers not just to physical artifacts such as steam turbines and distribution wires, but also immaterial or epistemic elements, such as the knowledge needed to repair a broken generator or to construct a new transmission line. Hughes uses this epistemic element of the electric utility system to explain why such systems vary between geographic regions; the different socio-technical environments in Britain, Germany, and the U.S. produced distinct types of electric utility networks. Hughes emphasizes that "electric power systems embody the physical, intellectual, and symbolic resources of the society that constructs them."[4]

2.3 Specific Concepts of the Systems Approach Applied in this Study

In *Networks of Power*, Hughes does more than conceptualize technological systems. He explores the evolution of the small intercity lighting systems of the 1880s into the regional power systems of the 1920s and demarcates five phases of technological evolution.[5] Hughes argues that the electric utility system—like all large technological

[4] Ibid, p. 2.

[5] Hughes carefully acknowledges that he was not the first or only theorist to apply a systems approach to technology. Hughes notes that the idea can be traced to Lynn White, Jr., whose work *Medieval Technology and Social Change* suggested that technology can be viewed as part of an overall system instead of an individual artifact. White argued that in the case of Medieval Europe, complex interactions between technologies (plows and tills), modes of plowing (square or vertical fields), wealth (communal or individual farms), leisure (hours of work), and cultural expression all interacted to establish a network. Similarly, in *The Visible Hand*, Alfred D. Chandler suggested that technological change cannot be understood without knowledge of such social institutions as the manager and the firm. Neil Smelser uses the systems approach in his 1959 work analyzing the growth of the Lancashire cotton industry in the industrial revolution, in which he connected conditions of family life to early modernization. John M. Staudenmair developed his own variant of the systems approach and suggested that technological systems undergo three phases: a design phase (when the flexibility of technology in question), a momentum stage

systems—progressed through five interconnected phases: (1) Invention and development, when inventor-entrepreneurs invent a product and enroll engineers and financers to their project; (2) Technology transfer, in which successful technologies are exported between societies; (3) System growth, in which reverse salients are solved and the system operators manage challenges and tests; (4) Momentum, in which the system acquires mass, velocity, and direction; and (5) Style, in which system operators become particularly adept at solving problems in their own way, creating technological differentiation.[6]

During their third phase, system growth, technological systems must overcome *reverse salients*. A reverse salient describes a problem that defies immediate solution, while other (possibly related) components in the system advance. According to Hughes, "a salient is a protrusion in a geometric figure, a line of battle, or an expanding weather front …. Reverse salients are components in the system that have fallen behind or are out of phase with the others."[7] The term "reverse salient" refers to delays in the growth of elements of systems and other enterprises as they attempt to evolve toward a goal. Thus reverse salients can be organizational and financial as well as political and physical. Analogies of reverse salients are notions like "bottlenecks," "drag," and "emergent friction."[8]

The concept offers insight into understanding one of the challenges facing the modern electric utility industry: thermal efficiency. Thermal efficiency refers to the conversion rate of a fuel into electricity (how much of the raw fuel energy gets transformed into electricity). The American electric utility system encountered what could be considered a reverse salient concerning the thermal efficiency of power plants in the late 1960s. Previously, electrical engineers focused on developing boilers that could withstand greater amounts of heat and pressure as a way to increase thermodynamic efficiency. Yet progress stalled in the late 1960s, when most power plants reached peak

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(when patterns of social adaptation make it increasing difficult to stop a given technology and its maintenance groups) and a senility stage (when technology becomes disconnected from these groups).

[6] Hughes, *Networks of Power*, pp. 6-18.

[7] Thomas P. Hughes, "The Evolution of Large Technological Systems," In Wiebe Bijker, Thomas P. Hughes, and Trevor Pinch (Eds.) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (London: MIT Press, 1987), pp. 51-82.

[8] Steven J. Garber, "Why Does the Space Shuttle Have Wings? A Look at the Social Construction of Air and Space," *NASA History Bulletin* (April, 2001), available at http://history.nasa.gov/sts1/pages/scot.html.

efficiencies around 30-33 percent (and the best reached about 40 percent). Even though the latest version of generators at the time employed state-of-the-art alloys and metals, such newer materials suffered numerous structural problems. The turbine blades twisted more frequently when exposed to superheated steam, furnaces often could not maintain high temperatures, and other material defects retarded reliability and performance.[9] These limits to thermal efficiency form part of Richard Hirsh's concept of technological stasis, or the apparent cessation of technical advances in an industrial process technology, when incremental improvements are no longer made and the technology seems to have reached its limits.[10]

It is precisely this technical cessation (or reverse salient or stasis), combined with broad political changes such those that occurred during the "energy crisis" of the 1970s, that motivated policymakers to consider the development of renewable and distributed energy technologies. Presidents Nixon and Ford hoped that concerted government efforts in developing newer energy technologies would yield "energy independence," which generally meant the end of reliance on unstable foreign supplies of energy (largely oil). At that time, oil was used as a primary fuel in the generation of electricity. Going beyond rhetoric and the modest legislation of his predecessors, President Carter proposed an aggressive energy policy that included incentives for increased domestic production of energy (including the use of renewables) and energy efficiency. One catalyst for these broader political events, however, remained the fact that engineers had been experiencing problems with fossil fueled generators. Or, to use the Hughesian term, reverse salients stopped the relative progress utility managers had been achieving through bigger plants.

Second, Hughes invented the social-science notion of *technological momentum*. The concept first appeared in a 1969 article about German use of hydrogenation to produce synthetic ammonia in Post World War I Germany. Hughes used the idea of "technological momentum" to explain how hydrogenation slowly replaced the more established process of nitrogen fixation and tied Germany's leading chemical

[9] See Hirsh, *Technology and Transformation*; Richard Munson, "Yes, In My Backyard: Distributed Electric Power," *Issues in Science and Technology* (Winter, 2006), pp. 50-51.
[10] See Hirsh, 1989.

manufacturer closer to the Nazi regime.[11] Put simply, "technological momentum infers that social development shapes and is shaped by society."[12] Hughes elaborated that the "mass" of a given system refers to the machines, structures, and physical artifacts where capital has been invested in a technology; the persons whose professional skills have been attached, trained, and associated with a technology; and the business interests and political concerns connected to a technology. Because the different groups associated with a technological system possess disparate goals, the "direction" of the system is often influenced by the professional, social, and business "culture" that comes to be formed as the technology matures. As technological systems become more developed, "the actions of educational and regulatory institutions, the work of numerous individuals, investment of billions of dollars in equipment, and the culture of people working in an industry. Together, these elements promote the continuation of business as usual and the appearance of a large degree of momentum."[13]

In his work on the origins of electric utility restructuring, historian Richard F. Hirsh (who also refers to Hughes) suggests that technological momentum grows as companies invest money in technologies, especially industry specific equipment. Moreover, momentum is built up as manufacturers, consulting firms, and educational institutions become connected to a technological system. The more parties that benefit from (or are enrolled to support) a given technology, the more momentum it achieves.[14] As historian Thomas J. Misa explains, "momentum is a social concept: it points not to the internal logic of technique but to the organizations and people committed by various interests to the system, to manufacturing corporations, research and development laboratories, investment banking houses, educational institutions, technical societies, and regulatory bodies"[15] Momentum is, according to Hughes, "the inertia of a mass in

[11] Thomas P. Hughes, "Technological Momentum in History: Hydrogenation in Germany 1898-1933," *Past and Present* 44(1) (1969): 106-132.
[12] Ibid.
[13] Richard F. Hirsh, "Power Struggle: Changing Momentum in the Restructured American Electric Utility System," In *L'Electricite en Reseaux: Networks of Power* (Paris: Victories Editions, 2004), p. 245.
[14] See Hirsh, *Power Loss*; Hirsh, *Technology and Transformation.*
[15] Thomas J. Misa, "How Machines Make History, and How Historians (And Others) Help Them to Do So," *Science, Technology, and Human Values* 13(3/4) (Summer/Autumn, 1988), p. 318.

motion … As systems become larger and more complex, they gather momentum; they become less shaped by, and more the shaper of, their context or environment."[16]

Hughes explains that momentum can be aided through the use of "conservative" inventions, i.e., new technologies that preserve the structure and power relationships among participants in the existing system. Managers of the system obviously prefer to maintain their control of affairs and, while they may seek increased efficiencies and profits, they do not want to see introduction of new and disruptive "radical" technologies—i.e., technologies that would disrupt the status quo in the system. Momentum, then, is a "change-resisting force constituted by an aggregate of vested interests. Large corporations, government agencies, and professions, for example, have stakes in the hardware, techniques, and knowledge in which they have invested substantial skill, intellect, and financial capital."[17]

The concept of momentum suggests that whether a given technology is perceived as conservative or radical depends not on some objective or external criteria, but its internal interaction within (and comparison to) the technological system. Put another way, the conservative or radical nature of a given technological artifact is not inherent, but socially constructed. This is why newer technologies and processes such as combined cycle natural gas turbines and clean coal technologies such as carbon sequestration, fluidized gas combustion, and integrated coal gasification combined cycle (IGCC)—despite their novelty—have had considerable success. In contrast, other novel technologies such as micro-turbines, reciprocating engines, and combined heat and power systems have had less success. The former technologies preserve the system, while the latter DG technologies challenge the assumption that power should be generated through large, centralized plants.

Third, while never explicitly stated as a formal part of his systems theory, Hughes emphasizes the *interoperability* of mechanisms in technological systems when discussing system evolution. Hughes argues that each module of the system must be designed to

[16] Thomas Hughes, "Afterword," In *L'Electricite en Reseaux: Networks of Power* (Paris: Victories Editions, 2004).
[17] Thomas P. Hughes, "Convergent Themes in the History of Science, Medicine, and Technology," *Technology and Culture* 22(3) (July, 1981), p. 556.

interact harmoniously with the characteristics of the others.[18] Technological systems should be viewed as a collection of "interacting components coordinated by a common purpose—intellectual, economic, political, or other."[19] Viewing energy technologies as systems, rather as than components and unrelated aggregates, Hughes argues, allows analysts to "bring order out of the chaos" and to "work out explanations of dynamic and coherent interrelationships."

Historian Edward Constant adds that operators often organize the components of a system to be both interchangeable and hierarchical. Components are designed to give system designers and operators more control over the system's direction. Systems tend to be decomposable and can therefore be reconfigured or improved with much greater efficiency than individual artifacts. Sociologist Wiebe Bijker adds that technological systems can only be understood as a whole. A game of chess, for instance, cannot be reduced to the strategies of either one of the players. It is self evident, Bijker explains, that when two or more strategies mesh together, the end result is an emergent phenomenon. So it is with technological systems and their components: whatever the system builders attempt to achieve depends on the strategies of the whole range of other actors.[20]

The chess metaphor has its limits, since it implies that the rules of the game are fixed (which is not the case for technical development), but demonstration illustrates that the strategies and players are themselves built up in a field of complicated relations. The illustration cuts to a core element of technological systems—namely that actors are both shaped by, and yet help to shape, the context in or which technology is constructed.[21] Sociologist Brian Elliott argues that viewing technological systems in this way helps indicate that "the conventional distinctions between technology and science, or between technology and economics, politics, or society were scarcely recognized by the system builders themselves, and generally impeded rather than advanced understanding of the

[18] Thomas P. Hughes, "The Evolution of Large Technological Systems," In Wiebe Bijker, Thomas P. Hughes, and Trevor Pinch (Eds.) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (London: MIT Press, 1987), pp. 51-82.
[19] Thomas P. Hughes, "Convergent Themes in the History of Science, Medicine, and Technology," *Technology and Culture* 22(3) (July, 1981), p. 554.
[20] Wiebe Bijker and John Law, "General Introduction," In Wiebe Bijker and John Law (Eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), p. 10.
[21] Ibid.

processes of technological change."[22] This way of viewing technology—and DG technology in particular—allows us to recognize the heterogeneous and interrelated factors shaping utility, business, and consumer resistance of such electricity generators.

2.4 Contrasting Systems Theory with Structural Models, Technological Determinism, Social Construction of Technology, and Actor-Network Theory

The systems approach differs from at least four other historical and sociological methods used by analysts to investigate technology: structural models, technological determinism, social construction of technology, and actor-network theory. For example, structural models propose that technology progresses in a rational, ordered, and predictable manner. They see "science and technology as an assembly line," which begins with a scientist, followed with development and marketing of a given technology, and ending with the product being purchased by consumers.[23] This approach structures technological development and diffusion into at least four separate levels: (1) a design, development, and production phase undertaken by engineers and scientists; (2) an invention phase, in which other engineers actually create artifacts in laboratories, apply for patents, model the prototype, and test that prototype; (3) a market phase, in which technology is then passed onto sales people and managers, before (4) a consumption phase, in which technology is sold to the public, consumed, and perhaps modified by users. In other words, structural models suggest that all technologies move through a basic cycle, starting with pure and applied research, moving to technological development, full scale production, marketing, and maturity. Put simply: engineers design technology, manufacturers produce it, salespeople sell it, and users use it.[24]

Structural accounts of technology heavily populate thinking in the formal academic disciplines of organizational management, economics, and the "hard" sciences. Consider, for example, the work of economist Ederyn Williams, published in 2004, which argues that technology often follows a linear pattern, beginning with research funding that yields innovative work in new engineering and science principles, and then

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[22] Brian Elliott, "Introduction," In Brian Elliott (Ed.) *Technology and Social Process* (Edinburgh: Edinburgh University Press, 1988), p. 3.
[23] George Wise, "Science and Technology," *Osiris* 1 (1985), p. 229.
[24] Wiebe Bijker, "The Social Construction of Fluorescent Lighting, or How an Artifact Was Invented in its Diffusion Stage," In Wiebe Bijker and John Law (Eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), p. 76.

leads to the construction of a prototype, following finally with marketing and diffusion.[25] A similar view can be found in an article in *The Economic Journal*, which suggests that technology follows multiple, progressive stages from "invention" to "innovation" and "diffusion.[26] An older but prominent article in *Science* suggests that technology progresses through a predictable pattern of basic research and development, demonstration, and diffusion.[27] Another concluded that the production of technology always begins with the conception of a social problem, follows with research, development and planning, and finishes with the formation of that technology and diffusion into the marketplace.[28]

In contrast to structural accounts of technology, systems theory holds that no distinction exists between pure/applied research and the design/diffusion of a technology. Instead, the systems approach holds that whether a technology "works" can only be decided after it interacts with users and consumers. Philosopher Joseph Pitt adds that many technologies have emerged without preceding theoretical work in science, proving that the relationship is not always necessary.[29] As one classic example, consider the work of D.S.L. Cardwell on 18th century power technologies. Cardwell argues that steam engines emerged as successful technologies more than a century before the science of thermodynamics became formulated.[30] Furthermore, Derek De sola Price is quick to reject that technology is applied knowledge, stating that "inventions do not hang like fruits on a scientific tree."[31] Instead, technologies emerge in a nonlinear and unpredictable fashion that depends deeply on the way that a system challenges, rearranges, or supports sociotechnical arrangements.

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[25] Ederyn Williams, "Research and Development: Crossing the Valley of Death," *Ingenia* (December, 2004), pp. 23-26.
[26] Paul Stoneman and Paul Diederen, "Technology Diffusion and Public Policy," *The Economic Journal* 104(425) (July, 1994), pp. 918-930.
[27] Walter S. Baer, Leland L. Johnson, and Edward W. Merrow, "Government-Sponsored Demonstrations of New Technologies," *Science* 196(4293) (May 27, 1977), pp. 950-957.
[28] Muhittin Oral, Jean-Louise Malouin, and Joel Rahn, "Formulating Technology Policy and Planning Industrial R&D Activities," *Management Science* 27(11) (November, 1981), pp. 1294-1308.
[29] Joseph C. Pitt, *Thinking About Technology: Foundations of the Philosophy of Technology* (London: Seven Bridges Press, 2000).
[30] See D.S.L. Cardwell, "Power Technologies and the Advance of Science, 1700-1825," *Technology and Culture* 6(2) (Spring, 1965), pp. 188-207.
[31] Derek J. de S. Price, "The Parallel Structures of Science and Technology," In Barry Barnes and David Edge (Eds.) *Science in Context: Readings in the Sociology of Science* (London: Open University Press, 1982), p 169-170.

Furthermore, the notion of a technological system inherently rejects the notion of technological determinism. Much like the structural model, technological determinism posits that technology, as part of its essential property, follows a logical and predictable path. However, unlike the structural model, technological determinism asserts the auto-generative nature of technological innovation and suggests that technological imperatives dictate the pace and direction of social change. It views technology as external and independent, leading to the view that technological systems can become institutionally and financially self supporting.[32] Eugene S. Ferguson clarifies determinism as the belief that technology "makes demands upon those who would use it and transmits those values to those who embrace it …. A technological system has a logic of its own that leads to a deterministic if not predictable outcome."[33] Thus, determinism implies that technology operates in a measured and predictable way, and in a manner independent of human behavior, exerting unidirectional causal influences over humans, similar to those operating in nature.[34]

The concept of technological determinism has deep historical roots in Western literature, philosophy, and religion, and has become thematically embedded in much popular, social, and political thought. Benjamin Franklin and Thomas Jefferson, for instance, saw technologies as a means of achieving a virtuous and prosperous society.[35] Karl Marx famously remarked in 1847 that "the windmill gives you society with the feudal lord; the steam-mill, society with the industrial capitalist," implying that technologies determine the social structures of a given age.[36] In the 1930s, Abbott Payson Usher argued that societies undergo changes over time, and that technology epitomized the innovative process. For Usher, technological sequences make sense only when read forward, meaning that technology is therefore deeply embedded in time and

[32] See Mark Winskel, "Autonomy's End: Nuclear Power and the Privatization of the British Electricity Supply Industry," *Social Studies of Science* 32(3) (June, 2002), pp. 439-467.
[33] Eugene S. Ferguson, "Toward a Discipline of the History of Technology," *Technology and Culture* 15(1) (January, 1974), p. 20, 23.
[34] Wanda J. Orlikowski, "The Duality of Technology: Rethinking the Concept of Technology in Organizations," *Organizational Science* 3(3) (August, 1992), pp. 398-427.
[35] See Merritt Roe Smith, "Technological Determinism in American Culture," In Merritt Roe Smith and Leo Marx (Eds.) *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, MA: MIT Press, 1994), pp. 2-35.
[36] See Karl Mark, *The Poverty of Philosophy* (New York: Progress Publishers, 1955), p. 23.

among the most intense "manifestations of the dynamic processes of history."[37] Similarly, the work of Lewis Mumford called attention to technology as the "critical problem of the day," as he attempted to document the social and spiritual ills of the Machine Age, or how technology enabled conflicts between spiritual and material values in an era of automation and mass production. The work of Sigfried Giedion is also influential here, since Giedion proposed that the cultural wounds inflicted by mechanization could be related to an artificial schism generated by humanity's domination over nature. Giedion emphasized the human need to reassume cultural control through merger of feeling, thought, culture, and art.

Ideas of technological determinism exert profound cultural significance, Leo Marx notes, because they are tied to notions of human progress and mastery over nature. Deterministic accounts promote a comforting theme in technology, since they display the "linear advance of humanity as a series of transformations, chiefly responsible by particular inventions—from primitive tools to complex machines—by means of which Homo sapiens acquired its unique power over nature."[38] Such ideas have become widely diffused through the news media. Thomas P. Hughes warns that people are constantly hearing about how computers are changing work patterns, automation is changing industry, that western televisions will determine elections or attitudes of democracy in Europe, that nuclear weapons maintain a lasting peace, and so on.[39]

Systems theory challenges technological determinism because it refutes the idea that all technical artifacts (whether coffee makers or chemical weapons) are homogeneous, and it challenges the notion that all technologies progress in a similar manner. Sociologists Wiebe Bijker and John Law comment that the systems approach attempts to demonstrate that "technologies do not evolve under the impetus of some necessary inner technological or scientific logic … If they evolve or change, it is because

[37] Arthur P. Molella, "The First Generation: Usher, Mumford, and Giedion," In Stephen H. Cutcliffe and Robert C. Post (Eds.) *In Context: History and the History of Technology* (London: Lehigh University Press, 1989), p. 95.
[38] Leo Marx, "Technology: The Emergence of a Hazardous Concept," *Social Research* 64(3) (Fall, 1997), p. 24.
[39] Thomas P. Hughes, "From Deterministic Dynamos to Seamless-Web Systems," In Hedy E. Sladovich (Ed.) *Engineering as a Social Enterprise* (Washington, DC: National Academy Press, 1991), pp. 7-25.

they have been pressed into that shape."[40] Analogously, political scientist Langdon Winner comments that "a careful examination of how emerging technologies develop" replaces "forces and laws" with a "panoply of social, cultural, and political choices."[41] For example, this project will show, historically, that such "choices" made by utility system participants for about seven decades have conditioned engineers, academics, and utility operators to favor large, centralized plants instead of smaller, decentralized renewable units. Such choices have also convinced consumers to place more trust and familiarity with centralized, fossil-fueled technologies. Superficially, the events occurring in the electric utility system may appear to have occurred as a result of technological determinism. This project will demonstrate that, instead, they resulted from a host of choices made by actors having various concerns and interests.

Systems thinking also differs from two other approaches frequently used in the history and sociology of technology: the social construction of technology (SCOT) and actor-network theory (ANT). The methodological approach known as SCOT draws from the empirical program of relativism, which argues that knowledge—even that previously regarded as true or false—involves material resources, psychological processes, and social practices. Like systems theory, SCOT holds that technology emerges in society as a "seamless web," or what Bruno Latour calls a "sociotechnical imbroglio."[42] However, unlike the systems approach, SCOT focuses on how relevant social groups share the same sets of meanings attached to particular technological artifacts.[43] SCOT also centers more on the array of values, methods, goals, tacit knowledge, user practices, and testing procedures used by a group of practitioners when developing a particular technology (part of Wiebe Bijker's concept of a technological frame). SCOT, then, rests on the

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[40] Wiebe Bijker and John Law, "General Introduction," In Wiebe Bijker and John Law (Eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), p. 3.
[41] Langdon Winner, "Prophets of Inevitability," *Technology Review* (March/April, 1998), p. 62.
[42] Bruno Latour, *Pandora's Hope: Essays on the Reality of Science Studies* (Cambridge, MA: Harvard University Press, 1999).
[43] See Wiebe E. Bijker, "Sociohistorical Technology Studies," In Shelia Jasanoff, Gerald Markle, James Petersen, and Trevor Pinch (Eds.) *Handbook of Science and Technology Studies* (London: Sage Publications, 1995), pp. 229-256; Trevor J. Pinch and Wiebe Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," *Social Studies of Science* 14(3) (August, 1984), pp. 399-441; Wiebe Bijker, "The Social Construction of Fluorescent Lighting, or How an Artifact Was Invented in its Diffusion Stage," In Wiebe Bijker and John Law (Eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), pp. 75-102; Wiebe Bijker, "Do Not Despair: There is Life After Constructivism," *Science, Technology, and Human Values* 18(1) (Winter, 1993), pp. 113-138.

assumption that the social lies behind and directs the stabilization of artifacts, where the systems approach does not especially privilege the social, since social interests are seen as variable at least within certain limits. The systems approach emphasizes the interconnected nature of technologies, whereas the SCOT approach spotlights how different social groups affect the design of a given technology.[44]

And, unlike the systems approach, ANT emphasizes the importance of symmetry—i.e., the inclusion of nonhuman actors in treatments of science and technology. One ANT approach assessing the development of the French electric vehicle, for example, included electrons, motorists, accumulators, researchers, manufacturers, government departments, and engineers all as "actors."[45] By doing so, the author intended to create a radical reconceptualization of how humans conceive the social and the technical. Bruno Latour clarifies that "[i]t is that society itself is to be rethought from top to bottom once we add to it the facts and the artifacts that make up large sections of our social identities"[46] Thus, ANT is much more abstract than systems theory, since it assumes that sociotechnical networks subsume science, technology, and other categories. ANT is also skeptical about the existence of any stable social structure, and instead sees a constantly open-ended interaction between a multitude of actors.[47] In contrast to systems theory, ANT teaches us not to think of society as some kind of external structure shaping technology, and that viewing "technology" and "society" as two separate things is fundamentally misleading.[48] So, while ANT can be used to supplement the systems approach, its concepts remain too abstract for use in this study.

2.5 Empirical Use of the Systems Approach

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[44] Donald MacKenzie, Personal Interview, November 8, 2005.
[45] Michel Callon, "Society in the Making: The Study of Technology as a Tool for Sociological Analysis," In Wiebe Bijker, Thomas P. Hughes, and Trevor Pinch (Eds.) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (London: MIT Press, 1987), pp. 83-106.
[46] Bruno Latour, "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts," In Wiebe Bijker and John Law (Eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), p. 254.
[47] Donald MacKenzie, "Theories of Technology and the Abolition of Nuclear Weapons," In Donald MacKenzie and Judy Wajcman (Eds.) *The Social Shaping of Technology* (2nd Edition) (Philadelphia: Open University Press, 1999), pp. 419-442; Wiebe Bijker and John Law, "General Introduction," In Wiebe Bijker and John Law (Eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), pp. 1-16.
[48] Donald MacKenzie, Personal Interview, November 8, 2005. .

The ability for systems theory to reveal how technologies shape the way that people think about their world explains (perhaps) why it has been used by scholars to illustrate the socially constructed nature of transportation and energy enterprises. Iskender Gokalp's work on the French railroad offers insight here. Golkalp argues that correlations exist between technological systems and political ideologies. Railroads evolved only with advances in the concept of the territorial nation state, the establishment of electronic communications, and the evolution of the global economy. The French railroad system, he notes, was developed from 1823 to 1842 with separate lines and the lack of an overall plan, as French society debated its physical and social structure. From 1842-1850, however, the railroad network underwent accelerated development. The length of track increased from 1,931 km to 4,100 km in five years, and then to 23,600 km ten years later. The rate of the system's growth slowed, and then turned negative as it was replaced by motorways in the 1920s. Golkalp concludes that the French railroad can only be read as co-evolving with economic, political, and social advances. Economic changes, such as ease of access to natural resources, subsidies in iron and steel sector, and improved agriculture from distribution of fertilizer, created the need for better transportation systems. Political advances, such as the treaty of 1860 ending a ban on English imports into France and the growth of liberalism, generated state support for the railway system. And social advances, such as new methods of managing large-scale companies, the idea of a collective labor force, and the growth of capitalism, enabled the owners and investors of the French railway network to maintain the system's momentum.[49] In other words, the evolution of the French railway system cannot be understood solely as a social or technical phenomenon. Instead, the system acquired (and lost) its momentum through a seamless combination of sociotechnical changes.

Similarly, Gabrielle Hecht's *The Radiance of France* employs the systems approach to reveal how French nuclear power systems became intertwined with visions of national identity and progress.[50] Hecht argues that the end of World War II left France humiliated and defeated as the country lacked infrastructure, food, and political influence.

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[49] Iskender Gokalp, "On the Analysis of Large Technical Systems," *Science, Technology, and Human Values* 17(1) (Winter, 1992), pp. 57-78.
[50] Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity After World War II* (MIT Press, 1998).

French technical and scientific experts attempted to respond to these infrastructure challenges by linking technological advancement to French identity (its radiance). French policymakers saw technology as a way to simultaneously rebuild France's economy and reestablish its role as a world leader. After the American creation and demonstration of the atomic bomb, the French believed that "nuclear technology became a quintessential symbol of modernity and national power."[51] Hecht skillfully applies the systems approach to spotlight the role that nuclear technology played in constructing French national identity, and her work shows that the credibility of energy systems is often tied to more than just technical capacity. For instance, Hecht suggests that the fierce debates between early French energy agencies over reactor design were also about primacy over policymaking in the industry. The agencies that held the upper hand had to prove that they were committed to a nuclear strike force and a more explicitly stated vision of showcasing engineers as "national champions."

2.6 Applying the Systems Approach to DG Technologies

When applied to distributed and renewable electric generators, the systems approach uncovers at least five important themes. First, viewing renewable energy systems and DG technologies as part of a technological system *rejects the distinction between the technical and the social*. Traditionally, technologists and policymakers often attempted to describe technological development by sharply demarcating the "technical" from the "social." Sociologist John Law comments that such descriptions often supplemented technical discussions with a list of the "social" factors that influenced development, as if "one is presented with a balance sheet with society (or the economy, or science, or politics) on the one hand and technology on the other. Analysis becomes the study of transfers between columns."[52] Sociologist Bruno Latour agrees, and argues that "technology and society are two artifacts created by the analyst's duplicity."[53] Steven Flank adds that the systems approach rejects "the dichotomy of society and technology," and that "in place of these traditional categories, we see system builders

[51] Hecht, p. 2.
[52] John Law, in Johan W. Schot, "Constructive Technology Assessment and Technology Dynamics: The Case of Clean Technologies," *Science, Technology, and Human Values* 17(1) (Winter, 1992),p. 38.
[53] Bruno Latour, "The Prince for Machines as Well as for Machinations," In Brian Elliott (Ed.) *Technology and Social Process* (Edinburgh: Edinburgh University Press, 1988), p. 22.

who corral diverse allies and resources as components for the evolving networks for which they are a part."[54]

Clashes over the technical feasibility of a system, then, are not merely technical debates, but contests over social ideology, interests, values and power. Therefore, conflicts over the technical aspects of a given technology are often about more than just technology. As we will see in the case of renewable and distributed generation technologies, the way that such technologies redistribute social, political, and economic power is as important as how such technologies generate electricity.

Second, the systems approach recognizes the *contingency* of technological development. No energy technology—from steam turbines to hybrid fuel cells—will ever achieve inevitable success. As David Nye comments, "large-scale systems, such as the electric grid, do have some flexibility when being defined in their initial phases; however, as ownership, control, and technical specifications are established, they become more rigid and less responsive to social pressures."[55] In other words, Nye suggests that successful energy technologies often appear predictable only after they become widely used. Thus, in the beginning phases of any hardware, the systems approach shows that the evolution of technologies might have been different, allowing us to reach beyond simple explanations that technological development would have progressed in a linear and predictable fashion.

The assumption that technology, the social world, and its history should be treated as messy contingencies implies that no grand rational plan or history exists for technological development.[56] David J. Hess clarifies that:

> by examining the history and variation of a technological field (both over time and across geographic and socially different sites), one can come to understand the contingency of technological development and see better

[54] Steven Flank, "Exploding the Black Box: The Historical Sociology of Nuclear Proliferation," *Security Studies* 3(2) (1994), p. 263.
[55] David Nye, *Consuming Power: A Social History of American Energies* (New York: MIT Press, 1999), p. 3.
[56] Wiebe Bijker and John Law, "General Introduction," In Wiebe Bijker and John Law (Eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), pp. 1-16.

> the alternatives and "lost" technologies that have been marginalized in the development of the technological field.[57]

In this way, the systems approach emphasizes that the question of whether a technology works—whether it remains "lost" and "marginalized"—cannot be answered prior to its adoption. The question must remain open-ended; only when such technologies become fully integrated into society can such a question be answered.

Emphasizing the contingency of technical development has at least two implications for understanding the evolution of energy technologies. For one, it reminds us that the current electric utility system—with its substations, transmission lines, expansive natural gas pipelines, coal mines, and varying types of generating technology—was and is by no means inevitable. Instead, each of these technologies is the product of social negotiation and compromise. Since the current system was *chosen* and elaborated upon by actors, it can also be changed by human participants as well. Additionally, making visible the contingency of the electric power grid allows us to study and analyze the factors that make current technologies socially acceptable. In other words, the systems approach helps show us what social conditions are necessary for a given technology (or set of technologies) to succeed, at the same time such conditions may make other technologies unacceptable.

Third, the systems approach suggests that *energy technologies can be read as congealed culture*.[58] Since systems evolve by soliciting broad socio-technical support by actors/participants/stakeholders, a number of different people (with their own interests) become enrolled to support them. Philosopher Andrew Feenberg argues that "each configuration of components [in a technological system] corresponds not only to a technical logic, but also to the social logic of its selection … the interests and worldview of the actors are expressed in the technologies they participate in designing."[59] In other words, the social interests of those designing the system get built *into* the system, rather than becoming a latent or unintended result. The builders of technological systems attempt to maintain or establish a particular set of technical arrangements along with a set

[57] David J. Hess, Personal Interview, October 19, 2005.
[58] Thomas P. Hughes, "Convergent Themes in the History of Science, Medicine, and Technology," *Technology and Culture* 22(3) (July, 1981), p. 556.
[59] Andrew Feenberg, *Questioning Technology* (New York: Routledge, 1999), p. 10-11.

of social, scientific, economic, or organizational relations. Wiebe Bijker and John Law comment that:

> Technology does not spring, *ab initio,* from some disinterested fount of innovation. Rather, it is born of the social, the economic, and the technical relations that are already in place. A product of the existing structure of opportunities and constraints, it extends, shapes, reworks, or reproduces that structure in ways that are more or less unpredictable. And, in doing so, it distributes, or redistributes, opportunities and constraints equally or unequally, fairly or unfairly.[60]

Put another way, technologies do not exist in isolation from broader political and social forces. Instead, technological systems reflect the values and interests of society, and such systems serve as powerful cultural, economic, and political symbols that redistribute social power and entrench established practices and methods of reasoning.

Fourth, viewing technology as part of a system *helps explain how some technologies become invisible*. Historian James C. Williams argues that people know that technology and technological systems are the tools with which they interact in their everyday lives. But once technological landscapes are in place, people fold them so completely into their psyches that those very landscapes become almost invisible.[61] Some technologies are intentionally invisible. The invisibility of energy systems, however, is largely unintentional, and an exploration into the social genesis of this invisibility can inform analysts seeking to understand other fully integrated technologies in telecommunications, transportation, and food preparation. This project will show how the mere existence of traditional technological systems shapes an individual's historical consciousness in such a way that manmade technologies sometimes appear as natural as the non-manmade environment. Moreover, it appears that most people have become enfolded into the vast technological network of the electric utility system so that they don't even realize such a system exists. Any change to the invisible system, therefore,

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[60] Wiebe Bijker and John Law, "General Introduction," In Wiebe Bijker and John Law (Eds.) *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, 1992), p. 11.
[61] See James C. Williams, "Strictly Business: Notes on Deregulating Electricity." *Technology & Culture* 42 (July, 2001), 626-630.

elicits a reaction (and usually a protest) to that change, as shall be shown in the case of DG technologies.

And fifth, systems thinking *challenges notions of technological failure and failed technology*. Most assessments of technology continue to understand technological failure as a purely technical phenomenon. The work of Charles Perrow provides excellent case studies into how the "interactive complexity" and "tight coupling" of technological systems like those used at chemical plants, nuclear weapons laboratories, and air traffic control, will inevitably produce accidents.[62] E. J. Woodhouse comments that since technological endeavors are incredibly complex, new technology—especially military weapons systems—can be expected to respond to their environment in unforeseeable ways, a problem further compounded by significant lag time between the introduction of new technologies and discovering their inherent risks.[63] Kenneth Lipartito notes that linear explanations of failure are often deployed to clarify the failure of the electric vehicle, the Beta videotape system, and early metal airplanes.[64] The case of renewable energy technologies, in contrast to a linear explanation, highlights how any such notion of "technological failure" must include both the technical and social dimensions of a given technology.

2.7 Limitations of the Systems Approach

Despite its potential to uncover the sociotechnical aspects of DG technologies, the systems approach has not remained immune from criticism on both substantive and stylistic grounds. On a substantive level, historian Langdon Winner notes that idioms like the systems approach tend to disregard the dynamics evident in technological change beyond those revealed by immediate interests, problems, and solutions of specific groups.[65] Yves Gingras goes much further, attacking the refusal for systems theorists to distinguish between social and technical factors. Gingas argues that conflating the social

[62] Charles Perrow, *Normal Accidents: Living with High-Risk Technologies* (New York: Basic Books, 1984).
[63] E. J. Woodhouse, "Is Large-Scale Military R&D Defensible Theoretically?" *Science, Technology, and Human Values* 15(4) (Autumn, 1990), pp. 442-460.
[64] Kenneth Lipartito, "Picturephone and the Information Age: The Social Meaning of Failure." *Technology & Culture* 44(1) (2003): 50-81.
[65] Langdon Winner, "Upon Opening the Black Box and Finding it Empty: Social Constructivism and the Philosophy of Technology," *Science, Technology, and Human Values* 18(3) (Summer, 1993), pp. 362-378.

and technical as "the same" regresses to the idea that "everything is in everything."[66] Keith Grint and Steve Woolgar add that systems thinking permits a dangerous ambivalence associated with the idea of antecedent circumstances being built into technology. The notion that values are built into technology implies that technology can be neutral until such time as political or social values are attributed to it. Attributes such as interests and values are assumed to be straightforwardly available to the analyst, who can ignore interpretive work that goes into rendering the motives of social interests.[67] Andrew Feenberg raised a similar objection when he stated that "where the old determinism overstated the independent impact of the artifactual on the social world, the new approach has so disaggregated the question of technology as to deprive it of philosophical significance."[68]

In response, the systems approach does still yield a wealth of information about technical, social, economic, and political dimensions of technology. Yet in order to contribute to understanding, this information needs to be conceptually organized; order must be created out of chaos, or else such an approach merely repeats the details of the case study. In this way, it is true that the systems approach is only one interpretation or construction of the sociotechnical world. Trevor Pinch and Wiebe Bijker explain that:

> All forms of sociological explanation in which groups or structures are identified can never be adequate in the sense that all groups are themselves embedded within an endless web of other groups and structures. Spelling out all such contexts is clearly impossible. All that can be attempted is to spell out sufficient context for the purposes at hand.[69]

In the end, however, the point is not whether such approaches create an objective, philosophically-fulfilling and infallible description of reality, but whether they are *useful.*[70] The systems approach is useful in this study because it demonstrates that

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[66] Yves Gingras, "Following Scientists Through Society? Yes, but At Arm's Length," In Jed Z. Buchwald (Ed.) *Scientific Practice: Theories and Stories of Doing Physics* (Chicago: University of Chicago Press, 1995).
[67] Keith Grint and Steve Woolgar, "On Some Failures of Nerve in Constructivist and Feminist Analyses of Technology," *Science, Technology, & Human Values* 20(3) (Summer, 1995), pp. 286-310.
[68] Andrew Feenberg, *Questioning Technology* (New York: Routledge, 1999), p. 12.
[69] Trevor Pinch and Wiebe Bijker, "Science, Relativism, and the New Sociology of Technology," *Social Studies of Science* 16(2) (May, 1986), p. 353.
[70] Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, "Common Themes in Sociological and Historical Studies of Technology," In Wiebe Bijker, Thomas P. Hughes, and Trevor Pinch (Eds.) *The*

electric supply systems must rely on technical artifacts and social institutions in order to evolve, grow, and function.

Stylistically, the systems approach has been critiqued for relying on a technical and jargon ridden vocabulary. John Law once humored that "sociology is a description of the obvious in a language that no one is able to understand."[71] David Edgerton comments that the language used in methodologies such as the systems approach has "fabricated an intellectual missile gap" between "popular accounts of technology and our critical abilities."[72] Wiber Bijker agrees that:

> Our field has a tendency of too easily inventing new words. And I say "words" because I refuse to call them new concepts. I think that this is a bad habit, for it doesn't help us to relate to other disciplines or wider society, or to politicians and policymakers. People read constructivist literature in science and technology studies, and end up concluding that it is simply loaded with unnecessary jargon.[73]

And R. A. Buchanan commented that "the imposition of an alien conceptual vocabulary on the subject matter of history is misleading, causing obfuscation and unjustified selectivity in the use of historical evidence."[74]

In reply, it is not the intent of this project to advance an "alien" and "unnecessarily complicated" terminology onto unsuspecting readings. However, a certain amount of "jargon" can be useful when laying out new concepts, such as *reverse salients* and *technological momentum*, with which readers may be unfamiliar. Moreover, such terms can help clarify the conceptual boundaries of systems thinking from other methods assessing technology used by sociologists and historians.

2.8 Conclusion

Social Construction of Technological Systems: New Directions in the Sociology and History of Technology (London: MIT Press, 1987), pp. 1-15.

[71] John Law, "Theory and Narrative in the History of Technology: Response," *Technology and Culture* 32(2) (April, 1991), p. 379.

[72] David Edgerton, "Tilting at Paper Tigers," *British Journal for the History of Science* 26 (1993), pp. 27-75.

[73] Wieber Bijker, "Revisiting the Social Construction of Technology," *Personal Interview With Benjamin Sovacool* (Pasadena, California: October 20, 2005), pp. 1-3.

[74] R. A. Buchanan, "Theory and Narrative in the History of Technology," *Technology and Culture* 32(2) (April, 1991), p. 370-371.

Instead of deterministic accounts of technological innovation and change, the systems approach reveals that the process of creating and adopting technologies is complex, interactive, and political. To be successful, technologies must not only get built, but get built into society. Viewing technologies as part of a system shows that knowledge, artifacts, and people must be aligned, molded, and disciplined to accept technological development. In the process of creating any technological system, a wide diversity of entities must be enrolled so that their primary function becomes the promotion of that technology. And systems theory insists that once a technology has been stabilized or successful, the bulk of this complex and heterogeneous world fades from view.[75] In the end, technological systems are neither static, linear, nor predictable. Rather they are constituted in the course of complicated, evolving, dynamic and unpredictable interactions between individuals and technical artifacts.

This dissertation uses the systems approach to demonstrate that renewable energy systems and DG technologies can be understood profitably in their wider socio-technical context. Attempting to understand energy technology without assessing its political, social, and economic evolution is, in the words of Bruno Latour, like "trying to make a mayonnaise with neither eggs nor oil—that is, out of hot air alone."[76] Having origins in politics, history, and culture, the socio-technical (rather than purely social or technical) impediments faced by DG technologies play a huge role in inhibiting their widespread acceptance and use. The following chapters will show that a resolution to the power production paradox—that energy technologies with immense potential advantages find the least use—will depend not on technical breakthroughs, but on the understanding that resistance to DG technologies is a social phenomenon having a combination of obvious and subtle components.

[75] Maggie Mort, *Building the Trident Network: A Study of the Enrollment of People, Knowledge, and Machines* (Cambridge, MA: MIT Press, 2002).
[76] Bruno Latour, "The Powers of Association," In J. Law (Ed.) *Power, Action, and Belief: A New Sociology of Knowledge* (Cambridge: Cambridge University Press, 1986), p. 277.

Chapter 3—The Promise of DG Technologies

"There is no substitute for energy. The whole edifice of modern society is built upon it … It is not 'just another commodity' but the precondition of all commodities, a basic factor equal with air, water, and earth."

--E.F. Schumacher, Nobel Prize winning economist, 1973

3.1 Introduction

The systems approach posits that, in order maintain momentum, technological systems must connect themselves to various groups of actors and social institutions. These actors help control and organize the system, and they also steer that system to achieve its goals. For the moment, most of the individuals involved with the modern, electric utility system remain committed to the classic "hub and spoke" model of electricity supply: using large, fossil fueled generators to create electricity that is then distributed over an ever larger transmission and distribution network.

But there are also those, concerned with the electric utility system, that want to challenge the "hub and spoke" model on the grounds that smaller, more distributed generators (including renewables) would best respond to the problems the electricity industry faces. This chapter is primarily about them: the arguments presented by entrepreneurs, scholars, technologists, and (a few) utility operators in favor of DG. These individuals argue that the present electric utility system faces at least four, serious (and interconnected) socio-technical obstacles, or reverse salients. Demand for (and consumption of) electricity continues to grow, but utilities are finding it more difficult to provide it to customers due to aging generation technology and the capital resources needed to build large generators. Additionally, the two primary fuels used in American electricity generation—coal and natural gas—must pass through many layers of vertically and horizontally managed subsystems before they can be converted into electricity. Thus, such fuels are susceptible to interruptions in supply and price volatility. Furthermore, these advocates of DG argue that the transmission grid used to deliver electricity is becoming more insecure and fragile, and that the human health and environmental consequences of the fossil-fuel paradigm continue to grow.

To respond to these concerns, proponents argue that distributed generation and renewable energy technologies offer a host of potential advantages: in some cases, they produce power more cheaply than traditional fossil-fuel burning generators; they offer electricity with reduced environmental harm; and they can meet increased demand for power without exacerbating problems on the strained distribution and transmission grid. Despite offering these possible benefits, DG and renewable energy technologies face certain technical hurdles, in the form of connecting safely and effectively with the existing electric power network, for example. Moreover, these technologies often prove difficult to standardize, being susceptible to location-specific sources of natural "fuel" and other resources.

The chapter accentuates one the power production paradox: if distributed and renewable energy resources are perceived by some to offer so many benefits, why aren't they more widely used? The dilemma appears not to be that such technologies have immense advantages, but that the wider use of renewable energy systems and DG technologies threatens to defy the conventional thinking about how the electric utility system should be conceived, managed, and operated.

3.2 A Primer on the Existing Electric Utility System

Before understanding how distributed and renewable technologies change the game, however, it is necessary to briefly describe how the contemporary electricity industry is structured. From the beginning of the twentieth century until the 1970s (and one could argue beyond then), the electric utility industry took advantage of incrementally improving, large-scale technology and managerial innovations to produce growing amounts of centralized power at declining costs.[1] Driven by resource availability, economies of scale, and lower staffing levels per facility, the predominately fossil-fuel and nuclear-fueled units produced immense amounts of electricity, often between 300 and 1,300 MW.[2] Power *plants*, made up of several units, generate multiples of these amounts. In addition, utility managers situated most large plants built after the 1950s outside cities. Urban expansion depleted the amount of property available for land-intensive electricity generators, and residents living in American cities became more

[1] See Hirsh, 1989.
[2] See Lovins et al. 2002, p. 284; Neil Petchers, *Combined Heating, Cooling & Power Handbook: Technologies & Applications* (New York: The Fairmount Press), pp. 5-6,

aware of air pollution and environmental problems associated with energy production. Planners located nuclear plants outside cities as a safety measure as well. The location of coal plants also tended to be bimodal—early ones were placed in cities, newer ones outside to better accommodate associated transportation costs. Furthermore, since water is essential for the transfer of heat in the electrical generation process, it made sense to place plants near its adequate availability, resulting in a tendency for power plants to concentrate near rivers, lakes, seas, and oceans.[3]

Even though the industry's recent growth has been stunted by escalating fuel prices, changing consumer preferences, and technological stasis, the modern electric utility industry is highly integrated and complex. In 2002, the U.S. electricity industry possessed over $700 billion of embedded investment, making it the largest investment sector of the American economy (representing 10 percent of total U.S. capital investment). Annual sales of electricity for the same year were approximately $260 billion, close to 4 percent of gross domestic product (GDP). To generate this revenue, the industry consumes 38 percent of the country's energy and nearly 6 percent of its gross national product.[4] Furthermore, in 2003 the electric utility industry was regulated by 53 federal, state, and city public service commissions and more than 44,000 different state and local codes. During the same year, 242 investor owned utilities (such as Exelon, Dominion, and American Electric Power) owned and operated about 75 percent of the country's total electrical capacity. In addition to these investor owned utilities, more than 3,187 other private utilities provided power along with 900 cooperatives, 2,012 public utilities, 400 power marketers, 2,168 non-utility generating entities, and nine federal utilities (such as the Tennessee Valley Authority and Bonneville Power Administration). These utilities distributed their electricity through roughly 500,000 miles of bulk transmission lines (and an unknown number of distribution lines).[5]

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[3] Martin J. Pasqualetti, "Morality, Space, and the Power of Wind-Energy Landscapes," *Geographical Review* 90(3) (July 1, 2000), p. 383.

[4] See Lovins et. al, pp. 69-71; Mozelle W. Thompson, "Electricity Competition: Volume 1," *Hearings Before the Subcommittee on Energy and Power of the Committee on Commerce, House of Representatives*. (March 18-May 6, 1999), pp 264-270; Ann-Marie Borbely and Jan F. Kreider, *Distributed Generation: The Power Paradigm for the New Millennium* (New York: CRC Press, 2001), pp. 262-263.

[5] See Greg Palast, Jarrold Oppenheim and Theo MacGregor, *Democracy and Regulation: How the Public Can Govern Essential Services* (London: Pluto Press, 2003), p. 85; Borbely and Kreider 2001, pp. 324-325; Lovins et al. 2001, p. 70.

These statistics suggest that the American electric utility sector has placed significant investment (creating momentum) in fossil fueled technologies and the supporting transmission and distribution grid. Billions of dollars and countless institutions exist to sustain the existing electricity infrastructure, which has become fully integrated into modern society. And, while alternative power providers exist as part of the system (in the form of cooperatives and public utilities), these organizations control less than twenty percent of the remaining power market. In other words, significant political and technological capital has been invested in maintaining the current electric utility system.

3.3 The Demand Challenge: Meeting Growth Projections

Despite the complexity of the electric utility industry, its overarching problem is stark in its simplicity (and almost universally agreed upon by both proponents and opponents of DG): demand for electricity will continue to grow, while supply and transmission may stagnate. Analysts estimate that total American electricity consumption will grow from 3,657 billion kWh in 2003 to 5,467 billion kWh in 2025, increasing at an average rate of 1.8 percent per year. Put another way, the demand for electricity in the United States will double by 2050.[6] While this projected rate of consumption is much lower than in other historical periods (rates of increased consumption averaged around seven and eight percent throughout most of the 1960s and 1970s), it will still create an immense challenge in finding adequate sources of electricity supply. If one were to assume that such projections would be met by nuclear power, the nation would need to build thousands of nuclear plants—one lobbyist even estimated a new nuclear plant would need to be built about every 10 days—to meet demand.[7]

It is true that remarkable improvements in energy efficiency have contributed greatly to reducing the growth rate of electricity consumption. Sadly, the historical record suggests that energy efficiency practices and demand-side reduction programs seem unable to offset steady increases in demand. For example, on-site electricity consumption per household in the United States dropped 27 percent between 1978 and 1997, yet the number of households grew by 33 percent. Over the same period,

[6] U.S. Energy Information Administration, *Annual Energy Outlook 2005: With Projections to 2025*, p. 3-5.
[7] In S. Julio Friedman and Thomas Homer-Dixon, "Out of the Energy Box." *Foreign Affairs* 83(6) (November/December, 2004), pp. 72-83.

electricity's share of household energy consumption actually increased from 23 percent to 35 percent.[8] John Wilson, a staff member for the California Energy Commission put it this way:

> New Californian homes use one sixth of the energy per square foot for air conditioning than they did 20 years ago. The bad news is that homes are almost twice as big as they were 30 years ago. We are making things more efficient, but making more of them.[9]

Therefore, despite the significant gains made by energy efficiency improvements, demand has historically outpaced them.

In addition, the American economy is changing. In the past twenty years, many industries have shifted to digital controls and electronic communications and computing equipment, placing greater stress on the power grid. Joe Loper, Vice President for Research at the Alliance to Save Energy, comments that "electric generation and electric-using equipment are far more efficient than they used to be, but demand for electricity continues to soar due to new uses, bigger homes to heat, and increased population."[10] Hans Blix, the former director of the International Atomic Energy Agency, stated that "the more efficient use of energy will only partially slow down the expanding use of energy. Although our light bulbs will save electricity, we shall have more lights."[11] The EIA's *International Energy Outlook* also noted that "rapid additions to commercial floorspace, the continuing penetration of new telecommunications technologies and medical imaging equipment, and increased use of office equipment are projected to offset efficiency gains for electric equipment in the sector."[12]

Advocates argue that distributed and renewable energy sources can help meet rising demand, and in a way less risky and easier for communities to control than large, centralized plants. Smaller technologies limit financial risk and capital exposure. Modular plants can be cancelled easier, so that stopping a project is not a complete loss (and the portability of most DG systems means value can still be recovered if the

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[8] Paula Berinstein, *Alternative Energy: Facts, Statistics, and Issues* (New York: Oryx Press, 2001), pp. 2-3.
[9] John Wilson, Personal Interview, December 6, 2005; Full transcript available in Appendix 2.
[10] Joe Loper, Personal Interview, February 7, 2006; Full transcript available in Appendix 2.
[11] Hans Blix, "Nuclear Energy in the 21st Century." *Nuclear News* (September, 1997), pp. 34-48.
[12] U.S. Energy Information Administration, *International Energy Outlook*, July 2005, Available at http://www.eia.doe.gov/oiaf/ieo/electricity.html.

technologies would need to be resold as commodities in a secondary market).[13] Smaller units with shorter lead times, the thinking goes, reduce the risk of purchasing a technology that becomes obsolete before it is installed, and quick installations can better exploit rapid learning, as many generations of product development can be compressed into the time it would take simply to build one giant plant.[14] In addition, outage durations tend to be shorter than those from larger plants and repairs for the more common DG technologies—such as reciprocating gas and diesel engines—often take less money, time, and skill.[15]

Proponents also argue that DG technologies also enable more cost-effective network management. Deploying DG systems in targeted areas provides an effective alternative to constructing new transmission and distribution power lines, transformers, local taps, feeders, and switchgears, especially in congested areas or regions where the permitting of new transmission networks is difficult.[16] One study found that up to 10 percent of total distribution capacity in ten years in high growth scenarios could be cost-effectively deferred using DG technologies.[17] The International Energy Agency even concluded that "by moving portable power generators to distribution substations, utilities have been able to cope with rapid load growth more quickly than by upgrading distribution facilities."[18] And, noted one study, "to an electric utility or system operator facing distribution capacity bottlenecks or uncertain load growth, distributed generation can be particularly valuable since units can be dispersed throughout the system and constructed relatively quickly."[19]

Finally, promoters argue that DG technologies may provide benefits in the form of more reliable power for industries that require uninterrupted service. In the modern

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[13] Lovins et al. 2002, p. 141.
[14] Ibid, p. 132.
[15] Ibid, pp. 186-187.
[16] See Resource Dynamics Corporation. (2001). "Assessment of Distributed Generation Technology Applications." *Report to the Maine Public Utilities Commission* (February). Vienna, VA: Resource Dynamics Corporation, pp. 5-9; Neil Strachan and Hadi Dowlatabadi, "Distributed Generation and Distribution Utilities." *Energy Policy* 30 (2002), pp. 649-661.
[17] Lovins et al. 2002, pp. 234-235.
[18] International Energy Agency, *Distributed Generation in Liberalized Electricity Markets* (Paris: International Energy Agency, 2002), p. 48.
[19] See Susan M. McCusker and Benjamin F. Hobbs, "A Nested Benders Decomposition Approach to Locating Distributed Generation in a Multiarea Power System." *Networks and Spatial Economics* 3 (2003), pp. 197-223.

digital economy, even short power outages can shut down communication devices, refrigerators, water and process pumping, and the use of credit card, fax, and electronic cash registers. One chief executive from a global microchip company commented that:

> My local utility tells me they only had 20 minutes of outages all year. I remind them that these four 5-minute episodes interrupted my process, shut down and burnt out some of my controls, idled my work force. I had to call my control service firm, call in my computer repair firm, direct my employees to test the system. They cost me eight days and millions of dollars."[20]

For instance, the Electric Power Research Institute, the research arm of the investor-owned utility industry, reported in 2002 that power outages and quality disturbances cost American businesses $119 billion per year.[21] In 2001, the International Energy Agency estimated that the average cost of a one-hour power outage was $6,480,000 for brokerage operations and $2,580,000 for credit card companies.[22] A 2005 Nielson and Advanced Technology Solutions survey found that one minute of down time cost automotive businesses an average of $22,000.[23] The figures grow more impressively for the semiconductor industry, where a two hour power outage can cost close to $48,000,000.[24]

3.4 The Fuel Supply Problem: Finding Clean but Abundant Sources of Energy

Proponents and opponents of DG also seem to agree that one of the more severe problems facing the electric utility industry relates to the extraction, distribution, and price of fuel for electrical generators. Disruptions and interruptions in supply due to accidents, severe weather, bottlenecks, and intentional market manipulation can all prevent fuels such as coal, oil, uranium, and natural gas from being adequately distributed. Michael Pomorskil, an energy trader, explains that such interruptions can drastically alter fuel prices, and that "whatever fuel is chosen to generate electricity will

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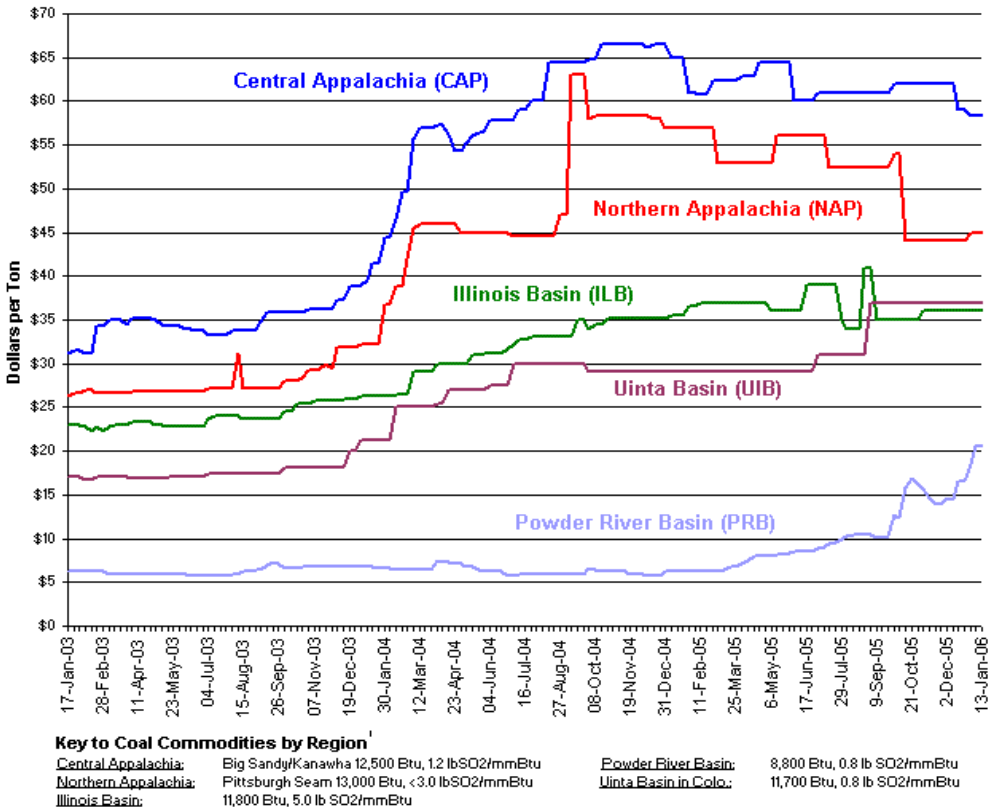
[20] In Scott Sklar, "New Dawn for Distributed Energy," *Cogeneration Onsite Power Production Magazine* (July/August 2005), pp. 115-123.
[21] Doug Hinrichs, Susan Conbere and Michael Lobash, "Taking Control of Power Supplies," In *Building Operating Management* (July 2002), available at http://www.findarticles.com/p/articles/mi_qa3922/is_200207/ai_n9110155.
[22] International Energy Agency 2002, p. 44.
[23] Advanced Technology Solutions/Nielson, *Industrial Survey 2005*, available at http://www.advancedtech.com/arccms/survey.html.
[24] Jackie Lin, "Power Outage Hits Industrial Park Hard," *Taipei Times* (April 11, 2004), p. 10.

always lead to a subsequent increase in demand, and thus price. The uncertainty of fuel prices— especially with the threat of a future carbon tax—makes choosing fuels for the generation of electricity exceptionally complicated and risky."[25]

For coal, the problem is not so much technical potential (known reserves) but achievable potential (known reserves that can be extracted at a competitive price and combusted within environmental guidelines). Most analysts agree that between 500 and 550 billion tons of coal remains in the United States, enough to last between 200 and 250 years at current rates of consumption.[26] In addition, energy analyst Vaclav Smil notes that coal's future is not fundamentally a matter of resource availability, but one of environmental acceptability. The majority of the remaining coal reserves in the United States contain large quantities of pollution-creating sulfur.[27] Fears about meeting the requirements of the Kyoto protocol and carbon emissions penalties have also tended to defer much-needed investment in coal facilities, as international companies are reluctant to invest in a technology that may soon become less competitive due to carbon restrictions.[28] Surges of demand in developing countries (such as India and China) are also starting to provoke significant price fluctuations that affect both the market price and availability of coal (See Figure 3.1). For example, a comprehensive 2005 International Energy Agency study revealed that more than half of the global coal powered plants reported significant price fluctuations in coal, varying by almost a factor of twenty.[29]

[25] Michael Pomorski, Personal Interview, January 21, 2006; Full transcript available in Appendix 2.
[26] See Joseph Barton, "Future Options for Generation of Electricity From Coal," *Hearing Before the Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce* (June 24, 2003), p. 1; Steven F. Leer, "Energy Production on Federal Lands," *Hearing Before the Senate Committee on Energy and Natural Resources* (February 27, 2003), pp. 37-41.
[27] Vaclav Smil, *Energy at the Crossroads: Global Perspectives and Uncertainties* (Cambridge, MA: MIT Press, 2003), p. 232-233.
[28] International Energy Agency, "Investment in the Coal Industry," *Background Paper on the Meeting with the IEA Governing Board* (November, 2003).
[29] International Energy Agency and the Nuclear Energy Agency, *Projected Costs of Generating Electricity: 2005 Update* (Paris: International Energy Agency, 2005), pp. 11-14.

Figure 3.1: Average Weekly Coal Commodity Spot Prices: 2003-2006[30]



The use of natural gas as a primary fuel is no more financially predictable than coal. Because natural gas—especially liquefied natural gas (LNG) (a highly pressured and dense form of natural gas)—is perceived by the public to be dangerous, comprehensive security regulations have been implemented to make its transportation and storage safer. Yet these same protections often cause significant delays in natural gas liquefaction, transportation, and re-gasification, and they require costly security inspections.

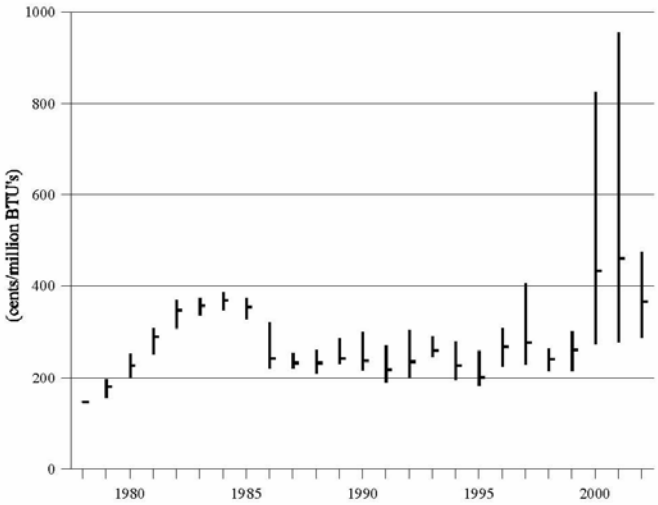
And, like coal, significant investments in distribution infrastructure will be needed to ensure natural gas supplies can be adequately distributed to power providers and consumers. In 2001, natural gas accounted for sixteen percent of electricity generation in the United States. The National Energy Policy Development Group expects this figure to grow to thirty-three percent by 2020.[31] Matching this projected growth with adequate

[30] Source: U.S. EIA, "Coal News and Markets," 2006, available at http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html. Figure courtesy of U.S. EIA, used under "Educational Fair Use Guidelines."

[31] National Energy Policy Development Group 2001, p. 1-7/1-8.

supply would require vast transportation networks and import agreements.[32] For instance, a 2002 Department of Energy Report estimated that an additional natural gas capacity consisting of 40,000 miles of new gas transmission lines and almost 275,000 miles of distribution mains will be needed to meet demand by 2015.[33] As of 2005, the United States only had four LNG re-gasification facilities in Massachusetts, Maryland, Georgia, and Louisiana. Three more are currently being built, with eight more applications pending.[34] In addition to requiring costly infrastructure to match demand, natural gas is already the fuel of choice for peak load electricity generating facilities that supplement peak demand for heating during cold months and hot air conditioning months during the summer.[35] The result has been significant price spikes in natural gas rates over the past three years. As Raj Gupta, Corporate Executive Officer of the Rohm and Hass Chemical Company, put it, "the recent history of natural gas prices is a study in commodity price volatility" (See Figure 3.2).[36]

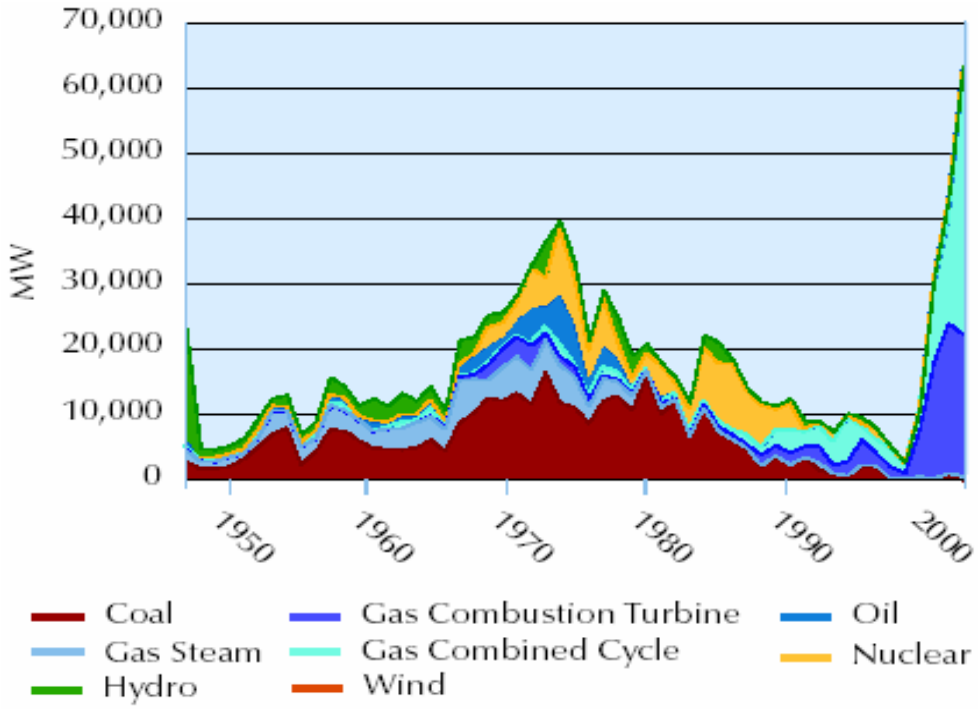
Figure 3.2: Natural Gas Prices for Electric Utilities, 1978-2002[37]



[32] S. Julio Friedman and Thomas Homer-Dixon, "Out of the Energy Box." *Foreign Affairs* 83(6) (November/December 2004), p. 72-83.
[33] United States Department of Energy, "Homeland Security: Safeguarding America's Future With Energy Efficiency and Renewable Energy Technologies." *Tenth Annual Report of the State Energy Advisory Board* (August, 2002), p. 5.
[34] J. Mark Robinson, "Liquefied Natural Gas." *Hearing Before the Senate Committee on Energy and Natural Resources* (February 15, 2005), p. 34.
[35] Paul W. Parformak, "Liquefied Natural Gas Infrastructure Security: Background and Issues for Congress," *CRS Report for Congress* (September 9, 2003), p. 7.
[36] Gupta 2003.
[37] Source: EIA *Monthly Energy Review*, June, 2003, Table 9.11. Figure courtesy of U.S. EIA, used under "Educational Fair Use Guidelines."

Further compounding the issue, the industry has largely invested in natural gas combustion turbines or combined cycle equipment to meet rising demand (Figure 3.3). Natural gas combined cycle generators have been cheaper and faster to build than conventional coal plants. The result of this trend has been the addition of over 150 GW of gas-fired power generation between 1999 and 2004. This surge in demand for natural gas comes at a time when domestic natural gas production has begun to plateau. Looking to the future, most U.S. coal plants today are 20 to 50 years old, and companies plan to replace them (in large part) with natural gas-fired generation.[38]

Figure 3.3: Investments in Electric Sector Generation Capacity[39]



What's more, questions of natural gas security are likely to emerge as imports begin to follow in the footsteps of petroleum markets—accounting for an increasing proportion of U.S. energy consumption. The Institute for the Analysis of Global Security estimates that American dependence on oil from countries either politically unstable or

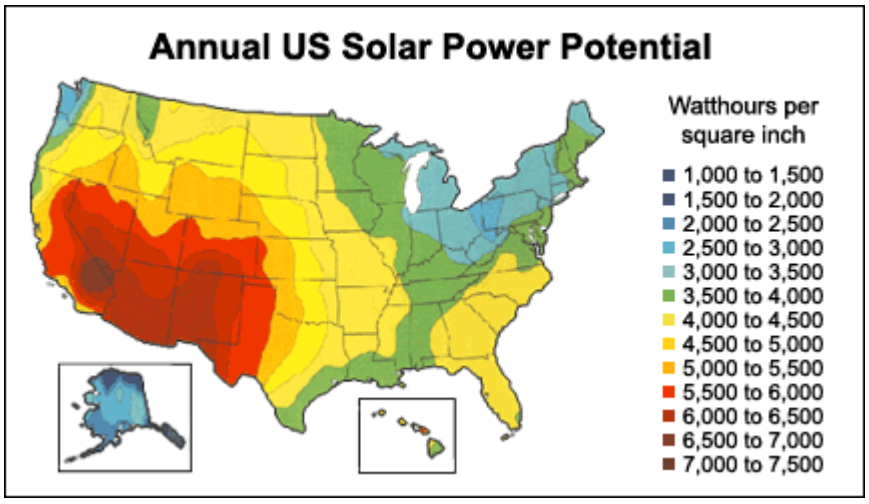
[38] Granger Morgan, Jay Apt, and Lester Lave, *The U.S. Electric Power Sector and Climate Change Mitigation* (Washington, DC: Pew Center on Global Climate Change, June, 2005).
[39] Source: National Commission on Energy Policy, 2004, Figure 4-3, p. 44. Figure used courtesy of Oak Ridge National Laboratory, permission given from Dr. Marilyn Brown.

unfriendly to the U.S. have cost the country more than $7 trillion (in 2004 dollars) over the past thirty years, more than the cumulative cost of all wars fought by the U.S. since the Revolutionary War. The Institute also estimated that the current price of securing American access to Middle East oil was more than $50 billion a year.[40] Having the electricity sector become more dependent on foreign sources of fuel, like the transportation sector, could produce similar problems. Since the largest remaining reserves of LNG are located outside of the United States, a growing dependence on natural gas could force a massive shift in U.S. military deployment to protect an entirely new collection of shipping lanes and distribution networks. Adam Serchuk, a senior program manager for the Energy Trust of Oregon, cautions that "the recent move towards natural gas fired electricity generation, combined with recent financial interest in LNG facilities, could make the power sector dependent, again, although this time for its marginal fuel from places like Venezuela, Algeria, Russia, and Indonesia."[41]

In contrast to technologies that generate electricity using coal and natural gas, advocates are quick to point out that renewable energy resources use "fuels" greatly abundant in the United States, and thus less susceptible to interruptions and shortages. Vikram Budhraja notes that "the beauty of renewable energy" is that it has no fuel input, and that the competitiveness of every other type of electrical generator—including CHP, fuel cells, and micro-turbines—"rises and falls on the basis of efficiency differentials."[42] Photovoltaic (solar) panels, for instance, have immense technical potential in the American southwest (See Figure 3.4), and are projected to have the fastest growth rate of any electrical generating technology. PV systems in the building sector alone are estimated to grow at an average annual rate of 17 percent to 3.7 billion kWh by 2025.[43]

[40] See Institute for the Analysis of Global Security, "The Real Cost of Oil: How Much are We Paying for a Gallon of Gas?", May, 2005, available at http://www.iags.org/costofoil.html.
[41] Adam Serchuk, Personal Interview, February 21, 2006; Full transcript available in Appendix 2.
[42] Vikram Budhraja, Personal Interview, September 27, 2005; Full transcript available in Appendix 2.
[43] EIA, *Annual Energy Outlook 2005: With Projections to 2025*, p. 64.

Figure 3.4: Annual U.S. Solar Power Potential[44]

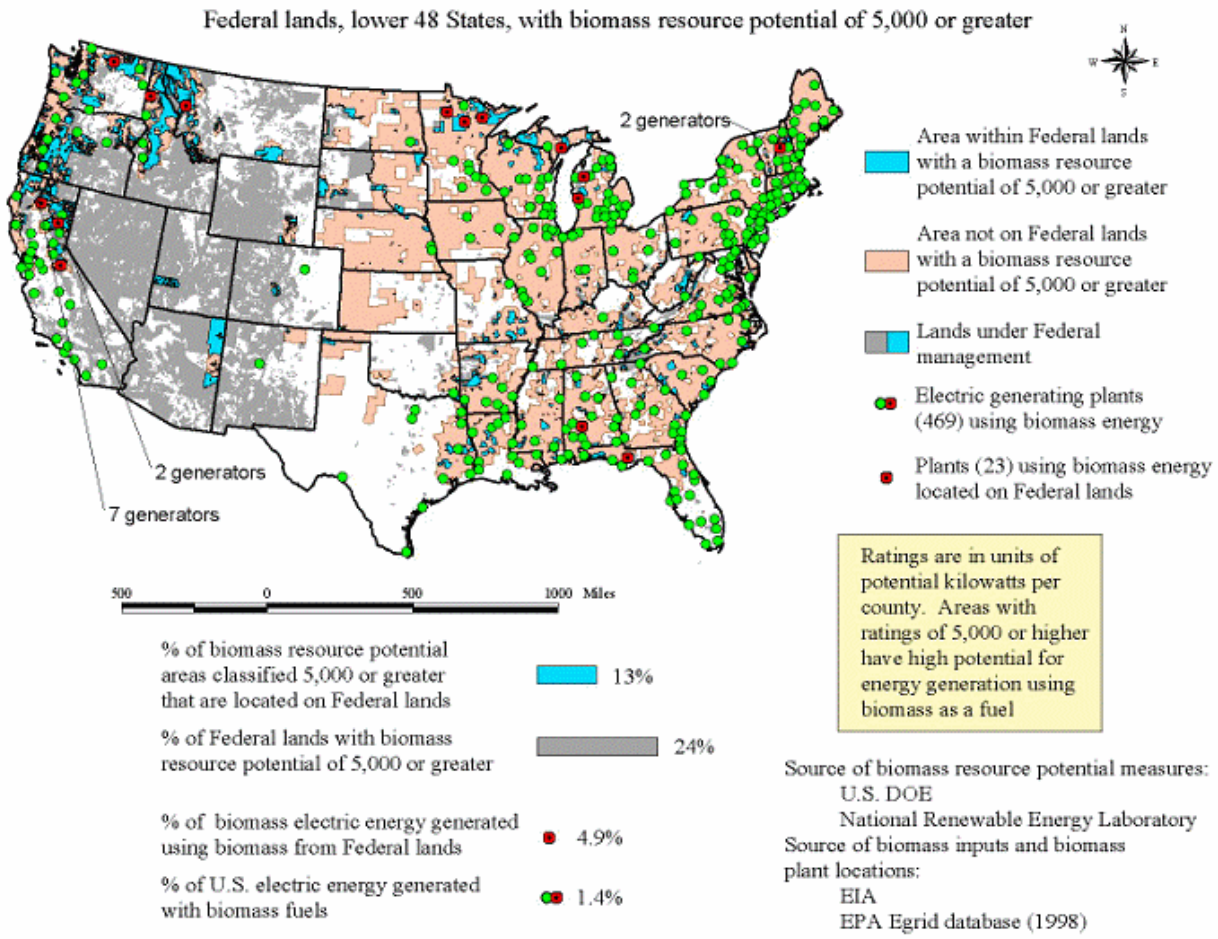


Additionally, supports of renewable energy suggest that fuel for biomass generators is widely available. Many industrial and agricultural processes produce significant amounts of combustible byproducts, including tobacco residue, chicken carcasses, coffee-grounds, peach pits, sawdust, scarp wood, and rice-hulls (See Figure 3.5). The Midwest possesses exceptionally large reserves of biomass fuel in the form of crop residues and energy crops, and the United States already has a surplus of available land that can be used for dedicated bioenergy crops. As one example, Federal programs have idled an average of 60 million acres over the past 10 years, and the Conservation Reserve Program removes around 36 million acres from production with the primary goal of erosion control. The vast majority of this land is planted in perennial grasses that could be harvested as energy crops while still meeting the goal of erosion prevention.[45]

[44] Source: U.S. EIA, "Solar Photovoltaic," 2005, available at http://www.eia.doe.gov/cneaf/solar.renewables/page/solarphotv/solarpv.html. Figure used courtesy of U.S. EIA under "Educational Fair Use Guidelines."

[45] Lee R. Lynd, "Overview and Evaluation of Fuel Ethanol from Cellulosic Biomass: Technology, Economics, the Environment, and Policy," *Annual Review of Energy and the Environment* 21 (November, 1996): 405-465.

Figure 3.5: Biomass Potential in the United States [46]

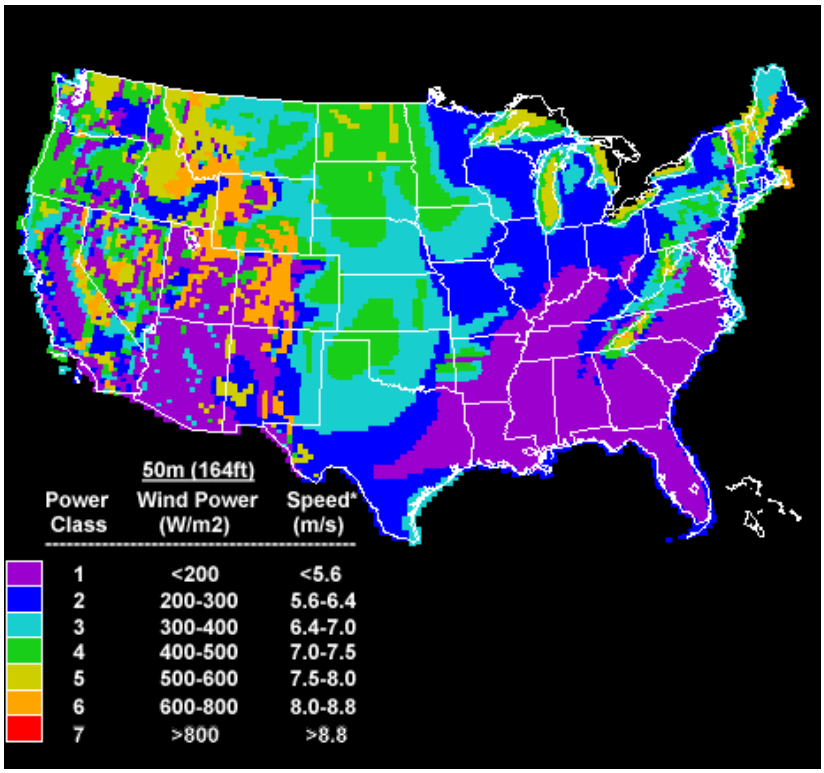


Similarly, promoters argue that the nation's fuel potential for wind energy—particularly in areas with frequent and strong winds—remains largely untapped. The Midwest and the Great Plains have been called the "Saudi Arabia of wind" and theoretically hold enough technical potential to fulfill the entire country's energy needs.[47] (See Figure 3.6)

[46] Source: U.S. EIA, "Biomass Generation," 2003, available at http://www.eia.doe.gov/cneaf/solar.renewables/page/biomass/biomass.html. Figure used courtesy of U.S. EIA under "Educational Fair Use Guidelines."

[47] United States Government Accountability Office, "Renewable Energy: Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities." *GAO Report to the Ranking Democratic Member, Committee on Agriculture, Nutrition, and Forestry, U.S. Senate* (Washington, DC: GAO, 2004), pp. 15-16.

Figure 3.6: Wind Potential in the United States[48]



Consequently, campaigners for renewable energy suggest that a greater use of renewable DG technologies would insulate the U.S. economy from fuel shocks, shortages, and interruptions, and distribute the security risks of the power grid. A recent report released by the Union of Concerned Scientists concludes that many components of the US energy system—power plants, refineries, pipelines, and tankers—present substantial security and safety risks.[49] These conclusions complement a similar study undertaken by the International Energy Agency, which noted that centralized energy facilities create significant targets for terrorism because attacking a few facilities can cause large power outages.[50] In contrast to the security risks of oil pipelines and refineries, decentralizing energy facilities and providing power through photovoltaic systems, wind turbines, and fuel cells helps minimize the risk of accidents and grid

[48] Source: U.S. EIA, "Wind," August, 2004, available at http://www.eia.doe.gov/cneaf/solar.renewables/page/wind/wind.html. Figure courtesy of U.S. EIA, used under "Educational Fair Use Guidelines."
[49] Union of Concerned Scientists, *Clean Energy: The Renewable Electricity Standard* (May 20, 2004), Retrieved from http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=46.
[50] International Energy Agency 2002.

failures.[51] The Union of Concerned Scientists remarks that "renewable energy facilities are small, geographically dispersed, and do not require transporting or storing radioactive or combustive materials."[52] Authors of a Congressional Research Service report concurred, concluding that "the development of small, modular distributed energy systems … helps reduce the security risk by decentralizing energy facilities and establishing some facilities off-grid."[53]

Supporters also claim that the use of such small-scale, onsite energy technologies—even when not renewable—diversifies the type of fuel used to generate electricity, thereby minimizing the risk of fuel shocks, interruptions, shortages, and accidents.[54] Together, distributed generation energy technologies can increase security by reducing the number of large and vulnerable targets on the grid, providing insulation for the grid in the event of an attack, and minimizing foreign dependence on oil and natural gas by diversifying fuel supplies.

Despite intense media focus on the security dangers from nuclear reactors and natural gas facilities, the most serious threat to energy security is, in fact, the nation's power grid. Paul Gilman, director of the Oak Ridge Center for Advanced Studies, remarks that:

> The security issues facing the modern electric utility grid are almost as serious as they are invisible. A deliberate, aggressive, well coordinated assault on the electric power grid could devastate the electricity sector. The replacement time it would take, if you thoughtfully went about knocking it apart, would be on the order of Iraq, not on the order of a lineman putting things up a pole.[55]

Thankfully, DG systems can help make the grid more secure. Tommy Thompson, former director of utilities at Virginia Commonwealth University and a current energy manager at the Virginia Department of Mines, Minerals, and Energy, argues that DG technologies

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[51] Friedman and Homer-Dixon 2003, p. 79.
[52] Union of Concerned Scientists, 2004.
[53] F. Sissine, "Energy Efficiency: Budget, Oil Conservation, and Electricity Conservation Issues," *CRS Issue Brief for Congress* (Library of Congress, Washington, DC, 2002), p. 20.
[54] B. Capehhart, P. Mehta, and W. Turner, "Distributed Generation and Your Energy Future," *Cogeneration and Distributed Generation Journal,* 18(4) (2003), pp. 17-33.
[55] See Paul Gilman, Personal Interview, August 3, 2005; Full transcript available in Appendix 2.

played a key role in insulating Virginia facilities from the risk of hurricane-induced electrical failures.[56]

Less obviously, some environmentalists and political scientists proclaim that DG technologies could bring political benefits beyond insulating the economy from fuel interruptions and improving security. In 2003, the European Union (EU) implemented its own mandatory greenhouse gas control program, a move that only shortly preceded the entry into force of the Kyoto Protocol. Emissions reduction strategies undertaken by countries in Europe (as well as Japan and other industrialized countries that have ratified Kyoto) will increase electricity prices. Countries such as the United States, Australia, and Canada, who refuse to abide by the protocol, will enjoy a competitive advantage in the form of lower energy costs and costs of production.

In response to this perceived competitive advantage, several non-governmental organizations within Europe have advocated trade sanctions against the United States, arguing that there cannot be free and fair trade with the United States under World Trade Organization Agreements on Subsidies and Countervailing Measures until it implements the Kyoto Protocol. In the past, the EU has used trade sanctions whenever the U.S. has garnered an unfair competitive advantage by subsidizing exports. Two recent examples—the sales corporation/extraterritorial income (FSC/ETI) and steel import cases—demonstrate that the EU will use trade sanctions to force a change in U.S. behavior.[57] Greenhouse gas emissions are also regarded by many analysts as the single most important factor in US-EU relations. When President George W. Bush chose to withdraw from the Kyoto Protocol, Margot Wallstrom, the EU environmental commissioner, called his decision "very worrying."[58] EU spokesperson Annika Ostergren went further when she stated that "sometimes people think that the Kyoto Protocol is only about the environment, but it's also about international relations and economic cooperation."[59] Accordingly, emissions-reducing technologies—like renewable energy systems and DG technologies—could help the U.S. informally meet

[56] Tommy Thompson, Personal Interview, September 15, 2005; Full transcript available in Appendix 2.
[57] See Peter Fontaine, "The Gathering Storm," *Public Utilities Fortnightly* 8(142) (2004), pp. 50-61.
[58] In Ross Gelbspan, *Boiling Point: How Politicians, Big Oil and Coal, Journalists, and Activists Are Fueling the Climate Crisis – And What We Can Do to Avert Disaster* (New York: Basic Books, 2004), pp. 94-97.
[59] Ibid.

obligations under the Kyoto Protocol. At a minimum, a greater use of renewable energy resources could improve the reputation and credibility of the managers of the American electric utility sector. If used more widely, renewables could ultimately help U.S. companies avoid trade sanctions and improve relations between the United States and the EU.

3.5 The Infrastructure Problem: The Fragile Transmission Grid

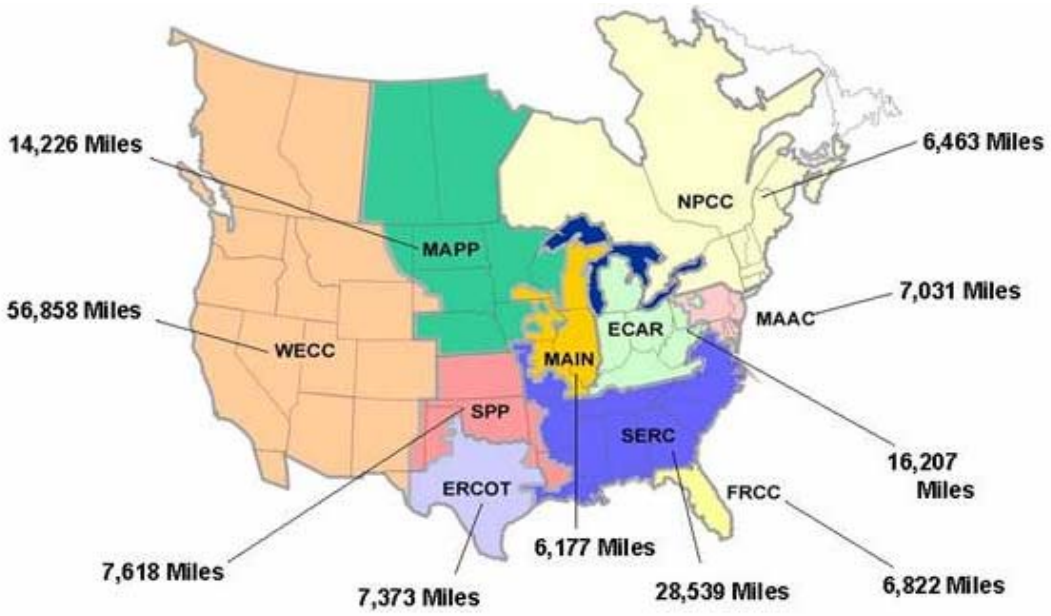
Nearly all primary energy sources require complex and expensive infrastructure to transform them into useful forms and to deliver them to markets. Once electricity is generated, it must be instantaneously moved through miles of interconnected transmission and distribution lines to users. Both those in favor of and against DG note that one of the most highly stressed energy infrastructures in the nation is its high voltage transmission grid. Scott Sklar, the president of a solar panel manufacturing firm, used the following analogy:

> The electric utility sector is like the Space Shuttle. When it works, it works fantastically well. But when it fails, it screws up devastatingly …. We spend billions of dollars on surge protectors, which means our electric utility system doesn't have the quality it needs. Instead, issues of quality (and when it fails) are shoved onto the consumer. And it may only get worse: twenty years ago the country wasn't moving towards a digitized economy. Now our manufacturing controls, computers, and telecommunications devices (even our appliances) are starting to move towards complete digitization, which will place even more stress on the existing power grid.[60]

David Hill, deputy laboratory director at the Idaho National Laboratory, explains that, despite its immense size, the electric power grid was not centrally planned in this country. Instead, the system grew up, full of "inefficiencies, instabilities, and piecemeal privatization of utilities," resulting in a collection of regional, interconnected systems, instead of one national, fluid system (See Figure 3.8).[61]

[60] Scott Sklar, Personal Interview, February 9, 2006; Full transcript available in Appendix 2.
[61] David Hill, Personal Interview, August 3, 2005; Full transcript available in Appendix 2.

Figure 3.7: U.S. High Voltage Transmission Grid[62]



To put the grid's complexity in perspective, Ralph Loomis, an Executive Vice President for Exelon, the largest utility in the United States, adds that the current grid is an enormously complicated mechanism. The transmission grid that Exelon uses to distribute power to its customers spans 13 states and millions of homes. Loomis notes that "it is one machine extending over hundreds of thousands of miles. It is amazing it works as well as it does."[63]

Perhaps incongruously, growth in electricity production has not been accompanied by a proportionate investment in transmission infrastructure. Indeed, U.S. expenditures in transmission infrastructure (in 2003 dollars) peaked at almost $10 billion in 1970 and have since declined to less than $4 billion in 2000 (See Figure 3.8). The Energy Policy Act of 1992 has further complicated the problem by increasing grid utilization while further removing incentives to invest in transmission. As a result, the ratio of transmission capacity to peak electricity demand has decreased—by 16 percent between 1989 and 1998, and generating capacity margins (the percent by which planned generating capacity resources are expected to be greater than expected peak demand) have decreased from 21.6 percent in 1990 to 19.2 percent in 2004. In New York, for

[62] Source: North American Electricity Reliability Council Database, 2001. Figure shows transmission lines for 230 kV and above.
[63] See Ralph Loomis, Personal Interview, October 5, 2005; Full transcript available in Appendix 2.

example, the aging underground electricity grid is so degraded that it costs local utilities over $1 billion a year just to replace corroded cable needed to make the system function as it is.[64] James Gallagher, the Director of the Office of Electricity and Environment for the New York State Public Service Commission, comments that the billion dollars "doesn't even allow us to get proactive to get ahead of the problem. The scale of the challenge is enormous."[65]

Figure 3.8: U.S. Expenditures in Transmission Investment, 1925-2000[66]

The result of transmission underinvestment has been reduced power reliability in many regions of the United States, with grid components being operated closer to their technical limits and beyond their originally planned lifetimes. Marilyn Brown, interim director of engineering science and technology at the Oak Ridge National Laboratory, cautions that throughout most of the 1990s "there has been a traumatic slowdown in investment in grid technologies."[67] Shelly Strand, an energy consultant, put it this way:

> The [current electric utility] model assumes that energy is like sugar: you can put sugar into X and get it out at Y and it will be the same sugar regardless of which terminus you get it from. Energy doesn't work that way. You cannot put energy into the grid in Texas and take it out in

[64] See James Gallagher, Personal Interview, October 4, 2005; Full transcript available in Appendix 2.
[65] Ibid.
[66] Source: Steven Brown, "How Will the Blackout Shape the Future of T&D?" *Utility Automation and Engineering T&D* 8(5) (September, 2003).
[67] Marilyn Brown, Personal Interview, August 4, 2005; Full transcript available in Appendix 2.

> California and have it be the same energy because of voltage drop and other factors. The whole deregulation model is set up on the false assumption that the grid system is national and reaches everywhere equally in scope. We don't have a national grid system in this country that works like that.[68]

In other words, Strand suggests that the current, balkanized power grid fails to meet even its own logic: is not responsive enough to meet the needs of a restructured and competitive electricity market. And it is precisely this market that utilities argued would better enable them to lower electricity prices through competition. Instead, such utilities have apparently used the rubric of "restructuring" to avoid making needed alterations to the system. For instance, Adam Serchuk argues that "the current transmission systems used to deliver electricity were designed for a different institutional structure, without the flexibility needed for an efficient trading-based energy system."[69]

Proponents state that distributed renewable and non-renewable energy systems can better enable utilities and system operators to stabilize the grid and improve reliability. Because distributed technologies can be produced at smaller scale, they can be located (or situated) almost anywhere, and their modularity means that generators can be deployed to precisely match smaller increments of demand. Shawn Collins, a project manager of distributed energy systems at United Technologies, notes that some of the large fossil-fueled generators currently in the planning stages will take at least two to three years to complete, too slow to even meet minor increases in projected demand.[70] Florentine Krause and Joseph Eto, energy analysts at the Lawrence Berkeley National Laboratory, also add that large, centralized plants—while useful in some situations—can lead to diseconomies of scale when their construction and unexpected lengthier lead times takes longer than expected. Krause and Eto comment that these diseconomies of scale are even more likely to happen in situations where only a finite amount of rare

[68] Shelly Strand, Personal Interview, August 15, 2005; Full transcript available in Appendix 2.
[69] See Serchuk, Personal Interview.
[70] Shawn Collins, Personal Interview, March 3, 2006; Full transcript available in Appendix 2.

materials and trained personnel for certain generators exist, a recurring problem that occurred in the construction of natural gas and nuclear generators throughout the 1980s.[71]

In contrast, advocates note that photovoltaic (solar) panels can be built in various sizes, placed in arrays ranging from watts to megawatts, and used in a wide variety of applications, including centralized plants, distributed sub-station plants, grid connected systems for home and business use, and off-grid systems for remote power use.[72] PV systems have long been used to power remote data relaying stations critical to the operation of supervisory control and data acquisition systems used by electric and gas utilities and government agencies.[73]

In a similar way, supporters suggest that DG systems can be strategically deployed to relieve congestion and bottlenecks on the power grid. Since modern DG technology enables utilities to remotely dispatch hundreds of scattered DG units, they could dramatically improve the ability for utilities to handle peak load and grid congestion problems.[74] A 1992 Pacific Gas and Electric Analysis comparing fifty 1-MW distributed photovoltaic plants versus one 50-MW central PV plant in Carissa Plains, California, found that the grid advantages (in forms of load savings and congestion) more than offset their generation disadvantages (in terms of high capital cost and interconnection).[75] The construction and use of DG technologies also allows managers to defer investments in transmission and distribution networks, which cost around between $74,000 and $340,000 per km (excluding right-of-way).[76] Moreover, transmission costs can significantly add to the retail price of electricity, especially in rural areas, where the average charge for transmitting and distributing the electricity accounts for more than 30 percent of the price of electricity.[77] DG would mitigate some of these costs by allowing power to be produced near the user.

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[71] Florentin Krause and Joseph Eto, *Least-Cost Utility Planning Handbook for Public Utility Commissioners* (Washington, DC: National Association of Regulatory Utility Commissioners, 1988).
[72] Howard A. Learner, "Cleaning, Greening, and Modernizing the Electric Power Sector in the Twenty-First Century." *Tulane Environmental Law Journal* 14 (2001), pp. 277-314.
[73] Peter F. Varadi and Gerald W. Braun, "SPV: The Security Photovoltaic Market," *Renewable Energy World* (September/October, 2003), Available at http://www.jxj.com/magsandj/rew/2003_05/spv.html.
[74] Capehart, Mehta, and Turner 2003.
[75] In Lovins et al. 2002, p. 237.
[76] Ibid, pp. 234-235.
[77] See Andrew Goett and Richard Farmer, *Prospects for Distributed Electricity Generation: A CBO Paper*. (Washington, DC: Congressional Budget Office, 2003), p. xiii, 16-17.

In the early 1990s, for example, Pacific Gas and Electric undertook another pioneering study (with real applications) showing that PV applications near large demand centers provided system operators with multiple benefits. The deployment of PV systems helped defer transmission and distribution upgrades, and also extended equipment maintenance schedules and improved distribution network reliability—all of which contributed to cost savings to the utility. The study demonstrated the value of more complex methods of analysis (and the abandonment of rule-of-thumb approaches that remain common in utility engineering circles) for reducing overall costs through the use of judiciously sited renewable energy and demand-side technologies.[78]

Some analysts have noted that DG systems can provide utilities with a variety of important ancillary services, including system control (how operators control generators on the grid), reactive supply (the injection of reactive power to maintain required voltages), and spinning reserves (alternating current generation capacity to offset load imbalances).[79] Because of their smaller size, DG technologies can often be started up more quickly and deployed more easily. Smaller units have lower forced outage rates, thereby decreasing the need for reserve margins and spinning reserves. And since such technologies can be constructed more quickly, they enable utility managers (and policymakers) to respond better to supply and demand fluctuations, especially when used with advanced functions like real time pricing and net metering.[80]

Finally, advocates argue that distributed generators, in contrast to centralized plants, help displace electricity normally produced by a large coal- or natural-gas fired turbine, backed up by a spinning reserve, and delivered through the power grid to the same location. In fact, a comprehensive study undertaken by the EIA in 1999 found that transmission and distribution losses in the United States averaged almost 7 percent of gross production (in kWh). During hot weather, when power lines stretch and conductivity decreases, the study also concluded that losses can exceed fifteen percent.[81] Imagine purchasing a dozen eggs at your local grocery store, but having between one and

[78] T. Hoff and D.S. Shugar, "The Value of Grid-Support Photovoltaics in Reducing Distribution System Losses," *IEEE Transactions on Energy Conversion* 10 (Sept. 1995), pp. 569-76; Charles D. Feinstein, Ren Orans, and Stephen W. Chapel, "The Distributed Utility: A New Electric Utility Planning and Pricing Paradigm," *Annual Review of Energy and the Environment* 22 (1997), p. 95.
[79] Borbely and Kreider 2001, pp. 304-305.
[80] Lovins et al. 2002, p. 63.
[81] Goett and Farmer 2003, pp. 16-17.

three eggs break *every* time you transported them to you home, year after year. In rural areas, transmission and distribution losses get even worse and can exceed forty percent.[82] A frequently cited International Energy Agency study, however, suggested that the on-site production of electricity could result in cost savings of about 30 percent of electricity costs since it displaces transmission and distribution expenses.[83]

3.6 The Environment Problem: Air Pollution and Global Warming

As a final reverse salient, electricity production from fossil fueles is one of the largest sources of air pollution. The connection between power production and air pollution was vividly documented by the August 14, 2003, Northeast blackout, which not only shut off electricity for 50 million people in the United States and Canada, but also stopped the pollution coming from fossil-fired power plants across the Ohio Valley and the Northeast. In effect, the power outage established an inadvertent experiment for gauging the atmosphere's response to the grid's collapse. Twenty-four hours after the blackout: SO_2 concentrations in the Northeast declined 90 percent; particulate matter dropped by 70 percent; and ozone concentrations fell by half.[84] These environmental problems—known well before the 2003 blackout— provoked the famous statement from *The Economist* magazine that "Using energy in today's ways leads to more environmental damage than any other peaceful human activity."

Despite three decades of "clean air" legislation in the United States, air pollution continues to be a serious threat to ecosystem health. American are experiencing a rise in respiratory illnesses (especially childhood asthma which has reached record highs), and visibility continues to degrade at least in part as a result of power plant and vehicle emissions. These problems are particularly severe in regions of the country that rely on coal-based electricity such as much of the Southeast. Contrary to the view that things are getting better, Rodney Sobin, former innovative technology manager at the Virginia Department of Environmental Quality, argues that:

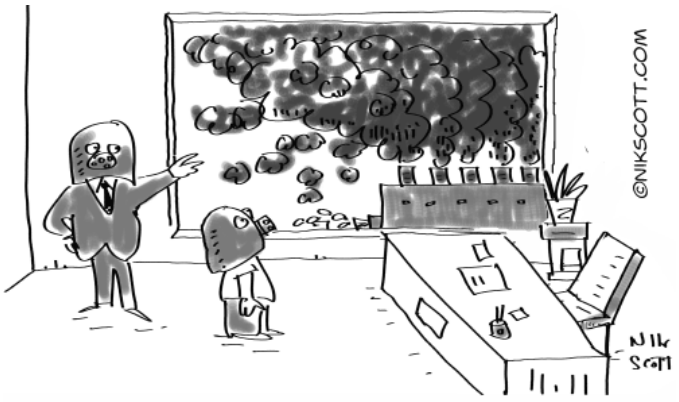
> Numerous reports show that the generation of electric power meeting

[82] Business Council for Sustainable Energy and the United States Agency for International Development, *Increasing Energy Access in Developing Countries: The Role of Distributed Generation* (Washington, DC: Bureau for Economic, Growth, Agriculture, and Trade of USAID, 2004), p. 2.
[83] See International Energy Agency 2002, p. 33.
[84] Marufu et al., *Geophysical Research Letters* 31 (2004), p. 3106.

> current standards creates enough pollution to result in measurable amounts of human suffering: asthma attacks, pulmonary disease, heart disease, and deaths. The data are reasonably credible that those health effects are real and happening every day, and I haven't even started talking about the ecological impacts or things like global warming. The real point is that we as society are paying external costs through damage to health and environment, either now or putting off costs to our children and their children.[85]

Furthermore, the combustion of fossil fuels is the dominant source of greenhouse gas (GHG) emissions—Every quad of energy consumed in the United States, for instance, results in approximately 59 million metric tons of carbon dioxide emissions.[86] Total U.S. emissions of carbon dioxide from energy consumption have increased 22% from 4,735 tons in 1980 to 5,781 tons in 2003.[87] The EIA forecasts that carbon dioxide emissions from electricity use will increase on average by 1.5% annually for the next 20 years resulting in 8,062 million metric tons of carbon dioxide emissions in 2025, almost double the emissions of 1970.[88] Clearly, the last 30 years have not provided the low-carbon power and fuels needed for the United States to help stabilize atmospheric concentrations of GHGs (See Figure 3.9).

Figure 3.9: Political Cartoon about Global Warming[89]



Some day, son, all this will be your problem

[85] Rodney Sobin, Personal Interview, September 16, 2005; Full transcript available in Appendix 2.
[86] EIA, *Annual Energy Outlook*, p. 341.
[87] Ibid.
[88] Ibid, p. 109.
[89] Figure is copyrighted by Nik Scott. Used with permission.

Those supporting DG argue that such technologies generally operate more efficiently and cleanly than emissions-producing coal- and natural-gas plants. As mentioned previously, electric utilities in the United States have tended to provide electricity using large centralized plants. The overall thermal efficiency—the rate that an electric generator converts fuel into electricity for every unit of fuel—of fossil-fueled plants remains modest, typically between thirty and thirty-five percent.[90] Put another way, about two-thirds of useful energy is wasted (in the form of steam or hot water, and then exhausted into the environment) in the combustion process of a typical coal-fired power plant.[91] Two Oak Ridge National Laboratory (ORNL) researchers suggest that the poor thermal efficiency of most power plants translates into between approximately forty-five to ninety GWh of potential power lost every year (the equivalent electricity needed for five to ten cities the size of Manhattan).[92]

Generating power on-site using one form of DG—combined heat and power (CHP) systems—offers a much more efficient approach towards generating electricity. Since they recycle the normally wasted excess heat through a process called cogeneration, CHP technologies consistently double the efficiency from combined cycle gas turbines and have lower labor and capital costs.[93] Jan Berry, a researcher at the Oak Ridge National Laboratory, comments that CHP systems are especially useful for district applications where they can recycle excess waste energy to provide heating and cooling to several buildings. They have the added potential of enabling more reliable and secure electricity in the event of a power outage or disruption (although not all systems can operate when the grid is down).

Additionally, some of the most congested and power hungry regions in the country are constrained by stringent environmental regulations, such as stationary source

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[90] Michael T. Maloney and Wayne Brough, *Promise for the Future, Penalties From the Past: The Nature and Causes of Stranded Costs in the Electric Industry.* (Washington, DC: Citizens for a Sound Energy Foundation, 1999), p. 51; National Energy Policy Development Group, *Reliable, Affordable, and Environmentally Sound Energy for America's Future* (Washington, DC: Whitehouse Printing Services, 2001), p. 3-5.

[91] Gary Nakarado and Holly Thomas, "Combined Heat & Power, Revisited," *Public Utilities Fortnightly* 141 (September 1, 2003): 39-41.

[92] Jan Berry and Steve Fischer, "More Than 200 Hospitals Nationwide Are Recycling Energy for Peak Performance," *Distributed Energy* (January/February 2004), p. 32.

[93] Thomas R. Casten, *Turing off the Heat: Why America Must Double Energy Efficiency to Save Money and Reduce Global Warming* (New York: Prometheus Books, 1998), pp.150-51.

pollution limits. The U.S. Environmental Protection Agency classifies the worst of these areas as "non-attainment" regions—locations where no pollution-emitting technologies can be used.[94] For these places, renewable energy systems that emit no nitrous oxides, sulfur dioxides, mercury, ozone, or carbon dioxide can be instrumental in preventing under-capacity.

Finally, large, centralized power plants emit significant amounts of carbon monoxide, sulfur oxides, particulate matter, and nitrogen oxides. The Environmental Protection Agency has long noted the correlation between high levels of sulfur oxide emissions and the creation of acid rain. Because they concentrate the amount of power they produce, large power plants also focus their pollution and waste heat, frequently destroying aquatic habitats and marine biodiversity.[95] On the other hand, two academic studies have confirmed that widespread use of DG technologies substantially reduces emissions: A British analysis estimated that domestic combined heat and power technologies reduced carbon dioxide emissions in the United Kingdom by 41 percent in 1999; a similar report on the Danish power system observed that widespread use of DG technologies throughout their country have cut emissions by 30 percent from 1998 to 2001.[96]

Renewable energy technology supporters argue that even combustion of biomass—i.e., the burning of a fuel—does not cause the same environmental problems as does combustion of fossil fuels. Although combusting biomass releases carbon dioxide, it is essentially the same carbon dioxide fixed by photosynthesis when the plants grew. Thus, dedicated biomass electrical plants release no net carbon dioxide emissions into the atmosphere as long as they avoid combusting fossilized fuel. Compared to coal and natural gas, biomass combustion also produces fewer toxic gases such as nitrous oxides and sulfur dioxides.[97] One study conducted by the Center for Energy Policy and Technology found that combined cycle biomass gasification plants produce one twentieth

[94] Sam Fleming, Personal Interview, October 25, 2005; Paul De Cotis, Personal Interview, October 4, 2005; Full transcripts available in Appendix 2.
[95] Paul Kleinbach and Henry Hinrichs, *Energy: Its Use and the Environment* (New York: Harcourt College Publishers, 2002), pp. 307-308.
[96] International Energy Association 2002, p. 92.
[97] Wolfram Jorb et al., *Decentralized Power Generation in the Liberalized EU Energy Markets: Results from the DECENT Research Project* (New York: Springer, 2003), p. 41; Gilbert M. Masters, *Renewable and Efficient Electric Power Systems* (London: Wiley and Sons, 2004), p. 192.

of the amount of pollutants emitted by coal-fired power plants (and one tenth the pollution of equivalent natural gas plants).[98] Moreover, wind turbines—another form of renewable and distributed energy—generate electricity free from carbon dioxide, acid rain, smog, and particulate matter. Wind energy also avoids the risks of accidents during transportation of fossil fuel. A study published in *Energy Policy* noted that when substituting for coal-based power generation, each kWh produced by wind power generates twenty times less carbon dioxide emissions than traditional fossil fueled technologies.[99]

3.7 Conclusion

In many ways, proponents of DG emphasize that the traditional, centralized structure of the electric utility industry is becoming antiquated and obsolete. Demand for electricity continues to outpace supply; the fuel used for most electric generators is expensive and located great distances from its point of combustion; power plants and the transmission grid continue to deteriorate; and the environmental problems from the combustion of fossil fuels continues to grow. Most utilities, argues Shalom Flank, Chief Technical Officer for Pareto Energy Limited, are "in long term stasis" and risk "simply disappearing" unless they change their business strategies.[100] Distributed and renewable energy technologies offer significant potential benefits for utilities, businesses, customers, and society at large. As Vikram Budhraja, former Senior Vice President at Southern California Edison, recently stated:

> The biggest problem facing the electric industry is to modernize the current infrastructure. We have power plants that are operating with an average age of thirty to forty years. We really need to replace them, modernize, and upgrade them, as well as build additional capacity to meet population increase and economic growth throughout the country. The industry needs to diversify the resource mix with renewables and replace

[98] Ausilio Bauen, Jeremy Woods, and Rebecca Hailes, "Bioelectricity Vision: Achieving a 15% of Electricity from Biomass in OECD Countries by 2020," *Reported by the Centre for Energy Policy and Technology* (London: WWF International, 2004), p. 25.
[99] Cheng-Dar, Yue, Chung Ming Liu, and Eric Liu., "A Transition Toward a Sustainable Energy Future," *Energy Policy* 29(12) (2001), pp. 155-163.
[100] See Shalom Flank, Personal Interview, March 20, 2006; Full transcript available in Appendix 2.

> aging power plants. The industry needs to invest in new grid technologies for reliability, market efficiency, and security.[101]

The industry, in other words, seems to realize that it must adapt and respond to many of its current challenges.

Advocates note that this is precisely where DG technologies can play an important role. While such proponents do definitely envision a future world where electricity is generated differently, they note that they do not want DG technologies to replace all, large generators. Supporters of distributed generation emphasize that DG technologies should not be viewed as a replacement for the current power grid. The U.S. Combined Heat and Power Association notes that DG would not serve as a reliable substitute for all large, centralized power plants, since it is unlikely to meet the needs of customers in urban areas with severe land, permitting, and siting constraints. Moreover, the fact that small and modular generators can be more efficient and less costly does not negate the useful role of large and centralized generators on the power grid, since in many situations large plants placed near points of consumption maximize thermal efficiency. Gary Mittleman, President and CEO of Plug Power, a fuel cell manufacturer and advocate of DG, acknowledged that power "plants and the grid will remain a part of our infrastructure."[102]

Such proponents, however, do firmly believe that, as a response to the challenges facing the electric power industry, renewable and distributed energy systems remain an excellent option for the provision of modular, clean, and efficient electricity generation. They hold that the modularity of renewable energy systems makes them ideal for industries and commercial enterprises wishing to generate a limited amount of electricity or to add incremental amounts of power generation to their portfolio. They believe that the emissions-free status of many renewable energy technologies makes them attractive for urban customers already suffering from pollution and those customers constrained by stringent environmental permitting. And they argue that renewable energy systems can increase the efficiency and reliability of the electric utility system by reducing demands on the transmission and distribution networks. In some cases, they are also simpler to

[101] Budhraja, Personal Interview.
[102] G. Mittleman, "Electricity Competition – Volume 3," *Hearing Before the House Subcommittee on Energy and Power* (September 13, 1999), p. 15.

operate and repair than their larger fossil-fueled brethren. As components of distributed generation systems, renewable energy technologies may enhance the reliability and security of the grid, especially during deliberate or unintentional malfunctions of critical transmission lines and large-scale power plants. In these applications, renewable energy technologies offer benefits that transcend simple dollar and cents comparisons with traditional, large-scale generation technologies.

But why, despite the potential for distributed and renewable systems to provide comparatively abundant, secure, efficient, and cleaner forms of electricity, aren't the technologies used more? Technically, the systems generate electricity, often in a more reliable and efficient manner than existing, centralized technologies. Nonetheless, as the next four chapters will explore in greater detail, utility resistance, consumer preferences, cultural attitudes, and environmental challenges impede the way that renewable and distributed energy systems are deployed, managed, and ultimately, understood.

Chapter 4—Business and Utility Impediments

"By and large, renewable energy resources are too rare, too diffuse, too distant, too uncertain, and too ill-timed to provide significant supplies at the times and places of need."

--Thomas Petersik, former analyst for the EIA, 2006[1]

4.1 Introduction

The next four chapters begin an exploration of the socio-technical (or economic, political, cultural, and ethical) impediments facing renewable and distributed energy systems. This chapter focuses primarily on how both proponents and opponents of DG technologies acknowledge that economic considerations such as capital costs, utility preferences, and business practices tend to deter people from investing in such technologies. The chapter begins by focusing on how DG systems are believed to have higher, comparative capital costs (in dollars per kilowatt) than other generators, which places many smaller, decentralized systems out of the price range of most residential consumers. Moreover, entrepreneurs and business owners argue that the comparative higher capital cost convinces them that investing in renewable or distributed systems is too expensive and deviates from the core mission of their corporate goals. Even electric utility managers generally shun renewable energy technologies, thinking that their power output is more intermittent than their fossil-fueled and nuclear alternatives, thus making them less viable providers of base-load and peaking power. Finally, since renewable and distributed energy systems, by their very nature, are more diverse and context dependent, transmission and distribution operators argue that they tend to be more difficult to permit, monitor, interconnect, and maintain.

4.2 Perceived Higher Capital Costs and Returns on Investment

While each of these obstacles raises serious concerns about the acceptance of renewable and distributed energy systems, by far the most commonly cited financial impediment to such technologies is their comparatively higher capital cost (per installed kilowatt). Out of the 62 formal interviews of utility executives, state and federal regulators, manufacturers, energy analysts, and economists, almost 90 percent considered "cost" as the single greatest impediment to distributed and renewable energy systems.

[1] Thomas Petersik, Personal Interview, February 1, 2006; Full transcript available in Appendix 2.

Despite all the benefits smaller and distributed systems can offer consumers and communities, their relatively higher installed capital cost make them too expensive for most residential customers and too risky for most utilities and businesses. This is especially true for two of the most common distributed renewable technologies: wind turbines and photovoltaic (solar) panels.

For wind turbines, the main capital cost is the turbine, although the cost of installing the tower, and the expense of delivery, interconnection, and metering hardware must also be included when calculating the turbine's total "up-front" expenses. Wind hardware designed for individual homes (in the range of 5 to 15 kW) costs between $2,500 and $3,000 per kW installed, yielding an average price of about $27,000 (including batteries and storage mechanisms).[2] Wind energy becomes much more competitive when purchased in bulk. The American Wind Energy Association noted in 2002 that the cost of utility-scale wind projects can be as low as $1,000 per kW, but most consumers don't have the ability to purchase multiple turbines. While wind turbines require less maintenance than a coal- or natural-gas plant of similar capacity, the expense of replacement parts for wind turbines can complicate or greatly diminish the rate of return for wind projects. A 2004 Department of Energy report cautioned that many turbines break during construction, and that costly drive-trains tend to wear out more rapidly at low wind speeds.[3] The relative novelty of wind projects in the United States (though not so much in countries such as Germany and Spain that have greater experience with wind than the U.S.) also increases the financing and insurance costs for wind farms, adding a further financial disincentive to invest in wind.[4]

Photovoltaic (solar) panels tend to be more expensive to manufacture, site, and install than both large centralized fossil fuel generators and non-renewable forms of distributed generation. Photovoltaic cells are manufactured from costly multi-crystalline materials (the most popular being silicon, but also including gallium-arsenide, copper-

[2] National Rural Electric Cooperative Association 2003, p. 61-62.
[3] See United States Department of Energy, "Wind Power: Today & Tomorrow," *Report from the U.S. Department of Energy Energy Efficiency and Renewable Energy Wind and Hydropower Technologies Program* (Washington, DC: Department of Energy, 2004), pp. 7-11.
[4] See American Wind Energy Association, "The Economics of Wind Energy." (March, 2002), Available at http://www.awea.org/pubs/factsheets/EconomicsofWind-March2002.pdf, p. 4.

indium-diselenide, and cadmium-telluride) in both "thick" and "thin" models.[5] Like wind turbines, they remain capital-intensive renewable technologies having low operating costs.[6] Solar installation sites must be carefully selected after consideration of several complex factors, including the amount of direct solar radiation, diffuse sky radiation, degree of cloudiness, and air temperature.[7] While these factors do not apply to all solar systems,[8] the complexity associated with solar systems has convinced some policymakers that the calculation of the total cost to produce a kilowatt-hour of PV-generated electricity can be difficult and imprecise.

For example, a typical "stand alone" photovoltaic system for home use requires a collector array, controller, inverter, and (usually) battery bank, representing an investment of more than $20,000 for a few kilowatts of power.[9] The International Energy Agency estimated in 2002 that the installation cost of a basic photovoltaic system for individual use ranges from $5,000 to $7,000 per peak kW.[10] A similar study undertaken by a U.S. solar cell manufacturer found that utility-scale PV farms often average around $7,000 per peak kW.[11] At even the best rates (i.e., when the cost of purchasing conventionally produced electricity is the most expensive), the capital expense of a PV system is three to seven times as expensive as coal and natural gas facilities (and up to four times as expensive as other renewable technologies such as biomass gasification and wind turbines).[12]

Nonprofit groups and utilities also claim that capital costs prevent investment in larger renewable energy resources, typically operated by utilities rather than businesses and residential consumers (such as hydro, ocean, and offshore wind power). The

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[5] For more on these manufacturing techniques, see Masters 2004, p. 485-500; Bent Sorensen, *Renewable Energy: Its Physics, Engineering, Use, Environmental Impacts, Economy and Planning Aspects* (New York: Academic Press, 2000), p. 116; Berinstein 2001, p. 64; and Willis, H. Lee and Walter G. Scott, *Distributed Power Generation: Planning and Evaluation* (New York: Marcel Dekker, 2000), p. 246-247.

[6] International Energy Agency 2002, p. 29-30.

[7] Nasir E. Bassam and Preben Maegaard, *Integrated Renewable Energy for Rural Communities: Planning Guidelines, Technologies, and Applications* (New York: Elsevier Publishing, 2004), p. 30; Sorenson 2000, p. 332

[8] For example, the use of solar shingles and amorphous silicon canopies do not require detailed design and site selection analysis.

[9] See Willis and Scott 2000, p. 256-257; Richard Heinberg, *The Party's Over: Oil, War, and the Fate of Industrial Societies* (New York: New Society Publications), p. 142-143.

[10] International Energy Agency 2002, p. 29-30.

[11] See Public Renewables Partnership, "PV Cost Factors," (2005), Available at http://www.repartners.org/solar/pvcost.htm.

[12] Taylor and Van Doren 2002, p. 4.

International Rivers Network—a nonprofit organization concerned with preserving the quality of the nation's rivers and streams—argues that both small and large hydroelectric facilities remain "hugely expensive to build and their costs are usually far higher than estimated."[13] After assessing more than 180 dam projects in 27 countries, the *World Commission on Dams Report* concluded that, on average, dams end up costing 56 percent more to build than predicted. Coupled with inflated costs comes underperformance and expensive maintenance needs, as well as costly resettlement programs for displaced people.[14] Also, larger dams take a long time to build, making it difficult for utility managers to match capacity accurately with projected demand.

Because tidal- and ocean-turbines are much newer than other renewables, the amount of data on their costs remains limited. Such plants do not currently exist in the commercial sector, and they remain in the planning and theoretical state. However, many utilities believe that the construction of tidal plants would be time-consuming and capital intensive. For instance, the construction of a proposed tidal plant across the Severn River in the United Kingdom is estimated to cost $12 billion. Such plants are also expected to be expensive to maintain, as they must deal with the risk of severe weather, corrosion from salt water, and erosion from the shifting tides. Marine growth can build up on turbine blades, and arrays of experimental tidal turbines have been known to cause ingresses of debris. To deal with these problems, tidal turbines will require expensive corrosion resistance materials, bearings, and sealants.[15] As a result, a 2001 Department of Energy report noted that such technologies are still in the developing stages, and that "the cost per kilowatt hour of tidal power is not competitive with conventional fossil fuel power … [W]ave energy sources cannot compete economically with traditional power sources."[16]

And, finally, while offshore wind turbines include many of the same parts (and costs) of land-based turbines, manufacturers admit that they are more expensive to install, operate, and maintain (although they also have a higher possible capacity, and thus

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[13] International Rivers Network, *Dammed Rivers, Damned Lives: The Case Against Large Dams* (Berkeley, California, 2004), Available at http://www.irn.org/basics/ard/pdf/wwf3pdfs/wwf3.1-dammedrivers.pdf, p.1.
[14] See *The Report of the World Commission on Dams* (November 16, 2000), available at http://www.dams.org/report/.
[15] Bassam and Maegaard 2004, p. 156-157.
[16] Department of Energy 2001, p. 6.

greater potential for making these costs back). A comprehensive study of distributed generators in Europe concluded that the foundations for off-shore turbines are understandably more expensive than their land-based counterparts because they must be moored and stabilized to the seabed floor. Additionally, the same study noted that the cost of sea transmission cables typically add more than 20 percent to the costs of an offshore wind project.[17]

Government and electric utility industry analysts believe that the same trends concerning capital costs hold true for most non-renewable distributed generation technologies. Thomas Petersik, a former analyst for the EIA, put it this way:

> The most significant impediments [to non-renewable DG systems] are cost, cost, and cost. More specifically, distributed generation technologies experience much higher (in the neighborhood of 50 percent) capital costs per kilowatt, in part because they lack economies of scale; they are much less fuel efficient; and operations and maintenance are much higher … As a result, the per kilowatthour costs of distributed generation from, say, microturbines, fuel cells, small wind, solar photovoltaics, and others, are significantly more than for central station supply.[18]

Brice Freeman, who models DG project economics for the Electric Power Research Institute, agrees and says that first-time capital costs are always "the Joker in the deck … because … any unexpected costs can sink project economics." [19] And Joe Catina, who manages all North American DG projects for the Ingersoll Rand Company, stated that the biggest issue in selling distributed energy technologies remains capital cost. Catina explains that:

> [r]elative to other forms of central power generation [DG technologies] are expensive in terms of capital costs …. From the DG generator side, the biggest issue right now is cost. It's all about cost.[20]

In the end, elevated capital costs deter customers, utilities, and businesses from investing in distributed renewable energy technologies. David Garman, Undersecretary of Energy

[17] See Jorb et al. 2003, p. 27-29.
[18] Thomas Petersik, Personal Interview, February 1, 2006; Full transcript available in Appendix 2.
[19] Brice Freeman, Personal Interview, February 22, 2006; Full transcript available in Appendix 2.
[20] Joe Catina, Personal Interview, September 20, 2005; Full transcript available in Appendix 2.

and former Assistant Secretary for Energy Efficiency and Renewable Energy for the U.S. Department of Energy, admits that "the capital cost of most renewable energy systems still places them out of the means of most residential customers."[21]

For businesses, renewable and DG energy projects cannot meet the extremely rapid rates of return that many companies set for their investments. Even though other, smaller businesses (that may not be investor owned) can purchase renewable energy systems in larger quantities than residential consumers (driving their price down as production increases), the payback periods for such technologies are substantially longer than some businesses are willing to permit. Solar energy offers a prime example. The average American business often looks for a two- to three-year payback on energy investments. Yet a recent *New York Times* article explained that "solar power cannot yet provide that; the average commercial installation is expected to pay for itself in five to nine years."[22] Perpetually low energy prices in some regions of the country only enhance this impediment, as it means PV systems take even longer to pay for themselves.

For similar reasons, utilities are reluctant to undertake investments in renewable and DG technologies because they fear such purchases will force them to initially raise their rates to cover the installed costs. Claudia J. Banner, a Senior Engineer and Renewable Energy Planning Lead for American Electric Power, explains that "utilities are usually not receptive to mandated renewable portfolio standards, citing an increase in generation costs that could get passed back to the consumer, resulting in larger utility bills."[23] Theresa M. Jurotich, a consulting engineer in the energy industry, adds that the problem is that utilities believe that "renewables combine high capital investment with low output. To recover the capital investment, utilities have to either charge a lot for each kWh generated or obtain long-term financing resulting in a lower annualized cost."[24] In the olden days of regulation, utilities didn't care too much about higher costs, since they could pass them on to consumers and still earn their guaranteed return on

[21] David Garman, Personal Interview, February 22, 2006; Full transcript available in Appendix 2.
[22] James Rendon, "In Search of Savings, Companies Turn to the Sun," *The New York Times* (October 12, 2003), p. B12.
[23] Claudia J. Banner, Personal Interview, March 6, 2006; Full transcript available in Appendix 2.
[24] Theresa M. Jurotich, *Network Infiltration: Gaining Utility Acceptance of Alternative Energy Systems* (Blacksburg, VA: Virginia Tech, Master's Thesis, May, 2003), pp. 2-3.

investment. But in a partially deregulated world, utility managers are conscious of costs so they don't get undersold by the new competitors in the market.

Why are costs so important? The above discussion seems to underscore one of the key elements of the systems approach: namely, that as successful technological systems acquire momentum, a greater number of actors and social institutions become enrolled in promoting that system. In an industry as large as the electric utility sector—with trillions of dollars of embedded investment, billions of dollars in sales, and millions of customers—a staggering number of banks, financing firms, manufacturers, and publicly traded utilities have become registered into the system. Such complexity, in turn, has convinced many utility managers to place priority on cost as a matter of maximizing profits and keeping prices low. All members of electric utility industry—from large, investor-owned utilities to small, rural electric cooperatives—are concerned with keeping prices stable for consumers. Additionally, market restructuring (also called "deregulation") of the electric utility industry occurred in some states in the late 1990s and early 2000. Such restructuring created wholesale markets in which electricity can be bought, traded, and sold like any other commodity. As a result of these changes, these power providers have become even more concerned with keeping financial edge over their competitors (and demonstrate yet another instance where the electric utility system has expanded its influence, this time over the American stock market).

4.3 Business Attitudes and Practices

In a similar vein, most small and large businesses resist investing in and using renewable and distributed energy sources because these technologies are believed to deviate from each company's core business mission. Keeping in mind the systems approach, it may be here that the electric utility system's influence ends. Even though these businesses obviously use electricity, they seem to have little to no interest in producing power (or promoting *any* type of technological system concerning energy, renewable or not). And this relates to another one of Hughes concepts: interoperability. Because most nonutility and non-energy businesses have goals and priorities that have nothing to do with electricity, they tend to be concerned with the promotion of their own corporate strategy. The interests and technologies such businesses promote are not

interoperable with the growth of the electric utility system, and so they refuse to invest in energy technologies.

For instance, manager of small businesses remain constrained by limited resources and time, and larger businesses believe that they can best maximize their profits by focusing on non-energy related issues. Rodney Sobin, former innovative technology manager at the Virginia Department of Environmental Quality, put it this way:

> The potential users of DG tend to be unfamiliar with the benefits such systems offer. The cookie baker is concerned with making a better chocolate chip cookie. The Chicken McNugget manufacturer is concerned with perfecting a better Chicken McNugget. The shopping mall managers are interested in providing retail services. None of them are interested in generating power and becoming a micro or quasi utility.[25]

In other words, most companies don't want to be in the "business of making energy," and would rather use their resources—financial and otherwise—promoting core business activities.

Tom Casten, who has almost three decades of experience selling cogeneration DG units to businesses, explains that both large and small manufacturing firms resist undertaking novel energy projects. According to Casten:

> The typical manufacturing enterprise focuses its intellectual and financial resources on core activities—making beer, or steel, or chemicals, etc. The vast bulk of industry will not invest in energy plants unless they are 'broken' or, in the best case, when an energy efficiency project will pay back the capital investment in 12 to 18 months. Companies have a much higher investment hurdle rate for core activities than non-core activities, and they employ very few specialists in any non-core activity. This focus on core activities has become the big buzz in management discussions over the last twenty years. Peter Drucker insists that to be successful in a world of globalization, companies must focus on their core mission and outsource all of the non-core functions to specialist firms. In general, this makes sense, and is widely practiced.

[25] Sobin, Personal Interview.

Even though, as Casten concludes, today's successful firms "outsource payroll, security, food service, janitorial services, grounds maintenance, call centers, and other functions," energy is not an important enough of an activity.[26]

Casten's comments parallel conclusions about business practices made by the Alliance to Save Energy (ASE), a non-profit institute dedicated to analyzing the impediments towards industrial energy efficiency projects. Chris Russell, the director or industry research at the ASE, notes that energy projects are often resisted by all levels of the business community because they distract personnel from more profitable ventures. Russell elaborates:

> Facilities are thinly staffed, running flat out every day to meet production goals. Therefore distractions aren't welcome. For them, routine is a good thing, and their mantra becomes "that's the way we've always done it." So when you propose energy [projects for] a facility, you are really proposing changes to the way they operate. You have people in operations, finance, procurement, and engineering—all of whom will be impacted by energy management, and all of whom usually have some reason to resist change … Decision makers are continually making a tradeoff between risk, time, and money. If you propose an energy efficiency measure that saves X dollars, the facility manager wonders what the additional costs are in terms of risk and time. What labor hours are needed to support energy efficiency efforts? Should they allocate labor hours to making dollars, or saving dimes?[27]

Company employees may also be reluctant to admit the need for more efficient energy technologies, Russell adds, because they believe such admissions become evidence of ineffective job performance.[28]

At the end of the day, energy use continues to be invisible to most companies. Shalom Flank, Chief Technical Officer for Pareto Energy Limited, explains that no single business "can improve their bottom line substantially with alternative energy

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[26] Tom Casten, Personal Interview, October 5, 2005; Full transcript available in Appendix 2.
[27] Christopher Russell, Personal Interview, February 8, 2005; Full transcript available in Appendix 2.
[28] Christopher Russell, *Barriers to Industrial Energy Cost Control: The Competitor Within* (Washington, DC: Alliance to Save Energy, 2004), pp. 1-2.

technologies, because energy inputs usually constitute less than 1 percent of their total cost structure."[29] In other words, companies will often choose to pursue more profitable ventures instead of investing in energy technologies. A systematic study of industrial energy usage undertaken by the ASE found that compressed air leaks were often overlooked because air was believed to be free, even though the same companies needed five horsepower of electricity to generate one horsepower of compressed air. Similarly, the study found that plant operators often assume that scrap rates are unimportant because scrap can be melted down and reused, not realizing that recycling scrap requires energy consumption and associated costs.[30]

Ironically, in the case of DG installations at industries and businesses, the smaller the project, the *less* likely it will be undertaken. Mark C. Hall, Senior Vice President at Primary Energy, and an advocate of DG technologies, argues that:

> Size matters—not necessarily from a capital cost or efficiency standpoint, but it takes a lot of effort to do a small project as it does a large project, so the tendency is for an organization like ours to focus on the bigger projects because they can support the kinds of efforts needed to get the projects done. In contrast, getting smaller projects done requires such a disproportionate amount of senior management attention, legal attention, and other time and effort that it really burdens those projects with greater and greater costs so that people say it's not worth it.[31]

This attitude helps explain, Hall concludes, why so many smaller businesses never undertake energy projects.

As a result of the aforementioned trends, non-energy related companies almost always choose to do nothing rather than undertake profitable energy investments. According to Casten:

> My son, who is CEO of a company that offers integrated steam turbine generator plants that convert wasted steam pressure drop into electricity, often with over 35 percent returns on investment, analyzed company activities over the last 17 years. Out of 7,000 proposals, all of which had at

[29] See Shalom Flank, Personal Interview, March 20, 2006; Full transcript available in Appendix 2.
[30] Russell 2004, p 4.
[31] See Mark C. Hall, Personal Interview, October 5, 2005; Full transcript available in Appendix 2.

> least 25 percent returns on investment, only around two percent were accepted. Only 1 percent were lost to another competitor. 'Mr. Do Nothing' won 97 percent of the time.[32]

Moreover, because energy use, energy efficiency, and energy projects seem so unimportant to businesses, general industry disinterest towards renewables and DG remains significant. For example, when the National Association of Manufacturers called on the Bush Administration to develop a "plentiful, flexible, diverse and affordable" energy supply in 2005 through a nine point plan, renewables, DG and CHP systems didn't even make the list. Instead, options to include increasing onshore access to oil and gas reserves in ANWR, expediting the permitting of LNG re-gasification facilities, authorizing new nuclear plants to generate 50,000 MW of nuclear energy by 2020, and investing in clean coal technologies were given priority.[33]

4.4 Difficulty in Dispatching Distributed Units

In addition to the aforesaid business impediments, system operators and utilities argue that renewables and smaller DG units may not be an ideal substitute for larger power plants. Such opponents of DG do not attempt to veil the fact that they wish to retain control over the generation, transmission, and distribution of electricity. Ryan Wiser, a research analyst at the Lawrence Berkeley National Laboratory, argues that utilities can exert a "profound influence" within the electricity sector since utilities serve as the only intermediary between a ubiquitous and much needed product—electricity—and consumers. Utility support and resistance can create an "immense impact on the types of technologies that can be developed and deployed" on the transmission system.[34]

Indeed, it is perhaps here that the tendency for technological systems to create a set of particular social arrangements is most evident. Utilities and system operators often view themselves as stewards of technological progress, gatekeepers to a world of widespread electrification and inexpensive power that promulgated the highest material standard of living in the world. They view themselves as responsible for allowing Americans to enjoy a civilization replete with electrical appliances that enhanced their

[32] Tom Casten, Personal Interview, October 5, 2005; Full transcript available in Appendix 2.
[33] National Association of Manufacturers, *Just In Time: The Publication of the NAM* (December 14, 2005), p. 1-2.
[34] Ryan Wiser, Personal Interview, October 25, 2005; Full transcript available in Appendix 2.

productivity, comfort, and entertainment, and achieved the strongest economy in the world. That attitude may have been reinforced as restructuring efforts of the utility system in the 1990s contributed (at least in their minds) to the California electricity crisis of 2000 to 2001 and the northeast blackout of 2003. It is an attitude that resists, often quite aggressively, the idea that "outsiders" should be permitted to attach nonutility equipment to the grid that they had so carefully built for decades.

For example, utilities are quick to argue that renewable sources like wind and solar only produce electricity when the wind blows or sun shines. As one analyst put it, "wind [energy] has unfavorable generation patterns, as its maximum generation does not typically coincide with the maximum energy demand and market clearing price in terms of their seasonality and daily variations."[35] Ralph Loomis, Senior Vice President at Exelon, argues that "you cannot dispatch wind. You get the energy when the wind blows, often in the cool of the night rather than the heat of the day."[36] Utilities call such intermittent generation resources "non-dispatchable," since they cannot be reliably called upon to generate electricity on demand.

At a minimum, system operators state that the intermittence of some renewable technologies greatly complicates forecasting. In the modern, restructured electricity market, system operators typically use five types of forecasts to determine how best to produce, price, and bill electricity the following day. Operators use a "day-ahead forecast" to estimate system load for each hour of the following day; a "day-ahead market forecast" in which generators and load-serving utilities bid for producing and purchasing energy and operating reserves; a "unit commitment forecast" in which system operators schedule the appropriate generation mix to serve the load factors (taking into account prices, start up time, and transmission congestion); a "real time operation forecast" in which system operators adjust generating resources to match actual demand in real time during the day; and a "market settlement forecast" in which power generation and consumption is logged, and imbalances from scheduled values are financially settled according to market rules. A report from the California Independent System Operator

[35] Yuri Makarov et al., "Incorporation of Wind Power Resources into the California Energy Market: Hands-On Experience," *Proceedings of the Windpower Conference and Exhibition in Denver, Colorado*, May 15-18, 2005, p. 2.
[36] Loomis, Ibid.

(ISO) found that relying on wind energy excessively complicated each of the five types of forecasts. As the study concluded, "although wind generator output can be forecast a day in advance, forecast errors of 20-50% are not uncommon."[37]

System operators also note that forecast errors can seriously add to the levelized costs of renewable energy systems. The intermittent nature of wind also results in penalties paid by utilities when generation supplies do not meet demand.[38] To overcome some of the forecasting problems associated with the intermittence of wind and solar energy, utilities and system operators have had to supplement renewable generation with either large renewable energy farms, fossil fueled generators, or expensive storage techniques. The problem, Tim Cross, a staff writer for the *Economist* argues, is that lags in wind can affect a great number of generators at once. As he explains:

> The Sustainable Development Commission, who are quite big fans of wind power, admit that the capacity value drops off sharply as wind's share of generation increases. If a widget breaks in a Combined Cycle Gas Turbine (CCGT) plant that has no impact on the probability of other CCGT plants shutting down. But obviously a drop in wind speed affects big swathes of your wind capacity since it affects all the turbines in an area equally. Forecasting can help to deal with this but the fact remains that a couple of calm days will mean that you need to get your power from somewhere else. There must be sufficient capacity on the system to cope with very low production from your wind turbines. I think, for example, that earlier this year, the capacity factor for Danish windmills dropped as low as 12% for one month.[39]

Thus, even though the fuel for renewable generators like wind and solar technologies are widely dispersed throughout the country, system operators highlight that they are not always available.

So, to smooth out fluctuations in generation capacity, utilities claim that wind-produced power works best when used in large numbers in geographically spaced

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[37] See Richard Piwko et al, "Wind Energy Delivery Issues: Transmission Planning and Competitive Electricity Market Operation," *IEEE Power & Energy Magazine* (November/December, 2005), pp. 3-14.
[38] National Rural Electric Cooperative Association, *NRECA White Paper on Wind* (Arlington, VA: NRECA, 2004), p. 57.
[39] Tim Cross, Personal Interview, September 30, 2005; Full transcript available in Appendix 2.

locations (so the law of averages yields a relative constant supply). Alternatively, they need to be connected to backup or supplemental power plants that operate continuously (often in the form of coal-, gas-fired, and nuclear plants).[40] The need for supplemental generation, such thinking goes, means that wind turbines typically cannot send their supply of power through the grid if there is a problem such as a blackout, and they need expensive storage technology to operate during times of inadequate flows of air.[41] For instance, California Energy Commissioner Arthur Rosenfeld comments that:

> Germany had to build a huge reserve margin (close to 50 percent) to back up its wind. People show lots of pictures of wind turbines in Germany, yet you never see the standby power plants in the picture. This is precisely why utilities fear wind: the cost per kWh of wind on the grid looks good only without the provision of large margins of standby power.[42]

Thomas Grahame, a senior researcher at the U.S. Department of Energy, comments that "when intermittent sources become a substantial part of the electricity generated in a region, the ability to integrate the resource into the grid becomes considerably more complex and expensive. It might require the use of electricity storage technologies, which will add to cost. Additionally, new transmission lines will also be needed to bring the new power to market. Both of these add to the cost."[43] The fact that Grahame is speaking on behalf of the U.S. Department of Energy only reflects how deeply entrenched utility attitudes against DG have become. Brice Freemen from EPRI notes that the renewables work best only when "large-scale energy storage devices" can "accept electricity when it is produced by renewable resources and inject it into the grid during periods of peak demand."[44]

These types of difficulties do not exist just for wind energy. System operators complain that, much like wind turbines, large- and utility-scale PV systems can only produce electricity intermittently. They cannot function during the night, and their users must rely on additional generating units (or the grid) to supplement lags in their

[40] David Dworzak, "The Cost of a Windless Day," *Electric Perspectives* 30(3) (May/June, 2005), p. 79.
[41] Ibid.
[42] Rosenfeld, Personal Interview. .
[43] Thomas Grahame, Personal Interview, February 13, 2006; Full transcript available in Appendix 2.
[44] Freeman, Personal Interview.

production of electricity.[45] The costs of storing electricity generated from PV technology using batteries, pumped storage, and flywheels also remain expensive. In addition, many regions of the world that consume the most energy (such as New York City, Washington, DC, and Richmond) do not have bright, year-round sunlight, and they suffer from long fall and winter seasons that result in greatly fluctuating power supplies from PV.[46] Again, as with wind turbines, utilities argue that this intermittency makes PV systems a poor choice for wholesale electricity markets and the provision of base-load power.

System managers and operators have even criticized hydroelectric power for being intermittent. Large and small hydroelectric systems must deal with the constant vagaries of weather and climate. Lack of adequate snowfall and rain leaves may hydroelectric facilities susceptible to disruptions and interruptions in supply. In the Pacific Northwest, where recent snowfalls have been below average, weather problems have forced policymakers to choose between further depletion of water resources to produce electricity for energy-intensive industries (such as the aluminum industry) or to protect these resources for use by commercial and recreational pursuits.[47] In addition, many utility analysts have highlighted the role that poor hydroelectric generation played in the 2000-2001 California electricity crisis, where a shortage of rainfall depleted needed hydroelectric reserves that could have provided enough generation to prevent blackouts throughout the state metropolitan regions.[48] Some scientists even believe that climate change will increase the frequency and severity of droughts, further compromising the reliability of hydroelectric power.[49]

Government analysts also argue that some non-renewable DG and CHP technologies also suffer dispatch problems. Dave Stinton, the CHP program manager at the Oak Ridge National Laboratory, comments that micro-turbines, reciprocating engines, and fuel cells do not match the ideal electrical loads demanded by most utilities. Most cogeneration equipment, Stinton notes, offer the most benefit to businesses that need

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[45] Bradley 1997, p. 12.
[46] Friedman and Homer-Dixon 2004, p. 76.
[47] John D. Dingell, "National Energy Policy Report of the National Energy Policy Development Group," *Hearing Before the Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce* (June 13, 2001), p. 5.
[48] For an excellent summary, see the Congressional Budget Office, *Causes of the 2001 California Blackout and Lessons for the Future*, 2002, available at http://www.cbo.gov/showdoc.cfm?index=3062&sequence=0
[49] International Rivers Network 2004, p. 2.

thermal energy and heat as their primary products, not utilities or companies trying to generate electricity. Moreover, Stinton believes that most CHP systems are not designed to run continually. He clarifies that:

> [For small businesses like hotels], there are some times during the day when cogeneration is useful, like the beginning of the day when people are getting up and laundry services are in use. Yet at 1:00 in the afternoon, no one is in the hotel and no one really needs the waste heat. The point is that it's really difficult to find the best application for DG/CHP systems, especially when it may not be optimal to run such systems for 24 or even 12 hours a day.[50]

Again, Stinton's remarks highlight that one of the reasons DG technologies have not gained acceptance among utilities is because they do not operate in ways conducive to the large, centralized utility model. Instead, DG technologies may work best when *not* connected to an extensive transmission and distribution system.

In the end, utilities and system operators use the intermittency and non-dispatchability of some distributed and renewable energy sources to raise their costs (in terms of storage or backup power) at the same time they lowers the net value of DG technologies on the wholesale market. Joe Loper clarifies that renewable energy systems do not truly displace fossil fueled generators. According to Loper:

> If a solar or wind plant is on during periods of low demand, then they are replacing coal plants, which could be good for emissions but may not help reduce cost. If the wind or solar systems are running during peak loads, they help to reduce emissions and perhaps even high variable costs since peak power is often generated with expensive natural gas. The wind and solar, however, do not displace the need to build the peak power plant in the first place.[51]

Ralph Loomis adds that, in fact, the economics are even more unfavorable towards renewable energy systems when such systems are compared with base-load fossil-fueled generators. According to Loomis:

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[50] See Dave Stinton, Personal Interview, August 2, 2005; Full transcript available in Appendix 2.
[51] See Joe Loper, Personal Interview, February 7, 2005; Full transcript available in Appendix 2.

> You need to install 6 MW of wind to get something comparable of 1 MW of a more traditional fossil-fueled generation source. So while the cost per MW of wind may be increasingly competitive, you still have to buy six times as much if you want to deal with the resource adequacy side of the equation.[52]

Consequently, Wilson Prichett, an energy consultant, argues that renewable systems should really be viewed as "supplemental" generators, since the generation of electricity only occurs when the resource is available, rather than when the load is needed by utilities. Prichett comments that "renewable energy technologies are not really substitutes for hydro, nuclear, and fossil fueled power plants."[53]

Thus, utilities choose to perceive the market value of renewable energy for utilities as equal only to the avoided costs of generation of most fossil fueled generators (around 2 to 3 cents per kWh) rather than the actual market prices of electricity (around 5 to 6 cents per kWh). Thomas Grahame, a Senior Research Analyst in the Office of Fossil Fuels at the U.S. Department of Energy, explained it in the following terms:

> Keep in mind that wind energy is intermittent—it only is generated when the wind is blowing, which may or may not be when it is most needed (which would be at or near peak daily demand). This means for most utilities that they have to build another type of plant anyway, to make sure they can meet peak demand. That added cost subtracts from the benefit of wind—what it means is that the wind is only worth, to the utility, the costs of the fuels that it displaces when the wind is blowing—sometimes cheap coal, sometimes much more expensive natural gas. [54]

To summarize, the intermittent nature of renewables tends to mean—in a wholesale competitive electricity market—that utilities value of the electricity generated by renewables as only worth as much as the cheap fuels it sometimes displaces, not the true market price the customer ends up paying for electricity.

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[52] Loomis, Personal Interview.
[53] See Wilson Prichett, Personal Interview, February 16, 2006; Full transcript available in Appendix 2.
[54] Thomas Grahame, Personal Interview, February 13, 2006; Full transcript available in Appendix 2.

Furthermore, utilities and system operators comment that connecting a large amount of distributed generators to the power grid excessively complicates system management. David Hawkins of the California Independent System Operator notes that:

> Wind, for instance, can be forecasted and has predictable patterns during some periods of the year. California uses wind as an energy resource but it has a low capacity factor for meeting summer peak loads. The total summer peak load is 45,000 MW of load, but in January daily peak loads are 29,000 MW, meaning that 16,000 MW of our system load is weather sensitive. In the winter and spring months, big storms come into California which creates dramatic changes in wind. We've can seen ramps as large as 800 MW of wind energy increases in 30 minutes, which can be quite challenging.[55]

In other words, system operators claim that the intermittent nature of wind power threatens to create power surges and shortages when used on a large scale or for a large portion of a system's needs. Western Denmark's principal Transmission System Operator stated that the production of electricity from its wind turbines "can be akin to maneuvering a rapidly moving articulated lorry train without a steering wheel, accelerator, clutch, or brakes."[56]

However, it must be emphasized that DG and renewables technologies are not the only types of generators that are difficult to standardize and dispatch. Fuels such as coal and oil are not uniform in their energy properties. Michael Karmis, the director of the Virginia Center for Coal and Energy Research, notes that "even a relatively simple and abundant fuel like coal, for example, is greatly variable in its energy density, price, and quality."[57] So, utility planners and engineers have had to design fossil-fuel turbines that could withstand the variability inherent in all types of coal. Similar to renewable energy systems, coal-, oil-, nuclear, and natural-gas fired plants are not always "on." Such plants must be periodically shut down for routine maintenance, and transmission system operators must constantly manage the power grid against accidental shut downs and

[55] David Hawkins, Personal Interview, October 13, 2005; Full transcript available in Appendix 2.
[56] V.C. Mason, "Environmentally Unfriendly Wind Power – A Personal Opinion," (February, 2004), available at. www.dartdorset.org/ Unfriendly%20WF%2018%20Feb%202004.pdf.
[57] Michael Karmis, Personal Interview, February 16, 2006; Full transcript available in Appendix 2.

failures. So, in essence, all energy systems—traditional or not—are capital intensive and intermittent to some degree, although not typically as much as DG or renewable systems.

Nonetheless, the question is why the capital intensity and intermittence of renewable generators is seemingly unresolved, while the same issues of fossil fuel and nuclear energy have received the political and social support needed to overcome them. Put another way, the infrastructure exists to deal with the intermittence of fossil fueled generators, but not DG technologies. In the case of each transition to a new energy system, significant groundwork had to be laid. For coal it consisted of mines, railways, and utilities. Oil relies on wells, refineries, pipelines, and gasoline stations to reach consumers, and natural gas needs wells, pipelines, tankers, and storage facilities. Such historical transitions can teach us two things: first, that all energy systems, to date, have exacted immense costs on the environment so that fuels could be discovered, mapped, extracted, shipped, refined or processed, distributed, and used. Second, those future transitions to any other energy source—whether in hydrogen or fusion—would likely require the same types of environmental costs.

More specifically, the U.S. has seen at least three significant energy transitions since 1900, and each of them required immense capital investment. Consider the following statistics: coal supplied an average of 83 percent of the country's energy needs from 1900 to 1920; in 1977 petroleum and natural gas supplied 75 percent of energy supplies (including electricity).[58] The use of coal as a primary fuel displacing wood and kerosene required the construction of more 8,994 mines to extract the fuel, 250,000 miles of railway track to distribute it, countless boilers and turbines to convert it into electricity.[59] Oil, which requires more advanced technology to extract than coal, necessitated a multitude of oil wells (roughly 300,000), pipelines, refineries, tankers, and almost half a million gasoline stations so that petroleum products could be distributed to utilities and automotive consumers.[60] The existing natural gas and LNG network needed

[58] John G. Clark, "The Energy Crisis of 1919-1924 and 1973-1975: A Comparative Analysis of Federal Energy Policies," *Energy Systems and Policy* 4(4) (1980): 239-271.
[59] John G. Clark, Energy and the Federal Government: Fossil Fuel Policies, 1900-1946 (Chicago: University of Illinois Press, 1987).
[60] See David Howard Davis, *Energy Politics* (4th Edition) (New York: St. Martin's Press, 1993); M. A. Adelman, *The Genie Out of the Bottle: World Oil Since 1970* (Cambridge, MA: MIT Press, 1995), pp. 48-52; Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Simon & Shuster,

380,000 natural gas wells, 142 large and specially designed double hulled tanker ships, 410 storage reservoirs and aquifers, and 1.4 million miles of separate pipelines to be built.[61] Finally, if it occurs, even a transition to the much-touted "hydrogen economy" will face many of the same infrastructural challenges: inability to manufacture cost effective fuel cells, problems extracting, compressing, storing, and distributing hydrogen based fuels.[62]

Yet, instead of working to overcome the impediments facing DG technologies—much like they have for coal, oil, and natural gas—utility managers frequently use non-dispatchability and intermittency as reasons to reject distributed energy resources. Taken together, the combination of these factors—intermittency, forecasting complexity, need for supplemental generation, and grid interaction—has convinced many system operators and utilities that renewable energy resources are not adequate providers of two forms of important power: base-load and peaking power. Base-load power is the power that is "always on," and must operate continuously to meet the minimal amount of demand that is always created by customers. Because it must always be available, this power is typically provided by large coal, natural gas, and nuclear plants and is often called the "backbone" of the electric utility industry. Many renewable technologies, in contrast, depend on weather-related phenomena and thus provide electricity intermittently (or at different times of the day). Paul Gilman states that:

> Renewable energy sources are not well designed (or designed at all) to provide base-load power … To force renewables to provide base-load power is like trying to make a pig fly: you won't succeed and you only make the pig unhappier.

1991); Bureau of Transportation Statistics, 2002, http://www.bts.gov/publications/national_transportation_statistics/2002/html/table_01_11.html.

[61] See Institute for Energy, Law, and Enterprise, "Introduction to LNG: An Overview on Liquefied Natural Gas, Its Properties, the LNG Industry, Safety Considerations," University of Houston Institute for Energy, Law, and Enterprise; Energy Information Administration. (2004). *U.S. LNG Markets and Uses: June 2004 Update*. June, Retrieved from http://www.eia.doe.gov; Paul W. Parformak, "Liquefied Natural Gas Infrastructure Security: Background and Issues for Congress." *CRS Report for Congress* (September 9, 2003); State Energy Advisory Board 2002, p. 4-5.

[62] See Brent D. Yacobucci and Aimee E. Curtright, "A Hydrogen Economy and Fuel Cells: An Overview." *CRS Report for Congress* (January 14, 2004); National Academy of Engineering, *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs* (2004); Joseph J. Romm, "Lots of Hot Air About Hydrogen," *Los Angeles Times*, March 28, 2004, p. M3; Clive Cookson, "The Hydrogen Economy," Financial Times (London, England), September 8, 2004, p. 4.

As a result, most renewable energy systems (especially wind and solar) are viewed as inappropriate for base-load applications. They can serve as intermediate-load or peak-load providers of power, generating electricity when customers demand electricity during the hottest part of the day, for example.

Furthermore, system operators can tend to rely on the dispatchability of non-renewable electricity resources to provide peak-load power. Peak-load power equipment refers to those generators that are switched on during times of high demand to supplement base-load generators. Many peak-load facilities use natural gas turbines because they can be started and turned off quickly, unlike most coal-and nuclear-fueled base-load units, which require hours to start up. These peaking facilities have become more important as demand for electricity in the United States continues to grow. For example, 90% of new power plants on order (as of 2003) were gas-fueled,[63] and between 80% and 90% of new generation capacity between 1999 and 2004 has been fueled by natural gas.[64] Because many renewable technologies cannot be switched "on" or "off" as quickly, system operators will likely continue to see natural gas peaking facilities as a better alternative for the provision of peak-load power.

One stipulation must be introduced when discussing this impediment, however. The tendency for renewable energy systems to provide only partial loads during different seasons and parts of the day does not mean that such technology can never be employed to provide base-load or peaking power. Some large hydroelectric plants, for instance, have reliable fuel sources (reservoirs of water) and can provide more reliable base-load power than some fossil fueled plants. The fact that some renewable systems provide intermittent power does not mean such power cannot be predicted and used. A photovoltaic farm operating in the Mohave Desert, for example, may provide electricity only during the day, but this also happens to be when demand for electricity surges (meaning it could provide consistent peak-load power). In addition, all generators—regardless of their fuel—periodically need to be shut down for maintenance and repairs, in essence making them "intermittent." Nonetheless, renewable systems are often

[63] Tom Gray, "Trans-Praire and Interior West Wind 'Pipelines,'" *Wind Energy Weekly* (July 31, 2003), p. 12.
[64] See Marvin S. Fertel, "The Future of Nuclear Power," *Hearing Before the Senate Subcommittee on Energy and Natural Resources* (March 4, 2004), p. 3; Robert Pirog, "Natural Gas Prices and Market Fundamentals," *CRS Report for Congress* (December 8, 2004), pp. 7-8.

perceived by utility managers as a poor choice for generating this power in certain contexts.

4.5 Difficulty in Setting Universal Standards for Design and Interconnection

Finally, system operators argue that smaller, dispersed forms of electricity generation are more difficult to standardize and interconnect to the grid. Since individual units produce smaller amounts of power than the behemoth power plants traditionally used, opponents suggest that DG technologies must be more numerous and require more frequent efforts to place them in appropriate locations and integrate them into the existing power network.

Small scale renewable-energy technologies do suffer especially from the difficulty in standardization, as access to renewable "fuels" often dictates site-specific requirements for the units. Indeed, this is often identified as one of the strongest advantages of DG systems: they can be tailored to match any load in any location. However, such flexibility is also perceived by system operators to have a down side. For example, a wind turbine might work best atop a cloudy mountain, whereas a photovoltaic system reaches optimal performance in a hot and cloudless desert. As a result, the costs, capacity, need for storage, and rate of payback will differ for installation of almost every renewable technology. The complexity of building a renewable energy plant in the right size and in the right place makes developing a "standard approach" like the one in use for constructing large fossil-fueled plants extremely difficult. As a result, renewable energy technologies are perceived as more problematic to design.[65] David Hawkins of the California ISO adds that DG technologies are much more difficult for system operators to observe and monitor. Hawkins argues that "DG operators, for example, need to know how many hours units have been operating so that they schedule oil changes, checkups, and maintenance inspections. Better information technologies are also needed to track those DG systems that are supplying power to the grid."[66]

Vikram Budhraja, the former President of Edison Technology Solutions and former Senior Vice President for Systems Planning, Fuels, and Operations at Southern

[65] See Jerry Taylor, "Not Cheap, Not Green," *CATO Institute Report* (August 4, 2003), available at http://www.cato.org/testimony/ct4-16-5.html; Jerry Taylor Peter VanDoren, "Evaluating the Case for Renewable Energy: Is Government Support Warranted?" *Cato Institute Policy Analysis No. 422* (January 10, 2002), p. 1-15.

[66] Haukins, Personal Intervivew.

California Edison Company, notes that utilities honestly believe that they do not have the time or resources to experiment with such disaggregated technologies. As Budhraja clarifies:

> Small decentralized solar units that need to be connected to the grid are more difficult to standardize and installation generally requires custom engineering. It would be the equivalent of buying individual appliances that each need custom engineering design, installation, and maintenance. Such smaller, individual units—especially when we are concerned with producing power, a relatively cheap commodity in the United States—tend to be prohibitively expensive. Look at small scale cogeneration or photovoltaic systems; each specific unit must be specially tailored and engineered at the site where it is installed, which adds substantial cost to an already higher costing technology …. Standardized packages can only come about when there are standardized ways to implement them. This necessitates standard approaches for interconnection and disconnection, as well as dispatchability, permitting, and monitoring. When you buy a toaster you just plug it in. You don't think about whether it will short out the light, blow up, etc. DG is much more complicated. All of those things that make DG systems usable for different applications makes it hard to come up with standardized installation and engineering design packages and lack of standard design raises costs. The reason that personal computers have proliferated so widely is because they can be mass produced according to a standard design, which drives down the cost of unit production.[67]

Never mind that the resources needed to manage current, massive electricity infrastructure necessitated coordinating thousands of large generators and maintaining hundreds of thousands of transmission wires. Despite the ability for utility managers to overcome those types of infrastructural problems, Budraja suggests that until DG systems become more standard, the technologies will continue to face resistance from utilities.[68]

[67] Budhraja, Personal Interview.
[68] Ibid.

Furthermore, even after a design has been decided upon, system operators claim that renewable and DG technologies face difficulties in the processes of permitting and monitoring. Many critics have warned that the deployment of a large number of small-scale renewable technologies greatly complicate permitting requirements by imposing a huge administrative burden. Likewise, measuring the environmental impacts associated with their construction, generation, maintenance, and decommissioning from the larger number of DG plants would be an onus for government regulators.[69] Confirming that view, the Congressional Budget Office noted in 2003 that widespread use of distributed, small-scale renewable energy systems would greatly increase the cost of environmental monitoring.[70] In short, government overseers certainly have an easier administrative task (on the per-megawatt basis) to permit and monitor traditional centralized power plants.

As an example of this complexity, opponents of renewable energy sometimes point to the difficulties in using biomass as a fuel used for electricity generation. The variability in the fuel—not just its energy density, but its moisture content, molecular composition, and purity—makes its combustion difficult to monitor. An oak tree burns differently than a pine tree, let alone tobacco residue, switch-grass, or sweet sorghum. Most biomass fuels possess high water content and are often wet when burned. Consequently, the argument goes, large amounts of wasted energy go up the stack as water vapor, leading to relatively low thermal efficiencies for converting fuel to electricity—usually less than 20%. On one hand, this statistic reveals two important advantages of biomass combustion, namely the ability to combust a variety of fuels, making the likelihood of fuel shortage unlikely, and that the steam produced by bioelectricity would be ideal for CHP applications. On the other hand, it also enables system operators to argue that more fuel must be burned to produce electricity. The result tends to be slightly more expensive electricity, often around 9 cents per kWh, using conventional means of analysis.[71] In addition, many biomass fuels—especially municipal waste and construction timber—are contaminated with chemical pollutants, pesticides,

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[69] See Arthur D. Little, "Distributed Generation: System Interfaces," *An Arthur D. Little White Paper* (Boston, MA: ADL Publishing, 2000), p. 18; John A. Casazza and George C. Loehr, *The Evolution of Electric Power Transmission Under Deregulation: Selected Readings* (New York: IEEE, 2000), p. 301; Robert Zavadil and Mark McGranaghan, "Working Group Struggles with DG Interconnection Standard." EC&M (June 1, 2002), available at http://www.powerquality.com/mag/power_working_group_strugges/.
[70] Goett and Farmer 2003, p. 22.
[71] Masters 2004, p. 192.

and paint. The separation of these non-biodegradable materials from combustible material are believed to increase the complexity and cost of bioelectric generation, and to impose an additional burden for environmental monitoring.[72]

As another example, utilities often argue that offshore wind projects face a more stringent and complicated permitting process than fossil fueled generators. The organizers of the Cape Wind project near Nantucket Sound in Massachusetts had to assess not only the effects of their turbines on avian species, noise, climate, and maritime security; they also needed to consider the effects on fish species, water quality, marine habitats, commercial and recreational navigation, and telecommunications systems.[73] The strenuousness of permitting and the need for conducting expensive environmental impact assessments can result in longer delays for the approval of off-shore wind projects.

Beyond these problems, DG and renewable energy technology advocates remain hampered by difficulties evidenced when they try to connect their generators to the existing power grid. Naturally, distribution and transmission system operators need to ensure that the hooked-up DG entrepreneurs do nothing that would imperil their ability to maintain voltage control, or keeping voltages within a certain range. DG technologies must not interrupt the balanced flow of alternating current to support proper grid synchronization. In addition, DG technologies cannot be allowed to endanger the lives of people working on the grid, by adding power to it when the workers think it has been de-energized.[74] Moreover, most local distribution networks have been designed as radial grids, meant only to send power in one direction (after they have received power from a transmission station). Renewable energy technologies complicate this design pattern because they enable the distribution of power in the opposite direction, away from transmission stations. Currently, those using distributed generation (DG) technologies, such as renewable-energy facilities, often depend on custom-designed electronics

[72] Bauen, Woods, and Hailes 2004, p. 33.
[73] Carolyn S. Kaplan, "Coastal Wind Energy Generation: Conflict and Capacity," *Boston College Environmental Affairs Law Review* 31 (2004), p. 170.
[74] See Sheldon Steiner, "Pure Power: The ABC's of DG," *Consulting-Specifying Engineer* (March 1, 2004), pp. 14-22; Borbely and Kreider 2001, p. 312; International Energy Agency 2002, pp. 73-85; Francis H. Cummings and Philip M. Marston, "Paradigm Buster: Why Distributed Power will Rewrite the Open-Access Rules," *Public Utilities Fortnightly* 137 (October 15, 1999), pp. 22-31.

packages to solve these problems. The great expense in developing such packages obviously creates a disincentive for new users.[75]

Again, Hughes's notion of momentum may help explain why DG technologies have not been interconnected to the existing system. Joe Catina summed it up nicely by stating that "utilities are by nature monopolistic entities that had a charter to provide adequate energy capacity, with near total control over the production of electricity with little responsibility for cost. Now, they are being asked to lose control over the market yet keep costs low. And many are uncomfortable with the issue of how to control a grid comprised of dispersed generators."[76]

Little incentive exists for utilities and system operators to overcome these impediments; such actors are less concerned about research and development on DG technologies, and more worried about competing in the restructured marketplace. Shawn Collins argues that "at the moment, [none of the utilities] want to work together because the reward for individually solving the problems and monopolizing the market is so high."[77] A 1998 study conducted by the U.S. Government Accountability Office (GAO) concluded that "increased competition from restructuring was cited as the primary reason for the biggest cutbacks in research to date by utilities in California, New York, and Florida."[78] The 2005 revocation of the Public Utilities Holding Company Act of 1935 (PUHCA) could further accelerate this trend, since the financial consolidation of utilities and holding companies will likely convince utilities to shift the focus of their R&D from collaborative projects benefiting society to proprietary R&D giving their affiliates a competitive edge. Empirically, the GAO has noted that when utilities must consolidate, the result is "slowing technology development, sacrificing future prosperity to meet short-term goals, and failing to meet national energy goals."[79]

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[75] Thomas J. Starrs, "National Electricity Policy: Barriers to Competitive Generation," *Hearing Before the Subcommittee on Energy and Air Quality House Committee on Energy and Commerce* (July 27, 2001), pp. 104-109; Allen 2002; Alderfer and Starrs 2000, p. i-ii.
[76] Catina, Personal Interview.
[77] Collins, Personal Interview.
[78] In Victor S. Rezendes, "Electricity Deregulation and Implications for R&D and Renewables," *Hearing Before the Subcommittee on Energy and Environment of the House Committee on Science*, March 31, 1998, p. 97.
[79] Ibid, p. 94-107.

For those who believe that the government should sponsor research and development on DG technologies, it seems unlikely that the federally sponsored R&D would be able to compensate for this underinvestment. Adam Segal, Senior Fellow at the Council on Foreign Relations notes that while federal R&D in technology reached $132 billion in 2005, it continues to be concentrated in the fields of defense, homeland security, and the space program.[80] Federal funding for R&D in efficiency measures, distributed generation, and renewable energy technologies have declined as a portion of real gross domestic product by more than seventy percent over the past ten years.[81] As Kurt Yeager, former president of the Electric Power Research Institute, remarked, "Today the United States invests at a lower rate than its major international competitors … Federal energy-related R&D has declined significantly."[82] Simply put: if PUHCA will promote less investment in private, utility sponsored R&D, don't expect the federal government to pick up the slack.

4.6 Conclusion

To summarize, a host of socio-technical impediments prevents residential customers, small and large businesses, industries, and utilities from investing in renewable and distributed energy systems. Wind and solar energy are perceived to have higher comparative capital costs per installed kW than larger fossil fueled generators. Comparatively greater capital costs make such systems too expensive for consumers and too capital intense for businesses. Business leaders and industrial manages also believe that the installation of DG systems deviates from their firm's core business mission, and most companies would rather do nothing and use their resources to maximize profits in other areas. Furthermore, utilities and system operators resist renewable systems because they are non-dispatchable and are believed only to be as cheap as the centralized fossil fuel technologies they displace. Since such fossil fueled generators typically generate electricity at an avoided cost of around 3 cents per kWh, most renewable systems just cannot compete in the marketplace. Finally, the modularity and flexibility of DG

[80] Adam Segal, "Is America Losing Its Edge? Innovation in a Globalized World," *Foreign Affairs* 83(6) (2004), p. 2-8.
[81] See Woodrow Clark and William Isherwood, "Distributed Generation: Remote Power Systems With Advanced Storage Technologies," *Energy Policy* 32 (2004), p. 1573-1589; S. Julio Friedman and Thomas Homer-Dixon, "Out of the Energy Box," *Foreign Affairs* 83(6) (2004), p. 72-83.
[82] Kurt E. Yeager, "Electricity Deregulation and Implications for R&D and Renewables," *Hearing Before the Subcommittee on Energy and Environment of the House Committee on Science*, March 31, 1998, p. 57.

systems, rather than being seen as advantages, are perceived to make them more difficult to design, install, interconnect, and maintain.

Chapter 5—Political and Regulatory Impediments

"The degree to which distributed generation of any variety threatens the monopoly franchise—that is generation owned in a service territory by somebody other than the monopoly franchise—is a direct assault on the business plan for that company, so they fight it tooth and nail."

--Alex Farrell, professor of energy resources at UC Berkeley, 2005[1]

5.1 Introduction

As the previous chapter emphasized, utility managers and system operators remark that the reason they refuse to invest in DG technologies is because such technologies have higher comparative capital costs per installed kW than fossil fuel generators. System operators also argue that DG technologies are more difficult to standardize. The advocates of DG—entrepreneurs, technologists, and less conservative energy analysts and scholars—acknowledge, too, that business impediments and capital costs can play a significant role in deterring the adoption of DG technologies. However, these advocates also believe that such "financial" impediments can only partially explain why DG technologies remain impeded. Instead, proponents argue that the political power of large utilities and discriminatory regulations they can impose plays a significant role—in addition to the business and utility impediments—in preventing a transition to DG technologies.

This chapter explores political and regulatory impediments to DG and renewable energy systems from the perspective of those making, selling, and attempting to use the technologies. It begins by noting that many analysts believe that the strong political support for DG technologies, after the energy crisis of the 1970s, inflated expectations among the public that the use of renewable energy resources would grow rapidly. Yet a number of unforeseen events occurred: the Reagan administration shifted the energy policy of the country, fossil fuel prices fell in the 1980s, and conventional technologies continued to improve. Advocates of DG suggest that voters and politicians became disillusioned with renewable energy, and relinquished whatever social capital they achieved after the energy crises to utility managers and system operators. After the 1970s, when the country shifted completely back into the fossil fuel paradigm,

[1] Farrell, Personal Interview (October, 2005). Full transcript available in Appendix 2.

inconsistent political support for tax credits created great uncertainty regarding DG technologies. This uncertainty deterred industry investment in renewable and distributed energy systems. As a result, strong utility bias became reflected in numerous state and federal regulations.

At a minimum, the following discussion highlights at least three more aspects of the systems approach. For one, the chapter will argue that immaterial and social aspects—such as public beliefs and expectations—played a large role in preventing the growth of DG technologies. Moreover, the chapter suggests that political and regulatory agencies have become active promoters of the existing electric utility system. Such promotion seems to occur largely because such politicians and regulators endorse the underlying vision held by utilities and system operators: that Americans should be entitled to abundant and cheap sources of electricity.

5.2 Flawed Expectations and Projections

Many of the manifold benefits offered by DG technologies—and elaborated in Chapter 3—convinced people, including President Carter, to zealously push for their adoption in the 1970s. As a result of the OPEC oil embargo of 1973, President Carter made energy policy his first major initiative. Among a set of five laws proposed by Carter and passed by Congress (albeit in greatly diluted form), the Public Utility Regulatory Policies Act (PURPA) of 1978 had the most far-reaching—and least intended—consequences for small-scale energy systems. PURPA spurred creation of radical technologies, began the process of deregulation, and challenged the control held by power company managers.

Superficially, PURPA appeared to pose little threat to utility companies. But one obscure portion of it offered incentives for the use of efficient cogeneration power plants. These small units often produced less than 100 MW of power—about 10 percent of what utility-owned nuclear and fossil units churned out—and they burned coal, natural gas, garbage, or biomass. The resulting heat first produced electricity using a traditional steam turbine. But instead of dumping the low-pressure steam into the environment, as was common practice for utility power plants, cogenerators employed it for industrial processes. A related provision of PURPA also spurred research on environmentally preferable technologies that used water, wind, or solar power to produce electricity.

More successful than anyone originally anticipated, PURPA established the first production tax credits for renewable energy systems such as wind turbines and solar panels.

While Carter's support was instrumental in making the public more aware about the benefits from comparatively cleaner energy, some analysts believe it also catalyzed some people to make unrealistic projections about how fast such energy systems could take off. As Joe Loper from the Alliance to Save Energy put it, "The projections [for renewable energy systems] were too optimistic."[2] Michael Karmis, director of the Virginia Center for Coal and Energy Research, comments that the rising political furor over renewable energy resources convinced policymakers and the public to overestimate the technological breakthroughs needed to transition to a renewable based electricity sector. Karmis concludes that "there was an overestimation of the potential for renewable energy systems and an underestimation of the time, resources, research, and development needed to make them work."[3]

Paul Gilman, former chief of staff for Senator Pete V. Domenici, believes that part of the problem is the way that American policymakers tackle energy problems. Gilman argues that:

> Lots of the energy legislation that was drafted in the 1970s was rather naïve and vague. It said that we should achieve x percentage of our generation from y source by this year, and there were lots of goals and laudable things … That tends to be the context in which Americans approach technological problems: we set lofty and daring goals. We were not smart, doing the market analysis of what is doable, and integrating that with an understanding of the energy sectors—transportation, buildings, and so on—and taking an integrated look at the overall picture.[4]

As a result, Gilman concludes that politicians went about promoting renewable energy systems "in the wrong way."

However, a number of unforeseen events shifted the electric utility system back in favor of fossil fuels. Chris Namovicz and Alex Farrell argue that many researchers

[2] See Joe Loper, Personal Interview, February 7, 2006; Full transcript available in Appendix 2.
[3] See Michael Karmis, Personal Interview, February 16, 2006; Full transcript available in Appendix 2.
[4] See Paul Gilman, Personal Interview, August 3, 2005; Full transcript available in Appendix 2.

believed natural gas supplies would run out and that oil prices would rise between $30 and $60 per barrel (in 1970s dollars). However, OPEC strategically decided to increase its supply, driving the price of oil down in 1974. A few years later, natural gas markets were deregulated with the Natural Gas Policy Act of 1978, lowering the cost of natural gas. Around the same time, the Staggers Act of 1980 restructured the railroads, further pushing the price of coal downward.[5] Brian Castelli, the Executive Vice President for the ASE and a former program officer at the U.S. Department of Energy during the 1970s, explains that:

> A big reason renewables never met its expected potential is because the target price for technologies that compete with renewable and distributed energy systems continues to drop relative and faster than the prices for most renewable technologies. For example, renewable systems compete against coal fired generation, and coal just becomes cheaper and cheaper. No matter now much we cut down the cost of PV and wind, the coal price continues to fall faster.[6]

When devising their original economic estimates about the future competitiveness of renewable energy systems, most analysts assumed that fossil fuel prices would continually escalate, rather than gradually decline.

The declining cost of fossil fuel was coupled with improvements in the technical proficiency of fossil fueled generators. Adam Serchuk, senior program officer at the Energy Trust of Oregon, explains that "established technologies didn't stay as they were built. Natural gas combined cycle turbines, for example, became more efficient, they didn't just stand still as a dead and dying technology."[7] And Chuck Goldman, program director for renewable energy at the Lawrence Berkeley National Laboratory, argues that "unforeseen improvements in traditional electrical generation technology also ended up distorting the initial estimates and cost targets for renewable systems."[8] Additionally, it took much longer than expected to bring down the capital costs of renewable energy systems. Scott Sklar, the president of a solar panel manufacturing company, notes that,

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[5] See Alex Farrell, interview; Chris Namovicz, Personal Interview, February 8, 2006; Full transcript available in Appendix 2.
[6] See Brian Castelli, Personal Interview, February 7, 2006; Full transcript available in Appendix 2.
[7] See Adam Serchuk, Personal Interview, February 21, 2006; Full transcript available in Appendix 2.
[8] See Chuck Goldman, Personal Interview, October 25, 2005; Full transcript available in Appendix 2.

while it was expected renewables would develop themselves almost by "immaculate conception," it instead took decades to scale up the manufacturing and delivery mechanisms needed to make renewable energy systems economically competitive.[9]

Consequently, people misestimated the cost of conventional fossil, renewable energy systems, and nuclear energy. Chris Namovicz, an energy analyst with the EIA, concludes that "fundamental assumptions of 1970s forecasts that saw huge markets for renewable energy were proven false."[10] Ryan Wiser, a staff scientist at the Lawrence Berkeley National Laboratory, argues that "this is the principle reason renewables never took off: the cost of fossil fuel and alternative fuels did not raise commeasurably."[11] John Warren, director of the Virginia DMME, comments that "the ability for renewables to enter the market and compete with traditional sources of energy just never occurred."[12]

Furthermore, on top of having to compete with more natural gas turbines using cheaper fuels, renewables had to compete with cost effective efficiency measures and overcome utility resistance. Chuck Goldman adds that:

> In relative terms, with energy efficiency, you can capture a sizeable amount of the resource at a cost considerably less than conventional supply-side options. And for renewables, it's only been in the last couple of years where some renewable technologies are cost competitive with traditional supply-side technologies. On the supply-side, fossil-fuels ended up being cheaper, and on the demand side, energy efficiency practices ended up being cheaper. Both impeded a wider use of renewable energy systems.[13]

Electric utilities—because they already served as the intermediary between consumers and fossil fuel providers—were also the ones often charged with promoting the use of renewable energy technologies. Adam Serchuk states that this "didn't make sense" and represented a classic conflict of interest: "utilities had the responsibility of returning profits to their shareholders (and thus trying to get Americans to purchase more electricity), but were also asked by regulators to use energy efficiency programs and

[9] See Scott Sklar, Personal Interview, February 9, 2006; Full transcript available in Appendix 2.
[10] Chris Namovicz, Personal Interview.
[11] Ryan Wiser, Personal Interview, October 25, 2005; Full transcript available in Appendix 2.
[12] John Warren, Personal Interview, September 16, 2005; Full transcript available in Appendix 2.
[13] Goldman, Personal Interview.

renewable resources to get Americans to conserve energy."[14] Toben Galvin, a senior energy analyst with the Vermont Energy Investment Corporation, suggests that even today "there is complete disinterest on the part of utilities and fossil fuel suppliers to conserve electricity or energy," either through energy efficiency programs or more efficient generation technologies.[15] Ralph Loomis, senior vice president for Exelon, comments that "utilities are not in the energy efficiency business. It is almost antithetical to say that the people making money selling electricity to people should somehow not be in the business of selling electricity."[16] David Garman, current undersecretary of energy for the U.S. Department of Energy, put it this way:

> Right now, a lot of investor owned utilities are in the business of selling electrons, and while they have legitimate interests in issues like backup or peaking power, they don't have much of an incentive to switch to a more distributed energy framework.[17]

As a result, utilities generally either paid lip service to renewables but chose energy efficiency practices instead, which they perceived as more cost effective, or did nothing.

The confluence of these events—lower fossil fuel costs, more efficient fossil fuel generators, comparatively higher renewable energy costs, and split incentives between renewables and other utility practices—greatly challenged the accuracy of predictions made about renewables in the 1970s. Ironically, the very same enthusiasm that engendered so much support for renewable energy systems also contributed to their "downfall." Marilyn Brown, interim director of engineering science and technology at the Oak Ridge National Laboratory, explains that such premature enthusiasm turned many people off from renewables all together, and that:

> The policies of the 1970s did not catalyze the renewable energy industry. The technologies, simply put, were not ready for prime time, and when they failed they gained a blemished reputation. Solar technology (for instance) wasn't ready, but political factors associated with the energy crisis pushed it ahead anyway. Renewable energy wasn't ready to be

[14] Serchuk, Personal Interview.
[15] Toben Galvin, Personal Interview, September 29, 2005; Full transcript available in Appendix 2.
[16] Loomis, Personal Interview.
[17] Ibid.

> incentivized, and the whole market disintegrated. This set the industry back instead of accelerating it.[18]

Theresa Jurotich adds that intermittent political support for renewable energy systems did more than just hurt government programs. When the American renewable market collapsed, it poisoned the country's intellectual consciousness towards alternative energy systems. The country's physical landscape was littered with images of broken down wind and solar farms, and its business landscape was haunted by memories of bankrupt American renewable energy manufacturers. Jurotich concludes that "the specter of failed American wind projects during the 70s and 80s has effectively kept wind power from becoming a major player in the U.S. electric industry."[19] James Gallagher, Director of the Office of Electricity and Environment for the New York State Department of Public Service, comments that "the early failures or hurdles with renewables turned people off from the technologies … people developed a bad taste in their mouth."[20] Thus, renewables were paradoxically a victim of their own success: public favor quickly turned to either apathy or resistance once the expectations for renewable energy failed to materialize.

5.3 Variable and Inconsistent Incentives for Renewable Energy Technologies

Moreover, DG advocates argue that public disinterestedness and contempt for renewable energy systems enabled utilities and interest groups to further fight against their adoption. The most obvious element of this apathy and opposition concerns the flagrant, inconsistent political support for renewable energy systems. Unlike subsidies and incentives for fossil fueled technologies, policies aimed at encouraging renewable energy (and distributed generation technologies) have changed frequently, greatly discouraging their widespread adoption. Since all policy is politically and ideologically motivated, such inconsistency should not seem unexpected. Joe Loper, Vice President for Research and Analysis at the Alliance to Save Energy, remarked that:

> It is going to take one hell of a crisis to get serious about energy issues in the United States. Politicians have some special interests driving them, but they—and their inability to confront energy issues seriously, challenge

[18] Marilyn Brown, Personal Interview, September 4, 2005; Full transcript available in Appendix 2.
[19] Jurotich, *Network Infiltration*, p. 3.
[20] See James Gallagher, Personal Interview, October 4, 2005; Full transcript available in Appendix 2.

> entrenched attitudes about consumption, and really raise awareness about energy issues—are really a reflection of society at large."[21]

Ken Tohinaka of the Vermont Energy Investment Corporation went so far as to claim that "I don't think there ever has been a true national energy policy in this country … the U.S. model tends to operate through annual appropriations which are routinely cut or adopted only at the last possible moment, making it hard to invest in or plan long-term energy efficiency practices."[22]

To be fair, some politicians have tried to actively promote DG technologies. Because of his political (and spiritual) beliefs that esteemed personal sacrifice and changes in fundamental values concerning consumption, President Carter advocated legislation, regulations, and tax credits to spur energy-efficiency and renewable-energy technologies. However, these incentives expired in 1986 with the Reagan Administration. The free-market believing Ronald Reagan symbolically removed the solar collectors from the roof of the White House and took more substantive measures to end federal programs and tax credits that encouraged efficiency and alternative energy technologies.[23] David Baylon, an energy consultant, argues that the end of the Carter Administration signified the end of the country's focus on energy policy:

> When people in the 1970s were saying they thought renewables were the way of the future, the U.S. government was pumping in over $1 billion into energy research and development. Since the 1980s, we've probably put a $1 billion all together into research and development.[24]

Reagan, in direct contrast to Carter, reverted back to what energy analyst Jan Harris refers to as the "subsidize oil and gas" and the "dig, dam, drill" approach to energy policy.[25] Such a shift in national priority had far reaching consequences in promoting fossil fuel technologies, and disadvantaging smaller DG technologies.

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[21] Joe Loper, Personal Interview, February 7, 2006; Full transcript available in Appendix 2.
[22] Ken Tohinaka, Personal Interview, September 29, 2005; Full transcript available in Appendix 2.
[23] Peter Behr, "Solar Industry Worried Reagan Might Pull the Plug; Solar Electric Industry Worried Reagan Might Pull the Plug," *Washington Post* (29 September 1981), p. D7; Stephen Greene, "Solar Energy Industry Slips Into the Shadows; Fall in Oil Prices, Changes in Tax Rules Hurt Sales," *Washington Post* (9 November 1986), p. B1; and M.K. Heiman, "Expectations for Renewable Energy Under Market Restructuring: The U.S. Experience," *Energy* 31 (2006), pp. 1052-1066.
[24] See David Baylon, Personal Interview, August 15, 2005; Full transcript available in Appendix 2.
[25] See Jan Harris, Personal Interview, September 29, 2005; Full transcript available in Appendix 2.

For instance, the transition from the Carter Administration to the Reagan Administration did more than financially endanger government research and development for distributed and renewable energy resources: it drove some people out of the renewable and small-scale energy industry altogether. Sam Fleming, an energy consultant with 30 years of experience building renewable energy projects, explained it this way:

> Many people in government had high expectations for renewables, including things that went to Congress for demonstration and commercialization programs, concentrating solar energy projects in the Mojave Desert, various kinds of incentives, power purchase agreements, and tax credits under PURPA which translated into a flurry of activity for renewables. However, in the early 1980s the government quickly removed key incentives—including accelerated depreciation—and several renewable energy projects had to be abandoned mid-way through construction and companies went bankrupt.[26]

Wilson Prichett, a consultant who has managed more than three hundred renewable energy projects in the United States, argues that President Reagan discouraged everyone—not just policymakers in the government—from working on energy systems. As a result of Reagan's policies, Prichett recalls that:

> By 1982 or 1983, most everyone had left the industry. All those thousands of people around the country working on ways to convert agricultural waste to fuels and different solar and wind designs just stopped doing it. There was no political encouragement. In fact, there was complete discouragement.[27]

And Tommy Thompson, a researcher for the Virginia DMME, explains that "when we were doing solar technologies back in the 1970s, it was only because of the incentives being given that made the projects viable. The incentives dried up, and then the renewable industry dried up."[28]

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[26] Fleming, Personal Interview.
[27] Prichett, Personal Interview.
[28] Thompson, Personal Interview.

As another sign of its potential bias towards fossil fuels and large generators, the federal government has been equally inconsistent in the promotion of tax credits for renewable energy resources. The Energy Policy Act of 1992, signed by Reagan's successor, George H.W. Bush, provided a production tax credit for certain renewable energy technologies (For a more complete list of political incentives, see Appendix 3). But those credits expired in 1999, and environmental advocates worked diligently to win Congressional approval for their reinstatement, often on an annual basis.[29] When Congress failed to restore the credits before the end of 2001, investment in wind turbine projects dropped precipitously. Developers installed only 410 MW of new wind turbines in 2002, down from about 1,600 MW in 2001 and 2003.[30] Janet Sawin, Director of the Energy and Climate Change Program at the Worldwatch Institute, comments that the conflicting policies for wind turbines in the United States have created "boom and bust cycles" within the industry, making it all but impossible to obtain financing for projects.[31] Today, analysts expect another boom cycle with passage of the Energy Policy Act of 2005, but even that law extends the credits only for construction of projects completed before the end of 2007.[32]

While government tax credits, in theory, are supposed to foster the development of novel technologies, in practice DG proponents argue that such tax credits have sometimes been tragic for renewable and distributed energy systems. Larry Papay, the Chair of the California Council on Science and Technology, sees a problem in at least two areas:

> Many of the well intentioned incentives put in place for renewables have been the wrong ones, such as investment tax credits rather than production tax credits thereby guaranteeing the technologies actually get into operations. And then, even when inventive programs can be the "right" ones, they tend to expire on a yearly or bi-yearly basis, meaning that

[29] CarolAnn Giovando, "Despite Banner Year, Wind Energy Faces Major Challenges," *Power* 143 (November/December 1999), p. 47.
[30] "Wind Group Says Loss of Tax Credits Stalls 1,000 MW," *Megawatt Daily* 9 (6 January 2004), p. 8.
[31] See Janet Sawin, Personal Interview, April 7, 2006; Full transcript available in Appendix 2.
[32] American Wind Energy Association, "New Energy Bill Extends Wind Power Incentive through 2007," available at http://www.awea.org/news/energy_bill_extends_wind_power_072905.html.

> developers are reluctant to commit large sums of money to renewable projects.[33]

Ralph D. Badinelli, a professor of business information technology at Virginia Tech, notes that certainty is the single most important factor in determining whether companies and manufacturers will choose to invest in certain energy technologies. As Badinelli explains:

> The more uncertainty there is about the future, the higher the risk premiums placed on investment returns. Furthermore, the risk of investments in alternative energy generation systems is amplified by the long terms of these investments – generators usually are considered capital investments with decades-long lifetimes.[34]

Adam Serchuk believes that "the mere uncertainty of the tax credit itself creates a host of problems … banks often refuse to finance DG projects, insurers refuse to protect them, and local employees resist them."[35] Chris Namovicz of the U.S. Energy Information Administration admits that tax credits have created "significant uncertainty regarding investment" in renewable resources.[36]

Consequently, the variability of policy relating to renewable energy technologies serves as a serious impediment. Entrepreneurs seeking investment from individuals and institutions often require consistent conditions upon which to make decisions. Forecasts of profitability usually require data concerning tax credits, depreciation schedules, cash flows, and the like, well into the future. When policymakers frequently change the factors that go into these financial calculations, they insert an extra level of uncertainty into the decision-making process. Donald Aiken has stated that "an effort to promote renewables has to be sustained, orderly, substantial, predictable, credible, and ramped."[37] In the United States, formal policy has tended to vary for DG technologies on each of those criteria at the same time it has remained consistent for fossil-fueled generators.

5.4 Lingering Utility Monopoly Rules and a History of Control

[33] Larry Papay, Personal Interview, September 21, 2005; Full transcript available in Appendix 2.
[34] Badinelli, Personal Interview.
[35] Serchuk, Personal Interview.
[36] Namovicz, Personal Interview.
[37] In Sobin, Personal Interview.

Analogously—and consistent to what Hughes would expect—some scholars and analysts argue that utilities have actively used their "power of incumbency" to further mold federal and state regulations in favor of large, centralized plants (and disadvantage small, decentralized units). Alex Farrell, a professor of energy resources at the University of California at Berkeley, stated the problem, simply, is that "whether local utilities or large manufacturing firms, once large-scale energy systems are in place, it becomes very difficult to dislodge them."[38] Alan Crane from the National Academies elaborates that perhaps the most significant impediment for DG and renewable energy systems is an institutional, rather than a technological, dilemma. According to him:

> System and transmission operators don't recognize many renewable and DG technologies as being part of their network because they are not dispatchable …. It's not in the "right people's" interest to fix interface problems like interconnection and intermittency when such improvements will do little (in their view) to improve control of the overall system. Technically, these technologies can be incorporated into the grid easily. Socially, much institutional resistance remains.[39]

Utility resistance to DG systems is often as much about institutional culture as it is about technology. Judi Greenwald of the Pew Center on Global Climate Change argues that, regarding DG, "the biggest impediment is inertia—institutional, market and technological. We have been doing central station generation for a long time and our institutions, markets and technologies have evolved along that paradigm. Attempts to shift that paradigm run into resistance on all these fronts."[40] Energy trader Michael Pomorski notes that an "institutional inertia problem exists that favors centrally dispatched power plants and requires rate-based recovery for capital expenditures up front."[41] Analyst Paul Gilman argues that "most utilities still defer to fossil-fuel fired, centralized generators" because "their mindset, existing infrastructure, and regulatory environment push them in that direction."[42]

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[38] Farrell, Personal Interview.
[39] Crane, Personal Interview.
[40] Judi Greenwald, Personal Interview, February 13, 2006; Full transcript available in Appendix 2.
[41] Pomorski, Personal Interview.
[42] Gilman, Personal Interview.

Ultimately, because the system had acquired so much momentum, industrial managers began to express a preference towards traditional energy technologies. A recent 2006 report undertaken by the American Council for an Energy Efficient Economy found that "the structure of the majority of state regulation in the U.S. makes the adoption of distributed energy resources projects unprofitable and thus highly unattractive for the utilities."[43] And David Moskovitz of the Regulatory Assistance Project believes that "how utilities are regulated is the most important determinant of whether they have an incentive to deploy or obstruct cost effective distributed resources."[44]

Consider the following narrative told by Tom Casten, CEO of Primary Energy, a company that installs CHP technologies, about the opposition he faced in when he tried to deploy six cogeneration units in New York City. As he explains:

> I'll tell you a funny story from the 1970s. We were trying to develop on-site combined heat and power plants in NYC, which is served by Consolidated Edison (Con Ed), one of the world's largest. Con Ed is threatened and asked the mayor for a special hearing to consider the health effects of cogeneration. In keeping with the societal mind-set that monopoly utilities are optimal and must be protected, the Mayor's office sets up a hearing, chaired by a Deputy Mayor, but fails to invite us. We are at this time the only active developer of on-site power in NYC. We learn of the meeting three days before, rush together a presentation and demand a spot. The hearing is a setup. The chairman of Con Ed, Charles Luce, is in the audience; a Con Ed Senior Vice President is running the show. They have an elaborate presentation made by Dr. Peter Freudenthal, Con Ed's environmental expert. We were proposing to install eight engines in the bottom of a commercial building in downtown New York to generate the building's electricity, and by recycling the waste heat to produce heat and chilled water, achieve double the efficiency of the Con Ed generation fleet. Our project would take one building in

[43] Susanne Brooks, Brent Elswick, and R. Neal Elliott, "Combined Heat and Power: Connecting the Gap Between Markets and Utility Interconnection and Tariff Practices," *Report for the American Council for an Energy Efficient Economy* (March, 2006), Report IE062, pp. 5-6.
[44] Ibid, p. 5.

> Manhattan off of the Con Ed system. Dr. Freudenthal made an elaborate, illustrated presentation that was designed to feel 'scientific', showing that the nitrous oxide from our 8 megawatt plant would exit the 40 story high stack, and miraculously drop right to street level, causing a condition he called 'pharyngeal dryness.' He didn't explain how this hot, bouyant exhaust was going to descend forty stories. He didn't explain how the exhaust from Con Ed's 2,000 megawatts of Manhattan power plants, whose stacks are not any higher than 40 stories, would obey different physical laws and obediently rise and move out over the Atlantic ocean.. But the good doctor claimed that if Cummins Cogeneration Company was allowed to install this relatively tiny plant, New Yorkers would begin to suffer from pharyngeal dryness. Thankfully, we persuaded the panel that this argument was silly, and the panel decided to not act on Con Ed's request to ban cogeneration until further study. Thirty years later, the story is funny, but it is sadly one of a great many experiences of monopoly electric utilities using their considerable resources to fight any generation that does not flow through their wires.[45]

Obviously, policy variability alone does not explain the difficulty that entrepreneurs have in employing DG technologies that have already become relatively mature, such as cogeneration plants and even some wind turbines. More significantly, these people face hurdles when dealing with the administrators of the existing transmission and distribution system, who seek to retain a number of traditional, "time-tested" regulatory and utility practices that have existed for upwards of a century. Also seeking to maintain control over a system they (and their predecessors) created, they have made it difficult for new players to play on their turf.

Numerous advocates of DG technologies argue that they have personally encountered utility resistance to their technologies. Tom Casten, for example, notes that in his experience:

> Regulated utilities have tremendous bias to increase throughput, and they instinctively fight against companies that provide electricity from

[45] Casten, Personal Interview.

> alternative sources. This is ultimately the much larger cost of our central generation paradigm approach: that unless the many barriers to competition in retail delivery of power are removed and third party providers are able to capture the true value of distributed generation, then the independent power companies will gravitate towards large remote generation and large industrial generation.

Edward Vine, who directs the energy efficiency research at the Lawrence Berkeley National Laboratory, commented that:

> The people in control of the power system—oil firms, coal companies, nuclear energy producers—have a substantial amount of investment in traditional technologies. Such institutions, which have become a powerful political force because of their market power, are reluctant to change their existing technologies and see the market share of these technologies dwindle. Historically, they have helped promote their existing technologies at the expense of renewable technologies.[46]

And Paul DeCotis, Director of Energy Analysis for the New York State Energy Research and Development Authority, comments that "the primary concern of facility owners, system operators, and utilities is personnel safety and security of the grid system. I think the reluctance on the utility's part to interconnect and buy generation serve as the most significant impediment to widespread adoption of DG. The more DG there is on a system, the less direct control a utility might have over its system."[47]

A few, independent studies have started to confirm that system operators have attempted to retain their control over the electric utility system by employing a wide variety of predatory and discriminatory practices. Such efforts typically begin with the imposition of fees to connect to the grid. In many states that have begun restructuring their utility systems, formerly regulated "natural monopoly" power companies have been permitted to charge customers "stranded costs."[48] These costs are intended to cover a "fair return" on generation and transmission investments made by utilities during the era

[46] Edward Vine, Personal Interview, October 25, 2005; Full transcript available in Appendix 2.
[47] Paul DeCotis, Personal Interview, October 4, 2005; Full transcript available in Appendix 2.
[48] See Arthur D. Little 2000; Anthony Allen, "The Legal Impediments to Distributed Generation," *Energy Law Journal* 23 (2002), pp. 505-523. For a great primer on stranded costs and their legitimacy, see Maloney and Brough 1999.

of regulation, when the investments were viewed as serving all users. Put simply, when a customer decides to install an electric generator independent from the utility, he or she arguably removes part of the grid's existing load requirement and "strands" part of the investment the utility made in the power system. But such fees greatly increase the cost of renewable energy systems because customers must pay them in addition to the cost of buying power from the new technology.[49]

Utilities also require payment of a host of charges on those who use renewable energy systems that run intermittently. Rodney Sobin, former innovative technology manager for the Virginia Department of Environmental Quality, comments that:

> Confronted with the uncertainty of restructuring, most utilities defer to their time-tested mentality of a centralized plant, owned and operated by a regulated utility being a monopoly provider of power. And a strong desire exists among many utilities to preserve that power and control …. Other utility governance policies are predicated on the one way model of the central utility selling power to the customer rather than the more interactive and fluid grid style management. Thus wires charges, stranded assets, unfair rates of return, and other practices continue to make it difficult for third party power producers—DG or not—to generate electricity.[50]

For example, they may ask for high rates for providing backup power for when the intermittent renewable-energy technologies do not produce power. They may also charge demand fees (a charge that penalizes customers for displacing demand from utilities) that discourage the use of intermittent power systems. A recent study undertaken by the National Renewable Energy Laboratory found more than seventeen different "extraneous" charges associated with the use of dispersed renewable technologies.[51]

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[49] Denise A. Bode, "The Role of Federal Electric Utilities," *Hearing Before the House Subcommittee on Energy and Power* (May 19, 1999), p. 137; Daniel W. Reicher, "Distributed Generation Technologies," *Hearing Before the Senate Committee on Energy and Natural Resources* (June 22, 2000), p. 8.
[50] Sobin, Personal Interview.
[51] See R. Brent Alderfer and Thomas J. Starrs, "Making Connections: Case Studies of Interconnection Barriers and Their Impact on Distributed Power Projects," *National Renewable Energy Laboratory Report NREL/SR-200-28053* (2000).

These types of charges, the senior editor of *Public Utilities Fortnightly* exclaimed, "are a major obstacle to the development of a competitive electricity market."[52]

Other obstacles seem to exist simply because of the newness of some DG technologies. Consider the case of the micro-turbine. Despite their apparent more efficient operation, dual-fuel capability, and modularity, micro-turbine technology is regarded by utility executives as too "new" and "untested" to deploy. Utilities argue that the number of experienced personnel and spare parts remains limited when compared to conventional generators. Only a small number of suppliers manufacture micro-turbine technology, resulting in low manufacturing volume and few corresponding sales channels.[53] Ultimately, perceived limited sales penetration means that a credible field performance database on system performance does not yet exist, although Capstone Turbine Corporation is in the process of developing one. The technology is also so new that it is not recognized in most building codes. Thus, incumbent utilities—and energy policymakers more generally—know little about the operation, control, and capability of the technology.[54] As a result, micro-turbine technology (and indeed, most new forms of CHP technology) lacks market penetration and credibility among policymakers and administrators making decisions about energy, predominately because most utilities are only familiar with a handful of traditional fossil-fueled technologies.[55]

And, as a particularly insidious example, consider the case of interconnection standards (briefly discussed in the previous chapter). Rather than trying to work with DG manufactures or local customers to resolve the legitimate issue about standardizing how distributed units interconnect to the grid, utilities have instead tended to actively block or impede small scale units from attaching to the grid. To be fair, no national standard for interconnection currently exists. Interconnection procedures that have been implemented—when they exist at all—vary greatly between utilities, municipalities, cities, and states.[56] David Garman admits that, despite almost a decade of discussion on

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[52] Richard Stavros, "Distributed Generation: Last Big Battle for State Regulators?" *Public Utilities Fortnightly* 137 (October 15, 1999), pp. 34-43.
[53] International Energy Agency 2002, p. 26-27.
[54] Borbely and Kreider 2001, p. 148-149.
[55] Jan Berry, Personal Interview, August 1, 2005.
[56] See David Garman, "National Energy Policy," *Hearing Before the Senate Finance Committee* (July 19, 2001), p. 23; Allen 2002, p. 507; Kolanowski 2000, p. 42-43.

the issue, "interconnection in this country is still highly inconsistent between states."[57]Scott Sklar calls the situation "totally absurd," and he elaborates that:

> The U.S. still needs a national interconnection standard. Currently, over 20 different states have varying technical rules (loosely based on the IEEE 1547** standard) for interconnection, and still they are different enough so that manufacturers of DG technologies' interconnection equipment have to make different devices for almost every different state market … When the telephone industry was deregulated, Congress passed a national interconnection standard for telephones so that, whether plugged into a home in New York or California, they would still work. We need the same thing for DG technologies. A national interconnection standard is absolutely essential to provoke an evolution in interconnection equipment desperately needed for DG systems to take off, and will also allow them to be more compatible with smart meters that will be critical in any building or facility.[58]

Instead, utilities and system operators often charge exorbitant sums of money to even begin the process of interconnecting a DG system to the grid.

For example, PJM Interconnection—not an incumbent utility, but an incumbent service operator responsible for one of the large power grids in the Northeast—mandates that customers wishing to interconnect distributed generators to the utility's transmission network conduct an extensive feasibility study. In addition, Section 36.1 of the PJM tariff requires a $10,000 surcharge—regardless of the size, ownership, or location of the connecting generator— for anyone who attempts to interconnect to PJM's transmission system.[59] This fee serves as an especially large disincentive for small-scale power generators. In the Pacific Northwest, some utilities require a $2 million bond to be placed by all parties seeking to connect DG systems with the utility in order to protect the grid. Adam Serchuk comments that "utilities pretty much still possess unadulterated

[57] Garman, Personal Interview.
[58] Sklar, Personal Interview.
[59] See PJM Interconnection LLC, "OATT Attachment Feasibility Study Agreement Form," 2005, Retrieved from http://www.pjm.com/planning/expansion-planning/form-oatt-feas-study.html.

control over electricity contract practices, and the negotiation process turns out to be real onerous for mid size businesses."[60]

Despite efforts by the National Association of Regulatory Utility Commissioners, the Federal Energy Regulatory Commission, and the Institute of Electrical and Electronics Engineers (IEEE), the federal government has not yet established standardized requirements for interconnecting renewable energy technologies and distributed generators with the grid.[61] As the National Energy Policy Development Group concluded in 2001, "the lack of interconnection standards or guidelines for electricity supply and load impedes the use of distributed energy technologies."[62] Forty-eight states (excluding Texas and Vermont) have not yet established standard interconnection procedures, making utility interconnection specifications greatly variable and inconsistent. A study assessing the impediments to DG systems in New York State cautioned that the complexity of utility interconnection procedures deters investment in DG systems, and that unclear responsibilities, time delays, and the cost of interconnection equipment (and associated studies) severely impede the adoption of DG systems.[63] Collectively, problems with interconnection prevent DG technologies from being fully preassembled for "plug and play" style installation, and make it difficult for industries or corporations to install DG systems in more than one region (since they then must accommodate competing standards and rules).[64] Standards remain oriented towards large generators, and often suffer from inflated tariffs and standby charges. The hurdles associated with interconnection therefore decrease the economic viability of DG technologies because they interfere with the ability for users to sell power back to the

[60] Serchuk, Personal Interview.
[61] And it's no wonder, given the experience at the IEEE, for example. Having recognized the interconnection problem, the IEEE established a standards coordinating committee that began to develop rules for interface technologies. However, no agreement on the specific details of new standards appears imminent. The list of committee members included 385 names (in early 2002), representing scores of investor-owned and public power utilities, manufacturers, government laboratories, state agencies, and consultants. Seeing advantages and disadvantages to acceptance of any single technical standard, members will have a difficult time reaching a consensus in a way that illustrates effectively the social nature of technological change. For more, see IEEE, "IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems," http://grouper.ieee.org/groups/scc21/1547/1547_index.html.
[62] National Energy Policy Development Group 2001, p. 6-15.
[63] Bourgeois et al 2003.
[64] Steven Nadel, "National Energy Policy: Conservation and Energy Efficiency," *Hearing Before the Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce* (June 22m 2001), p. 53-54.

grid (and thus pay off their initial capital investment, an impediment discussed previously in Chapter 4).

Ironically, large, centralized utilities are not always at fault for impeding the interconnection of DG energy systems. Shalom Flank, an energy consultant, notes that his experience has shown that:

> Interconnection rules and standards have been unable to overcome the absolute veto power of local utilities. Astonishingly, even when the executives of a utility have joined the DG/RES cause, they cannot overrule their own distribution departments. We've encountered that particular phenomenon multiple times. We've talked about getting some foundation to support the formation of an "Interconnection Strike Force": when a utility raises the usual roadblocks to a DG/RES project – such as delays, endless studies, safety objections, gold-plating, or simply outright refusal – we would parachute in with a crackerjack team of lawyers, engineers, and lobbyists to use the existing laws, regulations, and political pressure points to break through their resistance. Countless projects have died because of the lack of such a strike force, doomed by the expense, uncertainty, and delay that the utilities can impose almost effortlessly.[65]

In some instances, even when DG systems gain the support of large utilities, local public utility commissions and systems operators can still manage to thwart the adoption of DG technologies. Put another way: even when DG technologies gain the support of one of the layers in the current electric utility system, the rest of the system continues to act as an impediment. The fees and other efforts to frustrate the goals of DG entrepreneurs also appear based on the desire to achieve other goals, such as the apparent need to remain in control of "their" system.

5.5 Conclusion

The tendency for large, investor owned utilities, system operators, and local public utility commissions to oppose the introduction of smaller, decentralized technologies remains consistent with that the systems approach suggests about technology. The existing electric utility system has acquired so much momentum that it

[65] See Shalom Flank, Personal Interview.

exerts great influence on the political and regulatory structure in the United States. Even though Chapter 3 noted that DG systems may have the potential to greatly improve the stability and efficiency of transmission networks, utilities and system operators have convinced politicians to see things differently. Brice Freeman of the Electric Power Research Institute explains that many utilities will continue to view DG systems as a lose-lose situation. Utilities have to build feeder extensions, construct transmission lines, and deal with all of the challenges associated with interconnecting generators that they don't control to their grid, only to lose revenue from customers. Brice concludes, "since regulated utilities … often come out the looser on DG projects, the utilities have little incentive to promote the proliferation of DG in their service territory."[66] Because incumbent utilities and wires operators can still control access to their system, they erect regulations and policies that make it more difficult to use DG technologies.

[66] Freeman, Ibid.

Chapter 6—Cultural and Behavioral Impediments

"Twenty-five years of efforts towards developing industrial generation plants has taught me that there are other, deeper barriers to efficiency that go beyond legal impediments, obsolete monopoly protection rules, and flawed regulatory structures."

--Tom Casten, CEO of Primary Energy, 2005[67]

6.1 Introduction

Unlike the previous two chapters—which dealt with the perceived impediments facing DG systems from the perspective of utilities and businesses (Chapter 4) and policymakers and regulators (Chapter 5)—this chapter addresses the cultural and behavioral impediments to distributed and renewable energy systems. Because many of these deeper impediments tend to be more subtle and diffuse, the chapter draws heavily from work being done in the history and sociology of technology, energy, and the environment. Thus, while some relevant views from utilities, businesses, and energy analysts are included, the chapter attempts to take the "view from nowhere" in assessing cultural attitudes and practices. Thus, the chapter predominately focuses on what professors and academics have to say about the values and interests associated with electricity supply and consumption.

Electricity—while bought, sold, and traded as a commodity on the American market—is really unlike any other item. It is impossible to stockpile electricity without expensive storage technologies, and the product must be produced and consumed almost simultaneously. A unique disjuncture occurs between its appearance at the point of consumption (something clean and abundant) and its point of creation (something typically dirty and manufactured). The apparent disconnection between how electricity is made and how it is socially perceived perpetuates public apathy and misinformation about it. This misunderstanding pervades not just ordinary customers but also the builders of homes, facilities managers, zoning officers, and local officials. Furthermore, the American electricity market shelters consumers from the true costs of electricity generation. Thus, many Americans believe that they are entitled to cheap and abundant sources of electricity, but they lack the necessary understanding of what needs to occur so that they continue to have access to such a supply. As a result, renewable and DG energy

[67] Casten, Personal Interview.

systems are often opposed not because they are a poor alternative to fossil fuels, but because people simply don't comprehend why such technologies may be needed. Far from becoming an unintentional side effect of the "hub and spoke" model of electricity supply, some evidence suggests that public "ignorance" towards electricity is an important—and planned—part of the existing technological system. The lack of public interest in the electricity sector allows utilities and system operators to more easily maintain control over their system.

To explain how American consumers perceive electricity, it is necessary to briefly explore a few basic facts about the product itself. Ever since the 1880s, commentators have been speaking about how electricity is unique among all industrial enterprises. As the President of the American Educational Institute remarked in 2000:

> Electricity is difficult, really impossible, to visualize. I can hold a pound of coal, or a 16 ounce jar of oil or gas, in my hand. A few of us could hold a pork belly. But no one I know could hold a kilowatt-hour of electricity … electricity is different, it's an abstraction, not a commodity, but a phenomenon."[68]

A secure and constant supply of electricity is always needed, yet it cannot be easily saved in large quantities, meaning no surplus can ever be effectively maintained without generating more of it. Of course, batteries can store electricity, but such storage systems are still uneconomical for amassing large amounts of it, and options like pumped storage require the availability of significant sources of water. Moreover, there are no feasible substitutes for electricity. Demand is can be unresponsive to price, fluctuating from season to season and day to day. Electricity can only be transported through an extensive transmission and distribution network, yet the grid has essentially no switches for routing power, meaning that the actual physical delivery patterns for electricity can never match the contractual arrangements for the sale of electricity, since it flows through the entire grid.[69] These exceptional attributes of electricity make it unlike any other item bought, sold, and used in the marketplace.[70]

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[68] Casazza and Loehr 2000, p. 17.

[69] See Niels I. Meyer, "Distributed Generation and the Problematic Deregulation of Energy Markets in Europe," *International Journal of Sustainable Energy* 23(4): 217-221; Rolf Kehlhofer, et al., *Combined-Cycle Gas and Steam Turbine Power Plants* (Tulsa, OK: PennWell Publishing, 2003), p. 6; A. Douglas

6.2 General Public Apathy towards Energy and Electricity

Before the invention of large, expansive electric utility networks, people tended to more actively harness energy inside their home. When the primary fuel for energy in Europe was wood, the consequences of its use were immediate and local. Pollution shrouded cities wherever households combusted wood in large quantities, and forests felled faster than they regenerated. Over time, more expensive woodlands whittled away, and the search for substitute fuels sharpened. Yet in the modern electric utility sector, the tendency for power plants to be spatially isolated from population centers dilutes the aggregate impacts of electricity. Historian Martin J. Pasqualetti argues that:

> An out of sight, out of mind pattern misleads the public by suggesting that the environmental costs of electricity are less than they actually are …. As distance, technology, and our urbanized lifestyle came to cushion us from the direct environmental costs of energy, we become increasingly less aware and eventually less tolerant of the intrusions of energy development on our personal space.[71]

In other words, electricity places unique demands on natural resources, the environment, and the marketplace, yet its delivery segregates these impacts from the population to deliver a product seemingly pure, invisible, clean, and cheap.

Likewise, the public's attitude (or apathy) toward the utility industry serves as an impediment to the adoption of DG technologies. Once electric power becomes part of people's lives, they rarely think about how it is produced, how it gets to them, and how to save it. Larry Papay of the California Council for Science and Technology comments that "people, generally speaking, by and large don't want to be bothered with undertaking energy projects all by themselves."[72] Joe Catina, a manager for the Ingersoll Rand company, suggests that most electricity customers may want to save money, but they don't want to deal with the "permits, nuts, bolts, wires, and washers" to enable such

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Melamed, "Electricity Competition: Volume 1." *Hearings Before the Subcommittee on Energy and Power of the Committee on Commerce, House of Representatives* (March 18-May 6, 1999), pp. 257-264; Palast, Oppenheim MacGregor 2003, p. 34.

[70] DeCotis, Personal Interview.

[71] Martin J. Pasqualetti, "Morality, Space, and the Power of Wind-Energy Landscapes," *Geographical Review* 90(3) (July 1, 2000), pp. 384-386.

[72] Papay. Personal Interview.

savings.[73] Jack Barkenbus, Executive Director of the Energy, Environment and Resources Center at the University of Tennessee, argues that "people want energy without having to think about it."[74]

Despite three serious blackouts in the past five years—plus the devastating affects of Hurricane Katrina on the American energy sector—electricity problems remain insignificant in the minds of many Americans. A recent 2006 Wall Street Journal/NBC Poll found that while the public recognized social security, health care, the Iraq war, and unemployment as important issues, nether "energy" nor "electricity" made the list.[75] Toben Galvin of the Vermont Energy Investment Corporation notes that people could take a number of simple, easy steps (such as weatherizing their homes, insulating their boilers, switching their appliances and lights) to lower their energy bills, but they don't. Instead, Galvin concludes that the "lack of significant, sustained, national political support prevents energy efficiency mechanisms from being even partially effective throughout most areas of the country."[76]

As one result of public apathy, misinformation concerning electricity and energy flourishes. A comprehensive 1978 study undertaken by Southern California Edison, surveying thousands of consumers, asked them "Where does electricity come from?" Most people said "Out of the plug in the wall," while others even said "lightning" and "static electricity." One of the authors of the study concluded that "people in this country have no idea how electricity is generated or transmitted."[77] Similarly, most people never connect their own energy consumption with some of the environmental problems faced in the production of electricity. Paul Gilman argues "most people still don't conceive of their homes as places of energy consumption."[78]

In her surveys on the acceptance of energy efficiency practices among builders in Utah, consultant Shelly Strand concluded that most people lack "interest and knowledge" about even basic energy-efficiency practices. One of the more troubling conclusions reached by Strand concerned the widespread public stigma in Utah against more efficient

[73] Catina, Personal Interview.
[74] Jack Barkenbus, Personal Interview, August 4, 2005; Full transcript available in Appendix 2.
[75] *The Economist*, "Special Report: America's Health-Care Crisis," Vol 378 No 8462, January 28, 2006, pp 24-26.
[76] Galvin, Personal Interview.
[77] Papay. Personal Interview.
[78] Gilman, Personal Interview.

energy devices such as evaporative coolers, weatherization techniques, and geothermal heat pumps. Strand found that most builders perceived the more efficient technologies as "low-class" and "trashy" because, years earlier, a successful energy program had distributed these technologies primarily to low-income areas.[79]

Consumers often oppose renewable energy technology not because they believe it is a poor alternative to fossil fuels, but because they do not realize that new plants of any type appear necessary to provide additional electricity. Rodney Sobin explains that:

> Most Americans don't have any idea what has to happen so that electricity is delivered to their home. Thus they oppose wind turbines because they may ruin, in their mind, the view of a mountain top, but they never actually consider that the alternative to that turbine is more smokestacks, cooling towers, and even fly-ash and acid rain, which ultimately end up hurting the mountain much more. People don't campaign against birds hitting windows, cars, or cell phone towers, but they will campaign against birds hitting wind turbines. I think it demonstrates a lack of understanding of context and tradeoffs.[80]

People also tend not to connect their energy use with their energy prices. Alex Farrell comments that "people don't make the connection between inefficient energy use and higher prices that result from it."[81] Perhaps people would object as strongly to plans to build traditional power plants as well, if only they started to think about where power originates and how it gets to their premises.

Consumers are also less forbearing and broadminded about new energy technologies. Historian David Nye argues that strong appeals of tradition and familiarity explain the consumer choices made by many Americans regarding technology. According to Nye:

> The energy systems a society adopts create the structures that underlie personal expectations and assumptions about what is normal and possible … Each person lives within an envelope of such natural assumptions about how fast and far one can go in a day, about how much work one an

[79] Strand, Personal Interview.
[80] Soben, Personal Interview.
[81] Farrell, Personal Interview.

> do, about what tools are available, about how that work fits into the community, and so forth. These assumptions together form the habitual perception of a sustaining environment that is taken for granted as always there.[82]

Such technological environments appear natural because they have been there since the beginning of an individual's historical consciousness. A child, Nye notes, born into a world with automobiles and airplanes takes them for granted and learns to see the world naturally at hundreds of kilometers an hour.

Yet the familiarity consumers express towards the old often impedes the use of the new. Before the modern era of industrialization and electrification, utilities and corporations had to convince the public of the durable reliability of their products. However, such actors "did not present their products as being revolutionary, but rather as natural parts of the home, neither unfamiliar nor sensational, but rather safe, familiar, and comfortable."[83] From 1890s to 1910s, product styling imitated the fixtures and appliances being replaced. General Electric designed their first electric lights to look like gas-fired street lights. Early appliances such as electric stoves were made to look like gas ranges and coal stoves. Utilities, manufacturers, and marketers learned that people tend to resist technologies they perceive as untested, radical, or different. Yet many of those promoting renewable energy systems and DG technologies present them as novel and excessively revolutionary technologies. While notions of familiarity and personal identity are constantly shifting, tradition will always play a secondary but significant role in shaping cultural attitudes and decisions regarding technology.

Familiarity also plays an important role in determining which energy technologies public utility commissions and local regulators choose to adopt. Since most Americans refuse to take an active interest in electricity, utilities make decisions for people. The disjuncture between how electricity is made and how it is used—combined with immense technical skill required to manage power plants and an elaborate transmission and distribution grid—has supported the rise of a professionalized elite that desires to

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[82] David Nye, *Consuming Power: A Social History of American Energies* (Cambridge: MIT Press, 1999), pp. 7-8.
[83] David Nye, *Electrifying America: Social Meanings of a New Technology, 1880-1940* (Cambridge, MA: MIT Press, 1990), p. 353.

maintain control over as much of the utility system as possible. Jeff Jones of the U.S. Energy Information Administration explains that "there may also be a certain comfort level with the more 'traditional' technologies. Suppliers may have a tendency to do things that they have done before. They have considerable experience building coal, gas, and nuclear plants; they haven't built as many wind plants."[84] Utilities also don't want to dedicate the time or resources needed to learn about new technologies. This reflects a crucial element in systems theory: that conservative technology preserves the system. For example, an anonymous, high ranking executive for a large power trading company put it this way:

> [DG] is not a market [power generators] are interested in. A typical company, for example, sells power in 50 MW blocks. This is considered a modest size relative to the available generating capacity. It is equivalent to the output of a few small generators, or a fraction of a single medium to large generator. Staff sizes and the capital investment required to create power in this manner are very low compared to alternative methods.[85]

In other words, utilities believe that they would have to employ more staff to run several distributed units than they would for one large and centralized unit.

The same resistance towards the unfamiliar tends to hold true for local officials. When asked to comment about the most significant impediments towards DG systems, Brian Castelli responded that "fire marshals and zoning regulators" need better education on how stationary electricity sources such as fuel cells, micro-turbines, and reciprocating engines work. Currently, Castelli concludes, local officials may "know what a chiller or furnace is, but they don't know how a fuel cell operates. You have a great deal of problems stemming from institutional issues, and they can be a killer."[86]

Furthermore, consumers believe that they are entitled to more energy-intensive standards of living, and utilities believe it is their duty to give it to them at the lowest cost possible. For most of the past five decades, Americans have come to place faith in unbridled material progress linked to visions of a high-technology society, a success associated with new cars, large modern homes, and the accumulation of energy intensive

[84] Jeff Jones, Personal Interview, February 8, 2006; Full transcript available in Appendix 2.
[85] Anonymous, Personal Interview.
[86] Castelli, Personal Interview.

appliances. Martin V. Melosi argues that such visions are primarily founded on an overarching theme of energy abundance. Over the course of the country's development, historically plentiful sources of natural resources (including fossil fuels) enabled the transition from labor-intensive jobs into capital-intensive ones, and provided sources of vast commercial wealth. Americans, Melosi concludes, have become "endowed with an abundance of domestic sources of energy and having access to foreign sources," and continue to expect supplies to be simultaneously "never-ending and cheap."[87] Paul DeCotis made a similar conclusion when he stated that "as a culture we don't value conservation and energy efficiency to the extent that we could. We value consumption, bigger vehicles, bigger homes, and more toys that consume more electricity."[88]

Once values concerning familiarity and consumption are formed, they tend to be very difficult to alter, especially after they become transmitted between generations. John Warren, Director of the Division of Energy at the Virginia Department of Mines, Minerals, and Energy, noted that one of the biggest problems he faces is that:

> People tend to look at things very narrowly and hear the things that they want to. If you oppose wind turbines and you have a strong attitude towards that, you will read and absorb the information that opposes wind turbines as well. And you will be in a position to defend the arguments that they kill too many birds and bats, and even if information may contradict that, you will believe the information that you want to hear. And so it's hard to sway the public.[89]

Indeed, Americans have become so complacent that Thomas Petersik believes that, "in terms of forcing public acceptance, blackouts and other crises may actually provide benefits in overcoming public resistance." Yet, as Petersik concedes, "the local costs of crises are an extraordinarily expensive way of moving forward."[90]

6.3 Distorted Market Signals

Nonetheless, the belief that Americans are somehow entitled to cheap and abundant sources of electricity has become reflected in the American electricity market.

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[87] Martin V. Melosi, *Coping With Abundance: Energy and Environment in Industrial America* (New York: Alfred A. Knopf, 1985), pp. 8-10.
[88] DeCotis, Personal Interview.
[89] John Warren, Personal Interview, September 16, 2005; Full transcript available in Appendix 2.
[90] Petersik, Personal Interview.

The failure of electricity prices to reflect their true cost continues to disadvantage renewable and distributed energy systems. This failure is commonly referred to as an inability to include "externalities" in energy prices. Defined as costs and benefits resulting from an activity that do not accrue to the parties involved in the activity,[91] externalities have won attention in recent decades as a way to make equitable choices of generation equipment. Russell Lee explains that "externalities are part of the overall *social* cost of producing electric power … including the value of any damages to the environment, human health, or infrastructure."[92] The U.S. Department of Energy defines externalities as "inadvertent and unaccounted for effects of one or more parties on the welfare of another."[93] Take the classic example of unregulated pollution from a smokestack. Here, a factory produces products that are priced by taking into account the demand for the products, labor, capital, and other costs, but the damages from the factory's pollution—health and other effects—are true costs borne by society that are unaccounted for in the price of the factory's product. These latter costs are commonly referred to as "external costs" or "externalities."[94]

Renewable energy technologies have been largely disadvantaged by the general neglect of consideration of externalities. In one recent study, traditional coal boiler

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[91] Paraphrase of definition in John Carlin, "Environmental Externalities in Electric Power Markets: Acid Rain, Urban Ozone, and Climate Change," available at http://tonto.eia.doe.gov/reports/reportsD.asp?type=Environment ; See also NARUC, *Environmental Externalities and Electric Utility Regulation* (Washington, DC: NARUC, 1993), p. 3.

[92] Russell Lee, "Externalities and Electric Power: An Integrated Assessment Approach," *Oak Ridge National Laboratory CONF-9507-206—2* (1995), pp. 2-4.

[93] U.S. Department of Energy and the Commission of the European Communities, "U.S.-EC Fuel Cycle Study: Background Document to the Approach and Issues," *External Costs and Benefits of Fuel Cycles*, ORNL/M-2500 (November, 1992).

[94] By omitting discussion of these externalities, policymakers may create an uneven playing field for cost comparisons. In fact, some analysts believe the lack of consideration of such costs and benefits may be the greatest impediment to employing renewable energy systems in, and constitute an implicit and significant subsidy to fossil and nuclear energy systems. When dealing with large-scale electricity generation, externalities often include the costs to individuals whose health is impaired by pollution (in excess of regulated costs); the value of impaired (or improved) viewscapes; and the impact on employment patterns and tax payments. They also subsume the impacts of smog, nutrient deposition, acid rain, and global climate change on agriculture, forestry, fisheries, recreation, water resources, and wildlife; as well as the cost to government to deploy military forces to secure energy resources. On a different note, some analysts consider the positive effects of economic development resulting from the deployment of renewable (and nonrenewable energy) technologies to be an externality (though, in this case, a benefit). Because some of these external factors remain difficult to quantify, many economists and policy makers simply exclude discussion of them. By doing so, however, they make it impossible to perform valid comparisons between the costs of producing power from various generation technologies. Instead, policy makers often retain distorted notions of the costs of electricity and usually favor the use of traditional fossil-fuel generation technologies.

generation technology appeared to produce relatively cheap power—under 5 cents per kWh over the life of the equipment, which included capital, operating and maintenance, and fuel costs—while wind-turbine generators and biomass plants produced power that cost 7.4 cents per kWh and 8.9 cents per kWh respectively (and tended to require larger amounts of land). But when analysts factored in a host of externality costs, coal boiler technology costs rose to almost 17 cents per kWh, while wind turbines and biomass plants yielded power costing around 10 cents per kWh.[95] Reflecting the view of many economists and policy makers, the authors of that study noted that overlooked externality costs impede "efforts to develop optimal electricity resources."[96]

In addition, perhaps the most subtle yet significant cultural impediment facing DG technologies concerns a belief that markets, left to their own devices, can best determine the given price of a good or commodity. Such a belief is so great that even proponents of DG rely on claims that a better working "market" is all that would be needed to provoke a transition to DG technologies. Tom Casten, for instance, argues that successful electricity markets "work magic, enticing multiple suppliers to continuously innovate in hopes of gaining profits and market share, only to find that other suppliers have also lowered costs and are offering better value."[97] Florentine Krause and Joseph Eto from the Lawrence Berkeley National Laboratory argue that energy markets function properly as long as (1) consumers receive accurate price signals through an equal access to information; (2) such consumers then make rational decisions based purely on price considerations; and (3) such rational consumers respond to price signals by investing in efficient technology.

Yet, for now, the American electricity market possesses none of these preconditions. In the case of electric supply networks, the markets have *never* been able to adequately account for the true costs of electricity. Krause and Eto conclude that, instead, electricity prices become distorted through subsidies, inefficient competition

[95] Ian F. Roth and Lawrence L. Ambs, "Incorporating Externalities into a Full Cost Approach to Electric Power Generation Life-cycle Costing," *Energy* 29 (2004), pp. 2125-44.
[96] Ibid., p. 2142. Also see Anthony D. Owen, "Environmental Externalities, Market Distortions and the Economics of Renewable Energy Technologies," *Energy Journal* 25 (1 June 2004), pp. 127-56.
[97] Casten, Personal Interview.

among suppliers, and unequal access to information.[98] Undersecretary of energy David Garman explains that:

> Consumers have to get market signals …. A kWh of electricity at 8am is very different thing than at 3am. It is almost a completely different commodity, generated in a different fashion with different consequences. Thus far we have shielded consumers from market signals, rather than recognizing those differences.[99]

Garman argues that, unfortunately, only "accurate market signals would incentivize consumers to do the right things" and make "smarter choices" about their consumption of energy.[100] Instead, electricity markets in the United States continue to shelter consumers and distort electricity prices.

Even Ralph Loomis, an executive vice president for the largest utility in the country—Exelon—admits that distorted market signals can result in consumers slowly coming to believe that they are entitled to large amounts of electricity at cheap prices. He argues that:

> In the marketplace you promote [efficient energy use] by allowing prices to go up, customers get the signal, and they think to themselves, "Aha, this is a valuable commodity that needs to be carefully used and conserved. I need to use it wisely." However, if, as a matter of public policy you have a long history going back one hundred years of promoting economic development by having a very regulated utility industry that insures that prices don't go up, then residential customers never get that price signal. And, indeed, over time, customers become un-attuned to making intelligent decisions.

The United States, Loomis concludes, offers the best example of such a distorted market system.

In fact, DG technologies are sometimes resisted precisely *because* utilities believe that they would drastically alter electricity markets. Harvey Michaels, Chairman and

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[98] Florentin Krause and Joseph Eto, *Least-Cost Utility Planning Handbook for Public Utility Commissioners* (Washington, DC: National Association of Regulatory Utility Commissioners, 1988).
[99] Garman, Personal Interview.
[100] Ibid.

CEO of Nexus Energy Software, comments that DG technologies can enable the use of net metering systems—devices that meter electricity generation/consumption in real time—since they generate electricity close to the end-user. Net meters are resisted by utilities, Michaels comments, because they considerably alter current electricity markets by giving consumers "complete, objective information about market dimensions."[101] Furthermore, DG technologies that use net metering can also rotate the meter either forward or backwards, depending on who the supplier of electricity is at a particular moment. Thus, Harvard law professor Steven Ferrey notes, DG technologies change the market by allowing individuals to become their own quasi-utilities. According to Ferrey:

> Net metering profoundly reshapes the energy landscape, providing the most significant boost of any policy tool at any level of government—both qualitatively and quantitatively—to decentralize and green American energy sources.[102]

Utility resistance to DG technologies that facilitate net metering, Ferry concludes, should come as no surprise, since net metering makes renewable energy resources eligible to receive as much as four times the traditional, non-time-of-use rates for electricity.

Other forms of market distortion, however, appear unintentional. Many large apartment complexes from New York and Blacksburg, for example, do not measure electricity consumption according to individual use, but instead rely on metering individual buildings (and then dividing the energy costs by the number of tenants). The problem is that consumers never see the direct financial consequences of their personal energy consumption. Moreover, oftentimes people rent their homes or apartments from someone else. This classic problem of "split incentives" typically means that residents, who pay the electricity bills, don't want to invest in more efficient technologies (since they don't own their building). On the other hand, landlords, who own the building, don't want to invest in more efficient technologies since they don't pay the electric bill. These problems also occur in universities and office complexes. Wilson Prichett explains that:

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[101] See Harvey Michaels, "The Role of Federal Electric Utilities." *Hearing Before the House Subcommittee on Energy and Power* (May 19, 1999), pp. 264-267.
[102] See Steven Ferrey, "Nothing But Net: Renewable Energy and the Environment, Midamerican Legal Fictions, and Supremacy Doctrine," *Duke Environmental Law & Policy Forum* 14 (Fall, 2002), pp. 1-47.

> Most office buildings are owned by a company and the spaces are rented out to tenants. The rent for the complex includes the price of utilities, so the people that own the facilities don't care about electricity prices. And the people renting the space don't want to invest in a facility that they don't own. Similarly, universities don't want to spend extra money on fixing the university up and recovering utility savings, because the department that spends the money on the conservation improvements is not the same one that gets the energy savings.[103]

So among certain residences, office buildings, and universities, the market signals between the price and use of electricity are distorted.

The same types of split incentives occur in some of the country's most energy intensive industries. Christopher Russell exclaims that many industrial facilities have only one utility meter to measure plant-wide consumption. In these situations, traditional accounting practices treat energy as an overhead cost, which then becomes allocated across departments according to their numbers of workers or square feet of floor space. However, one drawback is that the cost of any one department's energy waste is distributed to all departments. Conversely, any department that undertakes energy savings will have its improvements diluted by the artificial allocation of costs.[104]

So, in the end, electricity has been viewed as a fundamental part of American progress and economic strength, and regulators and utility managers have created energy markets that shelter consumers from its true price signals. Some of this sheltering is intentional to keep electricity prices small. As Marylin Brown from the Oak Ridge National Laboratory explains, "the current externalities associated with fossil fuel consumption are hidden, so that the full costs of electricity from these sources are not reflected in market prices. The result is an artificially low price of fossil fueled electricity."[105] Michael Pomorsky of the Cambridge Energy Research Associates states that electricity prices "have not risen to a level that forces people to make conscious decisions about their energy use. Electricity prices are just too cheap, and costumers don't see the true environmental costs of their energy decisions reflected in electricity

[103] Prichett, Personal Interview.
[104] See Russell 2004.
[105] Brown, Personal Interview.

prices."[106] Zia Haq from the EIA elaborates that "consumers have no financial incentive to consider alternatives that might have a more attractive price once externalities are included."[107]

6.4 Conclusion

Why haven't policymakers "fixed" electricity markets so that externalities are included, split incentives overcome, accurate price signals extended to consumers, and individual behavior changed? Perhaps because the vested interests associated with the electric utility system don't want to pay for them. Or, perhaps it is because electricity markets will never, on their own, be sufficient to change consumer behavior. Even if the electricity market worked perfectly, some analysts argue that it would still not be enough to ensure a wider use of renewables and distributed energy resources. Historian Benjamin Cohen argues that "attempting to promote renewable energy technology from only a perspective of markets ignores the inter-related philosophical, political, and cultural dynamics that make energy distribution meaningful."[108] Cohen elaborates that:

> Belief in unlimited supply from customers and production of conceptual filters that block the customer from being able to see the source of all that energy [continue to impede DG systems]. That is, we love it, but we don't want to know where you make it.

Cohen concludes that the entire "political philosophy of late-modern post-industrial hyper-consumer global free market capitalism" will continue to impede alternative energy technologies as long as energy is viewed only as a consumer product and thus examined only for its market characteristics.[109]

Another reason may be that energy systems—including DG technologies—possess symbolic value for people that would be impossible to quantify in an electricity market. For example, opposition to the siting of new power plants can also occur because such technologies inflame preexisting social conflicts that have little, or nothing, to do with economics. Martin J. Pasqualetti, in his work on the opposition to the construction of wind turbines, notes that many forms of resistance to renewable energy

[106] Pomorski, Personal Interview.
[107] Haq, Personal Interview.
[108] Benjamin Cohen, Personal Interview, March 6, 2006; Full transcript available in Appendix 2.
[109] Ibid.

systems have little to do with the technology itself. Rural residents, for example, often resent urban developers who wish to build energy projects in their midst. Others oppose new generators because they feel that they have been excluded from the policymaking, permitting, or siting process. In other cases, rural residents want renewable energy projects for their own use—as a vehicle for economic development—and resent what seems like meddling by urban residents intent on preserving the countryside for its scenic and recreational value. In this way, wind turbines (and other similar technologies) become more than simply an electrical generation technology: they simultaneously symbolize a way of generating electricity, a way of organizing the landscape, a system of ownership and control, and a personal ethic or a reflection of attitudes.[110]

The confluence of these factors—utility preference for large, geographically distributed power plants, subtle yet deeply engrained attitudes favoring familiar technologies, American attitudes concerning their standard of living, and an improperly functioning energy market—result in an almost reckless consumption of electricity. Ironically, perhaps, people have become accustomed to low-priced electricity, and they often consume it indiscriminately, creating demand for construction of new power plants. Consequently, Americans' preferences for sprawling growth, automobiles, individualistic heating and huge electricity consumption impose conditions on their future energy choices. Historian David Nye notes that, "Americans have built energy dependence into their zoning and their architecture … they think it natural to demand the largest per capita share of the world's energy supply."[111] Increased consumption is often further encouraged by utilities (who make money selling power) and wires companies (who make money based on throughput, the amount of electricity traveling through their network). So, in other words, Americans simultaneously create a demand for more electricity, but they frequently oppose construction of new generation facilities (including renewable technologies) because they do not realize that they contribute to the necessity of new plants.

[110] Martin J. Pasqualetti, Paul Gipe, and Robert W. Righter, *Wind Power in View: Energy Landscapes in a Crowded World* (New York: Academic Press, 2002), pp. 10-12.
[111] Nye 1999, p. 257-258.

Chapter 7—Aesthetic and Environmental Impediments

"If the land … as a whole is good, then every part of it is good, whether we understand it or not. If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering."

--Aldo Leopold, forester and philosopher, 1947

7.1 Introduction

To a large degree, the previous three chapters have emphasized the impediments facing DG technologies described by utility managers, business owners, manufacturers, advocates, historians, and sociologists. Most of these obstacles have been inherently perceived as economic, political, and regulatory: higher capital costs are believed to prevent investment in DG technologies; lingering monopoly rules are blamed for continuing to favor utilities and fossil fueled generators; advocates of DG complain that discriminatory practices have become embedded in local regulations. In contrast to these perspectives, this chapter elaborates how environmentalists have started to attack DG systems for harming the environment and ruining the aesthetic beauty of the land. Rather than being viewed as a coherent, organized group of people, such actors can better be understood as a loosely defined collection of concerned farmers, property owners, environmental scientists, and activists.

The chapter begins by discussing the genesis of environmental ethics in the United States, or how some Americans came to place importance on the protection of the environment and preservation of species, ecosystems, and the biosphere. American concern towards the environment seems to have peaked in the 1970s, after the energy crisis precipitated a growing social frustration with the perceived mounting challenges of industrial pollution, population growth, and resource scarcity. These challenges convinced voters and politicians to acquiesce to an environmental movement that had been arguing for legislative actions to protect the country's environment. As a direct consequence of such legislation, and perhaps incongruously, renewable energy systems have become challenged on ethical and environmental grounds and are frequently opposed by local communities and environmentalists for aesthetic reasons.

7.2 The Emergence of Environmental Ethics in the United States

For most of the country's history, Americans have tended to place their own personal needs above that of the environment. Nearly two hundred years of cheap energy, industrial growth, abundant natural resources, and an environment that could seemingly absorb all pollution convinced many people that they were, in fact, entitled to dominate nature. These classical ideas created a worldview that correlated energy consumption with economic growth; that convinced many Americans that they are somehow entitled to consume as much energy as possible; and that technology can overcome all resource constraints.

Historically, such a worldview can be connected to New England Puritan ideals. The original pilgrims found their natural surroundings strange and threatening, and their writings often referred to nature as an "enemy to be subjugated."[1] Forests were cleared, wilderness declared an obstacle to progress, and the advancing frontier was conceived only as a terrain to be conquered through manifest destiny. To assist them in their conquest over nature, settlers placed their faith in technology and trust in the expert, an inherent confidence that American ingenuity can solve all problems. Mastery over nature went hand-in-hand with other American ideals including the right to own land and property, individualism, independence, and self-reliance, and it was connected to an overall belief in progress. Such progress was to be accomplished through technological development and more energy consumption.[2]

However, in the late 18th and 19th centuries, the emergence of the Romantic movement began to challenge this worldview. The work of William Blake, William Wordsworth, and Johann Wolfgang von Goethe (among others) argued that nature should not be viewed as an impersonal machine, but an organic process with which humanity is united. Other writers associated wilderness with the sublime, wild, and untouched landscape. The transcendentalists in New England referred in similar terms to the sacred dimension of nature. Henry Thoreau held that nature was a source of inspiration, vitality,

[1] Ian G. Barbour, *Technology, Environment, and Human Values* (New York: Praeger Scientific, 1980), p. 16.
[2] See Roderick Frazier Nash, *American Environmentalism: Readings in Conservation History* (New York: McGraw Hill, 1990), pp. 1-8; Barbour, 1980.

and spiritual renewal. As he wrote, "in wilderness is the preservation of the World."[3] During the 1870s John Muir circulated the philosophy of wilderness preservation, and the works of George Perkins Marsh (1864) and Charles Darwin (1859) described how species of plants and animals are part of nature in continuity with other forms of life, including humans.[4]

Such romanticist and transcendentalist ideals greatly influenced 20th century work arguing in favor of protecting wilderness and the environment. In his 1947 introduction to *A Sand County Almanac*, forester and philosopher Aldo Leopold directly challenges American economic growth and likens society to a hypochondriac, so obsessed with its own "economic health" that its people have lost the "capacity to remain healthy, the whole so greedy for more bathtubs that it has lost the stability necessary to build them, or even turn off the tap."[5] The fundamental flaw with such a strategy, Leopold argued, was that it transformed the landscape from a something humbling and natural into an economic symbol degradable and exploitable; a land that entails privileges but not obligations.[6] Likewise, Charles S. Elton's 1958 *The Ecology of Invasions by Animals and Plants* argued in favor of an environmental ethic. Elton suggested that protecting the environment could be justified from a very practical desire to protect the land, crops, forests, water, and sea fisheries that are needed to sustain human life. Rachel Carson's 1962 *Silent Spring* documented the terrifying threat from uncontrolled use of pesticides, and concluded that the challenges posed by threats could only be addressed by sustained, coordinated, and a thoroughly ecological worldview. And the 1970s work of David Ehrenfeld promoted the idea of the biologist and the scientific elite as an advocate for the natural world.[7]

These historical themes laid the foundation for the modern environmental ethics, advocated in turn by an organic environmental social movement. Even though, as a whole, the idea of "environmental ethics" is much more variegated than presented here, it advances at least four basic themes: humans are dependent on nonhuman forms of nature;

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[3] In Barber 1980, p. 21.
[4] See David Takacs, *The Idea of Biodiversity: Philosophies of Paradise* (Baltimore: Johns Hopkins University Press, 1996).
[5] Leopold 1947, ix.
[6] Leopold 1947, 214.
[7] In Takacs, 1996.

pollution of air, water, and land is clearly detrimental to human life; limits should be set on the exploitation and use of natural resources; and humans have a duty to preserve the biosphere for future generations. While certainly supported on strong spiritual and ethical grounds, the concept of an environmental ethic also has its connections to advances in ecology, conservation biology, and evolutionary biology. These sciences developed the idea that species exist as part of an ecosystem; that humans are interdependent with all members of a biotic community; that biological diversity is needed for ecological balance and stability; and that finite limits exist for population growth and the capacity of the environment to provide resources.

The force of the environmental movement on society and policy was most profound in the United States during the 1970s. Federal acts aimed at protecting the environment during this decade included the National Environmental Policy Act of 1970, Clean Air Act of 1970, Coastal Zone Management Act of 1972, Federal Water Pollution Control Act of 1972, Endangered Species Act of 1973, Toxic Substance Control Act of 1976, and the Alaska National Interest Lands Conservation Act of 1980. According to historian Robert Nash, it was during this time that:

> Environmentalism changed from a religion to a profession. The blue-jean-and-granola style of conservation evident at the time of the first Earth Day in 1970 gave way two decades later to pin-striped suits and briefcases full of sophisticated data.[8]

While laws aimed at protecting the environment have certainly been passed since the 1970s, it was during this time that the conceptual and political groundwork was laid to support the wider environmental movement.

Today, thirty years later, environmentalists continue to exert influence on state and federal policy. A 2006 article in *The Economist* concluded that "American's environmentalist movement has undeniable political clout and a huge reservoir of public sympathy."[9] A similar 2006 Yale University survey found that three-fifths of registered

[8] Roderick Frazier Nash, *American Environmentalism: Readings in Conservation History* (New York: McGraw Hill, 1990), p. 257.
[9] "The Environmental Movement: Endangered Species," *The Economist* February 18, 2006, p. 32.

American voters considered the environment to be an important consideration, and two-fifths believe that the federal government should do more to protect it.[10]

7.3 The Environmental Objections to Renewable Energy Systems

Many environmentalists have come to believe that, as part of protecting nature, distributed renewable energy systems should be opposed because they harm species and destroy ecosystems (See Figure 7.1). For wind energy, the most significant environmental concern relates to the death of birds and bats resulting from collisions with wind turbine blades. A 1992 California Energy Commission study estimated than more than 1,766 bats and 4,721 wild birds (including more than 40 species) die per year at the Altamount Pass Wind Resource Area, where more than 5,400 wind turbines operate.[11] Some wind farms operating in Tennessee and California had been known to kill of up to forty-eight bats per turbine annually.[12] Closer to home, several studies conducted in the Appalachian Mountains (focused on the region from Tennessee to Vermont) have found that large numbers of nocturnal migrants (including bats) are uniquely at risk of colliding with wind turbines.[13] The number of avian deaths could be especially large if wind turbines were deployed over the Allegheny Front (which includes parts of Virginia) during the migration season, when more than 1.7 million birds per night fly over the state.

[10] Ibid.
[11] For an excellent overview of the avian problems facing wind energy, see Peter Asmusl "Wind and Wings: The Environmental Impact of Windpower," *Electric Perspectives* 30(3) (May/June, 2005), pp.68-80.
[12] Ibid, p. 78.
[13] Boone, D. Daniel et al. (2005). Landscape Classification System: Addressing Environmental Issues Associated with Utility-Scale Wind Energy Development in Virginia. The Environmental Working Group of the Virginia Wind Energy Collaborative. Retrieved May, 2005 from http://www.VAwind.org/assets/docs/LCS-042105.pdf, p. 23-28.

Figure 7.1: Public Sign against Wind Turbines on Route 220 near Maxwelton, West Virginia, March 5, 2006

In response, wind advocates have mobilized their own coalition, and they hotly contest claims of avian mortality. Furthermore, wind proponents suggest that the potential damage from wind turbines on birds and bats pale in comparison to deaths created by other man-made objects. For example, wind supporters point out that more than 4 million birds die annually when they strike tall, stationary communications towers.[14] In addition, some promoters have suggested that road traffic, power-lines, and cats are a much greater risk to birds than wind-turbines.[15] Moreover, death-rates of all flying animals have decreased in recent years as wind power entrepreneurs have installed larger turbine blades that turn more slowly, and have used advanced thermal monitoring and radar tracking to install turbines more carefully.[16]

As a further impediment, environmentalists argue that effective and large wind farms are sometimes highly land intensive. The Department of Energy notes that large-capacity utility wind turbines usually require one acre of land per turbine.[17] When these big machines are built in densely forested areas or ecosystems rich in flora and fauna, they can also fragment large tracts of habitat. At the Mountaineer Wind Energy Center in

[14] See Chris Toffelson, "Reducing Bird Deaths From Tower Collisions," 2001, available at. http://permanent.access.gpo.gov/lps1515/febmar2001/fatal.htm
[15] See Bassam and Maegard 2004, p. 118; John Vidal, "An Ill Wind?" *The Guardian (London)* (May 7, 2004), p. 2; Wind Energy Weekly, "Research Finds Risk to Birds Low at Minnesota Wind Site," 18 (847) (May 11, 1999), available at http://www.awea.org/wew/847-1.html.
[16] See Asmus 2005, pp. 68-80.
[17] United States Department of Energy, *Guide to Purchasing Green Power: Renewable Energy Certificates and On-Site Renewable Generation* (Washington, DC: Department of Energy, 2004), p. 11.

West Virginia, for instance, more than forty acres of forest were bulldozed and 150 acres of forest-interior were lost to erect eight turbines. Similarly, 350 acres of forest habitat were destroyed to construct twenty wind turbines at a Meyersdale, Pennsylvania, windplant.[18] One recent study found wind turbines are the most land intensive form of electricity generation, since they need approximately 500 acres to generate 200 MW of power. In contrast, a typical power plant involving simple cycle combined cycle turbines (burning fossil fuel) requires approximately 25 acres of land to produce around 200 MW of power. PV systems fall in the middle, and usually require around 1 acre per MW.[19]

However, wind proponents respond that the land employed for wind turbines can have several uses. Outside of the concrete pad on which the turbine rests (and possibly a pathway to the pad), the land can still be used for farming, ranching, and foresting. Also, an assessment of the environmental impacts of wind turbines should be compared with those of alternative technologies—fossil, renewable, and nuclear—used for making electricity. The use of traditional technologies also imposes serious impacts on air and water quality, land use and habitat, and human health.

Activists also argue that the environmental concerns raised from the use of wind turbines are accompanied by a host of other issues. Older wind turbines from the 1970s sometimes created interference with radio, TV, and other electromagnetic transmissions. Moreover, while recent improvements in turbine technology can reduce these problems, blade noise from 1970s prototypes could often be heard up to one kilometer away.[20] Noise levels appear particularly problematic at night and are induced by low-frequency aerodynamic sounds generated by the interaction of turbine blades and the tower.[21] Finally, many people find wind turbines visually unattractive, especially in significant tourist or recreational destinations where the human-built turbines impose obtrusively in

[18] See Dane Boone et al., *A Landscape Classification System: Addressing Environmental Issues Associated With Utility-Scale Wind Development in Virginia* (2005), available at http://www.vawind.org/Assets/Docs/LCS-100805.pdf.
[19] See Jurotich, *Network Infiltration*.
[20] David Pimentel, "Renewable Energy: Economic and Environmental Issues," *BioScience*, 44(8) (September, 1994), p. 29.
[21] Boone et al. 2005.

a pristine natural environment.[22] Consequently, many citizens campaign aggressively against their construction, as they have in Virginia's Highland County.[23]

Environmental scholars also claim that offshore wind turbines usher in an additional collection of environmental concerns because of the possibility that they may endanger aquatic wildlife and ecosystem stability. Because only a small number of offshore wind projects exist in the United States, most studies on offshore wind have been undertaken by institutions in Europe. A study sponsored by the British government found that offshore wind turbines operating in the North Sea tended to disrupt sedimentation flows and reduce marine biodiversity.[24] A similar French and Norwegian study found that offshore turbines increase the risk of accidental collision between wind turbines and vessels. Such collisions could create chemical and oil spills that damage aquatic ecosystems.[25] Furthermore, the areas in the United States with the most offshore wind potential include areas along the eastern seaboard—coastlines highly valued for their fisheries, aesthetics, and recreational activities. A recent article in the *Boston College Environmental Affairs Law Review* noted that for many people, "fears of three hundred foot spinning turbines and blinking navigational lights blanketing the horizon have caused an uproar that threatens to drown out wind power's loudest advocates."[26]

For large-scale photovoltaic (solar) stations, environmentalists argue that such facilities require immense tracts of land to generate significant amounts of electricity. PV systems convert sunlight to electricity at relatively low rates of 7 to 17%.[27] Because of this low conversion rate, PV systems require prodigious amounts of land (or building roof

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[22] Ibid, p. 30-31.
[23] For example, see Calvin R. Trice, "Windmill plan good for county? Energy plan promises revenue for Highland, but at scenery's cost" *Richmond Times-Dispatch*, (July 10, 2005), available at http://www.timesdispatch.com/servlet/Satellite?pagename=RTD/MGArticle/RTD_BasicArticle&c=MGArticle&cid=1031783753002.
[24] K. Hiscock et al, "High Level Environmental Screening Study for Offshore Wind Farm Developments – Marine Habitats and Species Project," *Report for the Department of Trade and Industry New and Renewable Energy Programme* (August, 2002), pp. 3-6.
[25] OSPAR Commission, "Problems and Benefits Associated with the Development of Offshore Wind-Farms," 2004, available at http://mainweb.hgo.se/projekt/cvi.nsf/0B30C28CC94A6E64C1256FA100353241/$file/p00212_Win%20farms_Problems%20and%20benefits.pdf.
[26] Kaplan 2004, p. 198.
[27] Efficiency refers to the percentage of converting sunlight to electricity. See also Leonard G. Leslie, *Design and Analysis of a Grid Connected Photovoltaic Generation System With Active Filtering Function* (Blacksburg, VA: Master's Thesis, 2003), pp. 7-8..

space) to generate significant amounts of electricity.[28] While PV technology may offer benefits for stand alone power for some residences and for supplying electricity to remote applications, solar panels require too much space to generate large amounts of electricity. One study concluded that "satisfying current U.S. electrical consumption would require nearly 10 billion square meters of photovoltaic solar panels."[29] This technical fact may explain why, as of 2002, PV systems supplied only .02% of electricity in the United States, or 844 MWh.[30]

Environmental advocates are also wary of bioelectricity. Much like the combustion of coal, the burning of biomass emits a significant number of pollutants into the atmosphere. While biomass combustion has the advantage of not releasing any net carbon dioxide into the atmosphere (and thus contributes little to the global inventory of greenhouse gases,), it releases measurable levels of particulate matter, nitrous oxides, and sulfur oxides.[31] As an influential report written by the Energy Justice Network concluded, "all biomass combustion technologies put pollution in the air in order to make 'green energy'."[32] Moreover, ecologists and biologists have noted that dioxin and polyvinylchloride contamination can occur when wood waste derived from construction and demolition projects, urban tree trimmings, and paper and lumber mills are burned,.[33] A 1996 study undertaken by the Environmental Research Foundation concluded that biomass combustion, while much better for the environment than fossil-fueled generation, was still responsible for 2% of all dioxin contamination in the Great Lakes region.[34] To minimize the release of contaminants, biomass plants must employ pollution prevention technology in the form of scrubbers and filters.[35]

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[28] Borbely and Kreider 2001, p. 107.
[29] Friedman and Homer-Dixon 2004, p. 77.
[30] Cragg, Chris. (2002). "The Magic of Solar PV." *Platts Energy Economist* 254 (December), p. 9-15.
[31] For well written reports on these environmental implications concerning biomass combustion, see Michael Ewall, "The Burning Issues with Biomass," March, 2000, Retrieved from http://www.energyjustice.net/biomass/; R, Monastersky, "Biomass Burning Ignites Concern," *Science News* (March 31, 1999), p. 32-35; Pimentel et al. 1994; and Vinod Mishra, "Effect of Indoor Air Pollution from Biomass Combustion on Prevalance of Asthma in the Elderly." *Environmental Health Perspectives* 111(1) (2003), available at http://ehp.niehs.nih.gov/members/2003/5559/5559.html.
[32] Ewall 2000, p. 3.
[33] Ibid, p. 5.
[34] Peter Montague, "How to Eliminate Dioxin." *Rachel's Environment & Health Weekly* 508 (August 22, 1996). p. 4.
[35] Kathryn Casa, "Shades of Green: Biomass Plant Would Have Cross-Border Effects." *Vermont Guardian* (February 21, 2005), p. 13.

These environmental concerns parallel aesthetic concerns about land use, smell, and traffic congestion. The use of agricultural wastes and forest residues – including energy crops, sugar, legumes, and vineyard grain – to generate electricity sometimes strips local ecosystems of needed nutrients and minerals. Widespread use of these fuels can contribute to habitat destruction and deforestation.[36] Furthermore, the combustion of biomass has been reported to release foul odors near some plants, and they can contribute to traffic congestion when large amounts of fuel must be delivered by trucks.[37]

For hydroelectric facilities, the most extensively debated and complex problems facing hydropower relate to habitat and ecosystem destruction, emissions from reservoirs, water quality, and sedimentation. All these concerns arise because of the dam's role as a physical barrier interrupting water flows for lakes, rivers, and streams. Consequently, dams can drastically disrupt the movement of species and change upstream and downstream habitats. Such barriers also result in modified habitats with environments more conducive to invasive plant, fish, snail, insect and animal species, all of which may overwhelm local ecosystems.[38]

To maintain an adequate supply of energy resources in reserve, most dams impound water in extensive reservoirs. However, these reservoirs often emit large amounts of carbon dioxide from rotting vegetation and carbon inflows. The comprehensive *World Commission on Dams* report noted that "a first estimate suggests that gross emissions from reservoirs may account for between 10% and 28% of the global warming potential of greenhouse gas emissions."[39] The International Rivers Network warned that, "in some cases, reservoirs may have a greater impact on global warming than similar-sized gas-fired power stations."[40]

For smaller hydroelectric facilities, because most small hydropower systems operate in minute rivers and streams, they produce a different set of environmental impacts. These often include the significant environmental consequences of altering stream flow and disrupting the nutrient cycle, which hurts various types of plant life.

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[36] See Ewall,2000; Kleinbach and Hinrichs 2002, p. 562.
[37] Ben Myers, Personal Interview, May 6, 2005.
[38] World Commission on Dams. (2000). *Dams and Development: A New Framework for Decisonmaking*. November. London: Earthscan Publications, p. 80.
[39] Ibid, p. 75-76.
[40] International Rivers Network 2004, p. 4.

Many small dams can also drastically reduce fish populations (notably species of salmon in the Pacific Northwest) by cutting off tributaries and increasing the number of contaminants in freshwater.[41] Finally, a recent study undertaken by the Department of Energy on dead salmon at hydropower projects in the Columbia River Basin concluded that hydroelectric turbine and spillway turbulence has a tendency to disorient fish, making them more susceptible to predation by other fish and birds.[42]

Tidal and ocean turbines face similar hurdles. Although ocean-derived energy would theoretically require no fuel and produce no emissions, its operation would not come without environmental challenges. Collections of many turbines in a single location can alter ocean current and negatively influence water quality, especially the distribution of nutrients within marine ecosystems. And, similar to hydroelectric facilities, tidal power plants that dam estuaries can impede sea life migration and can shift sedimentation and silt movements within bays and river deltas.[43]

7.3 Conclusion

Even though all energy systems impoverish the environment to some degree, farmers, environmentalists, scientists, and concerned citizens have begun to oppose renewable energy systems—notably wind turbines, solar panels, biomass generators, and hydroelectric facilities—because they damage species and ecosystems. Wind turbines are attacked because their operation can threaten birds and bats. Wind turbines and large solar energy farms require large amounts of land to generate significant amounts of power. Such energy facilities often require access roads that can fragment forests and wetlands and require facilities that can occupy hundreds of acres. Biomass generators have been challenged for emitting air pollutants, hydroelectric generators for creating reservoirs that emit methane and carbon dioxide. Dams, off-shore wind turbines, and ocean and tidal turbines are also critiqued for threatening fish and aquatic wildlife.

Above and beyond these environmental concerns, renewable energy systems are opposed for a number of aesthetic reasons. Such opposition is frequently expressed politically through stringent zoning, permitting, and siting regulations. Wind turbines are

[41] See World Commission on Dams, 2000; F. Koch, "Hydropower, Society, and the Environment." *Energy Policy* 30(24) (2002), pp. 1251-1263.
[42] Glenn Cada, "Solving the Mystery of the Dead Salmon," *Oak Ridge National Laboratory Science & Technology Highlights* 1(1) (2005), p. 5.
[43] U.S. Department of Energy 2001, p. 3.

accused of creating a “visual blight,” and homeowners don’t want to see them near their property on the country’s coasts, pastures, and mountains. Large biomass electrical facilities are attacked for contributing to traffic congestion and emitting strange smells, especially when such facilities co-fire trash or waste. In the end, the aesthetic and environmental impediments facing distributed and renewable energy systems—or, in fact, all energy systems—serve as important reminders that technologies must not only technically work. In order to succeed, technologies must also fit within people’s values, expectations, and environmental ethics so that they are socially acceptable.

Chapter 8—Conclusions

"We must face the prospect of changing our basic ways of living. This change will either be made on our own initiative in a planned way, or forced on us with chaos and suffering by the inexorable laws of nature."

--Jimmy Carter, former president of the United States, 1976

8.1 Introduction

Ultimately, the more subtle—yet powerful—impediments to renewable and distributed energy systems seem about *culture*. American consumers believe that they are entitled to cheap and abundant forms of electricity. Utilities wish to retain the means to distribute electricity, and businesses and investors seek to ensure that any investments in energy have rapid payback schedules. More than just an interesting sociological insight, the cultural attitudes of consumers, utilities, business leaders, and local systems operators have manifold implications for the extensive deployment of renewable-energy and DG technologies. At least four conclusions concerning DG technologies and the modern American electric utility system can be offered: (1) DG technologies are impeded by more than just material or infrastructural obstacles; (2) The obstacles hindering DG technologies should not be viewed as inevitable or insurmountable; (3) Nonetheless, a confluence of socio-technical factors will continue to impede the growth of DG technologies; and (4) The barriers facing DG technologies cannot be divorced from their historical (and often contingent) origins.

8.2 DG Technologies Are Impeded by More than Just Material Obstacles

As Chapters 4, 5, and 6 note, people resist DG technologies for reasons relating to more than just business practices and technical arrangements. For example, Jack Barkenbus, the Executive Director of the Energy, Environment, and Resources Center, argues that Americans want contradictory things from their energy technologies. People desire technologies that can take advantage of abundant sources of energy, delivered through reliable distribution systems, but they also yearn for inexpensive prices and minimal harm to the environment. Additionally, people want energy systems to be

unobtrusive and invisible.[1] Because the values Americans espouse towards energy and the environment are contradictory, Barkenbus concludes, it should come as no surprise that the technologies people support (and oppose) remain inconsistent as well.

As Thomas Hughes infers in *Networks of Power*, decisions about technologies have always been about more than just technical feasibility. Since Hughes believes that large-scale systems possess significant political, social, economic, and cultural capital, the reasons for their growth—or decline—are always inherently socio-technical. From an intellectual standpoint, the clash between traditional centralized fossil-fueled electrical generators and novel, dispersed renewable energy resources is something more than a conflict over technology. It represents a battle about new technology versus unconscious and subtle social impediments; a contest over how best to manage power systems and control a vast and expanding electricity industry; and a clash over competing conceptiosn of modern life and identity. Moreover, the struggle is also about the immaterial and epistemic concepts of centralization versus decentralization, consolidated versus dispersed control over electrical resources, conducting business as usual contrasted with considering externalities like the environment, security, reliability, and efficiency.

Over this collision of technologies and ideas, the greatest impediments to DG technologies such as wind turbines, photovoltaic panels, and micro-turbines are both physical and immaterial: lingering utility monopoly rules continue to favor the design, financing, construction, and use of large-scale generators. Managerial practices and methods within the industry continue to rely on fossil-fueled technologies. Even more pervasive, deeply held social attitudes regarding a technological society, material standards of living, and consumption motivate consumers to use more electricity, but also impede the creation of new generators near population centers.

8.3 The Impediments Facing DG are Surmountable

Two of the biggest impediments facing distributed and renewable energy systems—capital cost and intermittency—exist, in some form, for any type of energy system. Multi-billion dollar nuclear plants and multi-million dollar industrial gas turbines are extremely capital intensive. Even though large plants tend to be less capital intensive per installed kW than renewable energy resources, large plants tend to have a

[1] Jack Barkenbus, Personal Interview, August 4, 2005; Full transcript available in Appendix 2.

unit cost can be more than one thousand times that of a single wind turbine or solar panel. In addition, the initial shift to the use of coal, and then natural gas, as a fuel for the electric utility sector required sustained political support, the construction of a vast supply and distribution network, among other institutional forms of support, to succeed. Even widespread use of gasoline in automobiles required the construction of an immense infrastructure early in the twentieth century to ensure that petroleum could be extracted, transported, refined, distributed, and used. The ability for policymakers in business and government to overcome the immense infrastructural challenges facing coal, oil, and natural gas suggests that, given the right mix of sociotechnical changes, similar obstacles could be overcome facing DG technologies.

In other words, some of the infrastructural and institutional problems facing DG can be partially overcome by coordinated policy mechanisms. DG and renewable technologies, for example, contribute significantly to electric capacity in some regions of the country. In Texas, voters managed to convince the legislature to radically reconfigure the state electricity market to favor DG technologies. In 2001, Texas forced utilities to unbundle transmission, power generation, and retail sales (so that any one category of utility cannot own or operate any of the other two). The legislature eliminated the ability for utilities to levy stranded costs and other discriminatory practices against DG technologies. In addition, local public utility commissions formed interconnection rules that did no require "extensive pre-interconnection studies."[2] Such commissions also mandated the use of net metering and real time pricing. Furthermore, the state legislature passed strict renewable portfolio standards and energy efficiency portfolio standards that mandate utilities provide more than 2,000 MW of renewable energy by 2009 (For a more detailed description of these incentives, see Appendix 3).[3] Taken together, these rules have, according to one legal analyst, "significantly challenged conventional thinking about distributed generation."[4] As a result, in 2003 the state featured the largest installed capacity of renewable energy—1,186 MW—in the country, more than twice that of any

[2] Allen, 2002.
[3] See Thomas Petersik, "State Renewable Energy Requirements and Goals: Status Through 2003," *Report for the Energy Information Administration*. (Washington, DC: Department of Energy, 2004).
[4] Allen, 2002, p. 507.

other state (and four times that of California), when large geothermal and hydroelectric sources of electricity are excluded.[5]

While arguably further behind than Texas regarding the deployment of small-scale renewable energy (California has more installed renewable capacity, but typically through large, utility-scale wind, solar, geothermal, and hydroelectric plants), California continues to lead the country in deployment of non-renewable DG technologies. Thanks to sustained political support from environmentalists and consumers since the 1970s, California removed excessive tariffs and challenged the ability of utilities to employ predatory practices against independent power producers.[6] Furthermore, the California Energy Commission—the state agency created in 1974 and now responsible for statewide energy policy—convinced the state legislature to enact a formal "Strategic Plan for Distributed Generation for the State of California" in 2002. The Plan increased state tax credits for cogeneration and renewables and instituted a large consumer awareness campaign concerning DG technologies. Consequently, even the U.S. Department of Energy has argued that California remains at "the forefront of using distributed generation technologies."[7] As a result, DG use jumped from a few hundred MW in the 1990s to over 2,000 MW in 2002.[8] California also passed one of the country's first—and most ambitious—renewable portfolio standards, which requires than an additional 1 percent of electricity sales must come from renewable resources each year (so that 20 percent of statewide generation becomes renewable by 2017).[9]

The two above examples suggest that, given the right configuration of political support, utility acceptance, and social awareness, DG and renewable technologies can achieve significantly more use. Nonetheless, for most of the country, the conditions for such a transition remain unlikely to occur. As the next section argues, the reason may have more to do with deeply embedded cultural attitudes than simple explanations of technical feasibility. Thus, for the moment, the success of DG technologies in Texas and

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[5] See Petersik, 2004; David Sibley, "The Role of Federal Electric Utilities." *Hearing Before the House Subcommittee on Energy and Power* (May 19, 1999).
[6] John A. Wetenkamp, "Power and Public Utilities: Chapter 12: Expedited Power Plant Siting as Response to Power Crisis." *McGeorge Law Review* 33 (2002), pp. 414-429.
[7] U.S. Department of Energy 2002, p. 18.
[8] See California Energy Commission, *Distributed Generation Strategic Plan—Final Report*, June 12, 2002, Available at http://www.energy.ca.gov/reports/2002-06-12_700-02-002.PDF.
[9] Petersik 2004.

California threaten to remain isolated anomalies rather than signals of an imminent transition.

8.4 DG Technologies Challenge Cultural Conventions about Electricity

Technological systems, according to Thomas P. Hughes, can be understood as more that just disconnected technical artifacts. As the previous chapters demonstrate, the classic utility paradigm of building large, centralized plants has become institutionalized and self-sustaining within the electric utility and government communities. Policymakers, managers, and system operators continue to seek construction of massive electrical generators as the "weapon of choice," largely because they are well understood and familiar. After all, the selection of large-scale, centralized technologies has generally led to creation of the biggest and most reliable utility system in the world (some say). In the risk-averse world of utility managers and legislators,[10] policymakers naturally resist adopting novel and less-experienced renewable energy technologies, even if they realize anomalies exist with the existing paradigm.

The growth of a technological system as complicated as the electric power grid—encompassing hundreds of thousands of miles of transmission and distribution lines, thousands of large generators, and hundreds of coal mines and LNG terminals—necessitates enrollment from all reaches of society in order to function. Engineers are needed to repair broken technologies, local utility commissioners attempt to ensure fair electricity prices, politicians attempt to enact legislation to maintain the status quo, banking managers and investors try to turn a profit, and so on. Yet, while people acknowledge the need for electricity, they do not want to see elements of the power infrastructure near their home. And even though a small number of people would therefore oppose construction of a big, centralized power plant—especially one built outside of population centers—more people would object to the greater number of installations of small-scale, distributed generation facilities needed to create the same amount of power. Put differently, the decentralized and modular nature of the technologies—which provide huge potential benefits to the utility system—make them

[10] The risk-averse nature of utility managers is explored in Richard F. Hirsh, *Technology and Transformation*.

especially visible and objectionable. And as Americans (and others around the globe) become increasingly aware that all energy technologies—including renewable technologies—contain environmental downsides, the new distributed systems painfully bring what previously seemed "invisible" to the foreground. It appears that the technical or economic benefits cannot totally trump the public's disapproval of what they perceive as highly evident and intrusive DG technologies.

8.5 The Impediments Facing DG Technologies Must be Historically Contextualized

Finally, Hughes suggests that the technologies a society adopts are always contingent, and thus only partly predictable. One sees such contingency expressed through the success of fossil fueled electricity generators, as well as the relative failure of renewable and distributed systems. Despite their prevalence today, fossil fueled generators were never an inevitable historical outcome for the electric utility industry. Instead, such technologies were *chosen* by the industry because they best matched the economically rational vision of how utilities wanted to manage the industry: distributing electricity based on large, centralized plants properly sized through economies of scale to deliver a product at perpetually declining prices. However, when progress with these larger generators appeared to stall in the 1960s and 1970s, distributed and renewable resources became more competitive. To use Hughes' term, engineers and system operators within the electric utility industry encountered *reverse salients*—something akin to a bottleneck and constraint—when trying to develop larger fossil-fuel generators. Thus, the thermal efficiency of large power plants and the effective scale of units reached plateaus, convincing some in the utility industry to investigate the potential for alternative sources of electricity. However, advocates and proponents of DG technologies also face a number of other, more difficult reverse salients. They have been unable to convince utilities, municipalities, and system opeators to abandon their classic model of electricity distribution and transmission, and they lack the socio-technical infrastructure needed to promote their technologies.

And here, the concept of *technological momentum* helps explain why alternative energy technologies such as renewables and distributed generators never took off. Notwithstanding the reverse salients encountered above, most investor owned utilities continued to rely on large plants and economies of scale. Such preferences, over time,

have connected a number of social institutions—banks, universities, political interest groups, regulatory agencies—to the current electric utility system. Because fossil fueled technologies acquired credibility among utility managers, financiers, political interest groups and regulatory agencies, they have received consistent state support throughout the past three decades. In contrast, newer, renewable and distributed systems have received only parochial and intermittent support in the form of constantly expiring tax benefits—a trend that has played a significant role in impeding their wider diffusion into the electric utility sector. Moreover, the tendency for utilities to locate power plants away from population centers reduced public interest—and consequently knowledge—in how electricity is generated. Isolating power plants from urban centers also disassociated the more direct problems of fossil fuel combustion (air and water pollution, carbon emissions) from society. Thus, renewable and distributed energy systems possessed less *momentum*—economic, political, and social capital, so to speak—than traditional technologies.[11]

The combination of these social factors has created a physical energy infrastructure populated by centralized plants. These large plants are complimented with a transmission grid that distributes power in a radial fashion. But such social factors have also created an immaterial epistemic infrastructure—honed and embedded over almost eight decades of operation—convincing utilities that the present system was the *best* model for generating, distributing, and selling electricity. And so, Americans prioritize abundant supply and cheap prices as important energy concerns. To meet these concerns, the electric utility sector has only been able to promote abundance and cheapness with the assistance of regulators and politicians, who subsidize all forms of energy to shield consumers from the true costs of energy extraction, generation, distribution, and use.

[11] A caveat must be introduced in advancing this conclusion, however. The way that the modern electric utility system has acquired momentum lends some legitimacy to those who adhere to notions of technological determinism. Of course, few seriously believe that the technologies used to generate, distribute, and consume electricity have any real chance of becoming autonomous or self-sustaining. However, the existing technological system in favor of fossil fuels and large power plants does condition the way that people—system builders, managers, and users—conceive electricity. In this way, the existing system constrains what individuals see as *possible* when they think about energy. This is not to say that the existing system controls society, but it certainly exerts influence on it, a sort of technological somnambulism instead of a technological determinism.

Thus, the dominant electric utility system has become naturalized, a taken-for-granted component of our modern landscape barely recognized by most customers.

And, finally, the concept of *interoperability* suggests that components of a technological system become acceptable only when they work to promote the goals of the network. In contrast to the established practices and technologies used by utilities, renewable and distributed energy technologies challenge not just the technical foundation of the current power structure, but also its economic, social, and political organization. Clashes over the technical feasibility of renewable energy and distributed generation are oftentimes more than just scientific debates, and have much to do with the interests and values of how the electric utility system should be managed.

8.6 Conclusion

In the end, a complicated amalgam of socio-technical, rather than purely technical or social, issues prevents the adoption of more DG and renewable energy technologies. Almost a century of utility preference for large, centralized plants has influenced the way that most engineers and modern day systems builders conceive of power generation. Additionally, government policy for DG and renewable energy technologies have helped advance their technical and economic feasibility, but legislative action often occurs inconsistently, changing dramatically and affected by a host of political and ideological factors. As important, business mangers and political leaders who still retain much control in the electric utility system have erected a large set of barriers and costs that discourages untraditional participants from entering the business of generating electricity. Finally, the public's lack of knowledge about electricity production and its use often leads to greater opposition to a large number of small, distributed power units (even those that create fewer environmental harms) than to a smaller number of traditional fossil-fuel burning plants located far from load centers. Renewables also suffer being attacked from both sides: they are too radical for conservative utility managers and investors, but too "ugly" and dangerous for environmental activists.

The tendency for the remaining impediments to novel energy technologies to be social or socio-technical, rather than just technical, means that policymakers continue to subsidize energy technologies in the wrong way. Many renewable energy technologies—notably wind turbines and biomass generators—have already caught up to fossil fueled

generators in terms of levelized costs of electricity. Many more would clearly complete if external costs were included in the price of electricity. Instead of creating government incentives that aim to further increase the efficiency and technical capacity of such systems, this study suggests that policymakers should shift their focus away from the technical to focus on efforts aimed at increasing public understanding of energy systems and challenging entrenched utility practices.

This discussion of impediments to novel renewable energy and DG technologies is important because it reminds us that large state and federal programs aimed at overcoming the technical difficulties associated with novel energy technologies are not enough. Part of the problem is that policymakers continue to rely exclusively on technology to provide solutions to the country's energy problems. In February, 2006, for example, President Bush unveiled his idea for the Advanced Energy Initiative in this State of the Union Address, which he promised would help fight American dependence on foreign sources of oil. "The best way to beat this oil addiction," insisted Mr. Bush, "is through technology."[12] The historical record, however, seems to contradict Mr. Bush's view. Despite billions of dollars in research and development, procurement, tax incentives, tax credits, subsidies, standards, and financial assistance, the impediments to a transition to a more environmentally sustainable form of electricity generation remain social (i.e., economic, political, and cultural). Until these remaining social barriers are targeted (in the same way that technical impediments were targeted twenty years ago), the promise of renewable energy and DG will remain unfulfilled. Technical solutions to socio-technical problems will always produce incrementally narrow and ephemeral results.

[12] *The Economist*, "Energy Policy: The Pusher-In-Chief," February 4, 2006, p. 26.

Appendix 1: List of Interviews Conducted

NAME	TITLE	INSTITUTION	DATE
Adam Serchuk	Senior Renewable Energy Program Manager	Energy Trust of Oregon	February 21, 2006
Alan Crane	Senior Program Officer	National Academies of Science	February 2, 2006
Alex Farrell	Assistant Professor, Energy Resources Group	University of California Berkeley	October 26, 2005
Anonymous Expert	High-ranking Executive	Large, American Independent Power Producer	March 4, 2006
Art Rosenfeld	Commissioner	California Energy Commission	December 6, 2005
Benjamin Cohen	Assistant Professor, Science & Technology Studies	University of Virginia	March 6, 2006
Brian Castelli	Executive Vice President	Alliance to Save Energy	February 7, 2006
Brice Freeman	Project Manager, Distributed Generation	Electric Power Research Institute	February 22, 2006
Chris Namovicz	Operations Research Analyst	U.S. Energy Information Administration	February 9, 2006
Christopher Russell	Director, Industry Sector	Alliance to Save Energy	February 9, 2006
Chuck Goldman	Group Leader, Electricity Markets and Policy Group	Lawrence Berkeley National Laboratory	October 25, 2005
Claudia J. Banner	Senior Engineer, Renewable Energy Planning	American Electric Power	March 6, 2006
Dave Stinton	Combined Heat and Power Program Manager	Oak Ridge National Laboratory	August 2, 2005
David Baylon	President	Ecotope Consulting, Research, and Design	August 15, 2005
David Garman	Undersecretary of Energy, Former Assistant Secretary for Energy Efficiency and Renewable Energy	U.S. Department of Energy	February 22, 2006
David Hawkins	Lead Industry Relations Representative	California Independent System Operator (ISO)	October 13, 2005
David Hill	Deputy Laboratory Director, Science and Technology	Idaho National Laboratory	August 3, 2005
Edward Vine	Staff Scientist	Lawrence Berkeley National Laboratory	October 25, 2005
Irene Leech	Professor, Department of Resource Management	Virginia Polytechnic Institute & State University	March 27, 2006
Jack Barkenbus	Executive Director, Energy, Environment, and Resources Center	University of Tennessee	August 4, 2005
James Gallagher	Director, Office of Electricity and Environment	New York State Department of Public Service	October 4, 2005
Jan Harris	Project Manager	Vermont Energy Investment Corporation	September 29, 2005

NAME	TITLE	INSTITUTION	DATE
Janet Sawin	Director, Energy and Climate Change Program	Worldwatch Institute	April 7, 2006
Jeff Jones	Operations Research Analyst	U.S. Energy Information Administration	February 8, 2006
Joe Catina	Manager of North American Projects	Ingersoll Rand Company	September 20, 2005
Joe Loper	Vice President for Research and Analysis	Alliance to Save Energy	February 7, 2006
John Plunkett	Partner and Former President	Optimal Energy Consulting	September 29, 2005
John Warren	Director, Division of Energy	Virginia Department of Mines, Minerals, and Energy	September 16, 2005
John Wilson	Senior Researcher	California Energy Commission	December 6, 2005
Judi Greenwald	Director of Innovative Solutions	Pew Center on Global Climate Change	February 13, 2006
Ken Tohinaka	Senior Energy Analyst	Vermont Energy Investment Corporation	September 29, 2005
Larry Papay	Former Senior Vice President	Southern California Edison	September 21, 2005
Marilyn Brown	Commissioner	National Commission on Energy Policy	August 4, 2005
Mark Hall	Senior Vice President	Primary Energy	October 5, 2005
Mark Levine	Division Director, Environmental Energy Technologies	Lawrence Berkeley National Laboratory	October 25, 2005
Michael Pomorski	Senior Associate	Cambridge Energy Research Associates	January 21, 2006
Michael Karmis	Director	Virginia Center for Coal and Energy Research	February 16, 2006
Paul DeCotis	Director of Energy Analysis	New York State Energy Research and Development Authority	October 4, 2005
Paul Gilman	Former Assistant Administrator for Research and Development	U.S. Environmental Protection Agency	August 3, 2005
Ralph Badinelli	Professor of Business Information Technology	Virginia Polytechnic Institute & State University	March 6, 2006
Ralph Loomis	Executive Vice President	Exelon Corporation	October 6, 2005
Rodney Sobin	Innovative Technology Manager	Virginia Department of Environmental Quality	September 16, 2005
Ryan Wiser	Staff Specialist, Renewable Energy Systems	Lawrence Berkeley National Laboratory	October 25, 2005
Sam Fleming	Former Program Manager, Renewable Energy Systems	Nextant Incorporated	October 27, 2005

NAME	TITLE	INSTITUTION	DATE
Scott Sklar	President	The Stella Group, Inc.	February 9, 2006
Shalom Flank	Chief Technical Officer	Pareto Energy Limited	March 20, 2006
Shawn Collins	Project Manager, Fuel Cells	United Technologies	March 3, 2006
Shelly Strand	Marketing and Project Manager	Ecotope Consulting, Research, and Design	August 15, 2005
Steffen Mueller	Senior Research Economist, Energy Resources Center	University of Illinois at Chicago	October 6, 2005
"Ted" (Edward C.) Fox	Interim Director, Energy and Engineering Sciences	Oak Ridge National Laboratory	August 1, 2005
Tim Cross	Staff Writer	*The Economist* Magazine	September 30, 2005
Tom Casten	Chairman and Chief Executive Officer	Primary Energy	October 5, 2005
Thomas Grahame	Senior Research Analyst, Office of Fossil Fuels	U.S. Department of Energy	February 13, 2006
Thomas Petersik	Former Renewable Energy Forecasting Expert	U.S. Energy Information Administration	February 1, 2006
Toben Galvin	Senior Energy Analyst	Vermont Energy Investment Corporation	September 29, 2005
Tommy Oliver	Assistant Director, Division of Economics and Finance	State Corporation Commission of Virginia	September 15, 2005
Tommy Thompson	Energy Manager	Virginia Department of Mines, Minerals, and Energy	September 15, 2005
Vijay V. Vaitheeswaran	Energy Correspondent and Author	*The Economist* Magazine	March 6, 2006
Vikram Budhraja	Former President, Edison Technology Solutions	Edison International Company	September 27, 2005
Wilson Prichett	Energy Consultant	ASEGI Incorporated	February 16, 2006
Zia Haq	Operations Research Analyst	U.S. Energy Information Administration	February 9, 2006

Appendix 2: Interview Questions and Transcripts

***NOTE:** The views expressed in the following interviews do not represent those of any particular company, institution, or agency. Individuals are speaking entirely—and only—on their own behalf.

Question 1: Renewable energy technologies received massive support after the 1970s energy crisis, and were expected to constitute a major percentage of future generation. Yet, as of 2005, they constitute a very small portion of the United State's energy portfolio. Why?

Adam Serchuk, Senior Renewable Energy Program Manager, Energy Trust of Oregon: For one, I think when Carter was president, people were predicting $50 barrels of oil in 1970s dollars. And oil is expensive now, but for a decade and a half it was rock bottom cheap, especially during the Reagan years. Carter also succeeded in deregulating natural gas, so energy prices became cheaper than anyone thought they would be. More generally, established technologies didn't stay as they were built. Natural gas combined cycle turbines, for example, became more efficient, they didn't just stand still as a dead and dying technology. Manufactures of traditional electricity generating technology took advantage of the market, just like everybody else.

It also turned out to be much more difficult to get policymakers and the public to really care about energy. I don't really care about it myself as a homeowner; I just want to flip a switch and have the lights come on. The whole idea that people would come together to form active, community groups to make democratic decisions about energy is ridiculous. Most people find it bad enough to attend one school board meeting a month. So it was a wrong headed idea among leftists about how Americans wanted to change their lives with respect to energy. People don't want to take responsibility for their energy decisions, they just want energy problems to go away.

Finally, you had a problem of split incentives. For years utilities were in charge of both getting people to use more energy and getting people to use less energy. Utilities had the responsibility of returning profits to their shareholders (and thus trying to get Americans to purchase more electricity), but were also asked by regulators to use energy efficiency programs and renewable resources to get Americans to conserve energy. It just didn't make sense.

Alan Crane, Senior Program Officer, National Academies of Science: Well, while some were pretty nice ideas, the technologies were simply too expensive. I also think that expectations of such technologies were grossly inflated. When oil prices came down in the 1980s and 1990s, renewable technologies could compete no better than a nuclear power plant could. And with the price of natural gas at $2 per million BTUs (and coal for even less), no one wanted to worry about putting up something that cost thousands of dollars per kilowatt, even if its fuel was free.

Two things are happening now, however, that threaten to change the game. Renewables are getting cheaper as their technology improves and advances, and the cost of fuel (notably coal and natural gas) is going up. This may not make a transition to renewables inevitable, but society is definitely getting over a threshold.

Alex Farrell, Assistant Professor for the Energy Resources Group, University of California Berkeley: It should first be noted that forecasts should not be taken seriously. A lot of them are normative scenarios. Vaclav Smil talks about scenarios in a thoughtful way; people were being purposely hopeful, advocates as much as analysts. So that's why I don't think those predictions necessarily came true.

But why else don't we see a larger fraction of renewable/DG use?

First, capacity: even right through the 1970s and the oil crises, which raised prices for everything, there was an enormous amount of capital being invested in all areas of energy infrastructure. Not just electricity technology in the United States, but petroleum production capacity in the Middle East was under construction then. Higher oil prices and inflation created excess capacity in the world energy systems—certainly in electricity and oil—right through the end of the 20th century. All of this spare capacity—and vested interests attached to it—disadvantaged renewable energy systems.

Also, relative cost: until recently, many of the renewable technologies were not cost effective, and the predicted drivers of pollution and scarcity did not show up rapidly or thoroughly enough in the way that those pushing renewables expected. The Staggers Act also deregulated the railroads, pushing the price of coal further down.

Anonymous, High-Ranking Executive for a Large, American Independent Power Producer: From the standpoint of most Merchant Power Generators, it's not a market they are interested in. A typical company, for example, sells power in 50 MW blocks. This is considered a modest size relative to the available generating capacity. It is equivalent to the output of a few small generators, or a fraction of a single medium to large generator. Staff sizes and the capital investment required to create power in this manner are very low compared to alternative methods.

Renewable energy, on the other hand, is produced in very small quantities. The largest wind turbine currently in service is only 3-3.5 MW, with 5MW sizes in the planning stages. Compare this with an average coal plant, where the generators are typically in the 200-600MW range and sometimes exceed 1,000MW. The cost on a per MW basis to build and then to maintain the wind turbine is much higher (or at least perceived to be higher).

It is hard to compete with the price, on the basis of cost per energy equivalent (i.e. $/BTU), of coal, nuclear and hydro power. Together these represent 80-85% of all power produced. Other fuels are more expensive, especially oil & gas.

Fossil fuels can generate power on demand. Renewables are not always available when the power is required. There is currently no practical means of storing large quantities of electric power.

Arthur Rosenfeld, Commissioner for the California Energy Commission: President Carter thought that they would get to 10 percent in eight years, yet his Administration had no serious planners. Sure, we had lots of legislation to prod things along (with a small but vociferous minority of solar advocates), but most of it was a premature wave of enthusiasm.

Benjamin Cohen, Assistant Professor of Science & Technology Studies, University of Virginia: Why? The political and philosophical—or the political philosophical—character of energy distribution. Attempts to develop alternative energy markets have been just that, market-based and/or market-driven. The commercial basis thus has been taken to be the only or primary basis for considering renewable energy technologies. But in the United States, the commercial (financial, economic, business, corporate) context is so thoroughly intertwined with the contexts of political philosophy and civil governance that attempting to promote renewable energy technology from only a perspective of markets ignores the inter-related philosophical, political, and cultural dynamics that make energy distribution meaningful. Not that this intertwining set of contexts does not exist in other nations or cultures, but that it is uniquely defined and understood in the US.

Brian Castelli, Executive Vice President and Chief Operating Officer, Alliance to Save Energy: A big reason renewables never met its expected potential is because the target price for technologies that compete with renewable and distributed energy systems continues to drop relative and faster than the prices for most renewable technologies. For example, renewable systems compete against coal fired generation, and coal just becomes cheaper and cheaper. No matter now much we cut down the cost of PV and wind, the coal price continues to fall faster. That's the real nub of the problem. However, wind has become fairly competitive now, price-wise, so it can compete. Yet you have to have the wind blowing (and for PV, the sun shining), and at best operators can achieve capacity factors between 30-35 percent. Now, a coal plant can go 97-98 percent capacity, just like the nuclear generators. So although the fuel is free for technologies like renewables, it's not always there.

Brice Freeman, Project Manager for Distributed Generation, Electric Power Research Institute: There are several major reasons for this. When you look at a conventional renewable or DG project, you typically have an end-user (a small industrial facility, or commercial facility), a project developer/financier, and the utility. Each of these three parties has a stake in the project. The end-user is looking to save money or improve power quality and reliability. Depending on the business model of the developer, they are looking to make money on and design build basis or possibly collect revenue through operation of the unit. The utility, in theory, could really benefit through improved power quality, voltage support, offset or delay a distribution upgrade. However, when you look at how these benefits are allocated in actual projects, it is seldom the case that all parties come out ahead. The utility usually comes out the looser

in this scenario because they must supply service (i.e. build out a feeder extensions to a new commercial development) even though the owner will be making their own power, but they will receive little revenue in return. They loose on power sales (note: some combined gas & electric utilities make up for some of this by increased gas sales). Since regulated utilities cannot own DG, and because they often come out the looser on DG projects, the utilities have little incentive to promote the proliferation of DG in their service territory.

A few utilities are embracing DG and are working with their customers to identify areas in their service territory where DG can provide assistance. For some (i.e. Portland General, SDG&E), they offer financial incentives for customers to run their units during periods of critical electricity shortages.

Another reason that DG has not taken off more quickly is the volatility of natural gas prices. For all intensive purposes, you can assume that all DGs run on natural gas. There are a few that don't but they are insignificant in number. When the country was in the $3-5/MMBtu gas range, the project economics made sense. And end-user could install a DG device and run it profitably for enough of the year to receive a favorable ROI, maybe 5 years or less. However, as the price of gas has risen to 8, 10, and sometimes over $12/MMBTU, it becomes nearly impossible for DG to compete with grid power which has largely gone unchanged due to the stable supply of coal and nuclear power prices.

A third, but perhaps less threatening barrier to adoption is "first time costs." When we model DG project economics, the first time costs are the Joker in the deck. In the early years of DG, end-users and utilities and manufactures didn't know how to play together. There were no interconnection standards that provided utilities with the protection they were familiar with and needed. There were a few larger merchant power plants in operation but that was about it. In the mid 1990s when DG began to come into its own, utilities, permitting agencies, and developers had to go through a learning process – how to install and permit the operation of these small generators. Sometimes this meant electrical impact studies or customer engineering designs, or a suite of emissions characterization and testing. Because DG units are, by nature, small and relatively inexpensive, any unexpected costs can sink project economics and these early project didn't get a lot of developer excited. Some of them would go into a seeming simple installation of a, lets say $30k Capstone microturbine, and ran into such things as full enclosure and fire suppression equipment requests by the fire department ($10-$50k) or a the inclusions of additional utility switchgear ($5-$40k).

All of these events and factors contribute to the slow rate of adoption for DG devices.

Chris Namovicz, Operations Research Analyst, U.S. Energy Information Administration: During the 1970s, American society faced a number of mostly artificial constraints on energy markets that caused turmoil in the key commodity markets. Natural gas supplies were expected to run out, oil prices were expected to rise to $30-$60 per barrel. So it seemed to make sense for policymakers then to invest in renewable technologies to start to offset high projected fuel prices, yet in most of the 1980s and

1990s those fuel prices remained very low, which was not generally predicted in the 70's. OPEC decided to increase supply, natural gas markets were deregulated. Fundamental assumptions of 1970s forecasts that saw huge markets for renewable energy were proven false. And while it's true that renewable technologies continued to go down in price, they didn't fall as quickly as their fossil and gas fueled competition.

Now, in the past five years, the electric utility industry is facing another fuel-price crisis. We've come almost full cycle in the past couple of years so that oil prices have risen to $60 per barrel and natural gas prices are skyrocketing. People are again saying that renewable energy looks pretty cheap again…at least in the near-term.

Christopher Russell, Director of the Industry Sector, Alliance to Save Energy: The people with the deepest pockets have the most sway over the government's R&D agenda. They determine where money will be invested in certain modes of technology. The utilities have a vested interest in continuing to generate an economic return from the assets that they already have. It's not in their interest to walk away from existing assets and accept DG or renewables. You run into the issue of stranded costs. They have to look out for their shareholders. It makes perfect sense from a corporate shareholder viewpoint. But the problem is that the people that advocate alternative fuels and technologies don't have deep pockets compared to the big oil and utility companies. They may not mind research, but they certainly mind the deployment of new technologies that threaten to displace their current cash-cow assets.

Chuck Goldman, Group Leader, Electricity Markets and Policy Group, Lawrence Berkeley National Laboratory: The big difference is cost. In relative terms, with energy efficiency, you can capture a sizeable amount of the resource at a cost considerably less than conventional supply-side options. And for renewables, it's only been in the last couple of years where some renewable technologies are cost competitive with traditional supply-side technologies. On the supply-side, fossil-fuels ended up being cheaper, and on the demand side, energy efficiency practices ended up being cheaper. Both impeded a wider use of renewable energy systems.

Also, people were overly optimistic about the ability to reduce the cost of renewable technologies over time. People, during that entire period, there was a world of low oil and natural gas prices (around $2-3 per million BTU). People also underestimated the impact of the aeroderiviative natural gas turbine. Radical yet unforeseen improvements in traditional electrical generation technology also ended up distorting the initial estimates and cost targets for renewable systems. It was thought that renewables would only have to compete against nuclear and coal, but it turns out that on the margin renewables really had to complete with natural gas plants that were using technology much more efficient. Because of that, the renewables folks have been playing catch up.

Claudia J. Banner, Senior Engineer for Renewable Energy Planning, American Electric Power: There are several reasons why Distributed Energy Resources (DER)/Distributed Generation (DG) are still only a small portion of the energy portfolio.

After the 1970's energy crisis, prices came back down and have remained relatively low, when you compare DG to traditional generation.

a) Cost. As an example, AEP Ohio utility bills state (in one case) that a provider would have to offer electricity at 4.8 cents/kW-hr or less for the customer to really consider switching energy providers. In mid-February, the website Solarbuzz.com was showing the cost of solar electricity at 21.44 cents/kW-hr.
[http://www.solarbuzz.com/SolarPrices.htm]

If those numbers are correct, then why would a customer install a more expensive system (such as solar panels) that doesn't necessarily work all the time (cloudy days, night, not providing all the electricity needed) when the existing utility provider is there 24-7 and provides electricity at a lower cost?

b) Energy storage. Another reason DG hasn't become more mainstream is that energy storage is a problem. The battery technologies aren't quite there (but they are getting better). Another reason DG has not become more mainstream is that their key enabler, energy storage, is not as inexpensive as it needs to be for mainstream application.

c) Impediments to installation. In the case of solar, some homeowner associations restrict installation of solar panels on houses, citing aesthetic concerns. Net metering in association with the utilities can be an issue, as can interconnections to the grid.

d) More work. If you have a distributed generation system, then you are most likely responsible for its operation and maintenance. Many of these systems do not require a lot of maintenance (e.g., solar) but some do (anaerobic digesters). With utility-provided electricity, the consumer does not have to deal with the headaches, but allows the utility to maintain the central stations and transmission and distribution lines.

Dave Stinton, CHP Program Manager, Oak Ridge National Laboratory: There are several problems. In most parts of the country, the utility is going to be against you and will view any independent power generation as competition, or they will attempt to make your system uneconomical with disconnection charges, interconnection charges, reconnection charges, and so on. There really is this poor relationship between utilities and customers.

The second is the volatility of natural gas prices. Companies are not willing to make a commitment to natural gas fired DG systems when they don't know what gas prices are going to be.

The systems that we are involved with at ORNL make sense only in a few parts of the country: the Northeast and California, where power rates are high. Electricity prices are too low. If you are trying to do an engineering analysis to suggest that DG systems are less costly, you have a hard case to make.

We also find that many of these applications are trying to capture the waste heat to use it productively. And it turns out that the head loads don't match so well, because it's not economical to run the engine and throw waste heat away.

For example in New York a guy machines plastics into complex shaped parts. He installed a DG system using microturbines, originally he was running 20 some microturbines to generate 600 kW of electricity, and thought his business was doing fine, and as he operated the thing for several years he started to realize it didn't make sense to use the microturbines for electricity. They should really be run to use waste heat to use; the electricity is almost the byproduct.

We find some of the same problems at hotels: there are some times during the day when cogeneration is useful, like the beginning of the day when people are getting up and laundry services are in use. Yet at 1:00 in the afternoon, no one is in the hotel and no one really needs the waste heat.

The point is that it's really difficult to find the best application for DG/CHP systems, especially when it may not be optimal to run such systems for 24 or even 12 hours a day.

David Baylon, President and Founder, Ecotope Consulting, Research, and Design: It turns out that if you start down this road very far, especially if you learn what the real answer here is, which is efficiency, you actually take all of the pressure off of renewable energy sources. No one really thought that the peak of oil production would be this far out. One of the features of not having a peak is that, when you come to the peak, even if the peak is quite high, incremental demand doesn't have incremental production to offset it, and it inevitably prices go up. The current model we are at now, is the Enron style of responsible energy management, and has been for the past five years, is the deregulation model. It is fundamentally incorrect that competition is good and will drive down the price of electricity. This is fundamentally incorrect if competition does not actually exist in a natural monopoly, and that is what the energy business is, and that is why competition will not work and we see the prices that we see. For those of us in the energy efficiency business, high prices are better for us since it makes it easier to sell energy efficiency.

Now, when people in the 1970s were saying they thought renewables were the way of the future, the U.S. government was pumping in over $1 billion into energy research and development. Since the 1980s, we've probably put a $1 billion all together into research and development. Focus on today, and it's even worse. President Bush and the current administration are ignorant, uninformed, and corrupt regarding energy policy. Energy decisions in this country have been bought by people who will make substantial short term profits. There isn't a good reason for oil to be $70 per barrel at this moment, but it is.

David Garman, Undersecretary of Energy and Former Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy: A couple of things. First, the price of renewable energy technologies never came down as much as

President Carter thought they would. I am not familiar with what sort of price point they projected for distributed renewables, but that work was not lost. Many people forget that the price of renewables has come significantly down. Photovoltaic panels had a fair price in the mid 1970s and 1980s around $2 per kWh, and today such systems can provide power in Phoenix, Arizona, for around 20 to 30 cents per kWh. As you can see, we have made great progress there.

The bad news is that the average retail residential price for delivered electricity is around 10 cents per kWh. Until photovoltaic panels really get down into that price range or less, they will not have much market penetration, regardless of what kind of policy instruments one uses to bring PV systems into force. This is not just an issue of scale. To keep focusing on the solar situation, right now the average cost of getting a module of PV installed for residential use is still only competitive in California and Germany. In many ways, the Germany subsidy for renewable energy is distorting the market. A current shortage of crystalline silicone are driving the cost of solar energy up, when the theory behind the subsidy was to dive the cost down by increasing scale. The issue may be a short term anomaly, but it is still a real issue. I am proud to say that the Department of Energy is currently looking at cadmium telluride, cadmium-indium-gallium sulfide (CIGS) and other sorts of thin film products that could really lead to a breakthrough in the design and manufacturing process of photovoltaic panels. With these newer and advanced materials, I expect to see the cost of solar energy below 10 cents per kWh by 2015. If that is the case, either the market will readily pull the technologies in, or the policy instruments that we have used to encourage, cajole, or compel people to do it will be less expensive than the policy measures we use today.

My message is that we have stayed the course: the current generation capacity for renewable energy in this country is not a failure at all. We are almost at the finish line. When I see people like Honda all of a sudden getting into the business of thin film photovoltaics, the marketplace is telling me that we are almost there.

Granted, there are many other information barriers, market failures, and policy constraints that continue to impede renewables. Interconnection in this country is still highly inconsistent between states. The capital cost of most renewable energy systems still places them out of the means of most residential customers. It takes a pretty dedicated individual to put solar energy on their roof that costs 20 to 30 cents per kWh; people have to do it for reasons other than price. Fundamentally, at the end of the day, if we do nothing else, we need to get the price of renewables down.

David Hawkins, Lead Industry Relations Representative, California Independent System Operator: Let me first say that the California ISO has been doing a lot of studies on geothermal, biomass, wind, small hydro, and solar (the five common categories of renewable resources). In California, 10-12% of resources come from renewables, we have 500 MW of solar, and 1,200 MW of geothermal.

What we've learned is that every generation resource has unique characteristics and issues. The real question is how to put forth the correct portfolio to properly manage and

operate a system. Wind, for instance, can be forecasted and has predictable patterns during some periods of the year. California uses wind as an energy resources but it has a low capacity factor for meeting summer peak loads. The Total Summer peak load is 45,000 MW of load, but in January daily peak loads are 29,000 MW, meaning that 16,000 MW of our system load is weather sensitive. In the Winter and Spring months, big storms come into California which creates dramatic changes in wind. We've can seen ramps as large as 800 MW of wind energy increases in 30 minutes, which can be quite challenging.

Now, to your original question, the renewable technologies that was installed predominately in the 1980s—the so-called first generation—had much learning left to do. Wind Generator developers had to try all types of different configurations. Many of the early wind mill types had very poor reliability and required lots of maintenance and repairs. We also didn't know that below 30 meters, the drag of the wind takes a lot of energy out of it so high wind mills are more productive. The early turbines also had environmental problems such as killing birds and stirring up television signals for those downstream of windmills. They also tended to vibrate the ground, which disturbed the land animals.

Because we've learned, however, these challenges have largely been overcome. Turbines today are much better, and can operate at much greater wind speed ranges. They can now run at wind-speeds between 5 mph and 50 mph, when they used to be confined to 8mph and 18mph. They also have wider band-with, and capacity as grown to encompass units sized between 1-3 MW. Each unit is much more productive. Variable pitch now exists on the blades; blades can be manufactured in fiberglass; and blades can bend and flex in the wind.

David Hill, Deputy Laboratory Director for Science and Technology, Idaho National Laboratory: It hasn't been realized around the world, it's not just this country. Possibly Denmark has 14 percent of their electricity from renewables and France generates 15 percent from large hydroelectric facilities. But I think it's simply an issue of cost, primarily. In the end, in this country, markets dominate. And if you think about what has happened to government as a whole in the 1970s to now, we have gravitated increasingly toward the market for solutions to social problems. Focusing on the stock market, returns have to be shown over increasingly shorter times, and that means large-scale things like nuclear large scale investment is a barrier, and for renewables, you cannot make an economic case.

On the technical side, renewables are smaller and more diffuse, making it harder to demonstrate a profit at any level. Where does renewable energy show up? We use renewable resources here, but in small, local sources like remote applications. Renewables just aren't ideal for large centralized generation.

Edward Vine, Staff Scientist, Lawrence Berkeley National Laboratory: Well, a combination of many factors is to blame.

(1) Cost/economics. The renewable energy technologies were too expensive for households and at the commercial level. People were not (and still are not) willing to spend a lot of money on generating energy when they could get cheap energy. If you look at the average household, energy costs are still a very small percentage of total expenses. Inexpensive energy is a barrier to the adoption of renewable energy technologies.
(2) Technology and risk factors. People are naturally risk averse, and all new technologies have an uncertainty factor associated with them. How reliable are they? People have demonstrated a reluctance to pay four to five times more for a product that they didn't believe would be as reliable as traditional technologies. This lack of familiarity with a new technology translated into uncertainty regarding the future of renewable energy.
(3) Politics. Probably the most important reason of all. The people in control of the power system—oil firms, coal companies, nuclear energy producers—have a substantial amount of investment in traditional technologies. Such institutions, which have become a powerful political force because of their market power, are reluctant to change their existing technologies and see the market share of these technologies dwindle. Historically, they have helped promote their existing technologies at the expense of renewable technologies.
(4) Subsidies. One final reason that renewables haven't been promoted is because other fuels are subsidized by the government. The true cost of energy is not reflected in the price of energy. There is a huge externality question—what are the environmental costs of pollution, or the armed forces costs to provide security for oil shipping lanes? And how can these externalities be internalized into the true cost of energy?

Jack Barkenbus, Executive Director of the Environment and Resources Center, University of Tennessee: American people want certain things out of their energy: abundance, reliability, inexpensive prices, they want it to be clean, safe, and unobtrusive. And the problem that we have is that fulfilling those criteria with the suite of opportunities that are out there is that advocates for one form of energy or another pick up on what that form of energy is best at in terms of those criteria. But obviously, they do have problems, and no energy source or energy policy meets all of those criteria. We have been struggling for the past 30 years, and in many ways we are no closer now than we were back then.

I always look at renewables in that context, and in many ways they fulfill some of those criteria, but in other ways they struggle. As a rule, renewables sometimes have a problem in meeting our reliability, cost, and unobtrusiveness criteria

We have this faith in science and the development of knowledge that over time we will make major breakthroughs that we simply have not been able to achieve, and its not just renewables. Look at fusion, for example. People have been saying for the past 40 years that fusion will be on a near commercial basis in 30 years. It is still 30 years away from commercialization today. It's not so much an indictment of renewable energy sources, but an indictment of our misplaced faith in our technological prowess to solve social

problems. Actually, I don't know if you've seen it, but there has been an interesting paper by Resources for the Future where they looked at the cost goals for renewables in the 1970s, and they found that virtually all of those goals have been met. We achieved our goals according to what we thought they should be back at that time. The problem is that the yardstick has been moving so that conventional sources of energy have become less expensive as well. So despite the success of lowering the cost of renewables, they haven't become cost competitive in the way originally envisioned. We just didn't anticipate breakthroughs on fossil fuel technology like coal and natural gas turbines.

James T. Gallagher, Director of the Office of Electricity and Environment, New York State Department of Public Service: First, politics. I recall from personal experience in the late 1970s at TVA, we had an incredibly large budget for our renewable program. At the same time we were trying to build up the solar branch of TVA. President Carter said at the time that he wanted TVA to be the solar showcase of the nation. TVA had a goal of 1,000 MW of solar. At the same time we were promoting renewable energy and energy efficiency, TVA had a massive nuclear generation product underway. Trying to do both paths at the same time was very difficult, and it was during that process that TVA ended up canceling projects in both areas. Yet the biggest challenge was the dramatic pullback in funding for energy efficiency and renewable energy once President Carter left office and President Reagan was inaugurated.

Also, the mood in the country changed. A number of people left those public sector jobs in the DOE and others to go into the private sector to start their own companies and do things on their own. But it didn't pick up steam again. A lot of it had to do with the economics of renewables. And we had a period of excess supply of electricity in most parts of the country.

And, finally, the early failures or hurdles with renewables turned people off from the technologies. The early experience with solar wasn't very convincing in showing that the technologies worked. So people developed a bad taste in their mouth concerning renewables. I remember a project at TVA involving 44 solar homes where the data on the success of those homes was never released, so people never learned a number of the positive attributes of such systems.

Jan Harris, Project Manager, Vermont Energy Investment Corporation: I think the reasons are primarily political, not technical. Some renewable energy systems, like photovoltaic (solar) panels, have scale and volume issues, but the larger constraints are directly correlated with political agendas. Something like ten of the current cabinet positions in the Federal Government all have strong ties to the oil industry. We subsidize oil and gas—the dig, dam, drill approach to energy—in this country. Both wars in Iraq can be viewed, in part, as indirect subsidies of our energy use. Renewables are not technologically constrained. Wind, solar, hydro, and biomass aren't complicated stuff. It's a question of resources. Why don't the resources get applied? I would argue that researchers have been steered away from that by the political powers that be. There is no logical or science-based reason, but a political one.

Janet Sawin, Director, Energy and Climate Change Program, Worldwatch Institute: Several reasons, including: 1) significant subsidies for conventional fuels and technologies, which are mature and should not require subsidization; 2) failure to internalize environmental, social, security and other external costs; and 3) inconsistent policies for renewable energy technologies, which have created boom and bust cycles in the industries, making it difficult to obtain financing for projects, to develop a domestic industry, etc.

Jeff Jones, Operations Research Analyst, U.S. Energy Information Administration: If you look at alternative supplies, there have always been cheaper alternatives to renewable energy resources. With coal prices low and coal widely available, coal has always been and will likely continue to be the primary source of electricity domestically. There may also be a certain comfort level with the more "traditional" technologies. Suppliers may have a tendency to do things that they have done before. They have considerable experience building coal, gas, and nuclear plants; they haven't built as many wind plants. But the biggest challenge is the cost issue.

Joe Catina, Manager of North American Projects, Ingersoll Rand Company: I think that you can break renewables into two classes: those that are time independent and predictable and those that aren't (wind being unpredictable). The issue with wind is it is incredibly hard to count on the resources the day you want them in the form that you want them. It's not as dispatchable or dependable as other renewables. On the other side, for dispersed technologies like reciprocating engines and microturbines, public policy issues and business policy issues prevent them from becoming mainstream. Overriding both classes is cost, since most DG technologies are relatively expensive at this point (and they were even more so back in the 1970's). Relative to other forms of central power generation they are expensive in terms of capital costs and in some cases fuel costs (the second biggest driver after capital cost). However, there are other issues like environmental benefits that are often not easily accounted for. I should caution that, from my work in this industry for over 20 years many predictions about future energy generating technologies simply never materialize.

Joe Loper, Vice President for Research and Analysis, Alliance to Save Energy: The projections were too optimistic, and probably still are. The cost of PV is at least on the order of 20 cents per kWh, and even the highest-efficiency PV panel will take up lots of space.

Intermittency is a problem for solar and wind. Utilities call it non-dispatchable, since operators cannot always call on it when they need it. The systems therefore require backup power. If a solar or wind plant is on during periods of low demand, then they are replacing coal plants, which could be good for emissions but may not help reduce cost. If the wind or solar systems are running during peak loads, they help to reduce emissions and perhaps even high variable costs since peak power is often generated with expensive natural gas. The wind and solar, however, do not displace the need to build the peak power plant in the first place.

Clean coal and nuclear power—I got into this business due to concerns about these technologies. However, I don't see any signs that the world is ready to shed its demand for energy, that people are ready to get out of their cars or to insist that their cars and houses are more efficient. And large scale solar and wind power are not competitive with fossil fuel and nuclear. That leaves us with nuclear and coal I'm afraid. I hope that the other technologies continue to improve, but people are probably going to accept global warming and nuclear waste before they'll accept serious measures to reduce energy use.

John Plunkett, Partner for Optimal Energy Consulting: There are scale and volume economies, so it's a sort of chicken and egg question. But, PV at least, has followed the cost trajectory that was originally predicted back then. They were supposed to come down in cost, and they have, but nobody expected them to ever reach a significant percentage of our portfolio. Personally, I am more interested in energy efficiency. For one, it's cheaper, especially when compared to the incredibly high capital costs of new generators, renewable or not. It's also cleaner than renewables and has completely zero emissions.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: Economics and markets have a lot to do with it. As long as energy is cheap, people will stick with cheap sources of energy. The ability for renewables to enter the market and compete with traditional sources of energy just never occurred. It is still a problem today. Now, what is happening today is starting to change people's philosophy, but it takes a long time. Energy crises have been so short in this country that the changes in behavior never become permanent. People go back to what is comfortable.

Judi Greenwald, Director of Innovative Solutions, Pew Center on Global Climate Change: Because the competing technologies (especially coal, oil and gas) have been too cheap, and we haven't been willing to tax conventional forms of energy or consistently fund and subsidize renewables. The recent oil and gas price increases have changed the outlook somewhat, although coal is still relatively cheap.

Ken Tohinaka, Senior Energy Analyst, Vermont Energy Investment Corporation: There are important differences between support in terms of funding, or programs, or initiatives or policies. Further, the U.S. tends to allocate money to individual states for them to decide how to spend it within some overly broad rules, so people at the state level try to use that money to their own advantage, not for national interests. I don't think there ever has been a true national energy policy in this country. If you have a clear goal, then it's easier to reach it, or at least get close, than if you don't know where you're going until you get there. The United Kingdom launched a 10 year program to reduce the energy burden of low income families. The program focused on changing the housing stock, and even though evaluations have found much to criticize, the government was willing to commit, long term, to make it work and adapt as necessary. In contrast, the U.S. model tends to operate through annual appropriations which are routinely cut or adopted only at the last possible moment, making it hard to invest in or plan long-term energy efficiency practices. Witness the low-income weatherization assistance program

which until very recently has been authorized only for a year or two at best, always resulting in a dog fight over appropriations. Even if there is confidence that money will be allocated over the long term, efforts tend to be dispersed through separate programs and departments. It was only a few months ago, for example, that the Department of Energy and HUD joined forces with the EPA to promote Home Performance with ENERGY STAR®, a program designed promote energy efficiency in existing housing. But the technology and techniques that result in superior housing energy performance have been around for decades They just haven't been promoted and supported adequately.

Larry Papay, Former Senior Vice President, Southern California Edison: Obviously, cost is the primary factor. Cost disadvantages can be overcome by putting incentives in place, but on their own most renewable energy technologies are currently still too expensive compared to other sources of electricity. Furthermore, many of the well intentioned incentives put in place for renewables have been the wrong ones, such as investment tax credits rather than production tax credits thereby guaranteeing the technologies actually get into operations . And then, even when inventive programs can be the "right" ones, they tend to expire on a yearly or bi-yearly basis, meaning that developers are reluctant to commit large sums of money to renewable projects.

Why not focus on individuals? People, generally speaking, by and large don't want to be bothered with undertaking energy projects all by themselves. If they have a dollar to invest in appliances, they will buy a newer TV set instead of a photovoltaic electrical system. Most people simply want to flip the switch and have the power constantly there. When dealing with individuals from a policy standpoint, one must understand what they place the most value on, and put the incentives there. During the 1970s, while some people placed investment in renewable energy technologies, most people generally chose to invest in other, more lucrative technologies. And people tend to resist visually blighting technologies such as wind turbines and land-intensive PV arrays.

Marilyn Brown, Commissioner, National Commission on Energy Policy: It's really three things. First, it is difficult for renewable technologies to compete head to head with fossil and nuclear technologies. The power density of coal, for example, is so great relative to what one can exploit from renewable energies. Because of this, it will take many years for renewable systems to become truly cost competitive.

Second, the current externalities associated with fossil fuel consumption are hidden, so that the full costs of electricity from these sources are not reflected in market prices. The result is an artificially low price of fossil fueled electricity.

Third, the policies of the 1970s did not catalyze the renewable energy industry. The technologies, simply put, were not ready for prime time, and when they failed they gained a blemished reputation. Solar technology (for instance) wasn't ready, but political factors associated with the energy crisis pushed it ahead anyway. Renewable energy wasn't ready to be incentivized, and the whole market disintegrated. This set the industry back instead of accelerating it.

Mark C. Hall, Senior Vice President, Primary Energy: For one, there is lack of an overall cohesive, sustained, and truly national approach to energy problems in this country. For example, one of the challenges getting the message about CHP across was the fact that the debate over energy and its impact on the environment were happening in at least three separate silos. The first was the first real rumblings of national restructuring legislation, or the question of who should be responsible for energy policy. The second was a huge debate on the transport of Nox emissions principally from the Midwest to the Northeast. The work of the Ozone Transport Commission was looking at how to deal with this transport issue to work out how to put emissions controls on plants in the Midwest. The third were strategies for dealing with climate change, and the country's self proclaimed economist Al Gore, talking about whether it would cost the economy lots of money. So when I came into my current role looking at the relationship to energy and environmental policy, the whole strategy was trying to break down and deal with these three extremely interrelated silos that are clearly related (you cannot solve one of those areas without affecting the other two; you certainly can solve all of them if you work them in a coordinated manner), but treated separately by different sets of people. And these people weren't trying to forge a cohesive organized way to address these issues. So that's a larger issue behind all energy issues in the United States.

Also, I think it boils down to one thing, and that is the price of energy. I bring it right to modern day because it hasn't been until recently that I see real, rational discussions within industry and the press concerning energy efficiency and the price of energy. We have subsidized energy prices in one shape or form since the 1970s, and people have not had that real price come through, directly, in a focused manner that affects their buying pattern. So energy—whether the gas bill, electric bill, or price of filling up your car—has always cost less than its true social or environmental price. Now we see a general rising up of prices through the board on all fuels, and subsidies are no longer able to mask some of the social costs to energy production.

Coupled with that, from an industry or business standpoint, people have a very short horizon for making energy efficiency investments. Most people are unwilling to tolerate long payback periods. People expect paybacks within three to five years. Our culture really just doesn't drive the type of behavior that focuses on long-term horizons. In business and industry, it is even shorter because the energy infrastructure is looked at as a cost and not as an integral strategic part of their business. Energy and electricity are commodities that all businesses need, but if you are a pharmaceutical company and you have an option between putting money into the core pharmaceutical infrastructure versus the energy infrastructure, they always choose the former. And second, their time horizon in terms of a simple payback tends to be required around 1-2 years. Or they tag an energy efficiency project with a higher return rate that they then require. We routinely come across projects where everybody inside an industrial facility realizes that technologies should and could become more energy efficient, but for do nothing about it for ten and even twenty years. So it really is amazing, but I don't think the 1970s energy crisis—and all of President Carter's talk of wearing a sweater in the winter and turning the thermostat up in the summer—have really affected the social fabric of this country.

To me, there are other subtleties, but this subsidy issue, or at least the fuel price issue, has got to be a significant obstacle. Energy prices are too artificially low.

Mark Levine, Environmental Energy Technologies Division Director, Lawrence Berkeley National Laboratory: There were some people who thought that renewable energy technologies would take off, but those people weren't looking closely at the technologies. President Carter stressed energy efficiency and some supply technologies. He did know the difference between conservation (doing without) and energy efficiency (improving technology so that energy can be converted and used more efficiently). Amory Lovins argued for a soft energy path, which included some distributed generators, but never necessarily specified that they were renewable. But even these advocates—including myself—didn't believe in the 1970s that the renewable world would be a large part of energy by 2000, nor did many of people, even the highly progressive energy analysts and policy folks.

Many of us had, and still have, much hope for renewable energy, and I believe them to be quite important for the future. Wind is competitive in many places, photovoltaic (solar) panels are within only a factor of four from being competitive. But the true impediments will be very difficult to overcome. Both wind and solar suffer from intermittency. When one turns on a switch, people are never sure if they will get it. PV systems are growing around 25 percent each year, and might get even as high as thirty-five percent, and have for many years now played a significant role in the business market. They are excellent for niche applications, but the niches aren't large (and they are currently focused mostly on remote applications). Wind took off in California, and is now taking off in Europe, and it may come back in the U.S. if it is able to capture a large part of the market.

Michael Pomorski, Senior Associate, Cambridge Energy Research Associates: I think the cost barrier is the biggest reason. Also, an institutional inertia problem exists that favors centrally dispatched power plants and requires rate-based recovery for capital expenditures up front. Coupled with the historically cheap price of most fossil fuels, renewable energy systems simply couldn't compete with their coal- and natural gas-fired equivalents.

Michael Karmis, Director, Virginia Center for Coal and Energy Research: I think both policymakers and the public overestimated the technological breakthroughs needed to transition to a renewable based electricity sector. And number two, I am not sure that they focused on the right technologies. Politics and peoples interest do not always point to the most promising technologies. So in the 1970s, there was an overestimation of the potential for renewable energy systems and an underestimation of the time, resources, research, and development needed to make them work.

Paul DeCotis, Director of Energy Analysis, New York State Energy Research and Development Authority: I think in the case of renewable energy technologies, there are many drawbacks and barriers that prohibit widespread adoption. First and foremost is lack of familiarity with and uncertainty about the technology; and even today there is a lot of skepticism concerning the performance and cost of renewable energy resources, even though we know that the technology is proven in certain applications. I think the higher-cost of the technology, although it has come down considerably for wind and solar technologies, remains a barrier; renewable resources remain comparatively expensive to more conventional energy alternatives. In most cases businesses require much shorter paybacks and higher returns on investment than offered by renewable energy resources – so renewable technologies don't fit their business strategies – this remains a barrier today. For renewable energy to constitute a significant percentage of our energy portfolio (mix), they have to be cost-effective and reliable.

Paul Gilman, Former Chief of Staff for Senator Domenici, Director of the Oak Ridge Center for Advanced Studies: If you really go back and ask yourself "What were we doing with the money that we spent?", "What were the programs that we put in place?", and "How were we going about facilitating the entry of renewables into our marketplaces?", you might decide that we went about it the wrong way, and that is one reason we shouldn't be that surprised that we didn't make any of the inroads that we thought we would. Lots of the energy legislation that was drafted in the 1970s was rather naïve and vague. It said that we should achieve x percentage of our generation from y source by this year, and there were lots of goals and laudable things. This usually took the form of a mandated purchase program. The government was going to go out and purchase wind machines and PV systems and do demonstration projects. And the notion always was that if we built up enough demand, that the economies of higher production would bring down these technologies to being cost competitive. The usual chronology of events was to do a demonstration project that proved it worked, followed by a big purchase program to create the industry, bring the price down, and permit the technology to enter the market on its own. It never was and never has been in the context of "What do we need to make the technologies truly competitive in different sectors of the economy."

One of the lessons I learned was watching the Japanese develop their photovoltaic industry, was finding applications for solar energy that were very competitive under current market conditions. So the calculators that you buy powered by solar power, that was one of the niche markets developed by the Japanese. They found that market, went after it, established it, developed the production capability. In the U.S., we went to the high end use and tried to power cities with photovoltaics. That tends to be the context in which Americans approach technological problems: we set lofty and daring goals. We were not smart, doing the market analysis of what is doable, and integrating that with an understanding of the energy sectors—transportation, buildings, and so on—and taking an integrated look at the overall picture.

And this was even reflected in the way that the U.S. Department of Energy was created, and thus stove-piped. There was no place in the DOE that had a good view of energy

issues and had us attacking them in a clever way. So we weren't putting the money in the right places. We still haven't solved some of the same problems then: how do you overcome the infrastructure in place, the problem of moving the smaller-scale technologies on a grid that is designed for central power production, the curse of having the most advanced central power system in the world. It just doesn't lend itself—nor do the regulatory schemes associated with it—to the question of smaller, distributed resources.

We have an aging distribution infrastructure, but utilities will still continue to invest in new generators and power plants because they have better rates of return. You would probably be sued by your shareholders if you didn't do that. At many different levels—the regulated utility level, the very infrastructure that we built—it is hard to imagine more distributed technologies in place, regardless of whether they were renewable or not. Today we are seeing some very cost competitive technologies, oftentimes not renewable (diesel generators or natural gas turbines), that can be distributed, but most utilities still defer to fossil-fuel fired, centralized generators. Their mindset, existing infrastructure, and regulatory environment push them in that direction.

Ralph Badinelli, Professor of Business Information Technology, Virginia Tech: First, renewable energy sources have not yet proven themselves to be economical on a large scale. Until they do, they will be considered scientific experiments as opposed to new technologies. Second, it is ironic that not all RES are considered environmentally friendly, e.g., wind turbines, photovoltaics, hydrogen.

Ralph Loomis, Executive Vice President, Exelon Corporation: This is not a question of industrial or energy policy, it is a question of social policy. How does one make procurement decisions? It is based on economics, politics, social needs, or a combination of all of those things. There is a constant tug and battle as to which will predominate under any circumstance.

The most direct answer to your question—the one that you won't like, but it is true anyway—is that it is simply a matter of economics. Traditional renewable technologies, even today, are not competitive with more traditional technologies. And the industry shares a common goal of finding the renewable technology that will compete with the other resources, and when we have that we will truly be on the cusp of having an economic policy that aligns with social policy.

Rodney Sobin, Innovative Technology Manager, Virginia Department of Environmental Quality: In many ways, renewable energy systems were the technology of the future, and today they still are. The primary reason is simply cost. The economics of the situation was that after the oil shocks prices moderated again, in part because of energy efficiency, but also in exogenous changes affecting the price of energy, so it was no longer as attractive to invest in renewable technologies. We continue to make progress in wind and photovoltaic systems because of the work done in that era, as well as for non renewables like coal gasification, but that progress has come only in niche

markets and has not been a rapid or overall takeoff. The price per kWh for photovoltaics and other systems are just too expensive.

Another social or psychological factor is that we tend to have short memories. After the oil shocks in the 1970s and after we threw a lot of money at energy, the shock sort of faded like a bad dream. We never learned the lessons we should have.

And we haven't even come close to meeting the potential for other, small-scale systems like generators that run from digester gas or fuel cells. There are a number of factors involved preventing their adoption. In this part of the country, it is still economics. Those technologies are only competitive in places like New York and California where the prices of electricity are much higher. Actually landfill digester gas is competitive in VA and we have some biomass power too but the point is that relatively cheap conventional energy makes it more difficult for most renewables to compete.

One of the largest impediments concerns high natural gas prices. The lingo in the DG community is something called the spark spread, and that is the difference in the cost of electricity and gas. And that is based on the supposition that most DG will tend to be natural gas. That has led DG proponents to then conclude that the benefits of DG are best maximized when opportunity fuels are present, such as landfill gas or digester gas. The way the economics is, you have to focus on opportunity fuels and/or other values rather than having the least cost for energy. It is in these places, and sometimes these places only, that DG systems will be the most competitive.

Utility attitudes also play a role. Utilities still don't know what to do in the modern environment of restructuring. They don't quite know how to play the game or how they want to play the game, nor does anyone else. Confronted with the uncertainty of restructuring, most utilities defer to their time-tested mentality of a centralized plant, owned and operated by a regulated utility being a monopoly provider of power. And a strong desire exists among many utilities to preserve that power and control.

Ryan Wiser, Staff Specialist in Renewable Energy Systems, Lawrence Berkeley National Laboratory: The answer is cost, simply cost. Generally, renewable energy technologies continue to be one of the most expensive options for generating electricity. And this isn't the fault of renewables. Policymakers back in the 1970s weren't that wrong about their projections for how much renewable energy systems would cost. What people were wrong about was the cost of conventional fossil and nuclear energy, which didn't rise as expected. And this is the principle reason renewables never took off: the cost of fossil and alternative fuels did not increase commensurably.

On other reason is some of the inherent barriers particular to renewable technologies themselves. When utilities had to face purchasing renewables against other, more traditional sources of electricity, renewables (because they were so new, but also because their deployment is extremely site-specific) often took more time and effort in terms of learning how to use them, permitting, and citing. The motivation for utilities to supply electricity with cheaper, fossil fueled technologies became even more attractive.

Sam Fleming, Former Program Manager for Renewable Energy Systems, Nextant Incorporated: Basically, renewable energy programs were born out of public recognition in the 1970s that the country needed to diversify the energy base, so it therefore became socially desirable that such technologies were clean. In the early 1970s, renewables were oversold with regard to their potential, particularly as it relates to economics. Many people in government had high expectations for renewables, including things that went to Congress for demonstration and commercialization programs, concentrating solar energy projects in the Mojave Desert, various kinds of incentives, power purchase agreements, and tax credits under PURPA which translated into a flurry of activity for renewables. However, in the early 1980s the government quickly removed key incentives—including accelerated depreciation—and several renewable energy projects had to be abandoned mid-way through construction and companies went bankrupt. So I see what happened to renewables as a classic public policy problem: the public wants cleaner energy technology in the near-term, the enthusiasm from developers further bolsters public opinion, Congress responds, and most of the technologies are oversold, especially in terms of economic viability. Realistic economic assessments coupled with policy incentives that are bankable are one of the keys to promoting commercialization of new technologies, as I see it. Otherwise, first-of-a-kind financial risk is perceived to be too high in most instances.

Scott Sklar, President of the Stella Group, Inc.: Put simply, in an industrialized country it takes a long time for technologies or businesses to penetrate an already advanced economy. In this case we are dealing with large monopolistic utilities or centralized systems like the oil and auto industries, and in the 1970s those pushing renewable technologies didn't possess an understanding of what was needed to bring new technologies on board, especially in a country dominated by traditional energy sources.

The secondary answer is that it takes a while to scale up manufacturing and develop the delivery mechanisms for energy systems once those other things are out of the way, it doesn't just happen with immaculate conception. And we are a big country, unlike Denmark or Monaco, where a couple of small plants can deliver electricity to a smaller population. It's just a different game for 300 million people.

Energy was not an issue before the embargo, because America has traditionally been a leader in energy. It's astounding how legislators in Japan and Germany have taken the lead on renewables, because they have nothing there like the historic relationship we have energy in our country. Oil was discovered in the United States. The first nuclear reactor was built here. Natural gas was virtually discovered here, and while coal wasn't, we had the strongest railroads to use and transport it.

Shalom Flank, Chief Technical Officer, Pareto Energy Limited: A question worthy of multiple dissertations to address it. Three easy answers: cheap oil prices, inadequate renewable technologies, and the ongoing capture (in the old-fashioned "iron triangle" sense) of the apparatus of government by the incumbent energy system (oil companies, automobile companies, etc). But all of those easy answers really beg the question. Oil

stayed cheap relative to other energy sources because of huge investment / subsidy / wars to keep it cheap. Alternative technologies didn't improve enough to matter because they didn't get the investment / subsidies. Power (in its political form) is clearly an important part of the answer. Two slightly more interesting answers are:
-- Our economic (and therefore political) system does poorly with economic externalities and with non-economic values. Some of the economic externalities are caused by market structures created and sustained by government policies, so that's still a little circular.
-- Energy matters tremendously in the aggregate, but only incidentally for any individual situation. No single user can improve their bottom line substantially with alternative energy technologies, because energy inputs usually constitute less than 1% of their total cost structure. Similarly, no single user can have a significant environmental impact through the adoption of alternative energy technologies. So we face a massive collective action / commons problem, even given the will to change.

Shawn Collins, Project Manager for Fuel Cells, United Technologies: My sense is that the "experienced" energy costs subsided after the 1970's so that they are currently much lower than the "true" energy costs. This creates a good deal of comfort with the status quo, so that people are not actively looking for alternatives. Since the US tends to depend heavily on market pull to develop new ideas, this has hurt the growth of DG technologies that could have occurred had energy costs remained at their 1970's levels or increased.

Shelly Strand, Marketing and Project Manager, Ecotope Consulting, Research, and Design: If you can reduce the amount of energy that you need, it is much harder to make any supply-side measure seem attractive. But with regards to renewables, it is the law of unforeseen consequences, which was the NIMBY thing. Those of us behind renewable systems thought that they were so cool that everybody would want them, and it turns out that not everyone wants them in their backyard. We didn't foresee, as a society, how much environmental damage hydroelectric power was going to cause, so we in the northwest found ourselves in a position where we feel like the choice is between power or salmon. What is presented as clean energy often has problems associated with it. Geothermal energy is a great idea, but it can damage the ocean bottom in some cases. Wind energy is a novel concept, but migratory birds are dying. So the renewables, themselves, have had difficulties that were not foreseen, and also cheap fossil fuel prices since the 1970s have allowed the economy to continue.

Also, I see this as primarily a political question, and I see it as a question of national will. I am of an age now where I have seen four really specific impacts in my business by the policy set by the president. For example, I came into this business at the end of the Carter era, and then there was an energy crisis in the country and Carter was a progressive, feel-good sort of person who put the moral authority of the office behind energy issues. Then Reagan came into office and the funding just stopped. It was an anti-priority. It was not only not supported, but there was a deliberate effort to de-fund energy efficiency and renewable energy.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: I think a lot has to do with the regulatory structures not being set up to take renewable energy systems in. You still have a lot of interconnection issues that are not being addressed as they could, and if you go into the theory of regulations, you have the regulatory capture scenario, where the regulators serve the industry they regulate rather than the end users who are supposed to benefit from regulation.

On the other side, there has been a lack of true talent within independent power producers. The PURPA rules enabled independent power producers to put in independent power plants, and they didn't have enough good entrepreneurs in that industry. It could be an educational issue—people simply weren't trained at universities to do that sort of thing. There was much more money to be made in other sector and areas, and some of the best engineers that did want to work on electricity were lured away by the more lucrative utility jobs.

Ted Fox, Interim Director, Energy and Engineering Sciences, Oak Ridge National Laboratory: At one point in our history, renewable energy was one hundred percent of our energy supply. It was all hydro and wood. Eventually, we started mining coal, but that was pretty small until the turn of the 20th century. Also, almost all of the American electricity generation was from hydroelectric resources until coal became the fuel choice. But all renewable energy resources—including hydro—have pluses and minuses. They all have environmental impacts. Everything has good aspects and negative aspects, but the one thing that drives our country is capitalism. So if something does not appear to be cost effective in the marketplace, it won't be adopted. And most renewable energy technologies still remain on the margin in terms of economics. So it becomes very difficult to get these technologies into the marketplace, because they all tend to be capital intensive. Depending on the cost of money, capital intensive things are difficult to get people to invest in unless the return is very high.

Tim Cross, Staff Writer for the *Economist*: I think it has to do with capacity. The Sustainable Development Commission, who are quite big fans of wind power, admit that the capacity value drops off sharply as wind's share of generation increases. If a widget breaks in a CCGT plant that has no impact on the probability of other CCGT plants shutting down. But obviously a drop in wind speed affects big swathes of your wind capacity since it affects all the turbines in an area equally. Forecasting can help to deal with this but the fact remains that a couple of calm days will mean that you need to get your power from somewhere else. There must be sufficient capacity on the system to cope with very low production from your wind turbines - I think, for example, that earlier this year, the capacity factor for Danish windmills dropped as low as 12% for one month.

Thomas Grahame, Senior Research Analyst for the Office of Fossil Fuels, U.S. Department of Energy: The broadest answer is cost; renewables simply cost more than alternatives over the last 25 years, although to an extent that is now changing, due to high prices of natural gas and lower costs of wind generation. This was true even though federal and private R&D did substantially reduce the costs over time.

Why does cost matter? Homeowners and businesses would love to have something they can install that would save as much in energy costs in, say, 3 years, as it cost to buy and install. But if it would take 20 years to get your money back, then few of us would do it. That is still where solar energy is right now, in my view. I have no friends who have installed solar panels. You might see if you can find a local provider of solar panels and get a quote, and see how much electricity you would save.

Electric utilities don't want to put in equipment that would raise their prices, in comparison to their competitors. That is why wind energy has expanded by a combination of production tax credits (lowering the cost from wind energy by the amount of the credit, about 1.5 cents per kWh from memory) and "renewable energy portfolio" (RPS) requirements. An RPS is a legal requirement that a certain percentage of the electricity a utility generates must come from renewables. If every utility in a state has to do it, then relative to each other, none is put at a price disadvantage. If the costs of the RPS are borne entirely by a utility's retail customers, then no utility is at a cost disadvantage in wholesale electricity markets to out-of-state utilities which don't have an RPS requirement. But if wind energy were currently economic, no utility would need an RPS requirement to build.

Today, with high natural gas prices, the marginal price of electricity in many parts of the country is considerably higher than it was 18 months ago. That makes wind energy more economic.

Also, keep in mind that wind energy is intermittent – it only is generated when the wind is blowing, which may or may not be when it is most needed (which would be at or near peak daily demand). This means for most utilities that they have to build another type of plant anyway, to make sure they can meet peak demand. That added cost subtracts from the benefit of wind – what it means is that the wind is only worth, to the utility, the costs of the fuels that it displaces when the wind is blowing – sometimes cheap coal, sometimes much more expensive natural gas. So the wind is worth more just because of rising natural gas prices. In addition, in the Pacific NW, where hydro is usually abundant, the hydro can be synchronized with wind power – hydro is reduced on windy days (saving the hydro for peak) and increased when it isn't windy. In this way, even off-peak wind can provide hydro for peaking power, making it considerably more valuable. So it is possible (I haven't explored this in detail) that wind could be economic today in Washington and Oregon states without an RPS.

That said, we as a country have to find ways to use R&D to reduce costs, and then find ways to bring newer technologies into service, as they approach but before they have reached costs low enough to need to subsidies. That goes for any promising technology, whether wind, solar, coal with CO2 sequestration, hybrid and plug-in hybrid cars, and so on. The key is finding the solution that will work politically.

One more point: NIMBY works against renewables just as much as it does against most every other type of energy system, be it pipeline or power plant. People in the West

Virginia mountains don't want their view spoiled, nor do residents of Cape Cod. This is one reason why so much wind is getting developed in west Texas (where there are so many rigs and so few mountains that nobody objects) and the flat, wind-swept Dakotas.

Going forward, there is another issue. When intermittent sources become a substantial part of the electricity generated in a region, the ability to integrate the resource into the grid because considerably more complex and expensive. It might require the use of electricity storage technologies, which will add to cost. Additionally, new transmission lines will also be needed to bring the new power to market. Both of these add to the cost.

Thomas Petersik, Former Renewable Energy Forecasting Expert, U.S. Energy Information Administration: Renewables constitute a very small portion of the United State's energy portfolio because renewables are significantly more costly than fossil-fueled alternatives. Although the delivered cost of electricity from renewable energy technologies has dropped significantly, (1) most renewables remain significantly more costly, (2) renewables are relatively scarce – inelastic in supply, and (3) both the cost of fossil fuels and especially the efficiency of the technologies using fossil fuels – both coal and natural gas – have improved tremendously, making fossil fuels even more competitive. In fact, fossil fuel improvements continue to outrun renewables. By way of further explanation for renewables' small shares, it is incorrect to suppose that renewables are infinite in supply, when in fact – at the time and place of demand, renewables are extraordinarily scarce and, in fact, very inelastic. By and large, renewable energy resources are too rare, too diffuse, too distant, too uncertain, and too ill-timed to provide significant supplies at the times and places of need.

We often find that renewable resources - like wind - can be installed at the costs referenced by the National Renewable Energy Laboratory, and that some sites have capacity factors that you reference, but that the sites at those costs and the sites at those capacity factors are not the same sites! Higher (even 35%) capacity factor sites in Virginia are likely to be more difficult to access and therefore of notably higher capital cost, whereas lower cost sites will also suffer even lower capacity factors. I have come to believe that most "excellent" wind sites are just too expensive to access; this first became clear to me when visiting the West Virginia wind sites, where the developer bemoaned the great difficulty in trucking the turbines to the wind site - and the windsite was on a basically level ridgeline adjacent to a highway; the cost of getting modern turbines up the steep ridges and then interconnecting them is currently prohibitive, but that is where the "excellent" winds are.

Second, and this is absolutely critical. I am very skeptical of NREL and most other (even EIA) renewable resource estimates, and very strongly suspect that the wind supply - and others - is far less elastic than shown in the draft report. Even if some sites can be developed and operate at low levelized costs, the quantities that can be developed at those introductory costs are likely just a small subset of the estimated totals shown. My recommendation is to be very careful in ascribing to much capacity the costs of the first units built (Of course, costs could go down some from the first to the nth and then increase again for the n+th plants.

Very high proportions of renewable resources sites get nixed for (a) transmission and (b) other land use reasons. Are those wind resources virtually adjacent to existing transmission lines that have available capacity (a) at the times needed and (b) without destabilizing either the local networks or other generators? Will new interconnections or more than a mile or so line need to be added? If so, who pays? And folks object for all kinds of reasons, valid and less sensible, even in places one hardly expects objections (I visited a remote site in Texas where a - to me - remote wind turbine site interfered with some members of a local golf course enjoyment of the golf course. I didn't realize there was anything nearby. I've witnessed towns refusing wind turbines on hills miles away that already had other structures and roads built on them.

Toben Galvin, Senior Energy Analyst, Vermont Energy Investment Corporation: I think the primary reason is because the cost of fossil fuels has remained so low. Back in the 1970s, oil prices were at the equivalent of around $90 per barrel. Today, while higher than the previous years, oil prices are at around $65 per barrel. So even oil is relatively inexpensive compared to thirty years ago. Until government incentives and requirements force more renewable energy systems into the marketplace, those technologies are not going to take hold.

Tom Casten, Chair and Chief Executive Officer, Primary Energy: Regulated utilities have tremendous bias to increase throughput, and they instinctively fight against companies that provide electricity from alternative sources. This is ultimately the much larger cost of our central generation paradigm approach: that unless the many barriers to competition in retail delivery of power are removed and third party providers are able to capture the true value of distributed generation, then the independent power companies will gravitate towards large remote generation and large industrial generation. As governments remove the barriers to distributed generation, smaller installations will become common and the learning curve will accelerate. Distributed generation makes economic and environmental sense in many locations, but the barriers add costs and shift revenue to the central utility's benefit, and this keeps the industry in a 'one-off' mode. As governments ease barriers, number of installations will grow, suppliers of equipment and engineering will offer standardized and more cost effective solutions, and a virtuous circle will begin..

I'll tell you a funny story from the 1970s. We were trying to develop on-site combined heat and power plants in NYC, which is served by Consolidated Edison (Con Ed), one of the world's largest. Con Ed is threatened and asked the Mayor for a special hearing to consider the health effects of cogeneration. In keeping with the societal mind-set that monopoly utilities are optimal and must be protected, the Mayor's office sets up a hearing, chaired by a Deputy Mayor, but fails to invite us. We are at this time the only active developer of on-site power in NYC. We learn of the meeting three days before, rush together a presentation and demand a spot. The hearing is a setup. The chairman of Con Ed, Charles Luce, is in the audience; a Con Ed Senior Vice President is running the show. They have an elaborate presentation made by Dr. Peter Freudenthal, Con Ed's environmental expert. We were proposing to install eight engines in the bottom of a

commercial building in downtown New York to generate the building's electricity, and by recycling the waste heat to produce heat and chilled water, achieve double the efficiency of the Con Ed generation fleet. Our project would take one building in Manhattan off of the Con Ed system. Dr. Freudenthal made an elaborate, illustrated presentation that was designed to feel 'scientific', showing that the nitrous oxide from our 8 megawatt plant would exit the 40 story high stack, and miraculously drop right to street level, causing a condition he called 'pharyngeal dryness.' He didn't explain how this hot, bouyant exhaust was going to descend forty stories. He didn't explain how the exhaust from Con Ed's 2,000 megawatts of Manhattan power plants, whose stacks are not any higher than 40 stories, would obey different physical laws and obediently rise and move out over the Atlantic ocean.. But the good Doctor claimed that if Cummins Cogeneration Company was allowed to install this relatively tiny plant, New Yorkers would begin to suffer from pharyngeal dryness. Thankfully, we persuaded the panel that this argument was silly, and the panel decided to not act on Con Ed's request to ban cogeneration until further study. Thirty years later, the story is funny, but it is sadly one of a great many experiences of monopoly electric utilities using their considerable resources to fight any generation that does not flow through their wires.

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: The dream was not realized because it was not economically viable. The cost of fossil fuels is still too low in relation to renewable energy sources. Until the economic break- even point is reached, when fossil fueled generation becomes as expensive as renewable generation, we are not going to see renewable resources take off. And you can take that back to the technologies involved. When we were doing solar technologies back in the 1970s, it was only because of the incentives being given that made the projects viable. The incentives dried up, and then the renewable industry dried up.

Vijay V. Vaitheeswaran, Energy Correspondent and Author for *The Economist* Magazine: I would define my terms if I were you. What is "massive," exactly? According to the OECD, more than half of al energy subsidies doled out in OECD countries from 1950 to 2000, in inflation adjusted terms, went to nuclear power. And yet, not a single new nuclear plant has been ordered and built in the U.S. since 1979. If you consider micro-power (that is clean forms of distributed generation, including renewables but also cogeneration), 2005 saw the global production of power from such seemingly irrelevant sources surpass all the power produced by all the nuclear plants in the world combined. The answer you get depends on the question you ask.

Vikram Budhraja, Former President of Edison Technology Solutions, Edison International Company: One has to look at technology maturity, cost, and the integration issues associated with renewable technologies. And you can take each one of them in turn. Large amounts of biomass and geothermal energy can be connected to the power grid, since the operating profiles and the ability to interconnect with the grid of these resources don't look much different than traditional power plants. However, they are limited in terms of their resource potential. On the other hand, solar and wind are plentiful. Solar comes in various shapes and sizes, many of them very small (often with capacities in the kilowatts, rather than megawatts). Small decentralized solar units that

need to be connected to the grid are more difficult to standardize and installation generally requires custom engineering. It would be the equivalent of buying individual appliances that each need custom engineering design, installation, and maintenance. Such smaller, individual units—especially when we are concerned with producing power, a relatively cheap commodity in the United States—tend to be prohibitively expensive. Look at small scale cogeneration or photovoltaic systems; each specific unit must be specially tailored and engineered at the site where it is installed, which adds substantial cost to an already higher costing technology. Wind resources have been relatively successful in reducing costs and improving performance, but has the problem of intermittency. Wind offers an excellent energy source but requires back-up capacity to keep the lights on when the wind is not blowing or the sun is not shining. Renewable resources all tend to be high first cost in terms of required capital investment and low or no fuel cost. The high initial cost has been a factor in their utilization.

Wilson Prichett, Energy Consultant, ASEGI Incorporated: Well, the first thing we did in the early 1970s was to create, out of the Energy Research and Development Authority (ERDA), a new department called the Department of Energy. And their responsibility was to promote, among other things, "Renewable" energy. Which they did for the Carter Administration's years, from 1976 to 1980. Personally, I was responsible for three hundred renewable energy projects in the United States. We worked on hydro-fracturing hot dry rocks in New Mexico basaltic magma-domes, solar thermal electric power using molten sodium as a coolant, photovoltaics, wave power, hydroelectric, and various types of different wind technologies (vertical and horizontal axis). We were going all speed ahead and then the country elected Ronald Reagan as president, and the first thing he did was gut the renewable energy programs.

He talked about shrinking the size of the government and went after the social programs and energy programs. So by 1982 or 1983, most everyone had left the industry. All those thousands of people around the country working on ways to convert agricultural waste to fuels and different solar and wind designs just stopped doing it. There was no political encouragement. In fact, there was complete discouragement. I was working in the rural electric area funded by the Rural Electric Administration (part of the USDA). They had a great program going to help people do research, but all of the money dried up. In the late 70s there were tax incentives and everybody was working on it. It was the equivalent of the war on energy. We were going to become energy independent.

Zia Haq, Operations Research Analyst, U.S. Energy Information Administration: The single biggest reason is the availability of cheap fossil fuels in the United States. Renewable technologies have a very tough barrier to beat, with coal at roughly $1.40 per million BTU. EIA's coal forecast in the AEO2006 reference case shows delivered coal prices rising slightly to about $1.50 per million Btu by 2030. This forecast assumes the implementation of the Clean Air Interstate Rule and the Clean Air Mercury Rule which results in significant reductions in emissions from coal fired power plants. Despite these regulations coal's share in the electricity generation sector continues to grow through 2030. Among renewables, only hydroelectric stations can generate electricity at 2-3 cents

per kWh. Therefore the electric utility sector has no incentive to move away from cheap fossil fuels into renewables.

The second factor is that there has not been any interest to examine the issue of externality impacts for all energy technologies. Part of the problem here is that this is a very new field and externality factors reported in the literature have such wide variances that it is difficult to justify one set of numbers over another. It is also extremely difficult to translate externality impacts into real financial benefits or costs. The electric utility cannot yet incorporate externalities into their pricing structure and get financing from a bank for power plants. This means that the price that the consumer pays does not reflect the environmental and waste disposal impacts of fossil or nuclear technologies. Consumers have no financial incentive to consider alternatives that might have a more attractive price once externalities are included.

A third factor is basic lack of knowledge. Consumers think that it is very expensive and difficult to build, maintain, and use renewable technologies. Good data on the potential supply of renewables is not available. A general fear of the unknown and lack of experience prevents renewables from playing a bigger part in the U.S. energy market. Renewable costs have declined significantly over the last 20 years as more experience has been gained with systems in niche markets. The potential remains for further cost reductions due to technological innovations and learning effects.

Question 2: What do you believe are the most important concerns – including reliability, efficiency, and security – facing the electric utility industry on the supply side?

Adam Serchuk, Senior Renewable Energy Program Manager, Energy Trust of Oregon: I believe that transmission—an issue that straddles the supply and demand side—is a huge issue. The current transmission systems used to deliver electricity were designed for a different institutional structure, without the flexibility needed for an efficient trading based energy system. The physical unsuitability of the transmission system, combined with the difficulty of getting new facilities sited, makes it unattractive for the private sector to invest in new transmission assets.

Running down the list, I would say that while I don't expect a rigorous climate change policy in the next ten years, I do expect something. And that will be a problem for the supply-side. People will end up asking where the money will come from to deal with climate change, and it has to come from somewhere.

We have also been kind of ambling towards a train wreck regarding nuclear power. Almost all of the country's 103 nuclear reactors have licenses that will expire in the next couple of decades. If we let them expire and switch away from nuclear, what will we replace them with? If we keep them going, where will we store the waste? It seems to me a question based on whether we are more willing to live with the local environmental crisis caused by nuclear waste, or the global environmental crisis caused by climate change.

Liquefied Natural Gas (LNG) is another big public policy challenge. The nation stopped using oil for its electricity infrastructure after the 1970s oil shocks, making the electric sector less vulnerable to international supply disruptions. Yet the recent move towards natural gas fired electricity generation, combined with recent financial interest in LNG facilities, could make the power sector dependent, again, although this time for its marginal fuel from places like Venezuela, Algeria, Russia, and Indonesia. All of a sudden, our electricity sector is vulnerable to the international market again.

Alan Crane, Senior Program Officer, National Academies of Science:
I think that fuel costs are the biggest concern. A high proportion of what we have been building over the past 10 years has been natural gas turbines, and the price of natural gas is four times higher than it used to be even just a few years ago. Simple-cycle gas turbines may be looking at 10 cents per kWh at the busbar for fuel in the very near future.

Greenhouse gas emissions are also a huge concern. Everybody that doesn't have a vested interest in denial acknowledges that some sort of carbon restriction—something in the form of a carbon tax or tradable permits—is coming. This severely dampens the prospects for fossil fuels, especially coal.

Gas transmission lines have to have compressor stations at intervals to keep up the pressure. Most compressors are powered by gas turbines, which burn a bit of the gas that is bled off from the pipeline. The gas-fired turbines are what are being replaced on some

lines. Since an increasing part of our electric power is generated by gas also, it makes each system dependent on the other. Not a big problem yet, as far as I know, but the less inter-dependence the better.

I also worry about the security risks facing the grid. Just a single, coordinated terrorist attack could shut down a significant portion of the country's power grid for a long time.

On the positive side, nationwide demand is increasing much slower than it used to, an advantage that gives policymakers much more time to respond to challenges. The current 1-2 percent projected increase in demand is much easier to deal with than the former 7-8 percents. A large part of that is the effectiveness of demand side measures that have been implemented in the past twenty years.

Alex Farrell, Assistant Professor for the Energy Resources Group, University of California Berkeley: The energy sector is a really interesting investment problem. It is an investment problem, because there are different types of capacity that can be invested in with very different risks and different lifetimes. One of the things that we are now realizing is that spare capacity is critically important in the power sector, and it's also important in the refining and petroleum sector. Why are crude prices so high? No spare capacity any more. Why are gasoline prices so high? We don't have spare capacity. This is one of the biggest challenges facing the energy sector as a whole.

Another huge problem is siting. Most people do not want loud, messy, and what they consider ugly equipment—whether it's a refinery, transmission line, wind turbine—near them. This creates significant challenges.

I do not think that there is a fuel supply challenge for any technology, including liquid hydrocarbons, since it is always feasible to turn coal or gas into liquids. It's not a technical problem, it's an investment problem.

The other main challenge is climate change, which is also an issue. Climate change is the big issue because it is so expensive to supply energy that is significantly less carbon intensive than what we have today.

Anonymous, High-Ranking Executive for a Large, American Independent Power Producer: In the Merchant market, power is marketed strictly on the basis of price. This means that low cost is paramount. Availability and efficiency are important, but not at the cost of making power more expensive. For example, a stand-by generator that may have been maintained in the past could currently be abandoned if the economics don't justify keeping it in service. It is up to the ISO to create market incentives to guarantee reliability. Stable market contracts. There are great benefits if power can be sold in advance.

Arthur Rosenfeld, Commissioner for the California Energy Commission: Public Utility Commission regulations usually mean that utilities have an obligation to serve, can build new power plants, and charge ratepayers for them. The larger difficulty I see

concerns long range contracts that lock in unrealistic prices for natural gas and other fuels. In principle, it should be easy to build more power plants today, to finalize different contracts and get away with charging ratepayers for them. Yet a combination of mistrust by Wall Street coupled with an obligation to serve by utilities produces horribly unjust contracts for fuel prices, challenging investment in modern power plants.

Benjamin Cohen, Assistant Professor of Science & Technology Studies, University of Virginia: Sense of self-importance of the energy sector; unawareness of environmental costs – not just by the extraction of resources, but by the contours of energy use, by the entire design and production process, including mining, factory production, shipment, and customer reliance; unwillingness to steer away from free market ideology and share-holder mentality. In fact, gleeful embrace of deregulated opportunities.

Brian Castelli, Executive Vice President and Chief Operating Officer, Alliance to Save Energy: The single most important concern facing the electric utility industry is the fact that policymakers don't consider efficiency as the greatest source of supply, which it is. We get more supply from efficiency than from any other source of fuel. We've saved around 40 quads of energy and no single fuel has given us those same number of quads over the last 30 years. Now, let me clarify, there has been an 80 quad drop compared to the business as usual trajectory from the 1970s, but 40 quads of that is moving from an industrial to a service oriented economy (one reason primary energy use is down). Half of the efficiency improvements in the economy are at least attributable to the restructuring of the economy. But that still leaves 40 quads attributed to energy efficiency.

Brice Freeman, Project Manager for Distributed Generation, Electric Power Research Institute: We spend a large amount of time at EPRI debating just this question. What is the ideal generation portfolio mix and method of electricity delivery that is the best for this country? In 1999 we conducted a seminal road mapping study with the leaders in the electricity industry (utilities, government, universities, NGOs, etc.) to define what the energy landscape should be in 2050 taking into account the need for becoming sustainable, reliable, with a minimal environmental impact. From this, and subsequent work since, we have found that maintaining the status quo won't work.

The rate of electricity demand is outpacing the construction of new plants and many of the existing plants are operating past retirement and are not nearly as efficient as newer plant designs.

Certainly, the impending Carbon tax will transition the economics to favor more efficient coal plants, more nuclear power, a continuation of wind power and the carbon capturing coal gasification plants – all important.

Also, the transmission and distribution of electricity will improve with a build-out of advanced sensors and controls which will minimize the number and duration of power

outages and provide Area controllers and operators with the information they need to dispatch according to ideal market or even daily environmental conditions. .

The most important concern is to remove the regulatory and political barriers that may inhibit the build out of new generation and T&D assets and apply incentives strategically to accelerate the rate of adoption of new electricity infrastructure.

Chris Namovicz, Operations Research Analyst, U.S. Energy Information Administration: At this point, there is a lot of uncertainty. Utilities have generally shown through the past 30 years that they can deal with the emissions challenges at a reasonable cost. The security—per the technical definition of ensuring reliable supply of electricity—of the grid has been pretty well maintained, except for dealing with a few low probability events. In the wake of such an event, there's typically a big outcry, but it doesn't seem to be such a "front-burner" issue as the event becomes more distant.

But at this point in time there is tremendous uncertainty about the commodity prices of fuels like coal and especially natural gas. Another big unknown in emissions control is carbon dioxide. At this point the U.S. is not seriously entertaining controls on C02 (there have been proposals in Congress, but none have advanced very far), but it seems like an increasing number of utility executives believe that there will eventually be some form of control on carbon dioxide in the U.S., either at the national or state level. The assumption has generally been that the utility industry would bear the brunt of carbon reductions, since they are a lot more fuel flexible than the transportation industry, and can more easily switch to less carbon-intense sources.

There is also a lot of policy uncertainty, especially for renewables. Key tax credits that have spurred recent industry growth have short term extensions, which the industry claims results in significant uncertainty regarding investment. Plus, there is uncertainty over state RPS programs, as there are 20 or so different programs with 20 different sets of rules. Most are relatively new, making it unclear how they will be implemented. On top of all that is uncertainty regarding electricity market deregulation, which some states have abandoned or postponed after the California electricity crisis. So the biggest challenge is uncertainty on multiple fronts.

Christopher Russell, Director of the Industry Sector, Alliance to Save Energy: Aging infrastructure and not having adequate sources of generation. We need to advance and improve the technology to make the system more reliable and secure. There are some institutional impediments. One of them is tax structure, which helps drive investment (People don't know how to invest their money if tax code is not clear and subject to frequent changes). The business plans of utility holding companies are often in limbo as they await clarification of regulations that prescribe how they will be allowed to organize themselves, merge, and acquire assets. Then, who should bear the costs of investment upgrades? Rate-payers? Government? Shareholders?

Claudia J. Banner, Senior Engineer for Renewable Energy Planning, American Electric Power: On the supply side, all of those issues are important. Any generation -

be it distributed or central station - must be reliable, efficient, secure, cost-effective, and safe (including environmentally). Depending on the jurisdiction and the regulations, cost is important and whether the utility can obtain cost recovery or not.

David Baylon, President and Founder, Ecotope Consulting, Research, and Design: The biggest single issue concerns the failure of restructuring. You cannot expect to build an infrastructure and then run it into the ground and then be surprised that it has bad consequences close to the ground. If you decide to deregulate the electricity market, then a utility is responsible for both distributing electricity to its customers, but also for its wholesale market, that is where it gets its electricity from to sell, including its own resources. When you deregulate, one of the features of deregulation is decoupling wholesale generation from retail distribution and sales. That has the effect of making it so an ambiguous relationship exists between the wholesale distribution service and the demand. And that is the formula for driving that part of the infrastructure into the ground. It was sort of like the telephone system in the 1980s. AT&T had the responsibility for keeping the system operational and up to date. Regulatory bodies provide a guaranteed rate of return on investment. In order to expand the profit, since your profit is limited, you have to increase the capital. At a minimum, you have no disincentive to invest. But once you are in the merchant power business, you have shareholders who are not long-term investors, short term profit margins become significantly more important. Once that's the case, it is no longer desirable to make a 30 year investment. It is not possible because you have third quarter goals to meet. If anything on a 30 year horizon ruins your short term goals, it doesn't work. In the past ten years, we have basically driven the wholesale distribution system to the brink. It is stunning. You cannot keep having marginal switching sources, marginal management systems, and keep doing that and expecting them to just keep on working, especially since the whole principle of merchant power is that you can dump power in at once place and get it out at another and that the whole grid is stout enough to handle it. Well that is just wrong. You have a merchant power model but not a merchant power grid. The market never knows when to build a plant, other than when some regulatory body says you should, sort of like a Stalinist model. But every state is different, and the collective decision making is just odd, each making quasi-independent decisions based on those local utilities and their view of how power plants work.

David Garman, Undersecretary of Energy and Former Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy: To me, the most significant and troubling issue is how to meet anticipated increased demand without adding to the carbon burden of the atmosphere. That means you must really focus on the carbon free sources of generation. And you just cannot look at renewables: distributed solar and wind can certainly play a larger role in our generation mix, but utilities still need large amounts of centrally generated base-load power. I like Amory Lovin's vision for distributed energy resources, and when I build my house in Idaho, I will generate a lot of my own electricity, so that I am less dependent on the grid and won't have to worry about reliability issues. The promise of DG is a great vision, and I find it personally compelling. But at the end of the day, I think that our economy will still need lots of carbon free or low carbon base-load generation for economic efficiency's sake.

Candidly, I am not sure that the political system is oriented towards dealing with the carbon issue yet. Carbon is a very difficult issue, and the bottom line is that nuclear energy will have to play a greater role: the country needs new nuclear plants to provide carbon free base-load generation. The Department of Energy needs to continue technological work on carbon sequestration and integrated gasification combined cycle with carbon sequestration. We need to bring down those costs to keep those options alive. The nation also needs more solar and wind energy farms and other dispersed resources along with central generators. If we aren't using biomass for transportation fuel through conversion of the cellulosic material, we might want to think about using a bit more biomass feedstock for central but smaller-scale DG.

David Hill, Deputy Laboratory Director for Science and Technology, Idaho National Laboratory: On the supply side, if I am in the business of supplying electricity, it's a cost issue. From a company's point of view, it's all about making money. I can still push C02 into the atmosphere without penalty. The stock market just wants me to make money.

From a national point of view, my concerns also extend to the environment. First thing I worry about is price of gasoline. But more substantially, the price of gasoline and diesel is reflected in the whole of the economy. Trucks transport everything in this country, not rail. Every consumer good is moved by road to order. The price of gasoline appears in the price of a pen, the price of your desk, the price of yogurt or fruit. In each of these is a component of the price of gasoline. That nectarine on my desk came from California, probably. How did it get here? It came by truck. I would be very worried about import dependence, not simply the price, but the inflexibility of the system to supplies of oil. Severe weather events can impact refining capacity. Oil suppliers can intentionally manipulate prices, and on and on.

From a policy standpoint, there is almost no component of the energy system that is as effective as it ought to be. This is not a centrally planned economy, therefore the grid system grew up, it wasn't planned, and thus it has inefficiencies and instabilities. It's not really one grid system, but five interconnected and there is no mechanism for investing in that sector. You have piecemeal privatization of utilities, including nuclear utilities, so it's not clear how these will make money. The issue for me is whether energy is too important to be left to markets. Things like water and roads in this country, made be metered, but they are protected. Why isn't energy that way? Where does the public good arise, and where does the government work with markets to produce affordable, clean, secure energy?

Edward Vine, Staff Scientist, Lawrence Berkeley National Laboratory: It's really a supply and demand question: things only work when a balance exists between energy supply and demand. Our country has relied on energy supplies from overseas, in the form of oil and natural gas from other countries. And our demand for energy continues to increase. As a result, a large imbalance between supply and demand in the United States exists, forcing us to import energy from other countries to meet our demand. The

U.S. administration also continues to push exclusively for coal and oil, the supply side of the equation, without focusing on the demand side.

Jack Barkenbus, Executive Director of the Environment and Resources Center, University of Tennessee: I think we are on our way to resolving the conventional air pollution issues that we associate with our utilities, especially coal power plants. I don't get exercised over Clear Skies. It is true, and this is what EPA loves to tell you, that since the 1970s we have had significant amounts of economic growth and the air is still cleaner today that it was back then. And it's true virtually all over the country. The good news is that we are making the air cleaner.

I happen to think the biggest issue facing the utilities is the climate change issue. We aren't even on the caboose, let alone the train or the front engine. The utility industry is a major player in that, but they will tell you that they are only 1/3 of the problem, and will point to transportation and industry, who also point at the other two when suggesting that they are only 1/3 of the problem. But anyway you look at it, these are big numbers, and everybody has to do something in the end to fight climate change. Climate change is the issue yet to be resolved and will be driving us in the future. Back in the 1970s we were hardly aware of the issue.

James T. Gallagher, Director of the Office of Electricity and Environment, New York State Department of Public Service: We have some issues here in New York with our ability to build new generation and new transmission and distribution facilities where they are needed. We really need to look at mechanisms in place that we can use to recover cost, and perhaps we need merchant transmission lines so companies can make a profit off of them. Couple that with the difficulty in siting new lines and plants, like in New York City which is bottlenecked and congested, and the problems get even worse. About 12,000 MW of the demand in the New York City region is within the city, and as a result prices are very high, and the city wants to see a new transmission bill. But it is so difficult siting transmission lines and building new plants that there hasn't been a plant built within the region for at least a decade. New proposals for plants face tremendous public resistance. The infrastructure challenges are quite great.

For us, it's also the distribution structure, we have an aging underground system where the utility is spending around $1 billion a year to maintain the system. Many parts were built over a hundred years ago, and we are busy replacing cable, but that $1 billion doesn't even allow us to get proactive to get ahead of the problem. The scale of the challenge is enormous.

We have to find a way to get more renewables into the mix, but at the same time renewables bring with them some load factor issues.

Heavy reliance on natural gas is also a problem. In the Northeast around 30% of our fuel mix is natural gas, and our commodity costs continue to rise due to high natural gas prices and Hurricane Katrina. The wholesale forecast for electricity prices this upcoming January are 100% higher than last January.

The siting issues, fuel price issues, and infrastructure issues will continue to be immense challenges that we have to deal with.

Jan Harris, Project Manager, Vermont Energy Investment Corporation: On the supply side, carbon will be the next regulated thing. We will start talking about impacts. Externalities will become internalities, and we will have to start measuring our carbon impacts. The polar ice cap is indeed melting. Twenty percent more than last year. And then it's a self perpetuating thing, the more water exposed the more ice that melts. We are well underway with this global experiment concerning fossil fuel use.

Jeff Jones, Operations Research Analyst, U.S. Energy Information Administration: Certainly, siting is an issue, if we continue to grow electricity demand near historical levels. The question is where to put the new plants. There is some resistance to siting power plants, especially new sites. Given what we project, the greatest challenge could be finding locations to build new power plants. Depending on what emissions regulations are, they could pose challenges, which could tilt the field away from fossil fuels. Also, prices of the fuels—particularly gas—have been increasing rapidly recently.

Joe Loper, Vice President for Research and Analysis, Alliance to Save Energy: Demand is expected to grow 40% over the next two decades. That means roughly 400 very large power plants, mostly coal and nuclear. Electric generation and electric-using equipment are far more efficient than they used to be, but demand for electricity continues to soar due to new uses, bigger homes to heat, increased population.

How do you respond to that demand, given all of these other concerns? If you can't curb the demand, then you don't have much choice. Nuclear has problems with waste and proliferation, issues that still haven't been dealt with. Coal has the problem of high carbon fuel source. People don't want LNG terminals near them and increased LNG imports would bring many of the same concerns that come with oil imports. Dependence on foreign supplies of energy makes us hostage to suppliers and supply routes.

John Plunkett, Partner for Optimal Energy Consulting: I think the chickens are coming home to roost, finally, for Americans. There are huge externalities that need internalized: carbon and global warming are here to stay, and irreversible and getting worse. I think that the biggest issue to me has always been tapping into the energy efficiency potential, and some renewable energy (although I'm less of a fan with any supply-side solution since efficiency is always the cheapest option). We will gradually need to shift to cogeneration and distributed generation facilities. DG/CHP are a huge issue, as there are huge reliability issues. Look at Hurricane Katrina. The issue is pollution, reliability, and economy.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: California, New York, and New Jersey are more prone to provide government incentives. Virginia has been traditionally more of a market driven state, and tend not to mandate lots of energy decisions. So the early adopters usually

adopt because they have some outside incentive to adopt cleaner technologies. Because Virginia is not an incentive or mandate state, we don't get a lot of renewable energy projects or DG/CHP projects.

So I see the biggest issue, nationally and for Virginia as well, as market development. Once the market develops and starts to get a foothold, things like bio-diesel as an alternative fuel will be set to takeoff. And that is a market thing. If the market is there and the product has a value to the person making, selling, and distributing the product, then they are going to let the other states develop that market before Virginia does.

John Wilson, Senior Researcher for the California Energy Commission: The largest issue is lack of political leadership. It's like a fisherman having one foot on a boat, the other on the dock, and it's perpetually unclear which direction he is going. In the same way regarding energy policy, as a society we don't know where to go or how to get there. One recent example concerns CalPine's potential bankruptcy, largely connected to natural gas prices exceeding expectations. We need more power plants in California, yet we have this irony that people who want to build cannot get financing, and those who did are going bankrupt.

Judi Greenwald, Director of Innovative Solutions, Pew Center on Global Climate Change: I think the biggest concern is climate change. Half of our electricity comes from coal, which is very carbon-intensive. We need to find ways both to shift the electricity mix toward lower-carbon energy sources (including renewables) and to capture CO2 emissions from coal-fired power.

Larry Papay, Former Senior Vice President, Southern California Edison: The biggest concern I see relates to not just electric energy, but all utilities in general (including gas, water, telephones, and electricity). All of our critical infrastructure for these types of technological systems—including roads, transmission lines, aqueducts, and cell phone towers—increase social vulnerability. Maybe what we should be doing is looking at a new paradigm, neighborhood based, a closed system of inputs and outputs. Water, energy, waste, recycling are all treated separately in the current system. We treat sludge and sewage in one location and create energy in another place. Society has done this on a massive scale through macro scale grid arrangements and critical infrastructure development. It is this arrangement that needs to change. We need to define a systems approach for infrastructure technologies rather than an individual technological approach, in thinking about cities of the future. In China, 40 new cities with over 1 million people in the next forty years will need to build new infrastructure. We must learn to think in terms of new approaches. So I see the biggest concern, from a security and natural disaster perspective as well as a resource conservation perspective, as changing our way of thinking about grids, infrastructure, and neighborhoods.

Marilyn Brown, Commissioner, National Commission on Energy Policy: For one, the grid. Deregulation as result of 1992 Energy Policy Act eliminated most of the incentives for improving the reliability of the grid. There has been a traumatic slowdown in investment in grid technologies. At large, this is illustrative of an infrastructure problem

that transcends the grid. Our whole infrastructure—from LNG port facilities to rural transmission lines transporting wind power—is deteriorating.

This is connected to the need for increasingly high quality power to fuel the information and digital economy, which continues to place new demands for reliable power that will be impossible to meet without changes in the electric utility industry.

Mark C. Hall, Senior Vice President, Primary Energy: I think the most serious issue for the electricity sector—something that causes reliability, efficiency, and security problems—is the fact that our requirements for power continue to grow. If you look at plug load per square foot—how many more things we have in our offices and homes that run on power, and how many things that we add that require more electricity and more reliable electricity—continues to increase. In order for us to meet that demand, we have to look at the entire delivery system for that power. Improving that delivery system requires more supply, but the more supply we add, the more pollution we create. The more we do that based on a centralized model, the more security issues we potentially face. The more reliant we are and the more we demand this highly reliable and larger amounts of power, the more we become as a society susceptible to the security issues that arise out of that system. I haven't seen anybody predicting that our near term use of power will go down. Everything continues to be projected in an upward direction. The question is can we produce that additional electricity with the same amount or less amount of fossil fuel, or will more widespread use of fossil fuels and their pollution become inevitable? And the second question is can we reliably deliver that electricity. All of those, of course, impinge on the role of DG and CHP because they have the ability to help out with all of those issues in a very direct way.

Mark Levine, Environmental Energy Technologies Division Director, Lawrence Berkeley National Laboratory: On the supply side, I see two huge challenges that are overwhelming. I think everything else pales in comparison to these two. First, how do we get off carbon to attain a carbon neutral source of energy. And second, what do we use to replace oil as we peak in oil and it becomes much more expensive (and over time, prohibitively expensive). We have no solutions to these problems, and humanity as we know it now depends on solutions to the greenhouse gas emissions problem. Industrial society as we know it depends on finding a way of powering transportation. Concerning from climate change and other environmental problems, I fear that our heads are still in the sand, and that we will soon find that we have waited too long to take action.

Michael Pomorski, Senior Associate, Cambridge Energy Research Associates: Fuel prices represent the single most significant concern facing the restructured electric utility industry. In the early 1980s, once the price of coal started to rise and its environmental impacts became better known, dispatchers started to switch to natural gas-fired plants, ultimately creating more demand. Whatever fuel is chosen to generate electricity will always lead to a subsequent increase in demand, and thus price. The uncertainty of fuel prices— especially with the threat of a future carbon price —makes choosing fuels for the generation of electricity exceptionally complicated and risky.

Also, people don't like new plants to be anywhere near them, so policymakers are confronted with problems of figuring out where to build them, especially people ever conscious about their property values. The same problem exists for transmission lines: businesses have no incentive to invest in them in a quasi-regulated market, and people don't want to live near high voltage power lines any more than they do nuclear plants.

Michael Karmis, Director, Virginia Center for Coal and Energy Research: I think the issue of emissions and controlling emissions is still a huge challenge. How to address the issue through cap and trade systems, tradable permits, and other regulatory mechanisms—finding the right mix of technology and policy, so to speak—is an incredible challenge.

Also, there is an issue with the flow of energy fuels. Even a relatively simply and abundant fuel like coal, for example, is greatly variable in its energy density, price, and quality. To handle the many different properties and characteristics of coal, utilities need to become much more flexible and better prepared to deal with material flows. Currently, utilities do not have great flexibility to undertake material flow changes, whether from a different quality of the same kind of fuel or to an entirely different type of fuel. Utilities need to look ahead in terms of generation, and work on their infrastructure to make them fuel flexible.

There is also the issue of the location of new power generation facilities. Where should plants be located? So I see a combination of challenges on the supply-side: fuel supply and flexibility, available technology, and geography.

Paul DeCotis, Director of Energy Analysis, New York State Energy Research and Development Authority: On the supply side the biggest issue the industry has to confront is energy resource diversification. There are many states that have strict and rigid environmental regulations—stationary source pollution limits, including power plants. NOx, SO2, and now emerging C02. What happened in New York state and is happening in other industrialized states throughout the Northeast and West, is that environmental regulation is in part driving the industry more toward cleaner burning natural gas, and away from coal and oil. We had a policy in the 1980s that was encouraging the conversion of oil plants to coal plants to minimize dependence on foreign oil, and then we started pursuing efficiency and promoting renewable technology in part to diversify away from oil and also largely for environmental reasons. So it became nearly impossible in New York to build a new coal plant or oil plant. And we all know what was happening in the nuclear industry following TMI and Chernobyl. That put New York in the position of having to pursue cleaner natural gas technology. The difficult problem it created was that the infrastructure wasn't available, in terms of gas supply deliverability. And it was difficult to site gas pipelines. But once the pipelines got sited, the plants could be built, and now we find ourselves in a position where natural gas is extremely expensive, it is still nearly impossible to build an oil or a coal plant, or a nuclear plant. The only other option, then, would be to diversify the generation mix to include renewable energy and more energy efficiency. And as a result, New York has a system benefits fund and a renewable portfolio standard – each in their own right,

providing much needed electricity service or displacement. So in the past, we became overly dependent on a cleaner burning fuel, and now that clean fuel is price constrained, we need to diversify into new fields like renewable energy, which offer greater price certainty. The diversification issue is really the critical issue: we need to ask ourselves how diverse our generation is, how expensive our fuels are, and how dependent are we on foreign energy sources. There are also national security implications that become important here.

Paul Gilman, Former Chief of Staff for Senator Domenici, Director of the Oak Ridge Center for Advanced Studies: If you ask the staff at FERC what keeps them awake at night, it is grid reliability and the ability to bring the grid back up if it were destructively taken down. The security issues facing the modern electric utility grid are almost as serious as they are invisible. A deliberate, aggressive, well coordinated assault on the electric power grid could devastate the electricity sector. The replacement time it would take, if you thoughtfully went about knocking it apart, would be on the order of Iraq, not on the order of a lineman putting things up a pole. And if you hit the right node, again, you could create significant trouble. The warning signs are there. People have already attacked the grid. In the open, unclassified literature there are discussions on cyber attacks on utilities and oil and gas pipeline disturbances. So there is a huge security concern. The security concern facing the grid will always come second to issues of bodies flying through the air. Bringing the grid down could cause severe economic hardship, but it inconveniences rather than kills people. Natural disasters bring the grid down all the time, and people seem to cope with it. Bringing the grid down just doesn't seem all that terror inspiring or inducing as some other things might be. The grid may not be the highest value target.

But there is also a reliability concern. As I recollect, our grid is really a number of barely interconnected smaller grids. Nobody has taken seriously the responsibility to worry about the grid as a whole. Nobody has an incentive to think about the grid as a total system. A small office in the DOE has the task of worrying about complete system reliability. I just don't get the sense that we have created a czar or a group that really wants to think through what we know, strategies for coping, and research agendas about electricity in this country. I get a sense that no one is really in charge here.

Ralph Badinelli, Professor of Business Information Technology, Virginia Tech: Your question refers to the "industry", which I will interpret in the narrow sense of the power generation business. As a collection of competitive business enterprises, the most important concern to the utility industry today is the path that re-structuring will take. A second concern is the path that environmental regulations will take. From a business standpoint, uncertainty about the direction of future regulation is as inhibiting as the regulations themselves. Financial investment of in any industry is inhibited by uncertainty. The more uncertainty there is about the future, the higher the risk premiums placed on investment returns. Furthermore, the risk of investments in alternative energy generation systems is amplified by the long terms of these investments – generators usually are considered capital investments with decades-long lifetimes.

Ralph Loomis, Executive Vice President, Exelon Corporation: There is nothing profound in what I am going to say. The electricity sector has to deal with two fundamental challenges:

First, there is resource adequacy. How do utilities balance their reliance on fossil fuels and their first obligation to keep the lights on and with a use of resources that are available in the most economically efficiency manner possible. That is a huge challenge today, especially with traditional fuel prices rising in global energy markets.

The second is the environmental challenge. And this is more than sox, nox, and mercury, and includes global warming and climate change. Jimmy Carter and Amory Lovins were not wrong in the 1970s when they said that we need to find different ways to generate electricity. That is still true today. We need to find different ways to do it that are cost effective. We need to do it, and I think this is the critical insight that I can offer you; it is not just enough to generate electricity using a renewable resource. You must do so in a way that is cost competitive, in a manner that delivers the product to customers and consumers at a price that they can afford, because so much of our economic well being these days is tied to electricity. It is because of the fundamental nature of the public service nature of the product that you have to assure a reasonable public price, or you will pay an enormous economic price.

There are also two sides to this equation, supply-side and demand-side. We as a company, I as a person, wouldn't argue about the importance of energy efficiency. Energy efficiency is critically important. How do you promote energy efficiency? Here is part of the political dilemma. In the marketplace you promote it by allowing prices to go up, customers get the signal, and they think to themselves, "Aha, this is a valuable commodity that needs to be carefully used and conserved. I need to use it wisely." However, if, as a matter of public policy you have a long history going back one hundred years of promoting economic development by having a very regulated utility industry that insures that prices don't go up, then residential customers never get that price signal. And, indeed, over time, customers have become so un-attuned to making these intelligent decisions, that today, you can go to almost any commercial or industrial facility in the country—apart from a notable few—and you can find ways to save them energy. Sometimes these energy efficiency measures can even be cost effective with a two year payback. And still people won't make more efficient decisions, because they have been attuned not to do it. So supply and demand issues are not the same, but they certainly operate on a continuum.

Rodney Sobin, Innovative Technology Manager, Virginia Department of Environmental Quality: My concern is about environmental impact. I am not an economist, but I can play one on television and use the term marginal properly, but I agree with the economists that look at the problem as one of externalities not being internalized. Numerous reports show that the generation of electric power meeting current standards creates enough pollution to result in measurable amounts of human suffering: asthma attacks, pulmonary disease, heart disease, and deaths. The data are reasonably credible that those health effects are real and happening every day, and I

haven't even started talking about the ecological impacts or things like global warming. The real point is that we as society are paying external costs through damage to health and environment, either now or putting off costs to our children and their children (e.g., climate).

Ryan Wiser, Staff Specialist in Renewable Energy Systems, Lawrence Berkeley National Laboratory: I see two significant supply-side challenges: high natural gas prices and global climate change. Natural gas prices are extraordinarily high, and they won't decline, which is great for renewables, since they can now compete economically against natural gas. However, high natural gas prices could also force a shift back towards coal, and to the extent that the country gets concerned with the second issue, climate change, it could cause massive problems.

Sam Fleming, Former Program Manager for Renewable Energy Systems, Nextant Incorporated: In the electric sector, here again, we have a public perception issue that needs to be addressed. In my view, in too many instances we have a philosophy of entitlement to cheap energy and low electricity prices. This doesn't reflect where we are in the world today with regards to energy in general.

On the supply-side, deregulation and the unbundling of electricity markets in transition has created the perception that investing in new generation sources is too risky, which has led to a lack of financability of new projects, and thus underinvestment in both generation and transmission. New York today is perhaps a good example, with system reliability beyond 2008 now in question, requiring both new generating and transmission capacity.

Overlaid on that, we see stringent environmental requirements that force under-capacity in some of the most congested (and thus power-hungry) regions of the country. Many have the expectation that energy should be cheap, but also that it should be clean. Some also want to push new analytical techniques to the limits, and retroactively lower allowable levels of pollutants. Mercury is an example. That's not to say the problem is not real. But to talk about it retrofitting the existing generating fleet, more or less to detection limits—we run out of economic room pretty fast in many cases. Similar thinking on other issues translates to costly retrofits, curtailmants, or the economic necessity to retire the plant. Then additional new capacity is needed, and that requires new capital investment, and so on.

Scott Sklar, President of the Stella Group, Inc.: I think it's reliability and quality. Not just producing power, but producing it at a quality that doesn't burn digital equipment out. We spend billions of dollars on surge protectors, which means our electric utility system doesn't have the quality it needs. Instead, issues of quality (and when it fails) are shoved onto the consumer. And it may only get worse: twenty years ago the country wasn't moving towards a digitized economy. Now our manufacturing controls, computers, and telecommunications devices (even our appliances) are starting to move towards complete digitization, which will place even more stress on the existing power grid.

The electric utility sector is like the Space Shuttle. When it works, it works fantastically well. But when it fails, it screws up devastatingly. Many of us believe that this means utilities need to totally rethink the industry. In telecommunications, for example, wired systems have redundancy and are supported by wireless networks. And such systems coexist and interact. We need the same sort of thinking in the electric utility sector, redundancy (renewables along transmission lines) and wireless (the equivalent of DG systems closer to the end user) are a must to keep any system of high quality.

Shalom Flank, Chief Technical Officer, Pareto Energy Limited: Although they may not know it yet, I think the biggest problem is loss of identity / purpose. Most utilities no longer generate power (because of restructuring). Most utilities no longer control the grid (having turned those responsibilities over to the regional ISO). They're in long-term stasis, with only a few remaining tasks: trying to earn predictable regulated returns for bond- (excuse me, share-) holders; keeping their linemen and engineers on the job until they can file for their pensions; and for the high-flying risk takers, performing M&A miracles of financing engineering to land the big jackpot (which has absolutely nothing to do with energy). When (not if) a new model of energy company emerges (some thought it might have been ESCO's, but that clearly hasn't happened), the old utilities are simply going to disappear, as rapidly as Sperry and Univac faded with the appearance of the minicomputer and DEC and Data General vanished with the PC.

Shawn Collins, Project Manager for Fuel Cells, United Technologies: Reliability and significant maintenance costs of aging infrastructure are two issues I hear regularly, especially as areas where DG would be superior. The other thing I've heard is that the multiple years (sometimes decades?) required to site and build new large-scale centralized generation plants is too slow for the growing demand that's being placed on the grid, and that it's getting harder to get permission to put the required power lines through impacted communities because of complaints like visual aesthetics.

Shelly Strand, Marketing and Project Manager, Ecotope Consulting, Research, and Design: Well, political stupidity. I see the biggest challenge as a lack of understanding how energy flows work. The deregulation model assumes that energy is like sugar, you can put sugar into X and get it out at Y and it will be the same sugar regardless of which terminus you get it from. Energy doesn't work that way. You cannot put energy into the grid in Texas and take it out in California and have it be the same energy because of voltage drop and other factors. The whole deregulation model is set up on the false assumption that the grid system is national and reaches everywhere equally in scope. We don't have a national grid system in this country that works like that.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: On the supply-side, I think reliability is a big issue, especially here in Chicago. Everybody remembers a huge blackout a few years ago from Commonwealth Edison. And CE has the franchise rights to serve buildings in Chicago. Everybody remembers that day and night, and the mayor yelling at Commonwealth Edison to get the system upgraded. System outages can be so catastrophic because they simultaneously affect multiple areas of the grid: industries and businesses relying on

energy, public buildings and institutions, and residential consumers. Poor residents are even worse off. So I think reliability is a huge issue.

Ted Fox, Interim Director, Energy and Engineering Sciences, Oak Ridge National Laboratory: On the supply-side, there always will be the need for centralized plants. Economies of scale are needed to drive electricity prices down. Perhaps there will ultimately be other ways, but in the near term society will have to rely on the combustion of fossil fuels through large centralized plants. And associated with that are a host of problems: permitting and siting, pollution, transmission constraints, etc. If you look at the modernized countries in the world, all of them use a lot of energy. Energy drives the economy. Human and animal energy needs to be replaced with intelligent forms of energy in order for economies to thrive. Energy is connected to poverty. Those who have it tend to be fed and well housed. The critical thing is to figure how to produce energy in abundance at affordable prices in a manner that protects the environment. Those are the challenges, and it is not easy. I think the marketplace will work it out eventually.

At the moment, transmission reliability is a concern. Our system is near capacity. Unfortunately in the 1990s we built natural gas plants almost exclusively. So we built all of these plants throughout the country, but we will no longer be able to use most of them, because the electricity will be too expensive. So the country will run out of capacity, or will have to start paying a lot more for electricity. We have foolishly built too many natural gas units and the trouble with those units is that in general they cannot be retrofitted to run on other fuels and we are limited by our transmission capacity to bring large amounts of power from other sources.

Thomas Grahame, Senior Research Analyst for the Office of Fossil Fuels, U.S. Department of Energy: Right now, my sense is that utilities are concerned more with reliability, because with so much electricity being sold in wholesale markets due to deregulation, transmission systems are often stretched to their limit. That means that even a small perturbation can bring a large geographical area down in a blackout. We have seen at least three major blackouts in this country in about 9 years or so, two on the west coast and one on the east coast. If transmission lines weren't so heavily loaded, and if more power were generated locally, then perhaps the systems could have avoided blackouts. But then, that would have meant that prices would have been higher, because the long-distance sales happen only because the distant power is cheaper. So it seems to me that the rules of governance under deregulation, and the ways to increase transmission capability from distant sources, are still a bit of a work in progress, and still with some economic peril should there be more blackouts.

By "security" I assume you mean against terror attacks. I am not privy to how concerned utilities or other owners of power plants and transmission lines are about security (and rightly so – they really shouldn't say too much about their plans!) although I know that they are concerned – I just don't know if security is a "10" or a "6" in terms of their level of concern.

By efficiency, I am going to assume you mean cost, as opposed to a narrow definition of efficiency (e.g., maximizing the kWh production from your input BTUs, regardless of cost to the consumer). In this formulation, most utilities are always trying to be efficient -- wholesale deregulation means that those entities that have the cheapest power to sell will get the most profit, and vice-versa. A utility could generate power very efficiently with the latest natural gas technology, but to do so, it would have to take a loss on power sales, because natural gas is so expensive. No Board of Directors would allow a for-profit entity to do that, and state regulators wouldn't allow the producer to recover monies. This is why there are over a hundred gigawatts of natural gas power plants either not in operation, or operating at lower than expected rates of use (e.g., capacity factor). Thus, in the name of lowering costs, we see pressures today to use more coal to displace natural gas use, because coal is now considerably cheaper.

Thomas Petersik, Former Renewable Energy Forecasting Expert, U.S. Energy Information Administration: I am not generally qualified to answer this question. However, my overall view is that the one most important concern of the electric utility industry is minimizing the delivered cost of electricity, given that both the standard of living of US consumers and the competitiveness of US industries in the global marketplace are dependent upon low-cost energy. Any other concerns rank below the cost objective. Environmental concerns—and managing those concerns—are increasingly important as well.

Toben Galvin, Senior Energy Analyst, Vermont Energy Investment Corporation: On the supply-side, I think the biggest issue is that policymakers lack a full perspective. It sounds to me like, currently, the biggest issue is transmission constraints, which contributed to the August 2004 blackout. But the deeper problem is the lack of comprehensive and lasting policies aimed at improving all sectors of the American energy infrastructure.

Tom Casten, Chair and Chief Executive Officer, Primary Energy: I think the biggest challenge is to remove barriers and thus create a true energy market. True markets work magic, enticing multiple suppliers to continuously innovate in hopes of gaining profits and market share, only to find that other suppliers have also lowered costs and are offering better value. The consumer wins. When the product is energy services, such competition also benefits the environment, since it wrings out inefficiencies and reduces the use of fossil fuel and associated pollution. But markets need several pre-conditions to work. They need accurate and honest price signals that are differentiated by time, place, and level of quality. Monopoly electric regulation sets one or two prices, without area differentiation. All third party power can only be sold on-site or to the grid at wholesale prices, even though potential customers across the street are paying three times wholesale. Competitors need freedom to deliver their product, but all fifty states ban private wires, forcing a would-be independent generator to accept monopoly rules. What markets do is take into consideration all of the elements that have associated costs or benefits and then find the optimal way to distribute resources based on those costs and benefits. And that is all. Markets may anticipate price changes, but they don't anticipate

policy changes very well. I believe successful markets require four, fundamental characteristics:

a. Free entry and exit, which we currently don't have in the electricity market. People cannot run a private wire, for example.
b. Clear, accurate price signals. And we don't have that.
c. Absence of subsidies, which distort all investment decisions. The energy business is the most subsidized industry in the world, and most of the subsidies, such as federal government support of hydroelectric projects, nuclear plants and transmission systems, buttress central generation, which is inherently unable to recycle waste energy.
d. The government must prevent incumbents from using predatory practices to disadvantage new entrants.

The U.S. electricity market lacks each of these characteristics.

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: On the supply-side, we face challenges for natural gas, fuel, and generation. Pipelines go out of service. Hurricane Katrina, for instance, disrupted Virginia's supply of natural gas for days. There is no market for wholesale electricity in the state of Virginia, much less taking it down to the retail level. And it comes back to the low cost of generating electricity with nuclear and coal technologies. All of this is based on the economies of the fuels being used. Once the fuels escalate, all of the businesses will jump on the band-wagon, when they see a profit, you will see the swing to environmentally friendly generation. Until then, unless someone has significant incentives it is not a good business model.

Vijay V. Vaitheeswaran, Energy Correspondent and Author for *The Economist* Magazine: In the U.S., the most important issue facing the electric utility industry is reliability in the short term. In Europe, it is carbon/environment. In the medium term, I believe the U.S. industry will also face carbon constraints—which pulverized coal plants will not be able to meet.

Vikram Budhraja, Former President of Edison Technology Solutions, Edison International Company: The biggest problem facing the electric industry is to modernize the current infrastructure. We have power plants that are operating with an average age of thirty to forty years. We really need to replace them, modernize, and upgrade them, as well as build additional capacity to meet population increase and economic growth throughout the country. The industry needs to diversify the resource mix with renewables and replace aging power plants. The industry needs to invest in new grid technologies for reliability, market efficiency, and security.

Wilson Prichett, Energy Consultant, ASEGI Incorporated: There are all kinds of problems. I have never met a building yet where I couldn't save at least 30 percent of what they use in electricity, and usually fifty percent. If you take that and multiply it across millions of buildings nation wide, that is the equivalent of hundreds of power plants. Amory Lovins coined a term for that, "negawatts", and his term refers to meeting

future growth capacity by reducing demand. We need to do that. Period. Everywhere I go, it's the same.

Also, we have a supply problem. I'm not sure what the answer is, because renewable energy, for the most part, is what we used to call in the 1970s "supplemental". The generation of electricity only occurs when the resource is available: the river is up, the sun is shining, the wind is blowing. It doesn't necessarily match electricity loads. It's less of an alternative, and more of a supplement. That is a very important distinction. A lot of renewable energy technologies are not really substitutes for hydro, nuclear, and fossil fueled power plants (unless we find a much better way to store energy, and that involves significant conversion inefficiencies). From the supply-side, there is great opportunity for DG, but the real solution to the problem is the demand.

Zia Haq, Operations Research Analyst, U.S. Energy Information Administration: Natural gas availability and supply will become a critical factor in the next 20 years. We are going to have to increasingly rely on LNG imports to meet our natural gas demand. Domestic natural gas resources are not sufficient to meet the needs of the U.S. economy. We will either have to explore and develop unfavorable areas—like the coast of Florida or ANWR—or we will have to import increasing quantities of natural gas. On the supply-side, that will be a really big issue because the electric utility sector is a big consumer of natural gas.

Coal is going to face a host of extremely challenging environmental issues such as climate change and mercury. Climate change issues will take more of a prominent position in the public discourse. Senator Pete Domenici and Jeff Binagmen have just produced a White Paper on climate change that looks at what the big issues are in regulating CO2 emissions and how to approach that problem. Senator McCain and Lieberman introduced a climate change bill (S.139, "Climate Stewardship Act of 2003") in the 108th Congressional session that failed. Still, the groundwork is being laid for the 109th Congress to take some action on climate change in the next year or two. We are also seeing several state and local initiatives in the area of climate change such as the Regional Greenhouse Gas Initiative (RGGI) involving seven New England states.

Question 3: What do you believe are the most important concerns facing the electric utility industry on the demand side?

Adam Serchuk, Senior Renewable Energy Program Manager, Energy Trust of Oregon: I see growing demand as the biggest challenges for utilities. It doesn't appear to me that anybody is using much less electricity. I don't see any particular political or social will towards using DG systems as a way of deferring or avoiding distribution system upgrades in practice. The geeks talk about it, but it hasn't been done on a wide scale or anything.

Power quality is also an issue. Not only do you have increasing numbers of industrial and commercial customers that require high quality electricity, but also even the old economy industries— such as glass and metals—have become so dependent on digital technology that power outages affect them as well. Everyone talks about the way that power outages affect semiconductor manufacturers and banks; that when the lights flicker, thousands of chips are lost or millions of bank records gone. But it is just as true that when the lights flicker, steel mills and paper processing facilities lose batches of their products.

Alan Crane, Senior Program Officer, National Academies of Science: Lots of consumers make improvements, especially when energy costs go up. Commercial and industrial customers tend to be much more bottom-line oriented than individuals. People might look at the energy stickers when they buy a new washing machine, but they tend to get more excited about saving $100 with the cheaper model than saving $20/ year in energy costs for the more efficient one. On lots of other choices they don't even get that much information, and on others they are completely out of the loop (e.g. landlord-tenant issues).

Alex Farrell, Assistant Professor for the Energy Resources Group, University of California Berkeley: On the demand side, the barriers towards efficiency are manifold and don't seem to be getting solved. These include, in the electricity sector: pricing that is flat pricing or block pricing, rather than time of use or critical peak pricing, which would actually encourage efficiency; a general reluctance of people to think of energy as something that is important, and they don't make the connection between inefficient energy use and higher prices that result from it.

It's not that we're going to educate people. I think that the idea that education is the answer has proved to be wrong for decades now. The answer is somewhat in pricing but also in product standards, probably the only reliable way to increase energy efficiency, yet this is also not a very politically acceptable answer right now. Particularly true in petroleum, we have simultaneous levels of high petroleum consumption and poor inefficiency, often by the very same people.

Anonymous, High-Ranking Executive for a Large, American Independent Power Producer: Merchant markets tend to ignore the demand side, other than to determine where to build more generating capacity. The main exceptions are for very large

consumers that can purchase power on a scale comparable to the merchant contract size (i.e. 50 MW or more at a time). Note the increase in municipalities and other organizations that are "bundling" smaller users into purchasing cooperatives. Smaller customers are the responsibility of the ISO and local distribution companies.

Arthur Rosenfeld, Commissioner for the California Energy Commission: On the demand side, funding for DSM has gone up hugely in California. However, on the average, the country is letting us down, despite leadership in California, New York, and some parts of New England. The real question is why efforts towards efficiency in the Southwest, West, and Midwest fall behind. It reminds me of an old joke, one of the things we find amusing around here is to compare per capita kW consumption between California and the rest of the country. We are real ahead here.

Yet even while California has done remarkably well, why aren't we all the way there? We do very well new buildings. We could probably capture 2/3 to ¾ of the measures that could go into new buildings. We need improvement on existing buildings, which should be benchmarked and continually commissioned and checked on. 2/3 of the electricity in California is consumed in buildings built before 1976. Every time a house or one of these buildings is sold, why don't we require the use of the most cost-effective, efficient materials and technologies?

Benjamin Cohen, Assistant Professor of Science & Technology Studies, University of Virginia: Belief in unlimited supply from customers and production of conceptual filters that block the customer from being able to see the source of all that energy. That is, we love it, but we don't want to know where you make it. Imagine if we had coal meters on our electrical outlets? And every time we plugged something in we could monitor the lowering levels of mountain tops being blown up because of our demands. It would be a visual representation of the natural, financial, and political costs of electricity.

Brian Castelli, Executive Vice President and Chief Operating Officer, Alliance to Save Energy: Getting utilities to accept that efficiency is the greatest source of supply, and convincing Public Utility Commissions to decouple sales from profit. If they don't do that, efficiency hurts the bottom line instead of contributing to the bottom line. The other is public education. We need to educate the public (including consumers, businesses, plant managers, and developers) that energy efficiency needs to be part of their business model. Those are the two biggest issues with efficiency.

Brice Freeman, Project Manager for Distributed Generation, Electric Power Research Institute: // I'm not an expert on the demand side management, so please treat my comments accordingly // Energy efficiency through conservation is every bit as critical for the U.S. as is clean, and sustainable electricity generation. With the wide spread adoption (22 states) of Renewable Portfolio Standards, there is an increased need for large-scale energy storage devices which can accept electricity when it is produced by renewable resources and inject it into the grid during periods of peak demand. Pumped hydro and compress air energy storage are the large-scale incumbent storage technologies but they have attributes which limit their ability to proliferate.

Certainly the adoption of combined cooling heating and power (CCHP) systems located at or near the point of use can bring tremendous benefit to reducing the overall electrical demand that a utility would have to manage. Real-time price signals will also manage demand by providing credit for end-users to shift peaks to off-hours and developing smart consumer appliances would allow this be done automatically and on a wide basis.

Chris Namovicz, Operations Research Analyst, U.S. Energy Information Administration: I don't follow demand side too much, so it's hard for me to answer that question.

Christopher Russell, Director of the Industry Sector, Alliance to Save Energy: Let me start by saying that industrial energy efficiency dialogue is driven primarily by and for engineers, who are trained to think in terms of technology and projects. That's why you see things like hardware and technology R&D dominating the agenda for energy efficiency. Technology is only one (albeit indispensable) part of the efficiency equation. It takes skilled people to get the most from this technology. American manufacturing facilities are begging for the talent needed to get the most from their current technologies, much less the cutting-edge variety. Getting technology and human capital to operate optimally, in concert, is really an organizational task that is beyond the abilities of plant managers at most small- to medium-sized facilities.

Facilities are thinly staffed, running flat out every day to meet production goals. Therefore distractions aren't welcome. For them, routine is a good thing, and their mantra becomes "that's the way we've always done it." So when you propose energy efficiency to a facility, you are really proposing changes to the way they operate. You have people in operations, finance, procurement, and engineering—all of whom will be impacted by energy management, and all of whom usually have some reason to resist change.

Energy is traditionally associated with the power house—that smokestack building off to the side that supports the main process activity. Power houses tend to get the remainders when it comes to budget, investment, and skilled analytical support. The powerhouse superintendent is lucky if he can articulate the fuel savings associate with energy efficiency, much less the simultaneous impacts on revenue (through greater productivity) and on risk abatement (by reducing exposure to emissions and safety liabilities).

Don't forget that "energy efficiency" is only one of many issues competing for facility managers' attention. They can't fix everything at once, or invest in every opportunity that's available. Why is industry slow to pursue efficiency, renewables, and distributed generation? We really get into uncharted territory when trying understanding why companies make the choices they do. It's not simply a money question. Decision makers are continually making a tradeoff between risk, time, and money. If you propose an energy efficiency measure that saves X dollars, the facility manager wonders what the additional costs are in terms of risk and time. What labor hours are needed to support energy efficiency efforts? Should they allocate labor hours to making dollars, or saving

dimes? Should they disrupt the process to make efficiency changes now, or wait until there's a shut down (either planned or unplanned)? Or if they choose not to act on efficiency opportunities, do they want to accept the risk of exposure to volatile fuel markets? There are no clearly right or wrong answers here. There's only the balance that decision-makers achieve when managing risk, time, and money in order to meet their goals.

Furthermore, business leaders tend to be evaluated on a quarter by quarter basis. That short time horizon leads to many of them to avoid long-term energy saving decisions. Company officials always intend to defer maintenance and swallow shot term expenses, but leave the long-term issues for the successor. As a result, many energy problems keep getting pushed back.

Also, getting people to be aware or to even care about energy efficiency. While energy waste is huge and has implications for quality and security of supply, the ultimate consumption decisions are made at the household level. At that level, that the magnitude of waste hasn't historically been worth their time. Gasoline prices hit $3 per gallon, and people still unnecessarily idle their car engines. It's very hard to motivate all of these individuals to do something about the little bit of waste that they incur. Yet each of those individuals add up to millions of decisions, and that adds up to significant amounts of waste.

Furthermore, it's often not in a corporate leader's interest to admit that their company has energy inefficiencies. They already think that they are as efficient as they can be. Part of this is denial, when admitting that they are anything less than 100% efficient is to potentially alienate shareholders. But another part of it is the way that people within a company pass "bad" information upward, since organizational practices ensure that many people only forward information that makes them and the company look good. Evidence of fuel waste or energy inefficiency within a company is not good news, so people don't report it. "Efficiency" can be described (or misrepresented) in a number of creative ways. Some facility people are proud to report that their system is operable 98-99 percent of the time, and let that become evidence of their "efficiency." Never mind how much energy is lost in typical operations.

Chuck Goldman, Group Leader, Electricity Markets and Policy Group, Lawrence Berkeley National Laboratory: I don't think that the actual price—delivery price that consumer's see—reflects the true social costs of their energy decisions. So, at a threshold level, I don't think we've incorporated the full externalities associated with the price of coal or natural gas production that people see in their electricity bills.

There's also a whole set of classic institutional impediments that any good economist would recognize: spit incentive problems, economic decisions made about investments in products that are not made by the final end consumer; new construction, new houses, equipment replacements, and a whole other set of decisions that are made during emergencies when water heaters and fridges go out. So the classic model of economic

decision making doesn't account for some of the major energy purchases, and parts of the economy don't really operate in that framework.

Then there are the more subtle, sociological barriers that connect to the theory of the firm. How do people make decisions in large institutions? It's sort of a complicated decision making process between facility managers and corporate finance people and procurement folks, who are capital constrained and all have a set of hurdle rates that are pretty short, and they are often times much shorter than the investment horizon that the utilities are looking at in a regulated environment for supply-side investments. The kinds of discount rates and paybacks expected for most of these markets are far different time horizons that people are willing to invest in energy efficiency, which results in an underinvestment in electricity saving technology.

That said, there have been some improvements in the transportation sector, and a fair amount of backsliding in the past seven years. There has been more improvement in the building sector, of you look at the rate of growth and what has happened. And the U.S. has developed a set of policies for energy efficiency—building codes, appliance standards, energy star, a number of voluntary programs funded by ratepayers peaked at around $2 billion in the 1990s, and $1.3 billion today—that are pretty good. Relative to other countries, the U.S. is sort of the leader in energy efficiency. Given that the prices of energy are relatively low, the consumption per capita are relatively high, but we have still made steady improvement.

There are still dramatic examples of states and regions have pursued policies on energy efficiency that have greatly impacted the rate of electricity consumption. California's energy use per capita is much lower than other states, and they show a dramatic divergence over time.

Claudia J. Banner, Senior Engineer for Renewable Energy Planning, American Electric Power: There are some genuine concerns about safety, reliability, security, controllability, and availability of customer-owned DG if that is large enough to become part of a utility's generation capacity. In order to minimize such adverse impacts and benefit from DG, AEP has started an initiative to deploy distributed energy storage on our system near customers.

David Baylon, President and Founder, Ecotope Consulting, Research, and Design: There are regulatory issues here. Utilities can easily support or sabotage energy efficiency programs. There is a substantial infrastructure for efficiency that doesn't really exist. The long term benefits are always competing with short term costs. Most of the decisions made in the housing sector, but also the building sector, have a one to two year horizon as a builder, and maybe zero or no years, since there is no market consequence for selling a house without efficiency. The only thing that stops this standard is enforceable building standards. But most of the country's energy codes for buildings are not enforced or differentially enforced. As long as there is no standard, there is no market reason why a builder would put an extra $3,000 into a house to make it more efficient. In fact, there are good reasons not to, and if you put that $3,000 into

granite marble countertops, it might actually raise the value of the house and improve your profit margin. You generally cannot see an energy efficient house. It is not visible. You could walk up to a house that is pretty efficient and you wouldn't be able to tell. The problem is the public is not in a position to judge energy efficiency. The people who are in that position have no interest to do so.

David Garman, Undersecretary of Energy and Former Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy: I think that if you allow consumers to receive pricing signals and market signals, the demand side issues will take care of themselves. Consumers have to get market signals; if there is a price of a pollution externality, it needs to be included. If a carbon price is set in some fashion, consumers need to see that. We've got to continue to push for things like time of use metering. A kWh of electricity at 8am is very different thing than 3am. It is almost a completely different commodity, generated in a different fashion with different consequences. Thus far we have shielded consumers from market signals, rather than recognizing those differences. Accurate market signals would incentivize consumers to do the right things.

What is remarkable to me is that we as a nation use less oil in 2005 than we did in 2004. This is a remarkable trend, and somewhat anomalous, but we did that because consumers were reacting to market signals. We have a whole manner of programs that try to achieve the same result, and they have not been successful. If the price goes up, people make smart choices, they consolidate trips, and buy smaller cars. Last year, for the first time in years consumers bought less trucks and SUVs in the United States. The market works: on the demand side, we need to let the market work, and quit shielding consumers from relevant price signals. We also need to get as many of the subsidies and distortions out of the market as possible. If it is deemed someday that a carbon tax is necessary, that that is what we ought to do.

David Hill, Deputy Laboratory Director for Science and Technology, Idaho National Laboratory: On the demand side, it's very difficult. It's obvious that change is needed. Any projection for future energy use assumes that the current rate of decreasing energy intensity of the economy will continue, but will only partially address growing consumption. The problem is no one has an incentive to invest in energy efficiency. The utility doesn't want to do it: they are selling you electricity, and want to sell you as much of it as they can. Guys who make the refrigerators are only going to do it if they can sell you a cheaper product. Only a small sector of the community will pay more for technologies that are more efficient. In other words, energy efficiency benefits are distributed, they benefit all of society, but it's difficult to make money from them. Unfortunately, successive governments have not fully taken the importance of energy efficiency on board. Lots more could be done, but it would take a change of approach in Washington, DC, which may be possible given climate change.

Edward Vine, Staff Scientist, Lawrence Berkeley National Laboratory: I see three significant impediments to energy efficiency best practices: (1) awareness and education: more work needs to be done to education and make people aware of our energy problems, so that people can understand the concept of energy efficiency, and how they can save

electricity; (2) the cost of energy must reflect externalities (see above) - the true social costs of energy must be internalized in the price of energy; and (3) leadership: this country lacks a strong national advocate for energy efficiency (or energy policy for that matter), and Americans need someone at the Presidential level giving importance to energy issues in general and energy efficiency in particular.

James T. Gallagher, Director of the Office of Electricity and Environment, New York State Department of Public Service: Political leadership is huge. I would say that the one thing we have going for us in New York that has helped tremendously, in my experience it's been true throughout my career, the leadership from the top is critical. In our case it is the governor, at TVA it was David Friedman, chairman of the board. When you have a message coming down from the top that is positive for renewable energy and energy efficiency, it will make things happen. I have been at organizations that were different, and that was the major impediment in moving energy efficiency. I think that same principle applies to many utilities. People who run and manage utilities, in many cases, are not advocates of energy efficiency or renewables.

One of the big impediments for energy efficiency is the impediment that has always been there: the first cost problem. We have significant incentives here through NYSERDA to raise money for energy efficiency, but we are always getting pressure to balance rate impacts with program size. The tension—the more you collect, rates will go up for everyone—so you need a balance with rate increases and the potential savings from energy efficiency. The issue of who pays for energy efficiency is often unresolved. We spent around $2.2 billion from 1992-2000 on demand side management in New York. The most important thing is an equitable program, so that as many people as possible can participate. The worst thing is a program that costs a lot but is targeted towards only a few customers.

In terms of impediments, it's been leadership and basic cost recovery incentives and approvals, at least for us in the utility business. We've had significant incentives (cost recovery, lost revenues, and a share of savings distributed over time) in place in New York for years.

One of the big impediments we had was that when these competitive markets were being rolled out, utilities didn't believe it was their job to promote energy efficiency. There was absolutely no enthusiasm from utilities for energy efficiency programs. We took the money that we were giving to utilities and essentially assigned it to NYSERDA. Lack of utility enthusiasm to deliver energy efficiency was overcome by having an independent entity deliver these programs statewide: we had uniformity and independence from utility influence.

Jan Harris, Project Manager, Vermont Energy Investment Corporation: On the demand side, how do we use less electricity and what will motivate people to consume less energy. The reality is that in this country energy costs are a trivial portion of most people's income. In my experience, the only way to motivate large amounts of Americans is through their pocketbooks. Everybody considers themselves an

environmentalist, but how many people actually change their behavior as a result of that brand. That means living in a smaller house, driving and flying less, some sacrifices. I would say that we could live comfortably using a lot less energy, but you have to make some lifestyle choices. Other developed cultures—notably Japan and Europe—have made them, and we need to start moving in the direction of taking responsibility for our actions, especially the fact that we use such a disproportionate amount of energy resources in this country. And that has been the mantra of people in our business for decades. Energy prices are not going to go down. It is only a question of how fast they will go up, and there is a degree of uncertainty in that, but just look globally: ever increasing demand and ever more constrained supply.

Jeff Jones, Operations Research Analyst, U.S. Energy Information Administration: You may get varying responses as to how elastic electricity demand is, but it is not as elastic as some other energy sources are. It can be expensive for houses to switch from electric heating to other sources and many uses (e.g., appliances) do not really have other alternatives.

Joe Loper, Vice President for Research and Analysis, Alliance to Save Energy: What is the major barrier to reducing demand? Number one is transaction costs. I think it is a very significant cost that is not acknowledged or recognized. There is a cost associated with learning about what to do, and analyzing whether to do it.. It's not part of most people's core mission. In addition, people have to make sure their energy saving investments perform as promised, that they're maintained properly, and that they don't interfere with their core mission, whether that is living in a house or a running a business.

We have achieved enormous economies of scale for energy production, but we haven't yet realized the same economies of scale for reducing energy use. Building a multi-billion dollar power plant requires a lot of up front investment and knowledge, but once you build it you get a lot out of power out of it. Getting informed about the energy saving aspects of a car, fridge, stove, and light bulb takes time, and its something most people won't spend time doing. Most would rather hand off the decision to the power plant operator, making it easier and simpler.

This is why policies can be so important. Product and appliance standards, for example, inform the marketplace. They give people fewer choices, but greater certainty and less hassle factor.

John Plunkett, Partner for Optimal Energy Consulting: This country has not had an energy policy at the federal level since President Carter. All the energy policies have been implemented at the state level, and a handful of states at that (California, Massachusetts, and Vermont). This is one of the reasons I love my job: many states haven't done anything yet, and demand for electricity just keeps going up (making energy efficiency practices more lucrative).

And, if you talked about global warming back in the 1970s, they laughed at you. So there have always been market barriers to energy efficiency, and they never really go away

because you can make the case that "we're done" for some technologies, but the story of America's economic history is that there is always something new, always innovation. There is stuff in the lab now that it too expensive and not commercial. Take Energy Star Washing Machines. They used to be a $700 cost premium, now down to around $100, because of volume. We will always be updating our analysis, so there will always be room for improvement as technologies progress.

Energy efficiency is the best option from any of these standpoints: it's cheap, it has huge risk mitigating advantages that nobody talks about. What other supply resources out there expand as the economy expands? As the load goes up, the savings go up. There is nothing else like that. Instead of concentrating things in big units, efficiency is over thousands of units, diversifying the portfolio in a way that supply-side solutions can never achieve. Whatever the energy question is, the answer is efficiency. It provides reliability, it provides huge economic benefits, it's also an economic stimulus, like some huge development policy. Going out and lowering everybody's energy bills is like lowering the cost of oil. The net economic savings—the difference between the avoided cost and the net cost of the efficiency—are immense.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: Speaking about nation-wide challenges, some of the obvious ones include with public transportation: the fact that so many people drive cars and are not willing to give up convenience and flexibility. As one example, I was talking to some neighbors the other day who were telling me that their high school son had gotten two speeding tickets the first week on the way to school. When I asked, "Why didn't you make him take the bus," they looked at me like I was from Mars, even with gasoline currently near $3 per gallon. They wouldn't even consider making their kids ride the bus because it was un-cool. Getting people to overcome that philosophy is the biggest national challenge. There is an issue, and we need to be smarter about the way that we use and produce energy. Public education, public acceptance, getting people to become more aware about their energy decisions remains the largest national problem. We need energy systems like wind turbines, coal fired plants, and nuclear generators, but people don't want these things anywhere near them. The bottom line is this stuff has to be near somebody, and I see that as one of the biggest issues.

People tend to look at things very narrowly and hear the things that they want to. If you oppose wind turbines and you have a strong attitude towards that, you will read and absorb the information that opposes wind turbines as well. And you will be in a position to defend the arguments that they kill too many birds and bats, and even if information may contradict that, you will believe the information that you want to hear. And so it's hard to sway the public.

John Wilson, Senior Researcher for the California Energy Commission: Unfortunately, it usually tends to be the case that consumption patterns outpace efficiency gains. I have always been concerned over the growing use of electricity swamping or mitigating gains made in traditional uses of energy, such as heating or cooling. New Californian homes use 1/6 energy per square foot for air conditioning than

they did 20 years ago. The bad news is that homes are almost twice as big as they were 30 years ago. We are making things more efficient, but making more of them.

My obsession with electronics goes along with that. Homes that used to have a few appliances or a single televisions now have a couple of televisions, one of them probably a new plasma monster, plus new DvD players, mp3 devices, cell phones, and computers.

Just think that a set of six or seven modern appliances can use 1,200 kWh per year, more than air conditioning for the average California home. One usually thinks of AC as primary energy concern, driven on hot days and at peak times, and most DSM is aimed at that. Yet we aren't focused on the vampires like appliances, which can use twice as much electricity as a new refrigerator. Small things, dust busters, gamecubes, and other things that are always plugged in, can add up to 80 Wh. The common fridge uses 40 Wh.

Judi Greenwald, Director of Innovative Solutions, Pew Center on Global Climate Change: Again, I think the biggest concern is climate change. We need to make our buildings more energy-efficient and move toward zero-energy buildings.

Ken Tohinaka, Senior Energy Analyst, Vermont Energy Investment Corporation: The states need to provide both a will and a way to promote energy efficiency. Vermont provides an interesting example. We are unusual in a number of ways: (1) twenty two electric utilities exist in the state of Vermont, and not that long ago each had its own efficiency programs. Some of these utilities were quite small. To get uniformity and comparable access to ratepayers, the state took all of that money and consolidated it and put delivery of a single set of efficiency programs out to bid. We, the Vermont Energy Investment Corporation, have had the contract to deliver that for almost six years. (2) Unlike most states, however, Vermont doesn't have much of an industry to speak of, so the opportunities for improving energy efficiency are more disperse. Our power sources are also relatively diverse. Roughly 1/3 of our power comes from a nuclear power plant (Vermont Yankee), about 1/3 from a large hydroelectric source (Hydro Quebec), and the rest from a variety of fossil-fuel power plants. If we wanted to improve energy efficiency broadly, opportunities to target point sources don't really exist here in Vermont in the way they do in lots of other states with large production facilities, for example. Here, the biggest opportunity is transportation. But we don't make the cars and trucks. Nevertheless, Efficiency Vermont has had a significant impact precisely because the state acted with a clear voice and vision.

Marilyn Brown, Commissioner, National Commission on Energy Policy: Again, I see at least three significant impediments. First, lack of visibility. Efficiency is oftentimes the cheapest and easiest alternative to building a new generator (or transmission and distribution line for that matter), yet people rarely see it at work, so they never realize that it holds so much potential. Efficient windows and air conditioning, for instance, don't have the high visibility of photovoltaic roof panels and wind turbines.

Second, the restructuring of the industry destroyed the incentives for demand side management that had developed so well through to the mid 1990s. The destruction of

that whole traditional approach to encouraging better energy management is a real loss. And there hasn't been much that has emerged to fill the gap, except in those few states that have taken the leadership in energy efficiency, especially California and New York. Nationally, the result is many states and whole regions (like much of the Southeast) that are behind the times in terms of energy efficiency.

And third, a vicious cycle continues to exist regarding appliances and equipment standards. Frequently, consumers simply cannot buy the best or most efficient equipment. Stores don't carry the latest efficiency devices because they don't see any demand for them, and lack of utility incentives (and thus programs) mean that there is limited demand for more efficient products. As a result, those who want to make the best energy efficiency decisions cannot because the products are unavailable.

Mark C. Hall, Senior Vice President, Primary Energy: The price subsidy and the lack of transparency over what energy costs, even throughout the day, has created this complete disconnect for most people as to their behavior on the demand side and what the generation and delivery side of the equation has to do. As we are starting to come out of the period of time when our first sets of state, restructured markets are starting raise electricity prices, they are now saying that earlier this year electricity rates would raise twenty to thirty-five percent. Now that will change behavior, but if people really understood how much of the electricity infrastructure is in place just to meet 20 hours a year of that middle peak, that time of the year with the absolute highest amount of demand, and if they got a signal—which is difficult for homeowners retail customers to react to—certainly they can react to that, and can take actions that can eliminate that needle peak. Until you get a demand response (people taking action to recognize that the cost to produce power from 3pm-6pm is five times what it costs on that same day from 9pm-midnight), until people get that, demand will continue to soar.

Mark Levine, Environmental Energy Technologies Division Director, Lawrence Berkeley National Laboratory: On the demand side, it is always very difficult to change consumer attitudes. Scientists can invent a more efficient system or device, but that doesn't mean it will be purchased or widely used. A number of barriers make it difficult to get energy efficiency devices into the markets. For example, people lack the basic knowledge about even simple things that would drastically increase the energy efficiency of their homes or businesses. On top of that we see an inadequacy of research and development to support such systems. It is also very easy to show how we could be almost fifty percent more efficient if we turned equipment off over night (and ameliorate supply-side problems), but we don't. Things aren't working out quite right at the moment. In fact, they are quite wrong.

Michael Pomorski, Senior Associate, Cambridge Energy Research Associates: The biggest challenge is probably getting customers to care about how much electricity they use. At every level of the industry—utilities, industries, businesses, and consumers—demand for fuel, power, and electricity will grow. The problem is that consumers don't care about the environment, or just don't care at all. Most don't even realize that we face problems extracting energy from the environment. Prices have not risen to a level that

forces people to make conscious decisions about their energy use. Electricity prices are just too cheap, and costumers don't see the true environmental costs of their energy decisions reflected in electricity prices.

Michael Karmis, Director, Virginia Center for Coal and Energy Research: The issue of balancing environmental and cleaner technologies and cost, and the impact of the marketplace, are big issues. The states are becoming more and more aggressive as to how one regulates, distributes, and places electricity in the marketplace. So I think that we know demand will increase and we can guess that, nothing is unknown there, but as you change technologies you have to deal with a balance between energy, environment, sustainability, and cost. It may not be the same for every state, since the factors are different. But the key is finding the right balance for each state.

Paul DeCotis, Director of Energy Analysis, New York State Energy Research and Development Authority: Nationally, the driver for the demand side alternatives is part technology and part what I refer to as an "energy efficiency ethic." I think the technology is available for building equipment that could substantially curtail electricity use without compromising service. But it is not widespread enough yet. The technology however, is not widespread yet because we don't really have the energy efficiency ethic well enough ingrained in people's minds and actions. Take the corollary of a work ethic. In a capitalistic democratic system like the U.S. anybody can do and be anything. There are ways to do anything here, freedoms we completely take for granted. There are opportunities here in the U.S. that do not exist anywhere else. Likewise, we have the opportunity to lead the world in promoting energy efficiency, yet we as a culture don't value conservation and energy efficiency to the extent that we could. We value consumption, bigger vehicles, bigger homes, and more toys that consume more electricity. If we are really going to make a significant change in energy use and consumption patterns we have to instill an energy efficiency ethic in our society. We need to assign greater value to more energy efficient vehicles that use fewer resources. We need to value buildings that are built with recycled materials as opposed to virgin materials. We need to be more conscious of the impact that our decisions have on the environment and future generations. When we buy light bulbs, we need to look at the wattage on the bulb and its output – not just the price. We can do it, I know we can, we have a variety of education programs that have been successful, but we haven't been able to create the energy efficiency ethic we need. I think the leadership has to start at the federal level, diligently pursued through educational institutions and schools, and it has to become a way of life.

I will also argue that 26 years ago when I started in the energy field we were talking about energy efficiency and renewable energy. We were talking about what we might be able to do in the next twenty years – and we saw an impossible road ahead. When I look back now at the accomplishments that we have made and current efficiency, energy, and vehicle technologies, I think that we have come a hell of a long way. Some would argue that it's not enough. I would argue that we are well on our way, and soon we will reach a tipping point where we successfully create this energy efficiency ethic and people make

decisions with this ethic in mind. Energy efficiency and demand response resources will be purchased and used to the point where they are commonplace, not the exception.

So I do not think that there are any technology impediments. The technologies that we promote through NYSERDA have been proven, demonstrated, and are largely well understood. However, there might be technology awareness impediments. I see the primary barrier as the energy efficiency ethic, and connected to that public awareness, marketing, and outreach. Which is one of the reasons New York is spending time, effort, and money on public awareness and marketing of energy efficiency, much like Coca Cola, Pepsi, or Gap spend promoting their products. People need to have the information before them when they buy energy related products. There is an informational gap that is causing impediments.

I also don't think that there is an economic or financial impediment, since energy efficiency technology is cost competitive. It's really a question of competing uses for money. Energy efficiency may be cost competitive and have a fairly short two to three year payback for a large industrial firm, yet its investment in human capital and new plant, equipment, and products have one to two year payback. So there isn't a cost competitive issue, but rather a threshold or payback or return on investment issue. And that holds for residential as well as industrial consumers. I know that when individuals make household decisions, they make decisions based on color and size and usefulness of something more than they would how much energy it uses. Again that comes back to the energy efficiency ethic. In their mind they are getting greater value from the color or the size than they are from choosing something that is more energy efficient. Whether they make that decision explicitly or implicitly doesn't matter, they are still making that decision.

Paul Gilman, Former Chief of Staff for Senator Domenici, Director of the Oak Ridge Center for Advanced Studies: Most people don't conceive of their homes as places of energy consumption, because the energy prices for electricity haven't been escalating the way they were in the early 1970s and 1980s. So people use electricity indiscriminately, they constantly waste it because there is little incentive to conserve.

Ralph Badinelli, Professor of Business Information Technology, Virginia Tech: One concern about the demand side is the potential for re-structuring to drive the less efficient power generators out of business as wholesalers are given the freedom to choose among energy suppliers.

Ryan Wiser, Staff Specialist in Renewable Energy Systems, Lawrence Berkeley National Laboratory: On the demand-side, the biggest issue is how to curb demand. Eventually we are not going to have the same base of fossil fuels as we have in the past. And we already see some of this rhetoric tied into the peak oil debate and the peak natural gas debate, which has recently started. Whether ten or fifty years away, when fossil fuels peak no timeframe is really too soon to start dealing with the problem. Our kids and our grandkids will care about the outcome. From a societal standpoint, we are talking about the energy sources that we have built this country on becoming ultimately

depleted. Eventually we will have to manage that risk, and part of that requires aggressive action now through renewables and other more efficient ways to curb demand.

Sam Fleming, Former Program Manager for Renewable Energy Systems, Nextant Incorporated: What is happening in New York concerns me, and I think is symptomatic of the challenges facing the country at large. But there is progress also, and balanced views and consensus are needed. New York faces an electricity crunch, but some policy adopted can force older plants to retire, followed by some public perception that Indian Point could be decommissioned on a short time frame. Throw in the fact that the state has made few additions or upgrades to its transmission system for over a decade (something that is now changing with the HVDC Neptune line, and proposals for others), and you have a potent crisis brewing. Here is deregulation, followed by environmental constraints, a public desire for cheap but clean energy, resulting in an over-constrained problem. One result, I think, is that it shows that technologists need to be better, more balanced in explaining the overall situation. Notice also that events like Enron and gaming the system and markets do not build public confidence. The electricity sector encompasses a very wide range of complex issues, but the public remains largely unconcerned and unaware of them. We need the public to be more aware of the common-interest issues, more about electricity markets in order to have a meaningful dialogue, and policy makers, technologists, government, industry and the financial community have to work together toward good solutions. That isn't at all easy, but I believe it to be what is required.

Secondly, this abundant, cheap, and clean philosophy translates into not a lot of discipline with regard to energy efficiency. Next winter may be a real eye opener, since prices for natural gas are already very high (more than triple what they were) and Henry Hub is down temporarily because of the Gulf Coast hurricanes. New York's reliance on natural gas will have an impact on transmission and fuel supply, which reflects an overall energy system problem, not just an electricity problem.

Scott Sklar, President of the Stella Group, Inc.: It's what California utilities and Washington are starting: advanced meters that can give time of day rates, but over time communicate with your appliances and other energy systems (like furnaces, heat pumps, HVAC systems, and on-site DG systems). In short, we need something that coordinates price and reliability. It makes the most sense to provide this coordination at the meter, logically speaking, but it could also be done with individual appliances or devices.

Shalom Flank, Chief Technical Officer, Pareto Energy Limited: Higher prices are getting a lot of attention. But again, energy costs are typically less than 1% of production costs for manufacturing or labor costs for service industries (or mortages or rents, on the residential side). So the increases may just be factored into overall costs, while users continue to ignore energy as something they need to pay attention to. I see two factors that could conceivably change that dynamic. First, reliability. The grid is not being maintained – not enough new transmission capacity, and more important, nowhere near enough investment in the local distribution system (and no real incentives for such investment). When power stops working, even for a few minutes per day, people will

pay a lot more attention than even a 40% price rise. Second, people might come to see the larger social issues as real problems, and be willing to follow non-economic incentives to achieve security and/or environmental goals. Though if enough economic actors start basing their decisions on that calculus, then the political actors would presumably follow in their wake and adopt subsidies (or drop subsidies of the incumbent system) to align economic and non-economic motivators.

Shawn Collins, Project Manager for Fuel Cells, United Technologies: I'm not familiar for DG, but for vehicles, I think the biggest concern is that the primary demand is to maintain the status quo. Technology Review had an article in the 2002 time frame discussing the technology available in automotive labs to take SUV's up to the 30 mpg level. The article said that although the solutions were available and could be implemented without much risk, the car companies were waiting for consumer pull. At the time, the feeling was that people would not be willing to pay the extra $2,000 to get things like more sophisticated combustion control. Incidentally, I think someone is seriously misinterpreting the market here. The same arguments were made by the Big 3 to justify not pursuing hybrid technology, and I think the explosion in demand following the 2004 Toyota Prius was completely unexpected.

Shelly Strand, Marketing and Project Manager, Ecotope Consulting, Research, and Design: There is lack of public interest and lack of public knowledge in energy efficiency practices. Even if you put in more efficient technologies end users can identify, very often there will be reasons that have nothing to do with energy that outweigh that in the consumer's mind. For example, evaporative coolers are a very efficient technology, but people see them as ugly so they won't put them into their house. In Utah, I did some builder interviews, and builders tended to perceive energy efficiency devices as low-income projects. There is a perception that only poor folk are concerned with energy efficiency. That perception came up because utilities in Utah are regulated and have to do a minimum amount of energy efficiency work, so they started low-income assistance projects that included conservation through energy efficiency. As a result, such technologies became stigmatized as lower-class, and undesirable in middle and higher class housing projects. Heat pumps are another good example. Heat pumps work great, but I would never put one in my house because I lived in the South and I hate being cold. The air that comes out of a heat pump is warm by the standard of getting the room up to 70 degrees, but that air feels cool to me. So I don't want that, and people will do things that resist technologies that have nothing to do with energy. Other people don't like the noise heat pumps make at night. We see the same impediments across many types of more energy efficient technologies: removable shades in offices, adaptive recovery controls, etc. Even if you do build an efficient building, we have found that people will do things like place tape over the light sensors because they don't like the lights going off unexpectedly. Or they don't like that damn thing moving up and down outside their window, so they defeat the technology that exists. And that is human nature. Geothermal heat pumps are a great idea. Why aren't they used more? People don't want to dig up half of their backyard only to run a system that is huge and clunky.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: I don't think most electric customers and utilities care about energy efficiency from an environmental point of view, but I think they are starting to care about it from a cost or economic sort of view.

Ted Fox, Interim Director, Energy and Engineering Sciences, Oak Ridge National Laboratory: On the demand-side, most people still aren't willing to put an extra $25,000 into their house to install a solar system to generate a few kilowatts of electricity. We are nearing another energy crisis. We are at 60 percent oil imports, compared to 20 percent in 1974. And oil prices just doubled from $30 to $60 per barrel without any disruption at all. And China and India continue to buy oil and coal as quickly as they can. The economic impacts of all of this are tremendous: unemployment, civil unrest, economic stagnation. What can we do about it?

We need to focus on the things we can do in the near term, we need to focus on more energy efficient vehicles. Our average fuel economy is around 24 miles per gallon. If we went to fifty, we would only need half as much oil. And it is something you could do within four or five years if the technology was available, since people do turn over their vehicles relatively quickly. There is no feasible way for this country to domestically produce enough energy: we don't have the time, resources, or capital investment. So, energy efficiency is the only option we really have to reduce our dependence on foreign sources of fuel.

Thomas Grahame, Senior Research Analyst for the Office of Fossil Fuels, U.S. Department of Energy: Electric utilities generally don't feel the demand side is their business; they are in the business of selling power. When prices go up, there is generally a conservation effect, because end users decide to find ways to reduce their bills. Unfortunately, some do so by shifting production abroad.

Thomas Petersik, Former Renewable Energy Forecasting Expert, U.S. Energy Information Administration: Rapid growth in demand in the face of energy resource constraints, particularly (1) increasing fuel costs, (2) difficult and increasing transmission and distribution challenges, and (3) environmental challenges, plus (4) consumer ignorance-to-hostility. Consumers appear to perceive electricity as cheap and plentiful with little recognition of the growing difficulty in providing low-cost, environmentally acceptable, reliable electricity. As a result, my impression is that the choice and siting of new power plants, as well as the transmission and distribution networks supporting them, are becoming increasingly difficult, so much so that in terms of forcing public acceptance, blackouts and other crises may actually provide benefits in triggering overcoming public resistance; the local costs of crises is an extraordinarily expensive way of moving forward.

Toben Galvin, Senior Energy Analyst, Vermont Energy Investment Corporation: On the demand-side, there is complete disinterest on the part of utilities and fossil fuel suppliers to conserve electricity or energy. Most states don't even have the funds or authorization to push for energy efficiency programs. People can really do a number of

simple things—weatherize their homes, insulate and change their boilers, switch the types of appliances and lights that they use—to drastically lower their electricity and heating bills. But they don't, since most people remain uninformed about energy efficient technology, and most states don't have the regulatory approval to inform them. And even when the states do have efficiency programs, they tend to be under-funded. I think this is tragic, since energy efficiency is the best approach towards lessening dependence on fossil fuels. Energy efficiency practices are often the most cost effective options, and their savings accrue over time. Yet the lack of significant, sustained, national political support prevents energy efficiency mechanisms from being even partially effective throughout most areas of the country.

Vijay V. Vaitheeswaran, Energy Correspondent and Author for *The Economist* Magazine: I believe the greatest challenge is managing demand growth, especially the spikes at peak demand. The solution lies very clearly in the spread of smart meters and real time/dynamic pricing, which can do a lot to shift/lessen the peak load.

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: On the demand-side, Virginia has a very good performance contracting program, where the governor's executive order 54 directs agencies to reduce energy consumption. As the cost of energy goes up, more and more energy efficiency projects become viable because the cost of the energy saved is larger. Energy conservation, more efficient buildings and equipment, and operation will reduce energy consumption.

Wilson Prichett, Energy Consultant, ASEGI Incorporated: To be truthful, the cost of energy is still not high enough to incentivize people to do something about it. They still are driving their huge vehicles around and consuming vast amounts of electricity at home. People just don't care about energy. It hasn't put enough of a crimp on the pocketbook. On the commercial scale, a plant I am working on in Tennessee is burning $800,000 in natural gas. I could save them $400,000 a year by spending $600,000 to redesign their process. That is a year and a half return on investment. That's not good enough for them. They want a return on investment within two business quarters (six months). That's what the corporate leadership wants.

Furthermore, in commercial, most office buildings are owned by a company and the spaces are rented out to tenants. The rent for the complex includes the price of utilities, so the people that own the facilities don't care about electricity prices. And the people renting the space don't want to invest in a facility that they don't own. Similarly, universities don't want to spend extra money on fixing the university up and recovering utility savings, because the department that spends the money on the conservation improvements is not the same one that gets the energy savings.

In general, people just don't have adequate incentive to do anything yet. But mark my words, they will have to do something, because this energy hog-ism will not continue. The end is in sight.

Zia Haq, Operations Research Analyst, U.S. Energy Information Administration: Let us consider demand in two different markets – transportation and electricity generation. We have done some internal modeling of the global transportation sector that suggests that at the world oil prices and GDP growth rates that EIA is projecting, we do not expect global oil demand to stabilize at all. In fact, this modeling shows that global oil demand will continue to grow quite robustly over the next 30 years at the price and economic growth levels being assumed by EIA. There is no way to stabilize that demand without very significant increases in world oil prices that are sustained over a long period of time. I believe this trend will continue despite the use in developing countries such as China and India of increasingly more fuel efficient and compact cars. There is simply too much unmet demand in the developing world and no good alternatives that can significantly displace petroleum in the transportation sector. I am discussing transportation in the global context because oil is globally traded in much larger quantities than coal or natural gas.

In the electricity generation market, I am going to limit the discussion to the U.S. market. Electricity prices are not forecasted to change very much in the 20-30 year time frame according to EIA. It's basically a fossil-dominated energy picture today and will remain so 30 years from today according to EIA. Therefore, demand for electricity in the U.S. is expected to continue to grow at these low prices. All of these forecasts will change significantly if there is a strict enough carbon policy. Despite these overall forecasts, there continues to be interest in DG technologies of all kinds because, in some niche markets with high fuel prices or transmission constraints, those systems make financial sense. Local regulators and public utility commissions have figured this out and have started to enable the process to get more DG systems sited. In Oregon and Washington, policymakers are putting monetary values on carbon dioxide emissions from electric generators.

Question 4: What do you see as the most significant impediments to the wider use of distributed generation technologies (including but not limited to distributed renewables)?

Adam Serchuk, Senior Renewable Energy Program Manager, Energy Trust of Oregon: First, let me say that for the people I work with, micro-turbines are not considered a proven technology. If a saw mill is talking about installing a biomass cogeneration facility, they are not talking about micro-turbines, but about installing a boiler with a condensing turbine. The pretty standard stuff manufactured by Caterpillar and General Electric.

In terms of the barriers I see everyday, I work with people in the wood products industry, as well as dairies, landfills, municipal wastewater plants, and the food products industries. The biggest issue for them is that they just don't care about energy. If you go out to a dairy, they have a waste management problem, not an energy problem. Dairy operators are concerned with the Clean Water Act and its regulations that prevent the release of water-bourne farm operation pathogens into the watershed. Dairy operators don't want to be in the energy business. They are farmers and dairy people. The real problem with DG systems is turning small-scale and relatively technical science experiments into (a) off the shelf, integrated technology and (b) developing a turnkey business model so that the people who want to install DG technologies don't have to maintain and repair them. In a saw mill, for example, the management is concerned with using process steam to dry their lumber. They don't know anything about the electricity business, and they don't want to hire a layer to negotiate some contract with an electric utility that it has viewed as an enemy for the past 80 years.

So the main challenge is that we care about electricity here in the energy policy world, but nobody else does.

Interconnection is also a big pain in the ass. Utilities pretty much still possess unadulterated control over electricity contract practices, and the negotiation process turns out to be real onerous for mid size businesses. Utilities can further complicate the process by requiring excessive security, insurance, and payback provisions in their contracts. For instance, some utilities require clauses in their contracts that force DG operators to post $2 million as a security protection in case their decentralized technology damages the grid. Many times, I have seen interconnection and power purchase agreements derail many otherwise viable DG projects.

Finally, there is the constant problem of the production tax credit. Right now, anybody interested in getting DG or renewable projects off the ground has to have them operational by 2007 to take advantage of the Energy Policy Act of 2005's tax credits. When the managers of industries start counting back the months, there isn't just enough time to install DG projects, especially when such plants have to consider suspending operations, building new facilities and roads, negotiating a delivery schedule for the physical technology, future weather conditions, and so on. It's just hard for managers to put money into a project with such a harsh deadline. And, on top of that, banks often refuse to finance it, insurers refuse to protect it, and local employees resist the project.

Thus, the mere uncertainty of the tax credit itself creates a host of problems, absent from the dark and bloody issues of how such credits are actually calculated and applied.

Alan Crane, Senior Program Officer, National Academies of Science: One significant impediment is institutional. System and transmission operators don't recognize many renewable and DG technologies as being part of their network because they are not dispatchable, either because the technologies are intermittent or because the operators cannot control them to crank power up and down. Additionally, it's not in the "right people's" interest to fix interface problems like interconnection and intermittency when such improvements will do little (in their view) to improve control of the overall system. Technically, these technologies can be incorporated into the grid easily. Socially, much institutional resistance remains.

Alex Farrell, Assistant Professor for the Energy Resources Group, University of California Berkeley: In electricity generation, the monopoly franchise is one of the most important facts. The degree to which DG of any variety threatens the monopoly franchise—that is generation owned in a service territory by somebody other than the monopoly franchise—is a direct assault on the business plan for that company, so they fight it tooth and nail. That's probably the most important one.

Distributed renewables are challenging because they are intermittent. Operating a system with a lot of intermittent generation is more challenging and requires the cooperation of the monopoly franchise.

Higher up-front capital costs continue to disadvantage all types of DG systems that produce longer pay-back periods.

And some distributed systems have a perception of being feasible when they are not. Small wind turbines on top of people's homes are one example. People think that such systems will find wide acceptance, and get permits for those things, but no one who really thinks they are a great idea has had to really live near one.

Anonymous, High-Ranking Executive for a Large, American Independent Power Producer: Initial Capital investment cost: developers typically want to build a project quickly and cheaply. DG adds to the first cost and time to complete. Maintenance costs: American management wants to "outsource" everything. DG represents a significant ongoing business venture that may not fit into the business plan of the company that owns the equipment. Environmental restrictions & other government regulations: lots of rules to permit initial projects, lots of reporting requirements, and lots of penalties if things go wrong. Large generating companies can afford staffs dedicated to environmental & regulatory issues. They also have big insurance policies. It's much harder for a small company to keep up with.

Arthur Rosenfeld, Commissioner for the California Energy Commission: The main advantage of wind is that it provides cheap electricity per kWh, which always sounds good, but wind isn't reliable enough. Only Germany and Denmark are doing better than

California with wind, and Germany had to build a huge reserve margin (close to 50 percent) to back up its wind. People show lots of pictures of wind turbines in Germany, yet you never see the standby power plants in the picture. This is precisely why utilities fear wind: the cost per kWh of wind on the grid looks good only without the provision of large margins of standby power.

Benjamin Cohen, Assistant Professor of Science & Technology Studies, University of Virginia: The political philosophy of late-modern post-industrial hyper-consumer global free market capitalism. How about that? That context defines energy as a consumer product only and thus examines it for its market characteristics. But "power" should be explored in a more thorough manner, such as in the scholarship of the fine researcher Richard Hirsh, to recognize its cultural role.

Brian Castelli, Executive Vice President and Chief Operating Officer, Alliance to Save Energy: Fire marshals and zoning regulators. You can cure all of technological issues, but you still have people with rules and lack of familiarity with new technologies. They fear putting a microturbine in a ten story building. They know what a chiller or furnace is, but they don't know how a fuel cell operates. You have a great deal of problems stemming from institutional issues, and they can be a killer. Policymakers see these kinds of problems with all new technologies. Stationary sources of DG like fuel cells, microturbines, and reciprocating engines are great, but they need more public education to make it into the marketplace.

Also, the notion of a competitive electricity market is an illusion. There is no such thing as a free market. People have a vested interest in the market for current technologies, and they don't want to see change, it's just human nature. The market doesn't welcome, rapidly, new technologies. The existing infrastructure will always act as a significant impediment to the adoption of novel energy technologies; think how the automobile industry continued building behemoth vehicles despite their poor efficiency and the huge losses the companies suffered to subsidize their purchase during the past year.

Brice Freeman, Project Manager for Distributed Generation, Electric Power Research Institute: First and foremost cost. If this question were asked five or ten years ago (as it was by the DOE in their 2000 report "Making Connections" NREL/SR-200-28052), I would say that interconnection standards and air permits were the two largest barriers. These two issues are largely resolved. IEEE has taken a leadership position in defining interconnection standards, and many air districts have resolved how to permit these small devices (see California's Air Resources Board work on emission certification).

The cost problem is two fold; capital cost and operational costs. The capital costs are a tough nut to crack. The manufacturers claim that if they get an orders of size "X", they can reduce the costs, through economies of scale, the price of the unit by "Y"%. To some extent, this is true, but for more exotic DG technologies, even the most favorable bottoms-up cost analysis doesn't show the price points that these devices need to hit in order to be cost competitive with grid-power. As for operational costs, the biggest

variable is natural gas costs (out of most everybody's control) and unit efficiencies (somewhat controllable). The heat rate (efficiencies) of small generators are not particularly good if operated as a power only device (i.e. no CHP). First generation microturbines were expected to lead the DG revolution ten years ago, but their simple cycle heat rates were very disappointing, particularly on hot days when they were to be used as peak-shavers. This heat-rate dilemma turns into an opportunity when CHP or CCHP projects are considered. If the natural gas prices are high in a particular region, the economics will favor the most efficient generators – all else being equal. When you are competing against grid-power, CHP plants have a significant advantage with their overall efficiency of 50-85% compared to 30-50% for central station generation.

Chris Namovicz, Operations Research Analyst, U.S. Energy Information Administration: Renewables in particular have the problem of both market and policy uncertainty. Natural gas prices are projected to gradually decline over the next few years. Uncertainty over fuel prices creates uncertainty over whether renewable technologies can compete with natural gas and coal generators.

Claudia J. Banner, Senior Engineer for Renewable Energy Planning, American Electric Power: Costs have to come down so that without government subsidies, these technologies can compete with central stations on a $/kW-hour basis. Concerns over connections to the grid have to be overcome and net metering issues have to be addressed. Customers have to be convinced of the benefits of using these systems.

Dave Stinton, CHP Program Manager, Oak Ridge National Laboratory: It's always cost. People aren't going to even consider it if you cannot convince them that it will clearly save them money. Payback periods often need to be less than four years, and it's hard for DG/CHP technologies to make money when they have to compete against the grid and its historically cheap electricity.

David Baylon, President and Founder, Ecotope Consulting, Research, and Design: There are two things. The first is this whole economic problem. Even when you actually have well developed systems that produce cost effective energy, the problem is that from the point of view from the consumer they aren't getting a benefit at that level. And rates of return are only a few percentage points. So they won't invest in technologies that have a 20 year horizon, even though that is the type of investment that utilities buying gas turbines make. People aren't utilities. They don't want to produce their own energy.

And second, American culture is an incredibly stupid culture. In the United States of America, people do not run their lives based on cost benefit analysis. If that were the case, we wouldn't see SUVs all over the place. There is no incremental benefit of $20,000 in an SUV.

David Garman, Undersecretary of Energy and Former Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy: Many utilities have a vested interest in fighting DG projects. The biggest challenge is often getting the rules right to create win-win situations, and that is hard to do. We have a

balkanized electricity market: retail electricity is handled at the state level, and different actors and players, with different points of view, play multiple roles. Some investor owned utilities are very intrigued with DG; but getting the rules right is a tough thing, and there isn't a one size fits all approach. I think the utility issue is something that state public utility commissions need to take on in their own manner and timeframe. Right now, a lot of investor owned utilities are in the business of selling electrons, and while they have legitimate interests in issues like backup or peaking power, they don't have much of an incentive to switch to a more distributed energy framework.

Let's take the issue home. Let is suppose that my rich uncle, assuming I had one, died and I decide to use the money he left me to install 5kW of solar electricity at my home. If I were to go down this path, I would have to cope with what my current electricity provider would demand—they might give me a fair or unfair interconnection agreement, charge me a backup charge, since they would be providing me power if my inverter or batteries failed, impose a monthly fee just for the ability to take my power when I have a surplus of it and want to sell it to them. Suddenly, if I had 5 kW of solar on my home, I would no longer be a good revenue customer for them, although they would still be responsible for universal service, for maintaining the transmission lines into my house, and for the safety and the stability of distribution service I would still be using. So we have to allow customers to install their solar, while being fair to the utilities that will still be providing services even as they are foregoing revenue. That's only fair. So public utility commissions need to find the best approach to create a partnership between customers and utilities to overcome these practical obstacles. And this challenge must be undertaken at the state and local levels.

David Hawkins, Lead Industry Relations Representative, California Independent System Operator: California has around 500-600 MW of DG. The greatest challenge is the need for observability back at the ISO, as well as better monitoring and information gathering. DG operators, for example, need to know how many hours units have been operating so that they schedule oil changes, checkups, and maintenance inspections. Better information technologies are also needed to track those DG systems that are supplying power to the grid.

Jack Barkenbus, Executive Director of the Environment and Resources Center, University of Tennessee: First, the intermittency and reliability issue of renewable generators. The kind of synchronization needed with the centralized sources of electricity can be offset with many types of smaller, distributed generators. The second issue with renewables is that they can be land intensive, especially when generating large amounts of power. They are also inherently decentralized, which means that they will be more scattered and diffuse. You have to remember that people want energy without having to think about it. People will always resist changing their lifestyle for the sake of energy. Looking from Oak Ridge up to Buffalo Mountain, those wind turbines look nice. But if there was a community up there, it would not be a welcome vista. So public resistance to even renewables is not a trivial matter. Mainstream American consumers don't want to think about energy, they just want the services acquired from them.

Jan Harris, Project Manager, Vermont Energy Investment Corporation: For renewables, the big problem is where to get research money. It has to be either done by deep pockets of oil companies who own most of the PV patents. Another source of funds is venture capital, but they need five times return on their investment in five years. Banks see renewables as unproven and too risky; the market simply isn't there. So, in the end, where do you get the money to finance renewable energy projects? The market is undercapitalized.

One way of fixing this would be public procurement. Like the city of Burlington adopting LEED standards for the entire city. Systems benefits funds or renewable portfolio standards are also good options, but in the end we need more public money to start putting renewable energy systems up before their markets will become attractive to investors and economies of scale and modes of production are created.

The uncertainty barrier is also huge: people don't see it they don't know it. Wind turbines are a proven technology, but you don't see them in this country because people think they are ugly. Purely a public perception thing. I think they are elegant and beautiful. The realistic option is a coal plant. People don't seem to make the connection that it is either or. A coal plant sited where I don't see it basically doesn't exist to me.

So the largest impediments are public perception, misunderstanding, lack of familiarity, and inability to get capital.

For energy efficiency, it's largely an education issue because efficiency is cost effective. It pays for itself. A cash flow analysis proves that quite easily. So why doesn't everybody do it? Do the math and it makes sense. It's education that is lacking. People don't understand it, they haven't been exposed to it.

Janet Sawin, Director, Energy and Climate Change Program, Worldwatch Institute: Inconsistent policies (which inhibits investment and makes it difficult to obtain low-cost, long-term financing); lack of understanding/awareness regarding potential of these technologies; perception that bigger (and centralized) is better; continued high subsidies for conventional fuels and technologies – particularly nuclear power; concerns about reliance on intermittent resources (whether real or perceived).

Jeff Jones, Operations Research Analyst, U.S. Energy Information Administration: DG systems share a number of similarities with renewable technologies, including the challenges to their wider adoption. Other technologies—coal, natural gas turbines, combined-cycle, nuclear reactors—have been around for awhile and can, to varying degrees, compete within the market. An important factor is economies of scale. Central station plants tend to produce cheaper electricity, since cost benefits typically result from building plants in larger increments.

Joe Catina, Manager of North American Projects, Ingersoll Rand Company: How do you stack them up?

(1) Customer resistance; the users of DG, the hosts, mostly do not want to be involved in the execution issues related to energy intensive capital projects. These users want to save money, but they don't want to deal with permits, nuts, bolts, wires, and washers.
(2) Utility resistance; many utilities still place artificial cost impediments on alternative suppliers of energy (and thus any alternative source of electricity generation). Some of that was overcome with the new Energy Bill, and California appears to be the most robust state in terms of underwriting renewables and efficiency programs with rebates, grants, research, and subsidies to increase market penetration to the point that it becomes a cost effective technology. However, most of the country is not there yet.

Also, for utilities, it's the threat of losing control. Utilities are by nature monopolistic entities that had a charter to provide adequate energy capacity, with near total control over the production of electricity with little responsibility for cost. Now, they are being asked to lose control over the market yet keep costs low. And many are uncomfortable with the issue of how to control a grid compromised of dispersed generators.

From the DG generator side, the biggest issue right now is cost. It's all about cost. If this technology was priced more competitively, or if it were incentivised, or credited for the environmental and societal benefits, you would still have resistance, but at a much lower level. If you eliminate manufacturing and execution cost issues, you still have to minimize a great number of hoops that new technologies have to jump through. Currently, the procedural hoops tend to be the same whether I am undertaking a 250 mW project or a 250 kW project. From a societal benefit, it just doesn't make sense: if society wants to encourage the development of renewables and DG, the process needs to be no less complicated than installing a boiler or furnace. If this were the case, DG (and renewables) would certainly multiply.

Another factor is natural gas prices, which are forcing a dichotomy in the market now: higher gas prices yield less interest in many types of DG systems, yet those using natural gas want to use it more efficiently (and reinvest in efficient technologies). It sometimes depends on whether they already buy gas for current needs. Either way, natural gas prices significantly change the economics of DG. For the moment, California and New York still have high electricity prices, making DG technologies more competitive. But for the rest of the nation—including Virginia—the cost of electricity is still much too low.

John Plunkett, Partner for Optimal Energy Consulting: The market barriers themselves are quite significant. The standard economist answer is that people respond to price signals. The manifestation of these market barriers are the people behave as if energy efficiency costs a lot more than it does. Put another way, people are much more willing to pay to waste energy than to save it. And it's because of the influence of these market barriers. Many energy efficiency options cost around two cents per kWh, yet people act like they cost multiples of that. And it usually costs around 8 cents per kWh to generate electricity. Economic theory would tell you that people would invest in energy

efficiency measures all the way up to but stopping at their rates. Why don't they do it? The prime manifestation of barriers is that people have short-term payback requirements. Sometimes I want to scream, "I'm sorry, it's an investment." Others include lack of information about energy efficient products or practices; lack of infrastructure to use more efficient devices; constrained rates on capital availability; split-incentives between tenants and landlords; product availability, and so on.

Market barriers lead to market failure. So then we realize that we can induce people to do the right thing. The solution is to overcome these barriers with good programs. So why aren't there more good energy efficiency programs out there? A big one is utility disincentive. One of them is lost revenue (which goes away once you take it away from the utilities, like we do in Vermont).

It also comes down to politics and political will. There is no incentive for utilities to want energy efficiency, so we need strong advocates of energy efficiency at the local, state, and federal level.

And finally there is the issue of externalities. People aren't even paying the full cost of electricity.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: The biggest one is dealing with the utilities: interconnection fees, rate schedules, payback periods, and incentives. Most CHP systems are beyond net metering, so they tend to want to connect to the grid. The utilities are more of a barrier, and then resist people adopting or using technologies out of their control.

Judi Greenwald, Director of Innovative Solutions, Pew Center on Global Climate Change: The biggest impediment is inertia – institutional, market and technological. We have been doing central station generation for a long time and our institutions, markets and technologies have evolved along that paradigm. Attempts to shift that paradigm run into resistance on all these fronts.

Marilyn Brown, Commissioner, National Commission on Energy Policy: For one, the benefits of DG systems must be balanced against natural gas concerns, security, and air problems. Bringing the generation of electricity closer to population centers brings hazardous and often combustible fuels closer to residences, and produces more localized air pollution.

Tariff-related pricing impediments also remain, including interconnection standards and a lack of uniformity among states regarding the classification of, permitting, monitoring, and siting of DG technologies (including renewables). And, with interconnection standards, it's not just a technical problem, since it's difficult getting any group of power engineers to agree if and how DG systems should interconnect to the grid. It's really a social and political problem as much as it is technical.

Now, for renewables, it's difficult to discuss them as a single category of options. "Solar energy," for instance, can include photovoltaic panels and also solar-thermal systems, parabolic dishes, and solar-water-heaters. "Wind energy" can include vertical and horizontal axis wind turbines and windmills.

For solar technologies, capital cost remains the biggest problem. Most PV systems are not cost competitive yet, though with time they may be. Currently the cost of PV systems needs to at least cut in half before they can compete with fossil fueled sources of electricity.

Hybrid systems do not usually qualify for renewable portfolio standards, and measuring their true benefits is difficult (since they are hard to classify).

With wind, at least three hurdles remain. Technical problems concerning power from low wind regimes need to be overcome so wind turbines can work closer to populated regions such as the Northeast. Wind speed (and thus potential) tends to be greatest in remote locations (like the Dakotas), so we need better ways to bring wind power to the market. As it currently stands, most wind energy is land-intense. It is hard to see how a technology so land intensive will meet the needs of population growing at almost two percent a year.

Mark C. Hall, Senior Vice President, Primary Energy: It is always hard to talk about the most important impediments. We've done this within the U.S. CHP association, a list of the ten big issues facing CHP, in isolation these issues can get fixed and some states have stepped forward and fixed them, only to find that a huge surge in DG or CHP use never happens. Things like utility backup tariffs, demand fees, and interconnection processes are really symptoms of a larger issue. The real issue is that there are all of these small barriers, not any one that absolutely kill a project, but it's the fact that it is so much harder because there are so many other steps to go through to get a DG project done.

On top of that, no one is usually aware of the benefits of DG systems, and people end up having to debate them every time they start a project.

And size matters—not necessarily from a capital cost or efficiency standpoint, but it takes a lot of effort to do a small project as it does a large project, so the tendency is for an organization like ours to focus on the bigger projects because they can support the kinds of efforts needed to get the projects done. In contrast, getting smaller projects done requires such a disproportionate amount of senior management attention, legal attention, and other time and effort that it really burdens those projects with greater and greater costs so that people say it's not worth it. My view is that the only way we will ever see much wider use of small-scale DG systems is when the guys doing it are already out there, in the streets, with a distribution network doing repairs in people's homes on other stuff. Now, some companies have to fly in teams of specialists from out of state to fix or maintain their micro-turbines because no one else in the region has that technology. And that adds significantly to the cost of DG products.

Michael Pomorski, Senior Associate, Cambridge Energy Research Associates: The same reasons as discussed above: there is a cost premium associated with most renewables, and it is difficult finding people to pay that up front. Problems of interconnection and convincing a utility to grant access to a grid they own, operate, and control is also a significant barrier.

Michael Karmis, Director, Virginia Center for Coal and Energy Research: Well, for one, their capital cost is much higher than other fossil-fueled systems. They also have more trouble connecting and moving power into the grid. Then there is the issue of how to deal with intermittence, and to what extent renewables can contribute to providing base load power and peaking power. And then, finally, are the other types of environmental issues that those technologies need to be overcome, such as the disposal of silicon from obsolete photovoltaic systems, residue concrete left over from outdated wind turbines, and the numerous wastes produced in the manufacturing process.

Paul DeCotis, Director of Energy Analysis, New York State Energy Research and Development Authority: For larger DG units, there is a system impact that these units have if they are selling into the grid, which rightfully has to be managed and controlled by the transmission operator. These impacts go well beyond the purview of facility management. I think that the primary concern of facility owners, system operators, and utilities is personnel safety and security of the grid system. I think the reluctance on the utility's part to interconnect and buy generation, serve as the most significant impediment to widespread adoption of DG. The more DG there is on a system, the less direct control a utility might have over its system—certainly, it would make system management more challenging.

There are environmental concerns also that need to be recognized. I know that most people wouldn't want a small distributed resource in their neighborhood or in their building that would be contributing to local air pollutant emissions. There is certainly a NIMBY issue that has to be dealt with.

Regarding smaller units, there are economic issues associated with DG. DG systems are widely perceived as not being cost effective, particularly with today's natural gas prices. Certainly CHP technology is more cost effective than straight DG. I think the uncertainty with the technology and the reliability of the technology has to be dealt with, and I think there needs to be a concerted effort to work with builders and DG equipment manufacturers to integrate DG/CHP more readily into building design. And I think there is a great deal in the U.S. that we can do with district heating and cooling. When we look at the way we develop corporate parks and commercial buildings—or even residential housing developments—they are clustered, making them prime targets for district heating and cooling. There is no reason we couldn't construct district heating and cooling for residential subdivisions or commercial parks, where you have a central plant serving the heating and cooling needs of all of the buildings in an area.

Paul Gilman, Former Chief of Staff for Senator Domenici, Director of the Oak Ridge Center for Advanced Studies: I think the biggest challenge is the legacy of fossil

fuel production. Renewable energy sources are not well designed (or designed at all) to provide base-load power. This makes it impossible to ever switch entirely to renewable energy sources for the provision of electricity. PV systems, for example, work best in a grid system that peaks during the middle of the day. Whereas in the northeast, the peak load is usually in the early evening when people start to go home and turn up the heat and watch television. To my mind, the right way to approach this isn't to say "How do we get renewables into the base-load," it's "Where do we put renewables where they are most cost competitive." To force renewables to provide base-load power is like trying to make a pig fly: you won't succeed and you only make the pig unhappier. The profile of the need doesn't match the profile of the production. Dispatch-able coal, nuclear, and natural gas generators are much better suited to that task.

Ralph Badinelli, Professor of Business Information Technology, Virginia Tech: There are two forms of DG that we need to consider. The first form is the islanded version of DG. This kind of DG is used for emergency power and supplemental power for universities, hospitals, industrial sites, etc. The problem with these units is that they generate electricity much more expensively that the large utilities. Also, the most popular emergency power units are diesel powered making them more environmentally unfriendly than a distant coal-fired plant. The second type of DG is the interconnected DG unit. These units can supplant a significant amount of power from incumbent, large power plants. The most significant impediments to these kinds of units are the lack of interconnection technologies and the economic performance of the units.

Ralph Loomis, Executive Vice President, Exelon Corporation: A very big reason is high natural gas prices. You also have historic infrastructure issues that have to be dealt with. I read the speculations about the interactive grid of the future with decentralized power much more like the internet. But it is how do you get there from where we are right now. What people don't understand is that the current grid, which is command-and-control, top-down, and has a lot of limitations with it, is still an enormously complicated machine. The PJM interface—just one market—cuts across 13 states and serves 50 million people with hundreds of thousands of megawatts. All of which has to be generated and maximized in real time, since you cannot conserve electricity. It is one machine extending over hundreds of thousands of miles. It is amazing it works as well as it does. How do you, then, convert that machine and all of the infrastructure meant to support it into a more digital, distributed, and decentralized mechanisms. Transmission grids are designed to go to specific central station generators. If we go to a DG network in the future, you have to rebuild and reconfigure that entire transmission grid, which is enormously expensive and time consuming, and has its whole host of other public policy issues. Transmission is hard to build, almost harder to build than a new generation facility. A central generation facility at least has a more localized imprint, where a transmission network can go for miles and miles and affect hundreds of communities. It's not that the idea isn't attractive, or that vision of the future isn't very compelling, and maybe when I retire from this business I will go work for some DG startup, because I think that it is exciting. I hope that is the future. I just don't know how to get there.

Rodney Sobin, Innovative Technology Manager, Virginia Department of Environmental Quality: I see at least four significant impediments. The first is economics. Economics and cost are number one for the average customers. It is still cheaper and easier to turn on the switch and buy whatever the utility is selling.

Second is familiarity. The potential users of DG tend to be unfamiliar with the benefits such systems offer. The cookie baker is concerned with making a better chocolate chip cookie. The Chicken Mc-Nugget manufacturer is concerned with perfecting a better Chicken Mc-Nugget. The shopping mall managers are interested in providing retail services. None of them are interested in generating power and becoming a micro or quasi utility. The proponents of DG need to make things as easy as possible for the potential users and customers. Those companies that want to sell DG systems need to provide the service as well.

Third, interconnection difficulties remain, despite some FERC rules. Requirements for interconnecting DG systems with the grid are often inconsistent and onerous. Some require $10,000 deposits charges to simply start the interconnection process.

And, fourth, other utility governance policies are predicated on the one way model of the central utility selling power to the customer rather than the more interactive and fluid grid style management. Thus wires charges, stranded assets, unfair rates of return, and other practices continue to make it difficult for third party power producers—DG or not—to generate electricity.

Ryan Wiser, Staff Specialist in Renewable Energy Systems, Lawrence Berkeley National Laboratory: Cost, transmission, and integration. Regarding levelized costs of electricity, some DG technologies do good, like wind, while others do poorly, like solar. Regardless, the cost of all DG systems needs to come down.

Regarding transmission, most renewable resources are located very far from demand sites. This means utilities have to deal with transmission on a grand scale. In order to connect a large number of renewable systems to the grid, utilities will have to redesign the entire transmission system.

And third, regarding integration, both wind and solar generators have variable generation sources that do impose extra costs on the system. These need to be better understood and integrated into planning and investment decisions. Also connected to this are permitting and siting concerns. Siting wind projects where people can see them often results in fierce local opposition.

Sam Fleming, Former Program Manager for Renewable Energy Systems, Nextant Incorporated: I think that, primarily, the capital cost must be driven down, and some of that requires further technological advances. Bio-ethanol is a great example, with substantial capacity being built and a number of programs supporting it, yet the economics of it are still not there, as I see it today. New technology, and in some instances new science, is needed, and the problem is being worked. And this reflects that

it takes a long time to perfect energy technologies so that they become not just technically feasible, but cost competitive.

Scott Sklar, President of the Stella Group, Inc.: The U.S. still needs a national interconnection standard. Currently, over 20 different states have varying technical rules (loosely based on the IEEE 1547** standard) for interconnection, and still they are different enough so that manufacturers of DG technologies' interconnection equipment have to make different devices for almost every different state market. It's totally absurd. When the telephone industry was deregulated, Congress passed a national interconnection standard for telephones so that, whether plugged into a home in New York or California, they would still work. We need the same thing for DG technologies. A national interconnection standard is absolutely essential to provoke an evolution in interconnection equipment desperately needed for DG systems to take off, and will also allow them to be more compatible with smart meters that will be critical in any building or facility.

Shalom Flank, Chief Technical Officer, Pareto Energy Limited: The first impediment was discussed above – inertia and ignorance. Energy is outside the core competence of most potential users, whether they are real developers, home owners, or commercial businesses. Larger sites may have a facilities manager with the relevant expertise, but in our experience, "selling" a system to the facilities manager doesn't get you anywhere, because they have so little power within the corporate hierarchy. People know how they've gotten power in the past: plug the cord into the wall. Or the equivalent, tell your engineers to hook up to the utility grid. Without a major crisis to change those habits of thinking, it won't happen.

The second impediment is the power of the incumbent utilities, and their captured regulatory partners. Interconnection rules and standards have been unable to overcome the absolute veto power of local utilities. Astonishingly, even when the executives of a utility have joined the DG/RES cause, **they** cannot overrule their own distribution departments. We've encountered that particular phenomenon multiple times. We've talked about getting some foundation to support the formation of an "Interconnection Strike Force": when a utility raises the usual roadblocks to a DG/RES project – such as delays, endless studies, safety objections, gold-plating, or simply outright refusal – we would parachute in with a crackerjack team of lawyers, engineers, and lobbyists to use the existing laws, regulations, and political pressure points to break through their resistance. Countless projects have died because of the lack of such a strike force, doomed by the expense, uncertainty, and delay that the utilities can impose almost effortlessly.

Shawn Collins, Project Manager for Fuel Cells, United Technologies: For fuel cells, their actual maturity is significantly below most of the popular press statements made by people who think that hydrogen is going to save the world. This has caused two problems: people making fuel cells expected it to be easy and weren't prepared for the degree of technical difficulty they encountered, people buying fuel cells have to adjust

expectations when they find out the widget they bought is more of a prototype than something that works consistently.

I asked you about this at IASTS in 2005, but I also believe the DG industry is extremely fragmented. Certainly this is the case with fuel cell companies. There is a degree of success that could be achieved if different companies collaborated to share best practices which would benefit the industry as a whole. At the moment, no-one wants to work together because the reward for individually solving the problems and monopolizing the market is so high. The cost and likelihood of failure is also high, but they would rather make this gamble than collaborate, which would be lower reward and lower failure probability.

At a presentation to a sustainability consortium last year, one of our CHP product managers said that for many potential customers, the alternative to CHP is to do nothing, which is generally acceptable. Consequently, people who sell CHP products are still learning how to frame their value proposition. For example, hotels and grocery stores haven't historically thought of themselves as sources of neighborhood power or sources of community health (using DG at a WalMart store would remove XX cars from the road, equivalent to YY benefits for local residents). People selling CHP products are still learning how to frame their value propositions in these terms. Some of this has been helped by things like the Northeast blackout, strong recent hurricane seasons, and urban pollution concerns, but the industry is still climbing the learning curve in terms of expanding rhetoric from what has historically been applied for the grid.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: If you look at CHP, the current cost of natural gas is an issue. The cost for other traditional fuels—nuclear and coal—are also increasing, although not as quickly as natural gas. On the other hand, you have cost reductions in prime mover, micro-turbine, solar, and particularly wind technology.

Ted Fox, Interim Director, Energy and Engineering Sciences, Oak Ridge National Laboratory: DG is really not necessarily connected at all with renewable energy. Most people talk about natural gas when they talk about DG. The majority of capital investment in power plants in this country has been natural gas power plants ever since the 1990s. I don't think that trend is going to continue. The demand for natural gas will make it too expensive for that to be a continued option. If the price of gas stays where it is, natural gas turbines will not be able to compete with other forms of electricity. And anything other than gas becomes difficult to burn in a distributed sense. Added research may open up more alternative fuel options.

If you are considering solar or wind there is the issue of grid stability. Solar power generation, for example, may or may not meet the grids needs. When you need it, the sun might not be out; we need electricity at night when the sun doesn't shine. We would end up having to build more gas turbines to supplement the intermittency of solar. The reason solar works now is because it is a trivial amount and doesn't affect the grid at all.

But a much wider use of solar could threaten grid stability. For solar to be successful some cost efficient storage technology is also needed.

Social concerns also impede renewable energy resources. For example, there was a demo in North Carolina twenty-five years ago where they built a large windmill (probably around 100 kW capacity) as a Department of Energy demonstration plant. And it operated for around two years. I understand it caused community problems that led to it being dismantled.

Thomas Grahame, Senior Research Analyst for the Office of Fossil Fuels, U.S. Department of Energy: I'm not an expert on DG, but since most of it in commercial buildings uses natural gas as a fuel, I would imagine cost would be a big impediment. Back when natural gas was $2.50/mcf, you could build a smallish generator in a commercial building, heat some water for cogeneration, and make a profit even while absorbing the higher cost per KW of building your small generator (the larger the generator, the lower the per KW cost usually will be, and utilities build the bigger generators).

That said, I am aware that when natural gas was cheaper, many who sought to build DG felt that utilities were discriminating against them in various ways, such as interconnection fees. I've never looked into those charges carefully, so I can't judge how big an issue this was. But until natural gas prices come down again, it may be a moot point.

For RES, I assume you mean renewables; see answer to Q.1.

Thomas Petersik, Former Renewable Energy Forecasting Expert, U.S. Energy Information Administration: The most significant impediments are cost, cost, and cost. More specifically, distributed generation technologies experience much higher (in the neighborhood of 50%) capital costs per kilowatt, in part because they lack economies of scale; they are much less fuel efficient, and operations and maintenance are much higher (Most households and most businesses do not want to bother with maintenance or even with the inconveniences of fuel supply). And there may be notable safety issues as well. As a result, the per kilowatthour costs of distributed generation from, say, microturbines, fuel cells, small wind, solar photovoltaics, and others, are significantly more than for central station supply. Anyone who can get electricity from a utility without having to pay much for interconnection charges is far better off buying central station power.

Toben Galvin, Senior Energy Analyst, Vermont Energy Investment Corporation: I think there are serious financial and economic impediments. When I use the word financial, I refer to how more efficient energy technologies area viewed from the standpoint of the homeowner. When I use the word economic, I mean how such technologies are viewed socially. The two are very different, and both are incredibly difficult to promote. Yet most homeowners and policymakers—those who make decisions about finance and economics—are reluctant to embrace both DG and

renewable technologies because they cost more up front, lack a sustained marketing effort, and have the perception of being harder to operate and maintain.

Tom Casten, Chair and Chief Executive Officer, Primary Energy: This is a profoundly interesting question. On-site Industrial generation projects, by recycling waste energy, reduce fossil fuel use and pollution. Because the generation is next to the user, these projects avoid the capital costs of new transmission and the line losses, which average 9% for the US. Industrial generation plants thus reduce costs by about 40% versus serving the same load from central plants, and often cut pollution and fossil fuel use in half. Yet these plants are the exception instead of the rule. The mind-sets are deeply biased in favor of yesterday's central generation approach and block the message about tomorrow's optimal energy system. I spend a great deal of time explaining the concept of distributed generation and how it enables waste energy to be recycled—how to convert industrial waste streams into profitable electricity, or to displace other fuel costs—and people often have no idea what I am talking about. Many needless regulatory barriers—legal and otherwise—still largely exist, but can be surmounted for industrial sized plants. It is deeply perplexing to see the rarity of new distributed generation in the industrial sector. Big, industrial firms with immense payrolls have political clout and can gain appropriate permissions to generate, often with one to two year paybacks on the generation investment.. And yet, most industrials continue to purchase from the grid. and fail to deploy more energy efficient systems that could save them millions of dollars.

Twenty –five years of efforts towards developing industrial generation plants has taught me that there are other, deeper barriers to efficiency that go beyond legal impediments, obsolete monopoly protection rules, and flawed regulatory structures. The typical manufacturing enterprise focuses its intellectual and financial resources on core activities – making beer, or steel, or chemicals, etc. The vast bulk of industry will not invest in energy plants unless they are 'broken' or, in the best case, when an energy efficiency project will pay back the capital investment in 12 to 18 months. Companies have a much higher investment hurdle rate for core activities than non-core activities, and they employ very few specialists in any non-core activity. This focus on core activities has become the big buzz in management discussions over the last twenty years. Peter Drucker insists that to be successful in a world of globalization, companies must focus on their core mission and outsource all of the non-core functions to specialist firms. In general, this makes sense, and is widely practiced. Today's successful firms outsource payroll, security, food service, janitorial services, grounds maintenance, call centers, and other functions. Energy is more complicated than any of these examples, and often represents a far larger percentage of revenues, yet is not a core activity.

So why not outsource energy services, consistent with current thinking on best practices? The question is, outsource to whom? The monopoly utilities have no reason to offer energy services to their customers. They already have the business, so why increase their complexity? Why increase staff to deal with the intricate flows of energy inside an industrial facility when you have a protected market to sell them electricity and natural gas. More efficient on-site conversion of fuel and waste energy streams to useful energy will reduce monopoly protected sales. With open markets, multiple third party providers

flock to provide services. Companies have many choices for outsourcing any of the services mentioned above. But the many legal barriers against local generation have killed most of the potential providers of on-site energy services before they reached breeding age. There is a dearth of credible providers of energy services.

I will give you an example from the steel business. For many years, steel companies have refused to fund energy conservation projects with greater than 12 to 18 month payback of capital. And an 18 month payback is a 67% annual rate of return. This does not sound credible and is little understood by policy makers. The American steel industry, in the good years, generates an eight or nine percent return on capital. The very best steel company in the world may earn 12% to 15% return on invested capital in this very capital intensive business. And yet the steel companies refuse to invest capital ina non-core, energy savings projects with 65% returns. And companies like U.S. Steel and Mittal have often pass on energy projects with over 100%returns, because they are conserving capital for a major steel making investment.

The way I explain it is the following: CEO's, have a limited number of top managers whom they totally trust. Let's say there are ten completely trusted managers in a big company. And that number doesn't go up with the size of the company, since the CEO has only have a limited amount of time. And everything important that the company undertakes must be under the personal supervision of one of these ten people. CEO's are human and can only manage a finite number of personal relationships at once. And there are many core pressures. They may beam trying to do an acquisition of another steel company in Serbia, or building a new rolling facility in South Africa, or reline a $350 million blast furnaces. In order to manage many, competing core-mission issues, businesses simply don't have the intellectual resources to efficiently perform non-core activities, and this is behind Peter Drucker and other management experts call to outsource non-core.

Non-energy functions that are also non-core are successfully outsourced I don't see the inefficient, suboptimal performance of payroll—a non-core activity—that I see in energy. There are a series of competing payroll companies, offering state of the art services and significantly more value than from internal performance of payroll. So why isn't this the case with energy?

Over the years, we have repeatedly offered to perform energy services for industrials, typically offering up to 40% savings over conventional approaches, and we have had modest success, taking two companies public and earning market rates of return for our owners. Howerver, we loose most of the time. Far and away, our most successful competitor is 'Mr. Do Nothing.'

My son, who is CEO of a company that offers integrated steam turbine generator plants that convert wasted steam pressure drop into electricity, often with over 35% returns on investment, analyzed company activities over the last 17 years. Out of 7,000 proposals, all of which had at least 25% returns on investment, only around two percent were

accepted. Only 1% were lost to another competitor. 'Mr. Do Nothing' won 97% of the time.
Policy makers can charge for carbon emissions, which would make energy efficiency projects more competitive. They can raise the price of electricity to include many of the externalities that are currently born by society, as is common in Europe, where 75 percent of your energy bill is tax, but I think these policies may still fail to address the key barriers to efficiency. Industries are moving off shore to obtain cheaper costs, yet are not making, nor allowing third parties to make major investments in energy with 18 month paybacks. This is the major problem that must be solved

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: You certainly have the technical issues, and as technology improves bringing down the unit cost of different mechanisms for generating electricity, you will see an increase in DG technologies. But it basically comes down to cost. As a former facilities and systems manager, the issues I have had to deal with have been primarily related to what is technically available off of the shelf, and how to pay for it. The policies are and have been beyond my scope.

Vijay V. Vaitheeswaran, Energy Correspondent and Author for *The Economist* Magazine: The biggest obstacle is the lack of smart meters and real time pricing. That means micro-power does not get the full financial reward it serves for (1) alleviating congestion on overloaded distribution lines, (2) for producing clean power on site, where it is needed most, in urban clusters, and (3) for selling power into the grid during stressful peak hours, when Enron would have been charging an outrageous fortune on the wholesale market for spot power.

Vikram Budhraja, Former President of Edison Technology Solutions, Edison International Company: For DG, it really is a cost issue. And the reason that I say that is because it is very difficult for DG systems to compete with grid-supplied power solely on the basis of direct costs of producing power. DG works best when focused on unique, local needs (such as more reliable power, the ability to use combined heat and power applications, the provision of emergency of backup power, or being able to operate isolated from the grid, and so forth). The biggest challenge is to get the cost curve of DG technologies down, so that they can capitalize on economies of scale. We need simpler and stable rules for interconnections, tariffs and regulations.

Wilson Prichett, Energy Consultant, ASEGI Incorporated: They are not the solution. If you are looking at the whole package of the electric utility industry in the United States, I could see DG contributing five to ten percent. If you did something about the demand, it is closer to fifty percent. DG—and even other supply-side options like clean coal, and renewables—is the icing on the cake. The real full-course meal is demand side management. We are just plain using too much energy.

Zia Haq, Operations Research Analyst, U.S. Energy Information Administration: In my opinion high capital cost is the most significant impediment to wider use of DG technologies. DG technologies are at a much smaller scale than utility systems. Due to

economies of scale capital costs are much lower for larger scale systems. Technology will have to be developed to reduce those costs as has already happened. I think that trend will accelerate with market acceptance.

Question 5: What can be done to overcome the impediments facing renewable energy systems and distributed generation technologies?

Adam Serchuk, Senior Renewable Energy Program Manager, Energy Trust of Oregon: Either a truly long term production tax credit or none at all would be one option. I also understand that the Energy Policy Act of 2005 commands state public utility commissions to do something about interconnection, but I honestly don't know what the law requires them to accomplish. In terms of power purchase agreements, there is a question of political will among public utility commissions to make contracts for DG and renewable systems fairer. Only when public utility commissions have the will to hammer out PURPA contracts without trapdoors will DG technologies really take off.

Alan Crane, Senior Program Officer, National Academies of Science: PV systems are already excellent for peaking, since their optimal performance is closer to load following in the hot summer months. PV units peak around the same time that people use their air conditioning in the summer. Some of the institutional impediments can be addressed more directly. Electric system operators can coordinate better with DG operators, at least the bigger ones, and have some degree of control over whether the DG units are operating and connected to the grid. AS DG grows, the system operators will have to learn to accommodate them. Like intermittent renewables, some will be operating at all times, and there should be some credit for the power availability.

Alex Farrell, Assistant Professor for the Energy Resources Group, University of California Berkeley: Allow, encourage, or incentivize monopoly franchises to own these types of assets. This then gets into the debate as to should we give it to franchises and re-enhancing their privilege and power, but I don't really care if that's what it takes. But it's also because I'm not sure if distributed renewables are what we should have to produce a big part of our power supply.

The answer to many energy problems is that more R&D is needed. Particularly, we need better ways to store and transport electricity. It is very likely that we will not have distributed renewables. We are more likely to have centralized renewable systems or remote renewables. I do think that lots of wind power in the middle of the country with a couple of HVDC power lines to the coast, and storage, is a reasonable possibility.

Anonymous, High-Ranking Executive for a Large, American Independent Power Producer: Capital cost: investment tax incentives. Wind power did well under the government tax plans established in the 1990s and into the early 2000s, then collapsed when those subsidies lapsed. Environmental & government: special regulations for smaller generators. Increased economic penalties for pollutant emissions. The more NOx, sulfur oxide, mercury and carbon dioxide emission credits cost, the better alternatives look economically.

Benjamin Cohen, Assistant Professor of Science & Technology Studies, University of Virginia: Fewer technocrats; more humanistic analysts. Fewer businesspeople; more

cultural progressives. Re-characterizing DG for its place in the social landscape; not its place in the spreadsheet. And you know how well that will work. That is, barely.

Brian Castelli, Executive Vice President and Chief Operating Officer, Alliance to Save Energy: A lot of deployment activities would help: controlled pilot programs, public education and awareness are critical. Having peer to peer exchanges is also really important.

Brice Freeman, Project Manager for Distributed Generation, Electric Power Research Institute: Regarding the two impediments I mention above, providing research dollars to manufactures of DG equipment to improve their heat rate would help although it would probably would not result in a favorable return on investment. Otherwise, anything that could be done to de-risk projects (standard installation designs, fleet emissions certification, etc.) would help lending companies feel better about backing projects. Following the California Energy Commission's lead in ranking their loading order to favor CHP and energy efficiency are good first steps.

Chris Namovicz, Operations Research Analyst, U.S. Energy Information Administration: The industry would like to see more long–term and nationally consistent policies. Of course, this doesn't mean these are the only solutions. Some might argue that there are advantages to incremental approaches and to letting each state experiment with their own policies to find what works best for them. There are lots of different ideas, and which ones work will largely depend on what the desired results are; not all stakeholders necessarily share all of the same goals. Ultimately, it will be up to industry and elected officials to find the solutions that work best.

Christopher Russell, Director of the Industry Sector, Alliance to Save Energy: The bulk of efficiency opportunities at the household level are manifested in the purchases of technologies like appliances and light bulbs. Varying amounts of savings are attributable to behavioral choices, but absolute savings come from the right choice of hardware. That's why it makes so much sense to have appliance standards, especially for refrigerators and HVAC systems.

Claudia J. Banner, Senior Engineer for Renewable Energy Planning, American Electric Power: Utilities are usually not receptive to mandated renewable portfolio standards, citing an increase in generation costs that could get passed back to the consumer, resulting in larger utility bills. Studies have shown that renewables are typically more expensive than traditional generation.

Until renewables can cost-effectively compete with traditional generation, mandated standards may be the only way to "encourage" renewable use. Somehow, the renewable or DG costs have to be paid. This can come in the form of incentives; increasing the cost of traditional generation to help pay for renewables; mandating conservation measures to offset the costs; mandating renewables and allowing the cost increases to pass through to the customer. Customers have to have DG and renewables as options. Homeowner association restrictions must be removed in order to encourage DG and renewables.

Home builders should provide DG (e.g., solar panels, passive solar) as options to potential buyers.

Dave Stinton, CHP Program Manager, Oak Ridge National Laboratory: More utility cooperation and participation is needed, and the establishment of interconnection standards.

David Garman, Undersecretary of Energy and Former Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy: Standard interconnection procedures, the availability of net metering, and the provision of supplemental or backup power are all important issues. Again, I think this should be handled at the state level. While the Energy Policy Act of 2005 requires these sorts of things be accommodated, the Bill is not prescriptive. It merely forces public utility commissions to pay attention to these issues.

David Hill, Deputy Laboratory Director for Science and Technology, Idaho National Laboratory: It is clear the energy efficiency needs to be promoted at the individual level or the corporate level. As electricity gets more expensive, saving energy becomes more profitable. The best energy solutions are those that make sense to businesses and can help them save money. Take automobiles in America. Consumers in the U.S. continue to emphasize performance rather than efficiency. What the auto industry will tell you is that they can give you a 100 mpg car, but you won't buy it.

Edward Vine, Staff Scientist, Lawrence Berkeley National Laboratory: Changes need to occur at multiple levels: at the federal (regulatory) level, at the state level (utility regulatory commissions), and within homes. Utility regulatory commissions, for example, should start to require the externalities associated with energy be internalized in the price of energy.

Also, when we look at utilities, policymakers should investigate how they procure resources and make sure that energy efficiency is the first resource that utilities should procure.

We need widespread investment in energy efficiency programs, including marketing, awareness, information, and rebate programs.

And we need a public goods charge, funded to demonstrate a leadership in energy efficiency and renewable energy and a commitment to energy efficiency and green energy.

Jan Harris, Project Manager, Vermont Energy Investment Corporation: Public procurement and systems benefit charges are useful, which we have in almost half of the states now.

I am a firm advocate of market based approaches. But you have to get a whole chain of events:

1. Getting public to see the value in energy efficiency and renewable energy: enhanced health, comfort, and financial benefits
2. Then, once consumers recognize it and seek products, suppliers will supply the products, or they will invent them
3. And then the whole thing should, at that point, be answered by market pressures

Also level the playing field. Why are there such huge subsidies for fossil fuels, and why aren't external costs included in the price of energy?

Janet Sawin, Director, Energy and Climate Change Program, Worldwatch Institute: Government leadership (strong, consistent and long-term policies that drive market for RES; government purchasing; education programs); reduced subsidies for conventional fuels and technologies and incorporation of externalities into the cost of energy; development of storage technologies.

Joe Catina, Manager of North American Projects, Ingersoll Rand Company: I think that the laboratory phase has passed for many technologies. We need incentives for the market introduction phase, for the market to accept these technologies. California, for instance, underwrites DG projects. Policymakers there, as a matter of public policy, have decided to be less dependent on centralized generators. Those incentives have people talking, looking, and doing things. The impediments mentioned above still slow down their speed of adoption, but at least there is a market. And herein lies the lesson: DG technologies can be widely used when supported by robust political support and clear policy goals.

John Plunkett, Partner for Optimal Energy Consulting: The big one is to have comprehensive energy efficiency investment portfolios, which means good program design and administration. Huge amounts of incontrovertible evidence suggest that these types of programs work in places like New York, Vermont, and California. So we should be doing this everywhere. And to make that happen, we need to remove barriers at the political level. The fact is that utilities have immense political power, but this can be overcome with a variety of options from total decoupling at one end to utility lost revenue adjustment at the other.

Economists disagree on everything except one thing: gas taxes. Let's get the price signals right. But there is no political will to do these things. Americans don't want to pay the full cost of energy, the full cost of electricity, the full market price of oil.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: For it to work in Virginia, it will have to be something market driven that stimulates the market. Things like production tax credits, subsidies, and rebates to stimulate the market. One thing that might help is to establish incentives for manufactures to come here and build products close to home. Take ethanol. If we could provide a manufacturer's incentive to get an ethanol plant here, all of those flex-fuel

vehicles on the road in Virginia currently running on just gasoline could now run on ethanol. Manufacturing incentives would be one way.

Judi Greenwald, Director of Innovative Solutions, Pew Center on Global Climate Change: We need to create rules that enable the players in the existing structure to be able to continue to have the opportunity to play under a transformed system. The 22 state-level renewable portfolio standards have created new structures that enabled traditional utilities as well as new developers to find opportunities in the new system. California's approach to enabling traditional electric utilities to earn reasonable rates of return on demand-side efficiency programs is a good example of this on the demand side.

Larry Papay, Former Senior Vice President, Southern California Edison: If incentives are put in place, they need to be there for extended periods of time. Some of the tax credit programs are still reviewed (and can expire) on an annual basis. There was a great deal of work done here in California when both federal and state incentives for efficiency and renewables were in place.

Marilyn Brown, Commissioner, National Commission on Energy Policy: Thankfully, DG interconnection standards will be improved as a result of the 2005 Energy Policy Act. Still, unfair tariff issues and utility practices need to be addressed by FERC. The government should support more research and development across all of the renewable energy systems and distributed generators, especially those with fuel flexibility, as private industry doesn't have the resources to develop those systems on their own. And, finally, policies continuing to promote the government as a leader are needed. The power of government procurement is quite large in driving costs down and setting an image that makes energy technologies more socially credible.

Mark C. Hall, Senior Vice President, Primary Energy: We need a comprehensive, coordinated policy solution to educate policymakers about the benefits of DG and CHP. We need to do some of the things already being tried in the states. First, we need a true champion or set of champions for DG and CHP that have the ability to affect policy. Generally in the states, you have maybe a few isolated people in state energy or environmental offices, but no lieutenant governors or governors, making it a priority for the state. The political leadership just isn't there. And this is also a problem with our national laboratories, like Oak Ridge, and the Department of Energy. These places offer great resources for DG and CHP, and are great technologists, but they are often (and intentionally so) isolated from policy discussion and advocacy. We have immense technical understanding of DG resources and issues. We need that political leadership to happen.

And then we need industry getting up and supporting that. As an industry, the electric utility sector (and within that, the CHP/DG business sector) is extremely fragmented for its size. A lot of the manufacturers of DG technology are coming out of organizations that produce lots of other things. Their sole purchase is not to be a DG organization. Or they sell a whole range of products. Many times DG products come out of research done at companies on other, unrelated areas. Fuel cells are a great example, since they were

designed for space travel, not for a local generation resource to be put in hospitals and army bases. So are natural gas turbines, which were originally based on airplane engine technologies. But we don't have a large group of people in industry that view themselves as the DG and CHP stakeholder community. Even to the extent that they may recognize common ground, they each have splintered interest, so its hard to get them to come together to work cohesively to advance broad policy change because they are so focused on getting individual technological or financial success.

Everybody in the renewable energy space, small DG space, and large DG/CHP space, many have the same interests and would benefit greatly from a full-press political leadership. What happens? They fight over renewable portfolio standards and people within the DG industry beating each other up rather than work together. There are so many DG organizations, but there is only one Edison Electric Institute, predominately pushing large-scale centralized generators.

Mark Levine, Environmental Energy Technologies Division Director, Lawrence Berkeley National Laboratory: There are certain ways to overcome them all, if society was willing to follow a consistent course over multiple administrations at the Federal and state level (including many states). For automobiles, we need serious corporate average fuel economy standards (or other ways to accomplish the same objective). My favorite is a fee-bate, or a tax on inefficient cars coupled with a rebate for efficient cars. Policymakers can also pursue revenue neutral policies (money taken from inefficient cars balanced over a number of years, adjusted each year to make efficiency standards tighter and tighter, forcing manufacturers to respond with more efficient cars). Because the money ends up being returned, it's not really a tax.

In industry, part of it is education, and so many industries think that they now how to make their processes efficient. Compared to other countries, the U.S. is far behind, but we don't want to tell them that because it will make places like the Lawrence Berkeley National Laboratory unpopular. Companies need to become more serious about training, organized industry by industry, as well as policies or practices that cross cut technologies including things like motor systems. These could help a lot. Appliance and building standards already take significant amounts of energy, but they could go much further than they go now.

Politically, I think we find the most difficult problems. To become much more energy efficient as a culture, it takes recognition at the highest levels of the government. And there is currently no call for that from the country. We are sort of wondering in a random stupor without any awareness of our path or where we are going. I suppose we will find out when we get there.

Michael Pomorski, Senior Associate, Cambridge Energy Research Associates: The best option would be to internalize externalities. For example, Congress would pass legislation creating a cost for carbon and mercury, something that would be formally recognized as exacting a cost on society (although something like this would be necessary but not sufficient). We have to start realizing that it is not inappropriate to

recognize the environmental costs for certain technologies up front, and for society's sake at large.

Michael Karmis, Director, Virginia Center for Coal and Energy Research: I think that the country—or at least the states—really needs to develop a comprehensive energy plan. Such a plan should look at both the current situation and the long term. And each state should look at the pressure points within their power grids, the limitations and impediments to generation sources, infrastructure, etc., and should try to develop their own energy philosophy. I say "states" because the states have acted much more aggressively in establishing energy policies, from things like emissions standards and smokestack restrictions to renewable portfolio standards and systems benefits funds. Within each state's own policy, there would be room for incentives, credits, and other factors given to push a more flexible and responsive energy policy.

Paul DeCotis, Director of Energy Analysis, New York State Energy Research and Development Authority: I think that programs like NYSERDA's and other public benefits and utility programs that support renewable energy technology are absolutely essential for at least two reasons. First, they help demonstrate the technology in certain applications and do bring costs down as new technologies are invented and new patents given and demonstrations made. Second, I think it is important that governments support the industry infrastructure in some way so that when breakthroughs do occur, that the infrastructure is in place to deliver. Breakthroughs can include technological innovations that improve performance and reduce costs, or very high costs for conventional energy resources that improve the economics of renewable energy alternatives.

Look at hybrid vehicles as an example. In the 1970s and 1980s, no one was doing research on alternative fuel vehicles with the exception of very creative inventors and entrepreneurs in garages. Yet as that technology progressed and advanced, the auto companies began to take notice. There was federal legislation (either the 1990 Clean Air Act Amendments or the 1992 Energy Policy Act) that required hybrid vehicles to make up a certain percentage of sales over the next decade. So a combination of private interest and public infrastructure support really enabled hybrid vehicle technologies to make significant inroads into the marketplace – but, the real boost for hybrids came when gasoline prices soared.

One of the advantages of energy efficiency is that it could easily be ramped up and ramped down. Back in the late 1970s and early 1980s, efficiency on the electric end-use and generation side was viewed as an alternative to building new plants, and was really pitted against things like an 800 MW nuclear plant. I think we actually hurt the cause by thinking that the two were equivalent. They really aren't equivalent at all. Demand side changes in efficiency and use, and supply side changes in generation are not the same: they have different use and load profiles, different characteristics, and they have different economic and environmental impacts. And we didn't understand that well enough at the time. We were arguing for efficiency simply as a substitute for generation, rather than looking at the many other non-energy attributes of efficiency that we didn't get (lost opportunity) if we bought a 800 MW central station generation plant. It took the

industry, advocates, and policymakers a while to realize that efficiency possesses benefits beyond simply displacing power generation.

Ralph Badinelli, Professor of Business Information Technology, Virginia Tech: Government subsidies, tax breaks, etc. could reduce the deficient economic performance of DG/RES. However, I do not see subsidies as a long-term solution unless those subsidies are limited to the actual cost of environmental remediation and protection that DG/RES units avoid. Government ***predictability*** with respect to re-structuring and environmental regulation is essential to allowing industry to proceed with those investments that are viable. Finally, the opening of a distributed generation wholesale market that would allow supply aggregators to manage multiple DG/RES units will be necessary to squeeze profits out of DG/RES and to maintain grid reliability.

Ralph Loomis, Executive Vice President, Exelon Corporation: We haven't found a good way to overcome some of these deeper impediments yet. Utilities are not in the energy efficiency business. It is almost antithetical to say that the people making money selling electricity to people should somehow not be in the business of selling electricity. Nonetheless, the most effective way to do it would be to recognize that energy efficiency has benefits, as they have in California. They are only getting around a 2 percent penetration rate on their energy efficiency programs, even there where there has been such a consistent emphasis on it. And if you look at their rates, they are among the highest in the nation, around 14 to 15 cents per kWh. That is expensive. And when you look at electricity as a commodity that cuts across all sectors of the economy, it is no surprise that industry has fled California. California has become very much a service oriented economy. And California also imports a large amount of power to fulfill its needs. So, again, that doesn't make energy efficiency bad, there is no one answer to this equation. We can talk about the limitations to coal fired generation, and they are significant. We can talk about the public policy issues surrounding nuclear power, and they are very, very difficult. We can talk about the pluses and minuses of renewables, the benefits of efficiency, and so on, but all of these things have advantages and disadvantages. And if you look at them from a truly national perspective, or from a macro public policy perspective, it is a matter of weighing all of these things and finding a solution that cuts across all of them. There is no single answer.

Ryan Wiser, Staff Specialist in Renewable Energy Systems, Lawrence Berkeley National Laboratory: For cost, the government needs to sponsor more research, development, and deployment on renewable energy systems, which will help motivate private research and development. This is especially true in basic solar energy science.

For transmission, we need a truly national commitment to renewables, with electricity from major wind farms in the Midwest being shipped to both coasts. This ultimately requires a huge level of national commitment. The construction of transmission lines would need to be supported the same way that the Federal Government got behind the construction of natural gas pipelines in Alaska.

And for integration, we need more research on understanding the ways that DG/renewable systems interact with the grid.

Shalom Flank, Chief Technical Officer, Pareto Energy Limited: Some looming crises may do it for us – the sorry state of our grid infrastructure, the national secure implications of foreign dependence for energy sources, or even global warming. On a tactical level, I'd love to help start the Interconnection Strike Force. And on a business level, what I think is actually the most likely long-term evolution is some new form of energy company that will swiftly overtake the incumbent utilities. Sorry I can't provide more details – but if I knew what the successful recipe for that business was, I'd be too busy implementing it to answer this survey.

Shawn Collins, Project Manager for Fuel Cells, United Technologies: The industry needs to become much more collaborative than it is right now. I'm not sure where the push for this will come from. Probably not from the companies themselves, but I don't know if the government would be willing to create "mandatory co-operation" policies since they're likely to get such resistance. Perhaps incentives for co-operation, but who is going provide funding when the potential beneficiaries aren't asking for it?

This collaboration needs to go through the whole supply chain and equipment life cycle. I had a fascinating discussion with engineers from GM (potential automotive customer for a UTC fuel cell) and Gore (membrane supplier to UTC for elements of the fuel cell stack) at an AIChE (American Institute for Chemical Engineers) conference in 2004. The gist of the conversation was the idea that we would be much more effective if we could work on true system-level integrated solutions, but that type of co-operation isn't happening because our respective companies are competing so hard with each other.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: Natural gas and oil prices are high, and I think they are going to be high for a while. I don't know if you can truly devise any policy interventions that would help there. I do think, however, that if you go to nuclear power, it is produced relatively cheaply here in Illinois, but society never sees the true cost of providing that electricity because the current rates do not include the added security and environmental costs to get rid of hazardous radioactive wastes. So while natural gas prices seem high right now, they only seem high relative to other fuels like nuclear, where you have not assessed the true cost of them either. One of the policy recommendations would be to actually assess the fuel costs or electric generation costs on an equal basis, taking all of the costs and externalities into account. I think then, most CHP and DG systems would look much better.

Thomas Grahame, Senior Research Analyst for the Office of Fossil Fuels, U.S. Department of Energy: Lower natural gas prices. Only problem is, prices have skyrocketed because despite drilling twice as many wells, we aren't increasing US lower 48 production. All the big wells are drying up, and the new ones are a lot smaller. Just as lower-48 on-land production of oil peaked in 1970, and is now about 1/3 of 1970 levels, so too we are probably at or near a peak for lower-48 natural gas production

(western Canada may be in the same boat as well). If considerably more land and coastline were opened for exploration, perhaps we could increase lower-48 production a little bit in the next few years, but long term, US natural gas production will decline, and will have to be augmented increasingly by imported natural gas (LNG). That is of course problematic, especially since so much of the world's natural gas reserves are in the Persian Gulf.

Except: If the US were to build considerable amounts of nuclear and/or coal-fired electricity (with CO2 sequestration), we could simultaneously reduce greenhouse gas emissions AND drive much of the natural gas use out of the electricity sector. If we were to be able to do that, then we might be able to bring natural gas demand down to the point where it would better match available domestic supply. Were that to happen, prices of natural gas would fall, and then DG would be more economic. This argument (displace natural gas in the electricity sector) goes for wind energy as well, but for a variety of reasons, including the intermittent energy issues, and energy storage issues when an intermittent source becomes a relatively large portion of a region's generation, my sense is that we really won't drive enough natural gas out of electricity with wind even though there will be a substantial increase in its use (strong advocates of the technology might disagree with me, but it takes a lot of land to generate just a little wind power – right now, despite many years of 10% to 20% annual growth, wind power is still only a little over ½ of 1% of US electricity production).

Thomas Petersik, Former Renewable Energy Forecasting Expert, U.S. Energy Information Administration: Considering "distributed generation" to be units placed on the customer side of the large distribution lines, in most cases, nothing much. Of course, technological improvement lowers cost and is welcome – but the same categories of improvement may also apply to central station competitors, like large turbines. There may be some gains in going to somewhat larger units within the distributed locale, that is, rather than individual, say, commercial units of, say, 20 kilowatts, clusters of consumers may achieve some economies if units of , say, 400 – 900 kilowatts can be successfully placed. Such placement may require zoning modifications. There may also need to be revisions to building codes to accommodate, for example, placement of larger dg units.

Although I am really not familiar with current practices, my impression is that some improvements might be able to occur relatively simply if (and I don't know the truth of it) utilities and existing or future dg units collaborated more closely so that onsite dg units could be more easily started by/for utility grid service during peak times or in other times of utility/grid emergency. These dg units may be underutilized; greater use would make such dg units more financially attractive.

Vijay V. Vaitheeswaran, Energy Correspondent and Author for *The Economist* Magazine: Smart meters, dynamic pricing is the best first step. Moving away from the hub and spoke mentality at utilities, which props up central plants, is another. Pushing utilities and regulators to drop spurious and obstructionist rules raising the cost and hindering the spread of micro-power is another.

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: One way of resolving the issue would be to take the cost of cleaning up the environment and add it to the fuel in some way, then all of a sudden the cost of energy goes up, and other methods of producing energy become more viable. As we run out of fossil fuels, the price will creep up. And other mechanisms for generating energy will become more competitive. Over time it will happen, but we are talking about decades. I won't see it in my lifetime.

So, basically, the only way renewables will see greater use would be to increase the cost of fuel or generation or providing incentives to alternative mechanisms, and it boils down to dollars and the availability of those dollars. Hurricane Katrina will put a severe ding in the economics of the nation, so arbitrarily adding costs just to shift to a different type of generation will not be very politically feasible. If it's not Katrina, than it's the war in Iraq, but there will always be something else to suck up the money that the public believes are more relevant and urgent.

Toben Galvin, Senior Energy Analyst, Vermont Energy Investment Corporation: I think a combination of top-down and bottom-up marketing approaches could resolve a number of issues. If the public were to see politicians speaking more about efficiency, they would remember that. Schools and communities also need pulled together to rally around energy issues. One, ultimately ineffective way, to promote more efficient lighting use would be to distribute flyers and posters on the issue. A much better way would be to actually hold a meeting that has everyone bring in an inefficient light-bulb, and have it physically exchanged with a more efficient device.

Vikram Budhraja, Former President of Edison Technology Solutions, Edison International Company: Tax incentives would help, but that is not all that is needed. Standardized packages can only come about when there are standardized ways to implement them. This necessitates standard approaches for interconnection and disconnection, as well as dispatchability, permitting, and monitoring. When you buy a toaster you just plug it in. You don't think about whether it will short out the light, blow up, etc. DG is much more complicated. All of those things that make DG systems usable for different applications makes it hard to come up with standardized installation and engineering design Packages and lack of standard design raises costs. The reason that personal computers have proliferated so widely is because they can be mass produced according to a standard design, which drives down the cost of unit production. DG systems need more standard designs, interconnection rules, and protection schemes. It is also important to note that DG systems vary greatly in terms of emissions, size, production profile, environmental footprint, etc. So I think that, for many years to come, DG technologies will continue to be utilized where those attributes are more important than cost.

Wilson Prichett, Energy Consultant, ASEGI Incorporated: Tax incentives, which are about to go into effect, will help. In the case of universities, putting the utility budget in the hands of the people that would make improvements so that they get a return on their investment would help greatly. In commercial office space, the only solution is to create a

standard for how much office space can consume per square foot, and have the government enforce it much like the automotive average fuel economy standards. I hate to bring the government into it, but since businesses are not set up to create their own incentives, there has to be a role for the government.

Zia Haq, Operations Research Analyst, U.S. Energy Information Administration: Policy options that can be considered include: Federal Renewable Portfolio standards, CO2 emission fee with carbon cap and trade mechanisms of various sorts, and long-term extension of the renewables production tax credit. European countries have been quite successful with fixed buyback rates, where the government mandates that the utility has to buy electricity from qualified producers at a set price. This price is set at a much higher value than the avoided cost of the utility.

Question 6: In Europe, many utilities—especially those in the Netherlands, Germany, and Denmark—have successfully integrated RES into their grid, so that RES provide a significant percentage of power. What makes Europe different from the United States?

Adam Serchuk, Senior Renewable Energy Program Manager, Energy Trust of Oregon: First, they are a bunch of god damn socialists, and they pay scandalous prices for electricity that are double to triple what we pay here. This makes their entire electricity market different.

Second, Europeans get a lot their natural gas from Russia, which is a big problem for them, especially those living in Central Europe. Here in the U.S., we never seriously think that Canada will invade us. So Europeans have an extra incentive to get off of natural gas pipelines; its an issue of political control.

Moreover, Europe has an ethic of community responsibility that is certainly not the case for most of America, except for progressive elements in the country. Europeans are willing to socialize the costs of public policy in a way that Americans seem unwilling to do.

In addition, people have less space in Europe, so people are more culturally aware of environmental issues, including climate change and pollution. Look at anaerobic digestors, which can generate electricity using a mixture of food waste, dairy waste, and municipal garbage as fuel. Hundreds of these digestors exist throughout Germany, Holland, and Denmark. Almost none of them are used in America.

Furthermore, European countries resist cross-border electricity trading, even though the European Union espouses an official policy of the "European electricity market." Instead, countries like France, Germany, and Holland do not want electricity imported from other parts of Europe. This keeps prices high, and also makes it much easier for renewables to compete. The Europeans care so much, they are even willing to subsidize stupid stuff: wind turbines exist in parts of Germany where wind speeds are pretty meager. Rather than putting the wind turbines somewhere outside Germany with higher winds, and purchasing electricity on an international basis, the countries are very protective of their own electricity market.

Let me also say that there are a lot of renewable energy advocates wandering around the United States that want the U.S. to be more like Europe. Personally, I think it is a dumb question to ask why we can't be more like the Europeans. Here, we need to find out what works for our culture.

Alan Crane, Senior Program Officer, National Academies of Science: The environmental ethic in Europe is more recent than here, and Europeans clearly are taking the climate change problem more seriously that our government does.

Alex Farrell, Assistant Professor for the Energy Resources Group, University of California Berkeley: It has to do with prices and being green. In California, for

example, people have more of a sense of how political energy decisions are. More consumers are green, a greater fraction of voters are green. These state politics produced the CEC, and also watch closely the things the CEC does. In Europe, my guess is that green politics are even stronger in places like Germany and the Netherlands. It also has to do with prices. People pay much more for electricity in California and Europe, which does explain why we see more industrial CHP in these regions.

Anonymous, High-Ranking Executive for a Large, American Independent Power Producer: NIMBY – major power plants in the US are generally far from population centers. In Europe, there is no place to hide. Shorter term profit/loss horizons in the US. Europe has more "patient" money than the US. Cheaper fuel costs in the US, especially for coal. Higher emission penalties in Europe. This includes restrictions on carbon, which don't exist in the US.

Brian Castelli, Executive Vice President and Chief Operating Officer, Alliance to Save Energy: Higher energy costs, for one. They definitely have higher energy costs. We are narrowing the gap now as our costs rise. Geographically they are much smaller, it's easier for them to distribute the energy. It's also a different type of utility thinking. I can think of a number of German states with high percentages of wind in their generation mix, whereas here in the United States, people are afraid if they have 5-6 percent of an intermittent resource in their mix, they won't be able to integrate it with their current mix of generation. Europe goes as high as 30 percent sometimes. The Europeans also have a greener ethic (and green parties) than we do in the United States. We haven't seen that ethic take place, despite great strides in the United States. Over there you see a huge political push to try and promote and implement emissions-free technology.

Brice Freeman, Project Manager for Distributed Generation, Electric Power Research Institute: // I'm not an expert on European markets, so please discount these comments accordingly // The European power markets cannot be compared to US markets evenly. The public awareness of energy conservation is everywhere. The Europeans pay more for heating fuels, electricity, water, and gasoline. They're homes are smaller and they drive shorter distances in smaller cars. Because the cost of utility electricity is higher than the cost of fuels (aka spark spread), there is more room in the spread for people to purchase and operate DG more economically. Certainly for PV systems, the components are largely the same in the US compared to the UK and Europe, save the inverter. When you are competing against higher utility prices (Europe), end-users will have a faster ROI and therefore be more inclined to purchase PV.

In Denmark and the Netherlands, there is a substantial amount of district heating. The city centers are very compact and because there is a significant heating load, they have selected to install banks of reciprocating engines in downtown areas and run a look of hot water to local buildings. These CHP systems are very efficient 60%+. These aren't RE devices, but they are significantly more efficient that grid power.

Chris Namovicz, Operations Research Analyst, U.S. Energy Information Administration: I see European policy decisions as the main driver. You need to be careful if you are looking at countries like Denmark, as a lot of the technical issues associated with some renewables have not arisen because they are a small market that is interconnected and tightly integrated with much larger markets. The reason that they get significant renewable generation is largely a matter of policy support. Some European governments guarantee the producers of renewable or green power a substantial purchase price for their power, which results in a very significant return on investment. That, in turn, has created a big market for alternative generation sources.

Christopher Russell, Director of the Industry Sector, Alliance to Save Energy: I'm just guessing now, but I think that it has to do with the culture, not their technology. The American way of life was predicated on subduing the frontier, a mindset of exhausting easily available resources and moving on. It's almost as of their motto was "Consume and be happy." The Europeans, for a variety of reasons—geography, history, greater attachment to the place that they call home where their family has been for thousands of years—tend to be better at protecting their resources and the environment.

Claudia J. Banner, Senior Engineer for Renewable Energy Planning, American Electric Power: For one thing, the utilities are receiving premium prices for renewable energy. Unlike the US Energy Policy Act, the European programs are longer-term and are truly incentives to renewables. The incentives are applied to a broader spectrum of technologies and fuels than in the US.

In the US, the IRS production tax credits are limited in their use as well as when they expire. Not all technologies are included and some technologies are viewed as "more favorable" than others (e.g., wind vs. biomass) such that the economics for the biomass projects are disadvantaged.

The European governments are encouraging use of renewables. The Europeans are more receptive to its use. The Europeans pay higher electricity (and fuel) costs than the Americans to begin with.

Due partly to the lack of space as well as other issues, in some cases Europeans are encouraged to recycle more and are not as much of a throw-away society as the US. (One example is taking a reusable shopping bag to the grocer's. If you don't take your own bag, you have to pay for getting a new one.)

Dave Stinton, CHP Program Manager, Oak Ridge National Laboratory: Economics and emissions standards are different, for one. The cost of fuel there—whether its gasoline, natural gas, or coal—is much higher than the United States (except for some places like California or New York).

Plus they are just far more concerned about emissions and greenhouse gas emissions, so the companies are pressured by the community to install the best, cleanest technology possible, and that's just not the case in most parts of California.

Europe doesn't have better technology—international companies that we are working with sells engines in Europe that are the same in the U.S. Its not different technology, just different emissions and environmental regulations that push for cleaner systems.

David Garman, Undersecretary of Energy and Former Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy: A couple of things. First, their price of electricity is higher. Obviously, the higher price of electricity in Europe makes it easier to integrate higher cost generation sources into the grid. Traditionally expensive technologies like renewable energy systems and distributed generators are inherently more competitive from the start.

Issue number two, subsidies. The Germans are willing to pay a feed-in tariff of 57 cents per kWh for some renewable resources. I think this ultimately distorts the renewable energy market, creating unrealistic expectations for solar and wind energy systems. Ratepayers here in the United States would never put up with that. Photovoltaic manufacturers see that, and are not willing to invest in more capacity, since they see that current demand gives them a premium price for their materials. In the short term, the German subsidy is a distorting and ultimately harmful practice. The Japanese had a much cleverer approach to renewable energy and subsidies: they created an upfront subsidy with a declining value. Early movers got a larger subsidy, and everyone knew that the subsidy would decline over time. The Japanese policy gave people a sense of what the future market would look like.

David Hawkins, Lead Industry Relations Representative, California Independent System Operator: The barrier isn't quite what you think it is. If you go to Europe, they have basically only one or two grid operators per country, which enables a smooth interconnection. With the U.S., in contrast, we see vast problems importing and exporting power between many control areas (and the baggage that goes with it). The institutional culture here in the U.S. tends to respond by putting up more barriers. Areas rich in wind generation in the US have problems exporting through control barriers. The country has been trying to eliminate boundary issues, but only to a limited success.

The perception also continues to exist that renewables and DG are more expensive than other types of resources, yet with high natural gas prices, wind generation and other RES/DG technologies are quite competitive now. Grid operators need more technologies to better match loads, and here some DG systems can play an excellent role, with those systems are more modular than centralized plants.

Now, it is true that wind doesn't know anything about the need to match loads, so it won't always be compatible with what system operators need. Grid operators, for instance, need to start and stop easily dispatchable units, and they cannot always forecast the wind. A small electric utility may not have resources to adequately forecast wind resources to make efficient use of wind energy.

David Hill, Deputy Laboratory Director for Science and Technology, Idaho National Laboratory: If you go to Europe and talk about energy, its all about the environment and meeting the Kyoto protocol demands. There is a greater social awareness and it is a politically driving force. It means that governments, therefore, are willing to pay the cost to meet the social balance and create a more sustainable energy system, and have thus driven down the cost of green solutions.

Europe is now believing that their companies have a significant technological edge over U.S. companies, and that they can make money on these technologies. Thus, Europeans are also developing renewable energy resources as a lucrative export market, exporting new technologies to the rest of the world. Social requirement has led to government action has led to technological development has lead to export market. This is a classic European government role in creating markets. We don't have the first condition in this country. Most people in America don't care about energy. We don't see marches or masses of people protesting the Kyoto Protocol. Such issues are greeted in this country with a deafening silence.

Europe is also denser, people live closer together. The effects of traffic pollution and carbon dioxide are more direct. It's a different social structure, it's a different geographical structure, and it's a different approach in terms of social awareness.

Edward Vine, Staff Scientist, Lawrence Berkeley National Laboratory: I think that technologies are taking off here, just a bit slower. The real question is the percentage compared to the overall resource portfolio and the amount of time needed to reach that goal. The simpler question is really: how much renewable energy can there be at all?

In Europe, they have a history of promoting renewable energy and efficiency practices since 1973. Unlike the U.S., the European commitment to minimizing reliance on fossil fuels and oil has not dwindled, in part to their stronger environmental ethic, and also in part to the higher taxes that they pay for imported energy (such higher costs make efficiency more important).

Finally, we see stronger leadership from green parties and green leaders that promote energy efficiency and renewables. The U.S. just doesn't have those parties or anything remotely resembling that type of leadership.

Jack Barkenbus, Executive Director of the Environment and Resources Center, University of Tennessee: It's a question of political will. In those countries they have been told to overcome the problems I have identified. Electricity suppliers then roll up their sleeves and see what can be done. In this country, you don't get that political driver. Utilities, preferring to operate as they have in the past, say that there is no way they can accomplish what Europe is in the process of achieving. I think on energy as a whole in the United States, there has undoubtedly been a lack of political will—despite all of the technical improvements in energy systems—that prevent more sustainable energy systems from being used.

Jan Harris, Project Manager, Vermont Energy Investment Corporation: Insight and foresight. We just don't have long term planning in the United States. Long term planning is five years. Germany and Japan (for photovoltaics) and Denmark and Spain (for wind) have huge tax breaks and subsidies for renewable energy systems to help level the playing field on the cost per installed kW with traditional technologies.

Geography also plays a role; Europe is much more space constrained than the United States. Siting a coal plant in a place like Northern Montana is just not an option in Europe. So the environmental effects of most energy systems are more localized and immediate there, thus they matter more.

For some reasons that I don't entirely understand, they are more forward thinking in Europe. Its not a technical factor at all. Evergreen solar is located in Massachusetts. Just about every panel that they make goes straight to Germany or Japan. Why do utilities here in the U.S. complain about interconnection issues, stranded costs, and intermittency? It's a misunderstanding. Interconnection rules can be solved in one legislative action, stranded costs are unjust, and Europe has already learned to predict the intermittency of wind and solar energy. It is not a technological constraint. The technical factors are in many ways an excuse for wider political and social barriers. The thinking in the U.S. is to look for excuses, not for solutions.

Janet Sawin, Director, Energy and Climate Change Program, Worldwatch Institute: This is also increasingly true in Spain, which now gets more than 6.5% of it's electricity from wind power (and aims for 15% by 2011).

Some key differences: Government policies—which in many European countries have provided greater incentives and have been far more consistent and long-term than those in the United States—have played a major role in these developments.

I believe that much of Europe has also benefited from a better/stronger, more-interconnected grid system. And Denmark, for example, which gets more than 20% of its electricity from the wind (and over 90% in some regions) can feed excess power to other Scandinavian countries to help maintain balance in the system. However, I'm not an expert on grid issues. Let me know if you need more information and I can probably point you to some good sources.

Joe Catina, Manager of North American Projects, Ingersoll Rand Company: First, I think it has to do with population density: the grid in Europe is much more integrated, much less spread out. DG and CHP technologies are deployed relatively around population centers, not spread out into rural areas. I started working on a CHP plant in Philadelphia that sold steam across the street to an entity that needed it. In Virginia, a utility has problems economically selling steam "across the street" to a company 20 miles down the road.

But there is also a cultural component: throughout the 1930s and 1940s, central power plants provided steam to a host customer. This stopped because people didn't want

power plants in big cities in the United States. The citizens of France, Switzerland, and Germany, in contrast, place much more emphasis on energy efficiency and the environment, and thus promote those policies to a greater extent.

Joe Loper, Vice President for Research and Analysis, Alliance to Save Energy: I cannot attest to your statement that these resources have successfully been integrated into the grid on a large scale. But they do seem more motivated. The standard answers are because they have been more resource constrained for a longer time, don't have the big distances and wide open spaces to overcome.

At the risk of over-generalizing, there is a different ethic there, a more conserving ethic. From having spent time in Europe and other places of the world, it's a concept of frugality and community and simpler living. There seems to be a lot less time spent at the mall, more time sitting around eating and that kind of thing.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: If I had to speculate, the energy prices have been a lot higher in Europe for a lot longer. That change in behavior that comes when the prices go up has taken hold in Europe where it hasn't taken hold here yet. They have had longer to work on renewable and CHP systems since the market better favors those technologies due to higher energy prices.

Plus, while I am no expert, the utilities may be regulated differently than the way that they are here. But higher fuel costs, favorable public attitudes, and a greener ethic can also play a role in getting constituents, and therefore the government, to convince utilities to adopt cleaner technologies.

Judi Greenwald, Director of Innovative Solutions, Pew Center on Global Climate Change: Europe doesn't have as much coal as we do. Europe has been more willing to generously and consistently subsidize renewables than we have. Our PTC is a good policy, but we keep letting it expire. Also, most utility policy is made here at the state level, which means that we have taken a somewhat fragmented approach, and it takes longer, although nearly half the U.S. is now covered by state-level Renewable Portfolio standards.

Marilyn Brown, Commissioner, National Commission on Energy Policy: For one, power costs more in Europe than it does here, which naturally brings more alternatives into the equation. Europeans also tend to be firm believers in global climate change, motivated now by the Kyoto Protocol, and thus they push for cleaner sources of electricity.

Mark C. Hall, Senior Vice President, Primary Energy: It very much goes back to fuel costs and that more expensive fuels mean that the most efficiency generators are deployed. Those tend to be ones close to the load and ones that can recycle the waste heat. There is a widespread recognition, that high energy costs push more efficient

technologies like DG and CHP systems. Does utility vested interest block this? Yes, but European utilities have much more of a mandate to support the public good.

Mark Levine, Environmental Energy Technologies Division Director, Lawrence Berkeley National Laboratory: In my opinion, California isn't much different than Europe, so it's a question really of why the rest of the country is different.

For one, Europe is taking climate change much more seriously than the United States is, which his somewhat of a fluke. Margaret Thatcher became very anti-coal because of the coal strike early in her term. This made her more sensitive to climate change, and the United Kingdom discovered the benefits of natural gas as an alternative fuel. The Germans got into nuclear power early because it doesn't case carbon emissions to speak of. And, perhaps most important, the influence of green parties was very important in pushing the Germans to try new things on the technological front. The same thing happened with the Japanese, and today a large proportion of leaders in Europe and Asia have become committed to climate change issues.

So, in Europe, it seems that energy efficiency practices and renewable energy systems were adopted sooner than the United States. Obviously, to some degree, each country is peculiar and driven in that direction for different reasons. But why not the United States? It seems that energy efficiency in this country has become an issue of one party versus another, which makes no sense to me from a rational point of view. Efficiency benefits Democrats as much as Republicans. I think a part of that is because renewables technologies were much more politically motivated in the 1970s, and energy efficiency became partisan. Because renewable energy technologies were seen as a silver bullet, they became embroiled in the middle of a political battle that needn't have been ours.

I think, finally, related to that, the American people think that we are invulnerable, that we can do what we want, that our technology and culture is stronger than nature. This is practically an extension of the myth of the conquest of the west. Most of the people in this country are not prepared to recognize the seriousness of the environmental problems associated with energy use. If they did, wouldn't matter whether it was Republican or Democratic matter. Leadership would matter, but that's only political.

Michael Pomorski, Senior Associate, Cambridge Energy Research Associates: I suspect that European markets are more regulated, and cultures exist there that care about the environment more. Therefore, it is much easier for regulators to impose environmentally friendly policy, where the political will for such measures doesn't exist in the United States.

Michael Karmis, Director, Virginia Center for Coal and Energy Research: A couple of things. Philosophically, Europeans have a much stronger environmental consciousness than Americans. Although people here may find it strange, since many Americans believe that they are environmentalists, the formal political structure in Europe is much greener. In Germany, for example, environmental parties hold strong political offices, including the former Secretary of State. Socially and politically, Europeans push for

more environmental planning, organization, and awareness. From an economic standpoint, part of that culture accepts that people should be willing to pay more to get cleaner energy. In Germany, people pay different rates for power based on whether its source of generation was fossil fueled or renewable. Choosing coal is a voluntary taxation. Third, communities in Europe respond well to government regulation. Look at energy efficiency requirements and fuel taxes in Germany, for instance. It is impossible to implement those types of policies here in the United States. Each of these trends pushes renewable and distributed energy systems irrespective of cost, since a combination of other factors are seen as equally or more important.

Paul DeCotis, Director of Energy Analysis, New York State Energy Research and Development Authority: I believe this to be a cultural issue. The utilities in the U.S. are far more parochial and conservative in thinking about the line of business that they are in. They are in the business of selling kWh and earning return on investment for shareholders in the U.S. They haven't fully adopted the customer service aspects that European utilities have. It doesn't matter whether a consumer gets a kWh delivered or saves a kWh, as long as the utility is getting the same value for the service. And in the U.S. there is this mindset that it has to be a kWh sold, not a kWh saved.

Interconnection issues with the utilities in the U.S. have to do with a culture of system control. Utilities feel that a larger number of smaller distributed systems will degrade their system leaving the utility with less control over system reliability, integrity, and dispatchability. And I do think that there might be some truth to that. I am aware of the frequent brownouts and blackouts in other countries that we do not have in the U.S. Granted they might be caused by any number of factors, but system control is certainly one of them. I don't know if that is because of the greater use of DG/CHP systems or just the lack of infrastructure, but it could be because of interconnection issues. But American utilities are worried that the more they give control to distributed resources, the less reliable their grid will be.

Paul Gilman, Former Chief of Staff for Senator Domenici, Director of the Oak Ridge Center for Advanced Studies: I personally think that you would make a great contribution to the debate if you figured that out, articulated, and explained it. It is one of those things where you need to drill down how it is that Europe has done it. My suspicion is that the integration of renewables in Europe is really nominal or minimal. Probably they are relying heavily on bought nuclear power from the French. But the question really goes beyond just technology. Do European countries have better technical solutions with their grid? Or is it financial solutions with the rate-makers? Or subsidies with manufacturers? Or better social programs and educational outreach? How does their grid configuration and load demand picture look versus the United Stats? I don't have the answer.

Ralph Badinelli, Professor of Business Information Technology, Virginia Tech: I disagree. Europe is struggling with the same impediments to DG/RES that United States is struggling. In fact, a recent report sponsored by the European Union expresses some

envy of the support for DG in the United States, see http://www.dgfer.org/Downloads/DGFER_Road_Map.pdf.

Ralph Loomis, Executive Vice President, Exelon Corporation: I am not an expert in worldwide energy systems, although I have some familiarity with what you are talking about. I think it reflects, in part, the governmental/social structure that surrounds the electric utility industry in Europe. My sense is that the industry in much of Europe is either government owned or centrally regulated, and a lot of decisions there are made on the basis of social policy rather than economic policy. I don't have a valid price comparison. The social structure there may foster the development of more distributed and renewable resources, but the economics are the same. As you look at renewables, examine not only the percentage of DG but also the entire price equation. Higher energy prices make economic development different there. That is not to say that Europe is wrong and we are right, they are just the product of different social choices.

Let's talk about wind, for example. Germany and the Netherlands have gone into wind in a big way. You can generate electricity with wind, and the costs of wind energy (although not capacity) are coming down. There are two pieces to the puzzle: the price of energy and the price of capacity. It's interesting for Exelon, since we have publicly stated that we will meet the objectives of the Illinois governor's sustainable energy forum. The installed price of wind is up to $1,500 per kilowatt. That's the same price of a coal plant, or next generation nuclear plants. Do I believe those figures? No, but nonetheless, wind, in terms of installed capacity, is no bargain, particularly when you look at its capacity factor. You cannot dispatch wind. You get the energy when the wind blows, often in the cool of the night rather than the heat of the day. You need to install 6 MW of wind to get something comparable of 1 MW of a more traditional fossil-fueled generation source. So while the cost per MW of wind may be increasingly competitive, you still have to buy six times as much if you want to deal with the resource adequacy side of the equation. Moreover, wind has enormous environmental benefits associated with it, but if you factor in how much wind you have to build to offset the emissions from 1 MW from a fossil plant, the same economics come into play. From a societal perspective, it costs you a lot of money to displace fossil-fueled power with wind, and that is only if you don't account for all of the subsidies lurking behind the scenes in favor of renewables. There are subsidies for all of the various forms of generation, but if we are talking strictly in terms of societal value, wind is still very much a work in progress.

Rodney Sobin, Innovative Technology Manager, Virginia Department of Environmental Quality: I am going to defer to the work of Donald Aitken. He was recently at a conference I attended, and he spoke about the lessons from Germany, Japan, and California. Part of it, again, is the economics of the situation. The cost of electricity in these countries are much higher than the United States, often around 18-25 cents pew kWh. And Aiken says that "an effort to promote renewables has to be sustained, orderly, substantial, predictable, credible, and ramped." I suppose the U.S. can learn a lot from that.

Ryan Wiser, Staff Specialist in Renewable Energy Systems, Lawrence Berkeley National Laboratory: Denmark, in particular, receives around 20 percent of their electricity with wind. But think of Demark as Connecticut within New England, interconnected with lots of other systems, ultimately incapable of meeting its own load and having to rely on power imported from other countries. Grids in the U.S. are fundamentally weaker than those in Europe. While experiences in Europe can still offer some policymakers some useful lessons, its not all that relevant to the American electric utility sector.

Sam Fleming, Former Program Manager for Renewable Energy Systems, Nextant Incorporated: First, that government there can and does play a large role in shaping the electric utility sector. The Spanish program in solar and wind is quite impressive, and it has been fully supported by Council of Ministers. Production incentive payments are a key there, and are at handsome level. But the plant has to work for the developer to get the benefit of the incentive. Not a bad idea! So that plays a big role in promoting cleaner technologies. Government there is much more aggressive in putting money up for renewables.

And second, the other thing is that the government exercises different control with regard to the grid and acceptance for guaranteed revenue. In Germany, the grid operates at maybe 60 percent capacity. Blackouts don't occur, and redundancy is built into the transmission and distribution system, which works very reliably. European countries generally have much more control over their grids, I believe, We have a different view, and "regulated competition," moving away from regulation, so I'm being observational, not suggesting going back to high regulation. But transitions are very important, and it is difficult always to get it right the first time.

Scott Sklar, President of the Stella Group, Inc.: The European federal governments control their own electric systems. Ours is controlled by state governments, and the Federal Government here only controls interstate distribution of electricity and natural gas and rules of the grid, rather than electricity rates. There is also a difference in markets. European support for renewables has created a sustained, orderly, and fully developed market for greener technologies. The U.S. assumes that just because we lead the world in terms of technology that we will inevitably produce the best energy technologies through innovation and competition, yet
it is astounding to me that the U.S. has abdicated its technological leadership on renewable energy systems merely because we didn't have the political will or fundamental understanding on how to catapult novel technologies into new markets.

Shalom Flank, Chief Technical Officer, Pareto Energy Limited: Corporatism. Europe has a long history of cooperative (if rather insular and inefficient) problem solving that involves all the relevant institutions sitting at the same table. The U.S. is adversarial, legalistic, and anarchic – there are no trade unions or rate-payer associations to speak of, and there is no table for everyone to sit at. Europeans are also not allergic to fees and taxes that capture externalities, or government mandates that smack of regulation or even (horrors!) socialism. Unlike Europe, social change is rarely

engineered from the top down in the U.S. It results either from massive popular demand / movement, or from entrepreneurial / business innovations.

Shawn Collins, Project Manager for Fuel Cells, United Technologies: My knowledge is slim here, but I'll venture two possibilities that are probably statements of the obvious. First is the availability of renewable sources that can be capitalized on, second is government policy actively pushing development of those sources. There was an IASTS presentation (Constantine Hadjalimbrinos in 2005 I think, maybe 2004) comparing utility policy in Norway and the UK. My recollection is that the two countries had comparable natural resources that could be used for renewable energy, but Norway had been much more successful than the UK at implementing this on a broad scale. The presenter attributed this in part to the ideological stance of the Thatcher government in terms of how industry in general was supposed to function, and how the industry / government relationship was supposed to work. It wasn't that the government was opposed to actively developing RES, but the vision was incorporated into a broader worldview that stifled it.

Shelly Strand, Marketing and Project Manager, Ecotope Consulting, Research, and Design: For one thing, it's just size. The size of European grids and energy sectors are much smaller than the United States. It is a whole lot easier to deal with Belgium and England than the United States. And it's also a much more regulated market. There also is a heightened sense of urgency over energy issues that is not shared in the United States. There is more willingness to coerce people that isn't in the American spirit. You get Scandinavian municipalities where you have enough of a critical mass that you force everybody that doesn't agree to go along with greener policies. The U.S. has built an economic strategy of short term wealth transfer. And while this causes good capitalization of certain things and makes some people wealthier, it also tends to create more corruption.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: I think in Europe, the people are more open towards renewable energy. Energy prices have always been higher in Europe. People are used more to cutting back on energy consumption, and with people being more open towards green energy, politicians are more comfortable placing renewable energy requirements on utilities, and utilities are more comfortable passing those costs through to the people. It is the fact that in many European countries policymakers have been successful in getting utilities on board and accepting renewable energy, and a little more open electorate of the consumers towards accepting higher charges for cleaner electricity sources. There is a much greener mentality in Europe. In contrast, here in the United States there is a significant aversion towards forcing people to change their lifestyles to create a greener, cleaner, or more environmentally friendly way of living.

In the U.S., you always had more space to put landfills, power plants, coupled with less dense population, which gave people lots of leeway in where to place things. In Europe, any environmental sin caught up with society much quicker. If you polluted a river, there are tons of people living on the river. The population density is much higher, so pollution

affects people right away. In the U.S., you have more room to pollute on a per capita basis, so it takes longer to catch up with the people.

Ted Fox, Interim Director, Energy and Engineering Sciences, Oak Ridge National Laboratory: It is hard to say. Renewables are heavily subsidized in Europe. It is always a tradeoff. We could do that, too, but whether it is a good thing in the long run remains to be seen. It is hard to compare the Netherlands, which is a small country, to the United States. I do know that European utilities tend to be government owned, and almost all of ours are privately owned. So it is a completely different system. Because they are government owned, they probably don't have to pay taxes; they can potentially operate at a loss, and operate in other different ways than American utilities. Their choices probably reflect social values rather than economics. It would be interesting to know what the Europeans did to make RES economic, if indeed they have.

Tim Cross, Staff Writer for the *Economist*: My understanding was that Spain, Denmark and Germany all have substantial interconnector capacity with other European countries that allow them to import and export power on a big scale. Wind power production charts and spot power prices graphs from Denmark certainly support the contention that wind production can drop off extremely quickly, meaning that big power imports are needed to compensate. The UK, by contrast, does not have much in the way of interconnector capacity (we have a single 2GW connector to France), so we are unable to import power on the same scale as our continental cousins.

Thomas Grahame, Senior Research Analyst for the Office of Fossil Fuels, U.S. Department of Energy: I don't think the problems are that different in Europe as here. I've copied and pasted some press from Denmark at the bottom – take a look at it. German electricity prices are now escalating, for at least two reasons: the costs of CO2 credits, and the requirement that so much renewables be purchased. German industry is saying that it will have to shift production elsewhere if something isn't done about high electricity prices. Most of the issue has to do with CO2 credits, but the costs of renewables are a part, and will become a bigger part as time goes on. In the UK, there are aesthetic objections to having so many huge turbines in what had previously been pristine viewscapes. So I think the main difference is that Denmark, Germany, and UK did more (as a percentage of generation in kWh) than the US has done, but they are getting the same pushback we are for the same reasons.

If I had to bet, I would think that 10 years from now, the US might have added as much wind power in this next decade than Europe (as a percentage of the country's generation), because we have the twin advantages of huge windy remote areas in west Texas and the Dakotas (Europe is so relatively compact that they don't have nearly as much windy and empty space) and the hydro resource of the Pacific NW (although Sweden and Norway have good hydro resources).

Thomas Petersik, Former Renewable Energy Forecasting Expert, U.S. Energy Information Administration: A series of differences appear to make Europe different from the United States with respect to renewables – and in other ways not so different at

all. Among the most important is the much higher costs of fossil fuels and the use of fossil fuels (coal, oil, and natural gas) in Europe, making the relative costs of renewables much lower compared with the same comparisons in the United States. The fact that both the costs and consumer prices of electricity in Europe are much much higher than in the United States alone makes renewables more attractive in Europe.

In addition, however, are other differences. My personal impression is that Europeans have a stronger environmental ethic than may be incurred in the United States and also a stronger communal sense, all translated into a willingness to pay a higher price for both individual land the (perceived) common good.

In some places renewables – wind power – are somewhat plentiful.

But Europe may not be all that different in basic behavior. Although some countries appear to have significant dependence on wind power, in fact the grid upon which they depend is the European grid, of which renewables are a relatively small share; these countries are, in fact, depending upon the fossil and nuclear supplies accessible from the grid, and they are pumping the less reliable and less well timed renewables into that same pan European grid. Finally, we are seeing g rowing resistance to expanding wind power as costs rise, reliability problems increase, and visual intrusion becomes more troubling.

Toben Galvin, Senior Energy Analyst, Vermont Energy Investment Corporation: The Europeans tax their energy much more than the United States. Americans have hidden taxes in our energy (such as military presences in the Middle East), but those are less direct. In Europe, a gallon of gas can cost as much as $10. By nature, that is one element (supply, demand, and price) driving people to be much more efficient in their energy decisions.

Overall, European culture is also less affluent and, culturally, a less wasteful society. And they fully support the Kyoto protocol, connecting the promotion of energy efficiency as one way to reduce global greenhouse gas emissions. Front and center, energy is an important social issue for Europe. In the United States the issue is always lurking in the shadows.

Vijay V. Vaitheeswaran, Energy Correspondent and Author for *The Economist* Magazine: Political will, and a willingness to waste a lot of money on blanket subsidies for political reasons—like the obscene giveaways to solar power in Germany, a country with very poor solar energy potential.

Vikram Budhraja, Former President of Edison Technology Solutions, Edison International Company: I think that European countries are more like individual states when compared to the U.S. experience. Because each state is only concerned with producing power in a relatively smaller geographical area, they have less issue with transmission.

Take wind, for example. The reason that Europe is able to achieve such high levels of wind energy penetration is because some of the issues wind technology raises have been accommodated by the European grid system due to: high reserve margins, supportive regulatory policies and standardized tariffs.

Wilson Prichett, Energy Consultant, ASEGI Incorporated: Have you looked at the cost of energy in Europe? Face it, especially where we are in the South, energy is cheap. The wholesale cost of electricity is 2.5 cents per kWh. Southern Company, Georgia Power, and TVA sell electricity for 5 to 6 cents per kWh. They are paying close to 20 cents per kWh in Europe. It's just economics. If the price of energy continues to escalate here, we will eventually create more incentives to save energy.

Zia Haq, Operations Research Analyst, U.S. Energy Information Administration: First, European consumers pay much higher prices for electricity than we do in the U.S. This makes DG and renewable technologies much more attractive options. Because of such high prices everybody is very conscious about the energy that they use. Europeans drive in much smaller cars, many people do not have clothes dryers or dishwashers, and they use smaller refrigerators. These are among the many lifestyle differences between them and the U.S. that result in lower energy use.

There is also a geographical reason: Europe has a grid system that was built years before the U.S. Their grid is a much "tighter" and densely laid out grid than in the U.S. In other words, it is a grid where there are many ways to route electricity from one point to another. In the U.S. because of the vast distances involved, the grid system is very spread out, especially throughout the Midwest and West (except in the urban centers). The grid system in Europe has really helped them. For example, they can then respond to variability in wind generation by routing that power to other types of backup systems or storage technologies. They can also integrate their power system in a pool with other countries, thereby helping them to absorb shocks unlike the U.S.

Third and finally, Europeans possess a certain level of awareness about the environment and energy that does not exist here in the U.S. Their governments have generally been much more supportive of climate change agreements such as the Kyoto Protocol than the U.S. has been. Even though it will be difficult for them to meet Kyoto goals, the point is that legislators are actively involved in the debate about what to do with climate change and are willing to attempt new policies in this area.

Question 7: What can the US learn from Europe regarding renewable energy and DG technologies?

Adam Serchuk, Senior Renewable Energy Program Manager, Energy Trust of Oregon: We can learn some stuff on the technical end, in terms of technologies that we can import. But in terms of public policy and business models, I don't think we can learn that much. Policymakers should instead look at business and political models that work here in the U.S. and how to apply them to DG and renewables, rather than focusing on what political models worked for DG and renewables in Europe, and trying to apply them to the U.S.

Anonymous, High-Ranking Executive for a Large, American Independent Power Producer: Environmental benefits come at a cost.

Benjamin Cohen, Assistant Professor of Science & Technology Studies, University of Virginia: Get over ourselves. Recognize the importance of political and philosophical contexts – I mean economic philosophy as well, about free market ideals and consumer arrogance ('I want it, and I want it now. Always'). Also acknowledge that we can't have a system like the Europeans and we should not try to – we are not going to go back to an idyllic past where energy use and demand was in perfect sync, and environmental costs were unheard of. We can only go forward, so we have to address the broadly conceived impediments now, not later. So don't go on thinking that if we could only be like someone else, everything would be fine. Because to be more European would mean to be like an earlier era. Which is neither feasible nor laudable.

Brian Castelli, Executive Vice President and Chief Operating Officer, Alliance to Save Energy: The U.S. can learn that being open and flexible to changing the way that we generate and the way that we consume and use energy—whether its electricity, gasoline, or fuel oil, can make us an energy efficient nation. The Europeans have chosen a different manner.

Brice Freeman, Project Manager for Distributed Generation, Electric Power Research Institute: Public sentiment has a lot of power. At the beginning of deregulation, we were offered the option of switching power companies for cost savings or to switch to power companies that generated with renewable energy – i.e. Green Mountain Energy. In focus groups and surveys, consumers acknowledged that greet power is a good thing and indicated that they would be willing to pay a premium for it, but when it came time to take action, very few people did. In Europe, *I think* the public view is to sacrifice for the sake of the environment. In the US, I think people realize what needs to be done, but don't want to make the sacrifice.

Chris Namovicz, Operations Research Analyst, U.S. Energy Information Administration: I'm not sure that there are any deep lessons other than if you throw enough money at an industry that industry will survive and/or prosper, regardless of whether it would on its own. The political will has been a lot different in Europe.

Claudia J. Banner, Senior Engineer for Renewable Energy Planning, American Electric Power: Incentive programs have to be longer term, not a 1 or 2-year program, let it expire, renew it at the last minute for another year or 2, let it expire, ... Costs for renewables and/or distributed generation will have to come down or utility costs will have to go up to make renewables/DG more enticing. Regulations have to be flexible enough to permit co-firing, install solar panels.

David Hill, Deputy Laboratory Director for Science and Technology, Idaho National Laboratory: The right solution for this country is a portfolio of supplies starting at nuclear at one extreme moving to clean coal, and then hydroelectric, photovoltaic, wind, biomass, in a way that produces an integrated system that is c02 neutral and competitive.

Janet Sawin, Director, Energy and Climate Change Program, Worldwatch Institute: Importance of consistent, long-term government policy; need to strengthen grid.

Joe Loper, Vice President for Research and Analysis, Alliance to Save Energy: While there are European technologies that we can learn from, the U.S. is still a world leader in technology. Our country still has a lot of technological prowess: we demonstrate, experiment, and innovate. Our policies need updating, but we know what needs to be done, we know what is out there, which technologies to use, and how much they cost. The perpetual question, always, is whether we're willing to pay the price to use them. Do we really want to restructure the electric utility industry to address global warming when coal is the country's largest energy asset. Is it worth it? Fear of climate change must be deep in people's hearts for that to happen.

Judi Greenwald, Director of Innovative Solutions, Pew Center on Global Climate Change: I'm not sure we will ever be willing to subsidize renewables as heavily as Europe has, but we could certainly be somewhat more generous and we could certainly more consistently fund the PTC. The EU's investment has paid off. Most of the successful renewables companies world wide are now European.

Michael Karmis, Director, Virginia Center for Coal and Energy Research: The Europeans have aggressive policies, and companies are much more supportive of renewable energy systems. If you compare the website of typical U.S. energy versus a European energy company like Shell or British Petroleum, you can quickly tell that those companies spend much more time promoting corporate responsibility and environmental sustainability. And this shows something: the corporate sector in Europe, even with so-called global companies, has been much more amenable to supporting cleaner energy policies and technologies.

Ralph Badinelli, Professor of Business Information Technology, Virginia Tech: Research groups and government study groups in the US could join forces with their counterparts in the EU to share information, perform joint research and motivate consolidated investments in technology that could serve both markets.

Shalom Flank, Chief Technical Officer, Pareto Energy Limited: I think we can take some of the European-style thinking about externalities and apply them successfully in a market-based approach. We're creeping along with some tradable emissions and renewable-energy credits, still resisted by business, regulators, and environmental groups. But cap-and-trade, RPS / REC, and similar systems will eventually come to dominate our policy tool-kit.

We can also accept our differences, and leverage them. Business success is a more powerful instrument of change in the U.S. than anywhere else. (So is popular demand, but I don't expect that to play an essential role for DG/RES.) If we set up the right market conditions, or if the right entrepreneur finds new opportunities under the current conditions, change could happen remarkably quickly, especially if we can keep the state regulators from tamping it down. Export markets might be an important piece, where technological and business innovations that originate in the U.S. find their first important applications elsewhere (China?), and are then brought back home as proven approaches with serious capital behind them.

Shawn Collins, Project Manager for Fuel Cells, United Technologies: Again, two thoughts. First, target RES at the places where the natural resources exist to support it, especially when trying to grow an immature industry. For example, solar energy where I live in Connecticut is probably not a good idea unless it's part of a portfolio of solutions because our access to sunlight is so unreliable. Along those lines, RES may be more successful if pushed at the state level, as that would be the comparable unit of analysis to country implementation in Europe. However, this raises a difficulty the US faces that Europe may not. I believe the countries you mention can develop unique RES programs without having to coordinate with each other. In the US, the cost of conflicting RES programs (for example with codes and standards), particularly between adjacent states, may be much higher. For example, suppose Illinois and Missouri independently work on hydrogen highways but no-one bothers to make sure the highways connect to each other at the state borders. You wind up with a reduced benefit to the whole exercise. I think the analogous challenge would be workable RES policy at the EU level instead of individual countries. I don't know if it's been done, but I imagine it is a monumental task. Second, at a more philosophical level, worldview makes a big difference. If RES worked in Norway & not in UK with comparable resources, then the UK has to decide which is more important: implementing RES or adhering to their ideology of how economics and government / industry relations are supposed to work. If the ideology is more important, perhaps better to stop talking about an RES industry that will never be able to develop in that context.

Thomas Grahame, Senior Research Analyst for the Office of Fossil Fuels, U.S. Department of Energy: A different lesson than some might think. I think the lesson for us is: don't go building too much uneconomic power before you bring the cost down, or you could drive industry away. Instead, do the R&D (and to be fair, some implementation, such as the RPS that several states have) to get the costs down – then, when you build it, there will be fewer objections and more opportunities. And we are approaching that point in the U.S. with wind today.

Thomas Petersik, Former Renewable Energy Forecasting Expert, U.S. Energy Information Administration: The United States should be able to learn quite a bit from Europe's generally greater proportionate integration of wind and other (solar) intermittent power into the grid. We are very uncertain what percentage wind power can provide of total supply; such issues as accelerated deterioration of fossil units' fluctuating output to offset intermittents' varying output should provide additional education to US markets; maintaining reliability, especially in some locales, is likely an important learning area.

Vijay V. Vaitheeswaran, Energy Correspondent and Author for *The Economist* Magazine: The U.S. can learn to stop subsidizing every form of energy, be that fossil fuels or renewables. Part of that reform must include externalities pricing, which would force dirty fuels that harm human health and the global environment (like fossil fuels) to pay a carbon tax or equivalent.

Wilson Prichett, Energy Consultant, ASEGI Incorporated: There is also the fact that the Europeans seem to show greater interest in clean power. Of course, their stance on the Kyoto accord is in support of carbon reduction. And there are a lot of cultural differences.

The way this country was set up, was by taking raw natural landscapes and subduing them. So there is a tradition in this country about running rough-shot over nature. The Europeans have been doing it a lot longer than we have, and they learned to respect nature and the delicate balance of natural systems. They seem better at appreciating that. And thus it becomes incorporated into their lifestyles.

Zia Haq, Operations Research Analyst, U.S. Energy Information Administration: I think U.S. policymakers need to realize that to successfully manage energy problems requires leadership that might be unpopular and that energy demand cannot be treated as a sacred cow. It is possible to experiment with different kinds of policies in the electric utility and transportation sectors and be successful if one is willing to take the leadership to see things through and to adequately explain the benefits of policies to all stakeholders. If electricity rates are raised by a modest amount as a response to climate change, people will adapt. Everybody thinks that riots would occur if the U.S. raised electricity rates by $10 a month to respond to global warming, but I'm not so sure. We need to get away from this notion that you cannot touch customers and can never raise electricity prices. That is a big myth that has fed into the perception that electricity is cheap. A well designed program with adequate consultations with all affected groups and a demonstration of clear benefits would persuade people to consider these policies more seriously.

Question 8: Will the Energy Policy Act of 2005 create a truly sustainable energy future?

Adam Serchuk, Senior Renewable Energy Program Manager, Energy Trust of Oregon: No. Sustainability is just a political word at this point, it is not a policy word. Does it mean sustainable in the business sense, stable rate of return on electricity rates? In the environmental sense? If you are asking, is it a good law, I think the Act is atrocious public policy, pork barreling at its worst.

Alan Crane, Senior Program Officer, National Academies of Science: I'll give Bush some credit for noticing that oil is a serious security problem, even if he doesn't care about climate change. He isn't going to slap a tax on oil or raise CAFE standards because he is unwilling to risk pushing GM and Ford into bankruptcy, so he is focusing on long-term R&D or minor tweaks like alcohol.

Alex Farrell, Assistant Professor for the Energy Resources Group, University of California Berkeley: Absolutely not. The Act does two things: (1) provides payback to industries that supported the Republican Party very strongly, and (2) allows Republican politicians to claim that they have done something about the energy system. The Act is merely a dubious political instrument. It has a couple of things moderately right, but it falls short of helping even those it was designed to help. Strong advocates of nuclear power even admit they need more to get a nuclear power plant built.

Arthur Rosenfeld, Commissioner for the California Energy Commission: The Act is 9-1 in favor of supply instead of demand. Despite some of its encouraging measures, it favors supply measures 95 to 5.

Brian Castelli, Executive Vice President and Chief Operating Officer, Alliance to Save Energy: No. It paid a little homage to efficiency and renewables, but the biggest missing piece was that it did nothing to reduce our dependence on foreign oil, nothing to increase the efficiency of the vehicles, left transportation (one third of our primary fuel use) off of the table and that sector produces 1/3 of our global emissions problem. It's not really going to help us where we really need some help. It was a good start, but if it's all there is, it's not enough.

Christopher Russell, Director of the Industry Sector, Alliance to Save Energy: From an industrial perspective, it does virtually nothing to help energy efficiency. The industrial sector does not demand legislation that drives energy efficiency. It demands legislation for increasing the supply of fuels and driving the cost or price of energy down.

That is what is articulated by industrial policy advocates. Most manufacturers push for the usual energy policies of drilling, digging, and building more power plants, and this is the consolidated message that they send to legislators. Few, if any, high-profile industry advocates call for legislative action regarding energy efficiency. If you do, then what technologies do you support? You can't legislate behavior, or standard operating procedures. But the one solution that "fits all sizes" is to demand lower fuel prices.

Claudia J. Banner, Senior Engineer for Renewable Energy Planning, American Electric Power: Not as written. In some cases, the incentives are geared toward non-renewables and encourage additional coal use, not true renewables.

The EPAct provides incentives for oil and gas production, access to Federal Lands for oil and gas production, coal use incentives, some programs for automotive vehicles, and various studies (e.g., Section 138 – Intermittent escalator study (of which programs are in place in Europe)).

In the case of the US study of intermittent escalators (turning them off when no passengers are on them vs. letting them run all the time), if we know it works, as it does in Europe, then why is a study needed? Escalator savings will only be a small part. Other energy conservation measures, such as increased fuel efficiency standards, are also needed.

The EPAct does little to actually require or encourage renewables and applies only a Band-Aid® to the US dependence on oil. Truly lessening the dependence will require conservation, increased fuel efficiency standards, and use of renewables such as solar on a distributed basis, for the long-term.

David Baylon, President and Founder, Ecotope Consulting, Research, and Design: It allocated around $28 million for efficiency measures and billions of dollars towards supply-side measures. Which is to say that conservation got $28 million and oil and gas subsidies got around $28 billion.

David Garman, Undersecretary of Energy and Former Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy: It helps, but nothing by itself creates sustainability. The Act set some important authorities and program goals in place. It moved the ball forward, so to speak, but it certainly doesn't mean that we declare victory. The Act is another page turned, but it isn't the last Energy bill that Congress will ever have to pass.

The *Economist:* That grotesque law handed out tens of billions of dollars in subsidies to every imaginable source of energy. But it did nothing to promote carbon trading; it did not mention carbon taxes; it had no tightening of vehicle fuel-economy rules. The Administration's energy policy remains a disgrace … This grand new plan to end oil addiction is really no such thing. Take, for a start, that objective of replacing three-quarters of Middle Eastern imports of oil by 2025. Because oil is a fungible, globally-traded commodity, it does not matter where imports come from. Even if America got all of its oil from Canada, Venezuela, and Nigeria, an oil shock in Saudi Arabia would send the price of every barrel of oil skyrocketing—even Alaskan barrels. Only abandoning foreign oil completely would free America from the prospect of an oil shock …. In short, Mr. Bush is still avoiding most of the regulations that might actually encourage the market to ditch dirty technologies in favor of clean ones. And he is still avoiding any

attempt to make Americans pay the true cost of the energy they guzzle. Until that happens, he is firmly on the side of the pusher, not the addict.[478]

Edward Vine, Staff Scientist, Lawrence Berkeley National Laboratory: No, the Energy Policy Act of 2005 is really just a continuation of past, oil- and fossil-fuel-dominated policies and past technologies that use fossil fuels or nuclear energy. The Act itself is still fixated on a carbon based economy, which is not sustainable in the long run.

Jack Barkenbus, Executive Director of the Environment and Resources Center, University of Tennessee: I wouldn't call it a new energy policy at all. We still lack a rational, comprehensive, well-thought out approach to energy policy in this country. But there is a reason for that. People continue to place the importance of parochial politics above the needs of the environment and the consumer.

James T. Gallagher, Director of the Office of Electricity and Environment, New York State Department of Public Service: It is hard for me to speak about it broadly, since I am looking things it will help New York accomplish: it supports our renewable energy programs by extending tax credits. I wish they were extended for longer, but at least we have that continuation. We would have liked to have seen federal action on climate change. The regional greenhouse gas initiative has been spearheaded by this agency and the Department of Environmental Conservation.

In terms of efficiency and transportation sector, we feel that we need to go much beyond the national energy act. There are important provisions in the new act, and it doesn't impede what we are doing here in New York, but on the energy efficiency and renewable energy side the act really doesn't provide the long-term Federal leadership that we were looking for.

Jan Harris, Project Manager, Vermont Energy Investment Corporation: It will definitely not create a sustainable energy future, or sustainability of any kind (other than the sustainability of consumption). While The Energy Policy Act of 2005 is heavily weighted towards coal, nuclear, and oil, and it does provide some help for renewables and energy efficiency. At this point in the political cycle we can only hope for significant change in leadership to make a sincere commitment to moving this country away from ever increasing consumption and toward a more sustainable future.

Janet Sawin, Director, Energy and Climate Change Program, Worldwatch Institute: No.

Jeff Jones, Operations Research Analyst, U.S. Energy Information Administration: The Act included various subsidies to promote technologies like nuclear generators, renewables, clean coal systems, and so on. There are other energy issues that are not addressed in the bill, but it was a first step towards trying to improve the current energy situation.

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[478] See Economist, "Energy Policy: The Pusher-In-Chief," Volume 378 No 8463, February 4, 2006, p. 26.

Joe Loper, Vice President for Research and Analysis, Alliance to Save Energy: No. No matter how you define sustainability, EPAct 2005 just nibbles at the margins, at best. Most of the things that it proposes to do will never happen. There are tens of billions of dollars of funding touted by supported that will never be appropriated. So it mostly ends up being a lot of studies.

On the energy efficiency side, the only things that will have significant impact are appliance and equipment standards. The tax incentives are generally too complicated, too short-lived and rife with free-riders – in other words, much of the money will go to people and businesses that were already taking the action any way, thus the tax incentives will not induce much energy efficiency investments in my opinion.

This reflects a larger problem with the political process. Anything with a big impact is politically impossible, only small things are doable, so you end up with a bunch of little doable policies that will result in no real impact.

Realistically, savings from the energy efficiency provisions in EPAct 2005 will likely save around one Quad of energy by 2025, which implies that it would reduce 2025 energy consumption from about 130 quads to 129 quads. And these savings will likely be offset from the Act's numerous supply-side provisions.

It is going to take one hell of a crisis to get serious about energy issues in the United States. Politicians have some special interests driving them, but they—and their inability to confront energy issues seriously, challenge entrenched attitudes about consumption, and really raise awareness about energy issues—are really a reflection of society at large.

John Plunkett, Partner for Optimal Energy Consulting: It has some tax credits, and we've distilled down the new Act to what matters to us for energy efficiency programs. It has some good provisions, but overall it sucks, it's a dismal excuse for a comprehensive energy solution.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: It won't have much of an impact in Virginia if they don't fund any of the measures that they have approved. Approving and authorizing are very different, and if you look through that energy bill, many things are authorized but only time will tell how much money is appropriated toward those authorizations. The energy bill will only be as good as the financial support that it gets, and that is a direct function of how much the government is willing to appropriate.

To a more direct question, the energy bill by itself will not create a sustainable energy future. It takes people, ingenuity, and innovation, and a lot of other things to accomplish that. The bill is just a document, and it will all depend on how seriously people take it.

Judi Greenwald, Director of Innovative Solutions, Pew Center on Global Climate Change: No.

Ken Tohinaka, Senior Energy Analyst, Vermont Energy Investment Corporation: Everybody is still hustling to find out what it all means. I heard an account of the Act the other day at a meeting in New York. It's not that all clear to me that throwing money at the problem will be enough. Two-year tax credits for most renewable energy technologies, for example, seem like a very backwards way of trying to influence how people behave, and at the very end will have the least influence in changing consumer attitudes. It's interesting that rebate coupons tend to not to be redeemed, suggesting that many people would have made the purchase anyway. Of those that were influenced by the rebate, the sooner the rebate is made and the size of the rebate would appear to be the driving forces. But tax rebates can be a year or more after the purchase and even major residential energy efficiency improvements appear to worth only up to $500 over a two-year period. It's hard to believe this will have a major impact.

Larry Papay, Former Senior Vice President, Southern California Edison: It could, although we still need something to occur on a state by state basis, where public utility commissions set the rates for electricity prices. If the act isn't supplemented by state legislation, its contribution to energy efficiency and renewables will be ephemeral and incomplete.

Mark C. Hall, Senior Vice President, Primary Energy: No, I don't think the new act does much to create anything new. It does do some things. Generally speaking, it is a feeding frenzy for tax breaks and incentives that will promote the interest of one industrial group of manufacturer of something over others. And this inconsistency could be devastating for smaller scale systems like DG, CHP, and renewables. Look at wind power. Wind power is completely reliant on political consistency. Look at graphs that show thousands of MW of wind capacity being installed while wind tax credits exist, next to merely dozens of MW when the tax credits expire or are debated in Congress. The industry is completely reliant on that cycle of tax incentives. Tax incentives are supposed to get a fledging industry off the ground, or to provide some other public policy benefit. To the extent that the people that propose and get passed a renewable energy tax credit for wind or any other technology, they are saying they value the clean air, reliability, and the fact that we are diversifying our resource base. But you still have to have to tax credit on a sustainable path. If an industry simply invests up and down as a tax credit expires and is renewed, then you haven't solved the underlying issue. People often have to offer a credit for wind because we have subsidized and offered credits to fossil fueled companies to keep those prices artificially low, and we are still trapped in that cycle. The real price of energy is not coming through to people, and politicians are rightly scared to death to let that price come through unfettered because it would blow people away. It would be regressive. And in our current political structure, our society abhors policies that appear regressive, to take a step backwards, or to hurt those people in the lowest income bracket more than those in a higher income bracket.

Mark Levine, Environmental Energy Technologies Division Director, Lawrence Berkeley National Laboratory: No. It does have a lot of goodies, though. Its sort of like the Christmas tree of energy policies: everything for everybody, but after the gifts are gone the tree will wither and die. Most of the goodies (around 98 percent) focus on

energy suppliers, and around 2 percent focus on energy efficiency. So the bill is chalk full of incentives for exploration of natural gas reserves, coal gasification, etc. But nobody in a serious mood will say that the Energy Policy Act of 2005 will solve our energy problems. Its main effect is to move money from one pocket to another, with the true goals of energy dependence or sustainability secondary. Its main effect is to move money from one pocket to another, with the true goals of energy dependence or sustainability secondary. Right after the Act was passed, for instance, the price of oil and gasoline went up.

Michael Pomorski, Senior Associate, Cambridge Energy Research Associates: No. The Act places too much emphasis on fossil fuel development, oil exploration, and gas production, and doesn't focus enough on energy efficiency and conservation. It's better than nothing, and it does include some useful programs (the PTC for example), but it wont do anything to create long-term sustainability.

Michael Karmis, Director, Virginia Center for Coal and Energy Research: The bill that was passed does a lot things: it recognizes the need for R&D, invests a lot of money in certain areas which this government feels are key areas, and is widely supported in Congress both by Republicans and Democrats. Things like the FutureGen plan for coal, hydrogen fuel cells in cars, and carbon sequestration are big initiatives of the president, also highly supported by Congress. Where the budget falls short are conservation and efficiency incentives, rules, and policies.

Paul DeCotis, Director of Energy Analysis, New York State Energy Research and Development Authority: No. What it did was bring both houses of Congress together to deal with energy issues in some rather small way. But it did successfully put energy at the forefront in public dialogue, and coupled with higher energy prices, unstable supplies, and catastrophic events like Hurricanes Katrina and Rita, it has heightened the awareness of energy issues in the minds of consumers, policymakers, and politicians. But the Act itself stopped way short of having any meaningful, sustainable impact on energy markets.

Ralph Badinelli, Professor of Business Information Technology, Virginia Tech: A "truly sustainable energy future" is a lot to expect from one piece of legislation. The Energy Policy Act of 2005 is a step in the right direction, but sustainability can be achieved only through much greater reduction in demand and technological advances in environmental protection and remediation that are not even on the drawing boards yet.

Ralph Loomis, Executive Vice President, Exelon Corporation: I don't like the question, because I think it is a sort of "how often do you beat your wife" question. No is the answer to the question. But there were a number of things that we thought were steps in the right direction. In some ways we think there are parallels between what was included in the recommendations of the National Commission on Energy Policy and what Congress did. The Energy Policy Act recognizes that there is no one answer to our future energy needs. It has offered subsidies to a whole host of different industries and technologies, and has avoided the very ineffective "shot-gun approach." It doesn't pick winners or losers among technologies, it rightfully lets the marketplace decide.

Rodney Sobin, Innovative Technology Manager, Virginia Department of Environmental Quality: The Act was a great disappointment—it did not develop better corporate average fuel economy standards, a carbon dioxide cap and trade system of any type, or a national renewable portfolio standard. In short, some states are doing what the Federal Government should be doing on energy policy.

Ryan Wiser, Staff Specialist in Renewable Energy Systems, Lawrence Berkeley National Laboratory: The Energy Policy Act was very good for renewables, but the whole act itself stinks. Sure, renewables got a fair share of the pie and the treasury extensions were good, but Congress is unwilling to even think about mandatory actions beyond ethanol. On the whole, the Act only twiddled around the edges with tax incentives for wind, solar, and other technologies, and will be unable to provide long-term, sustained and incentivized support for any of these industries.

Scott Sklar, President of the Stella Group, Inc.: It will do very little for renewable energy. It did supply some tax credits for two years only, but these are compared to 16 years for natural gas pipelines and 20 years for nuclear, and any business operator knows that two years does not give the renewable energy market any comfort. In the end, it was not a good energy policy bill: it fails to reduce imports of oil or natural gas, and was really a feel-good feeding-frenzy subsidizing traditional energy sources.

Shalom Flank, Chief Technical Officer, Pareto Energy Limited: Hah! That bill is a piece of trash. It is a massive giveaway to energy incumbents, strengthens the power of the current counter-productive regulatory and business structures, and has a few minor throwaways to make people feel good about renewable energy without actually costing anything or threatening anyone. And by the way, it has one of the most conservative, unimaginative approaches to technology commercialization that I've seen. No new approaches to DG, RES, emissions control, or anything else, will owe its success to the provisions of that bill.

Shawn Collins, Project Manager for Fuel Cells, United Technologies: No. The rhetoric from both political parties is on developing a technical fix to move into the egalitarian hydrogen economy where everybody consumes as much as they want from unlimited resources. That society will never exist – human nature is fundamentally opposed to egalitarianism, and certainly no widget is going to change that. I think it is much more likely that you'll see one scarce commodity, oil, get replaced by a different scarce commodity, maybe platinum, maybe something else.

Shelly Strand, Marketing and Project Manager, Ecotope Consulting, Research, and Design: The Act is corrupt, and it is geared towards the oil industry that bought this government, and is a downright shame.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: I have not had a chance to really look through the implications. I am very cautions on what comes out of the current Administration with

regards to energy policy. There is some in there for efficiency, but much more for the current, big, utility, oil, and energy providers.

Thomas Grahame, Senior Research Analyst for the Office of Fossil Fuels, U.S. Department of Energy: Again, my answer may be different than you might think. A sustainable future involves both increased efficiency as well as increased national security. After all, how sustainable is an economy if it can't get the energy it needs? – here, I am thinking of foreign oil, which has already seen several interruptions. Future interruptions could well have far more adverse consequences that the earlier embargoes, given the possibility of "peak oil" arriving at some point in the next decade, maybe more, maybe less.

So my personal view of a sustainable future crosses sectors. We have to keep in mind that it takes a great deal of time to effect a major transformation, so we have to have a long range vision. What I would hope to accomplish are four things:

1. Reduce CO2 emissions substantially over time.
2. Reduce oil imports and use substantially over time
3. Keep costs of all energy (electricity, natural gas, liquid fuels) at reasonably low levels; and
4. Increase use of renewables over time, especially as each one approaches being economic.

I don't think these goals can be met by using mostly renewable technologies, although I want to see their use expanded as below. I think we have to expand use of our most abundant fuels as well to reach these goals.

I would like to see most personally owned vehicles be not just hybrids, but *plug-in* hybrids. The Energy Policy Act contains substantial subsidies for purchasers of hybrids. Also, DOE just increased its research budget for lithium ion batteries, the ones that will be needed for plug-in hybrids. With plug-in hybrids, the first 20 or 30 miles a day could come from electricity, not a liquid fuel.

For the liquid fuel, I would like to see biofuels (especially where they are more economic, in the Midwest). For trucks, I would like to see diesel from coal, with sequestration of the CO2 at the site where the fuel is made. Again, lots of research is going on, and the first large plant to produce these fuels just broke ground in Pennsylvania. DOE has substantially increased its research budget for CO2 sequestration in the past several years, and the Energy Policy Act contains funding to build several demonstration projects for some aspects of these technologies.

Because plug-in hybrids would require more electricity, I would like to see something like a tripling of nuclear power. Here, the Energy Policy Act contains provisions to incentivize the construction of about 6 new nuclear plants with a more advanced technology. Substantially increased nuclear power would also reduce natural gas prices by driving that fuel out of electricity generation, helping to meet the goal of reasonably

priced fuels, so we can retain our manufacturing base and not raise consumer heating bills too much.

We could really use all that wind in west Texas and the northern Great Plains as well to help with the plug in hybrids. And, when we finally do get economic solar power, I would expect to see it on many rooftops all over the southwest, and anywhere else there is enough sunlight. When that happens, people can fill up their plug-in hybrid at home.

The net result of this particular sustainable future vision would be much less oil used and imported, and much less CO2 emitted [due to (1) big increases in nuclear; (2) CO2 sequestration when making diesel from coal; (3) big near term increases in wind and biofuels; and (4) big long term increases in solar].

Finally, keep in mind that there are also incentives not in the Energy Policy Act. For example, the US government is spearheading a multinational effort to develop a new technology for recycling spent nuclear fuel. This technology would remove from spent nuclear fuel plutonium and uranium that could be reused in reactors, thus dramatically reducing the amount of waste that would need long term storage (which will help bring more acceptance of nuclear), and at the same time these products would be very hard to separate into bomb-making material – in other words, this technology wouldn't have the weakness of today's recycling technology, which isn't used commercially because the products wouldn't be that hard to use to make a bomb, should the wrong people get hold of them. I've attached a recent press release on that below as well. Sure beats having the fuel rods in pools at each plant, as is the case today.

Thomas Petersik, Former Renewable Energy Forecasting Expert, U.S. Energy Information Administration: Not likely! My impression is that the Energy Policy Act is a series of baby steps in many directions, carefully avoiding any fundamental movements on anything. With the exception of the PTC for wind, Federal subsidies to renewables, particularly in the form of research and development subsidies, are generally relatively small as a proportion of the total cost of these technologies. US taxpayer investment in renewables is really very small and, in my opinion, unlikely to result in major advances in themselves. This is not to say that taxpayer subsidies to investment in particular projects, such as the investment tax credit, are not costly or are insignificant, but simply that they are insufficiently large to offset the overall much higher costs or to afford large additional investment in most technologies.

I strongly recommend that your research include review of EIA's cost and performance estimates, both for capital costs published annually in EIA's Assumptions to the Annual Energy Outlook, and also for the current and forecast estimates of levelized costs per kilowatthour, currently available (but not published) in a file called "LevCost". You will see that biomass, geothermal, most hydro, solar, and wind, are significantly more costly.

Finally, I very strongly recommend that you look at the inelasticity of renewable energy resources supply. In most regions of the country, renewables for actual use are very very scarce. Geothermal, for example, tends to be more costly, located far from consumers

(meaning needing transmission lines), in arid places where cooling water costs are likely to be high, and all too often in environmentally sensitive areas. Actual sites often – so far – appear to be much less robust than estimated, and long-term sustainability is a critical issue. Actual opportunities for geothermal appear to be far lower than optimists effuse.

Tom Casten, Chair and Chief Executive Officer, Primary Energy: I read through most of the provisions, and was discouraged to find no underlying theme, no discernible vision, but 1700 pages of pork. It does not constitute energy policy in any sense of the word. The bill is a disgrace. To quote FERC commissioner Nora Brownell, "History will not look kindly on how we are managing energy in this country."

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: I haven't looked at it to a great extent, but from what I have seen the Act will have little impact on Virginia and how state facilities here manage their energy day to day.

Toben Galvin, Senior Energy Analyst, Vermont Energy Investment Corporation: No. I haven't looked at it fully, but the tax credits for solar and efficiency measures seem a wrong-headed way to go. The federal government should be investing money to support groups more like the Vermont Energy Investment Corporation to promote efficiency nationwide, so that energy efficiency advocates can achieve a lasting presence. Instead, they keep focusing on ephemeral tax credits.

Vijay V. Vaitheeswaran, Energy Correspondent and Author for *The Economist* Magazine: You must be joking. The Energy Policy Act of 2005 is the worst piece of pork-barrel legislation in a long time, which will serve only to retrench the status quo and hinder progress toward sustainability.

Vikram Budhraja, Former President of Edison Technology Solutions, Edison International Company: The new energy policy doesn't hurt things, but it isn't going to make a substantial difference in the energy supply picture. There is support for renewables, clean coal, nuclear, hydrogen and other initiatives. There is no goal or target for renewables. There is a continuing problem whereby everybody loves renewables and conservation, but there is a price tag in terms of higher first cost and the public support for paying the higher first cost is questionable. Amory Lovins has excellent arguments about total lifecycle cost, yet the whole U.S. economy and political structure has a short term focus and lower first cost appears to win out.

Wilson Prichett, Energy Consultant, ASEGI Incorporated: I don't see how. There are some tax incentives and energy conservation minor fundings, but the scale that we need to invest, right now, to form a bridge that we can walk out on when the terrain falls away from us when the oil runs out, that bridge is immense. There will be a tremendous disruption in our society. Everything we do is petroleum based. The Act does nothing to prepare America for its future energy challenges, although by then all of the experts responsible will be cozily ensconced within their security gates to protect them from the rampant, starving, and rebelling working class.

Zia Haq, Operations Research Analyst, U.S. Energy Information Administration: I don't believe that it will. Personally, I am extremely disappointed with the nuclear initiatives. Nuclear costs are far higher than most other technology costs (and we don't realize the true costs yet). The costs for Yucca Mountain are not included with the costs calculated for electricity from nuclear power plants. Many people do not include plant decommissioning costs in their nuclear costs. Then there are the issues associated with proliferation. These issues are so complex and have already gotten so out of control that they are not going to be solved in our lifetime even with technological innovations. I also think that nuclear is not completely carbon-free as many people claim.

One the whole, I think the Act is misguided, and did nothing new or interesting to promote conservation. Policymakers have a great deal of difficulty in managing the demand side, because they see demand growth as the only ways to keep the economy growing. So they focus only on responding to that challenge with more exploration, more nuclear, and more clean coal and that emphasis is not appropriate. We must deal with the demand side at the same time as we deal with the supply side. We have to at least begin a dialogue on CAFÉ standards and the Kyoto Protocol. At some time, we will have to deal with these tough issues. The Act will not do anything to increase energy sustainability.

Question 9: What types of benefits or advantages can DG systems—in contrast to large, centralized systems—provide the consumers, businesses, and utilities?

Dave Stinton, CHP Program Manager, Oak Ridge National Laboratory: From the kind of things that we do, typically, in many parts of the country, the system that has the reciprocating engine—there are so many of them, established business and marketing channels and manufacturers, and they are cheap around $250-300 per kW—those are the systems that are really the most economic.

Low emissions technologies are also growing in importance in regions like California and Texas, so those DG technologies that are either very efficient or emissions free hold immense promise.

Also, DG/CHP standardized units that don't need modified or assembled hold significant potential since they are easier to install, maintain, and use.

David Hill, Deputy Laboratory Director for Science and Technology, Idaho National Laboratory: The single greatest benefit to these systems is their distributed nature. The system most countries have today is based on large, central sources pumping massive amounts of power. We need a system more interconnected, where selling and buying can be two way (rather than one way, as it' currently designed). Right now most DG systems are intrinsically local, powering traffic lights and other similar technologies. For the moment, they are likely to stay that way.

It's a mistake to assume that the solution to energy problems is homogenous around the world. The solution is heterogeneous. What we may do in this country may be conditioned by our history and our infrastructure. As China and Vietnam develop their own energy sectors, they may take different routes depending on their social structure and the existing capabilities to move power around. Economics is not physics. It's not a universal truth. It's dependent on the social context at hand. Take the telephone as an example. It almost makes no sense for China to develop a large, land-based national telephone system. It makes more sense for them to go straight to cellular. Here, in this country, we will continue to use land- and cell-based phone systems because both are now in place. In the same way, a confluence of history, geography, and existing infrastructure will always play an immense role in framing how individuals view their energy choices.

Marilyn Brown, Commissioner, National Commission on Energy Policy: DG systems can provide greater security since they facilitate a more distributed infrastructure. With more DG systems in place, the grid cannot be taken down as easily. DG offers greater security for the grid, as a system of distributed providers would make it impossible to take down the power grid.

DG systems also provide much needed fuel flexibility. While not all DG systems are there yet, many have generators that can run on multiple fuels, including cheaper fuels (like coal) and cleaner fuels (like methane gas from landfills and bio-diesel).

But, again, I think that diversification is the single most important mechanism to provide energy security and reliability, the single most fundamental principle, if there is one. We are going to need it all—nuclear, renewable energy, natural gas, and coal—to meet rising electricity demand in this country, and the cleaner, the better.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: I do think you have better reliability and efficiency with DG systems. If you size DG systems—especially with heat recovery—correctly, you get a lot of efficiency out of them. But I also think that reliability issues can be addressed by them. You can back up information data systems with DG technologies, or really anywhere where you need highly reliable power, DG systems can improve the reliability of energy delivery and can save a lot of money. Outage times for hospitals and data centers, losing power for just one hour is significant damage and that goes a long way towards reducing the capital cost of a DG system.

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: The obvious thing is that in the event of a catastrophic failure as we had with Hurricane Gaston, while I was director of utilities at Virginia Commonwealth University, and the buildings with distributed emergency generators were the only buildings that were operable. Fortunately, we had large tanks of number two fuel for our boiler, and we were able to keep the generator tanks filled from that tank, so that the university had power. So DG gives you power during a catastrophic failure, and with PJM and their DG program, it will help not only the folks in our area, but folks in other states, when there is a critical failure of utility generation due to some unforeseen problem.

Question 10: What do you see as important trends (historical, economic, social, political) pushing the growth of renewable energy technologies and DG?

Dave Stinton, CHP Program Manager, Oak Ridge National Laboratory: There are at least four separate institutions that are promoting, albeit in a somewhat limited fashion, the benefits of DG systems:

(1) Utilities, that want to lower their emissions either in non-attainment areas or regions of the country that prioritize green power
(2) Businesses and industries that can benefit directly from continuously co-generated heat and electricity
(3) Military and security installations that require uninterruptible power, especially to safeguard against power failure
(4) And small independent utilities that need to purchase power during periods of peak demand

Jack Barkenbus, Executive Director of the Environment and Resources Center, University of Tennessee: There is a huge market out there for DG and renewable technologies, and there is a public that wants these kind of things in the sense that they recognize that they are clean, safe and abundant. Obviously, who wouldn't want these kinds of technologies? But they also tend to be intrusive and expensive. Those organizations that actually deliver power to people feel that renewables are still cost prohibitive. Almost any survey of the public will show that they are vastly in favor of renewables and willing to pay for them; then you offer a green power program and you will get around 1-2 percent of the population that will sign up. So there is a huge marketing issue that I don't quite understand to translate public attitudes towards renewables, which are positive, into getting them willing to pay. There is a mismatch or disconnect along the line.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: Higher energy prices of today and the notion today that the prices are here to say are convincing people that more efficient technologies are worth investing in. You see a lot of press about peak oil. Some people propose that the demand for fuels will not keep up with supply. Also, and this kinds of get back to the "necessity is the mother of invention" philosophy. People aren't going to do anything until they have to do something.

Marilyn Brown, Commissioner, National Commission on Energy Policy: One, the war in Iraq and high energy prices are having some role in revitalizing renewable energy investors.

More directly, between 18-20 states now have renewable portfolio standards, which are a very important breakthrough for pushing cleaner energy technologies. Having an agreed upon definition of what constitutes renewable energy—and the ability to certify that utilities are either using renewable energy or selling power generated from decentralized

renewable energy—means that the policy mechanisms for a wider use of renewables are in place.

Third, the clean air issue (not global warming, but air pollution) will continue to be a driver for years to come, especially in non-attainment areas.

Fourth, market demand for renewables is slowly but steadily growing. Some utilities have shown that customers are willing to pay a premium for renewable energy. So I think that something of a transformation is starting to take place among consumers.

Fifth and finally, global climate change and the issues of greenhouse gas emissions will continue to push the importance of renewable energy systems.

Paul Gilman, Former Chief of Staff for Senator Domenici, Director of the Oak Ridge Center for Advanced Studies: Trends exist at many different levels. There are some for whom renewable technologies are a philosophy of life, a passion. And the standard economics never come into it. Amory Lovins may have a wonderful refrigerator, but you or I couldn't afford it. There are a set of folks who have always believed that renewables are about less about technology and more about a mindset of how we run our lives and businesses to enable a more sustainable future. And that is one element of the resurgence. Those folks have felt empowered again by another set of energy cost run ups and centralized grid system failures. And then there are the business people who believe that there is a new opportunity for them with rising energy prices, and some investors have started to shift towards more smaller-scale technology.

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: Basically, people want to become better environmental citizens. Primarily, you are finding people who see the problems of pollution and global warming and are trying to address it. But, once again, until you get the economics in line, they are not going to be successful. They will try hard, there will be lots of noise, you will see bio-diesel, solar, and other technologies, but unless the technology reduces the cost or the cost of fossil fuel increases to the point where the economics tip, there may be small growth, but it will not truly accelerate.

Question 11: What general lessons would you say we have learned concerning society, energy, and technology?

Alex Farrell, Assistant Professor for the Energy Resources Group, University of California Berkeley: One answer is that, as in any human system, it is possible for technological systems to have crises. If people are prepared, such crises offer opportunity. If people are unprepared, these crises are truly disasters.

Second, the decisions people make about energy technologies are greatly shaped by the power of incumbency. Whether local utilities or large manufacturing firms, once large-scale energy systems are in place, it becomes very difficult to dislodge them.

Third, while subsidies and direct R&D help, the type of government action that matters the most is direct use, although the magnitude of these effects differ. The Air Force used jets, didn't think it was a good idea for someone else to develop them, yet the aircraft industry was able to adopt them. The Navy used nuclear power plants, built and operated them. This seems very different than the way that other technologies diffuse. In the military, people area willing to pay for high performance. If one wants a low temperature, high endurance power source (low infrared signature), the military is the place to look for applications before the green consumers. But direct government use of technology seems to influence how people perceive it.

David Hawkins, Lead Industry Relations Representative, California Independent System Operator: As a first observation, most everybody think electric power is old stuff. People have this idea that all the new stuff to be learned was taught 50 years ago. Yet we have some of the most exciting challenges I have ever seen in my life; we have technology and information and communication systems to see what is going on; we have much more robust concepts of what to do; we are more aware than ever after 2003 August blackout of how critically important it is to have infrastructures work. So the importance of energy is hidden in our culture, yet it still remains very important.

As we add more in more about information, we are looking at 100,000 data points every 4 seconds. How does one manage this quantity of data and detect the important ones? How do you forecast? We are learning that we need better risk management, tools at forecasting, if continue down this direction, running risks, since margins will get smaller.

David Hill, Deputy Laboratory Director for Science and Technology, Idaho National Laboratory: Everybody wishes—literally everybody—wishes renewables could take a larger portion of the baseload, regardless of their political stripe. There is an understanding in this country that we are in an unsustainable position, supply is too small, the level of demand which correlates with economic activity is going to increase. The problem at the political level is how do you incentivize it? Especially when people oppose the construction of any generator—whether nuclear or renewable—because they don't want to see it in their backyard. Every energy supply system comes with a set of problems and wastes, because you are engineering something. For a nuclear system, you have the well known problems of nonproliferation and how to handle the waste. For a

coal system, it's carbon dioxide and coal mines and impoverished mountaintops and contaminated rivers. For PV, its hazardous wastes in the production of the silicon wafers. There are literally tankers still in California driving around and trying to find where to put silicon wastes. Wind is dead birds and blemished landscapes. So society has to figure out what price it is willing to pay for electricity, and what that cost is and how to make it economic. If, literally, we decided c02 was just too big a problem, the response would be to build more nuclear plants and to accelerate wind and things like that. Right now, we haven't decided that. And for the short term, renewables will only be used in the margins (even including large hydro, since dams are more likely to go away than to be built). Everything you do to harvest energy from the environment results in some form of damage. There is no free lunch.

From working on energy issues in the early 1970s in England during the coal miners strike, I believe that supplies of electricity are actually intrinsic to social stability. My thesis at the time was that energy, and more specifically electricity, was intrinsic to social stability and I view it as the defining problem of the age, terrorism notwithstanding. I want people to understand the importance of energy as an issue, and there is an argument to be made that the causes to terrorism are exacerbated by the energy problem, if not driven by it.

Edward Vine, Staff Scientist, Lawrence Berkeley National Laboratory: The biggest lesson is that in order to study energy technologies one must not just study technologies but also study people and their attitudes, business practices, personal habits, and decision-making. I once thought, "If we only needed a new technology, why bother studying people?" However, technologies don't diffuse by themselves into the marketplace. Human behavior plays an instrumental—I'd even say a pivotal—role in how technologies are diffused. Oftentimes the biggest barriers to a given technology aren't technical but social, in how people come to accept, reject, adapt, or modify technology. To understand why technologies work in society, we need to go beyond technology to look at all of these human factors.

James T. Gallagher, Director of the Office of Electricity and Environment, New York State Department of Public Service: I would say my experience has been that quality is probably critical. Like many technologies, there were early rushes to implement technologies that were not ready, whether early solar water heaters, time of use meters, or energy management systems. With any technology, those early failures make it harder to deliver a product of higher quality to consumers down the road. Focusing on quality and support are critical in developing those technologies.

Also diversity, that policymakers need a multi-pronged approach that includes a diversity of portfolio options (including fuel cells, smaller systems, nuclear power, proper rate making, energy management systems) when dealing with energy problems.

Joe Catina, Manager of North American Projects, Ingersoll Rand Company: I think TMI and Chernobyl. I'm old enough to remember the promise of nuclear powered aircraft, and having nuclear power touted as one of the great human achievements, a

panacea for all future energy problems. The results of technology mistakes and foibles of human nature (things like lack of redundant systems, inability to anticipate the future waste problems, and so on) clearly put an end to that entire way of thinking. There never seems to be an end to what the next greatest thing is, and sooner or later, we continually hope that it may turn out to be just that. We continually focus on technologies as the solution to all of our problems—whether energy, food, or transportation related—and always place faith that our technical prowess can overcome all future problems.

John Warren, Director, Division of Energy, Virginia Department of Mines, Minerals, and Energy: The advancements in technology can do a lot of things to increase efficiency. I think one fundamental lesson is that if we keep going, we will manage to find technological breakthroughs to solve most problems. Technology has gotten so advanced that we are producing products and getting business done with a lot less energy per same unit of output. The lesson learned is to keep going, keep driving, keep looking, I feel like at some point there will be some technological scientific breakthrough—like cold fusion, as just an example—that at some point could provide the golden bullet to our energy problems. Maybe science and technology can find that golden bullet. Just because it doesn't exist now doesn't mean it doesn't exist now.

Ken Tohinaka, Senior Energy Analyst, Vermont Energy Investment Corporation: I think the biggest lesson is that the technology that produces more efficient gizmos works: condensing furnaces, using pressure differential diagnostics, high efficiency exhaust fans, and so on. The hardware all works, so the question is less about technology and more about society. Interestingly, although the gadgets tend to be more efficient, we use more of them as well as use them more so that actual consumption keeps increasing. And the actual efficiency of, for example, a furnace, is importantly a function of a number of external factors that involve human beings outside of the manufacturing process. While something can be operated efficiently, it doesn't mean that it will be. I don't know that technology should be relied upon for all the answers. Generations ago, the cartoonist, Walt Kelly, put it nicely: "We have met the enemy and he are us."

Larry Papay, Former Senior Vice President, Southern California Edison: As we become more dependent on technologies to run our daily lives, our culture seems to be coming more technologically illiterate. Knowledge of technical systems becomes more specialized. People tend to take technology completely for granted, they flip a switch and expect the lights to go on, turn a computer on and want it to run perfectly. Some people who can barely work the remote control to their Video Cassette Recorder want high definition televisions and digital videodisc players. People seem to have become more illiterate as to what is behind the technical devices that populate their everyday existence.

The meaning of that is that we need to go back and look at how we educate people, not today's adults, but the children in terms of having a better appreciation for technology. I am talking about sustained education in grades K-12, perhaps even extending into college. If you look at the statistics, teachers are not prepared to teach math, science and technology, by and large. We are forcing teachers to teach subjects and topics they are

not prepared to teach. We desperately need technology literacy for teachers, which can then be translated into the classroom with better knowledge being passed on.

This past fall, The National Academies issued a report at the request of Congress entitled "Rising Above the Gathering Storm." The report made several recommendations including Increase America's talent pool by vastly improving K–12 science and mathematics education. Congress has responded, through the efforts of Senators Alexander, Bingaman, Domenici and Mikulski, with proposed legislation (cosigned by over 60 Senators) that picks up on the recommendations cited above.

I remember years ago when I worked at Southern California Edison, we undertook a comprehensive survey of our customers asking them, "Where does electricity come from?" Most people said "Out of the plug in the wall." Others even said "lightning" and "static electricity." The study revealed that most people didn't even realize that electricity comes from fuels such as coal and natural gas, nuclear generators, hydroelectric facilities, or renewable energy systems. Many people in this country had no idea how electricity was generated or transmitted.

Mark C. Hall, Senior Vice President, Primary Energy: I don't think we have an energy technology issue at all. We have a deployment problem. We have lots of technologies that already work. And people will still work on developing them in terms of efficiency or capital cost through market competition, but we still have an under-deployment of energy technology. We don't recognize the benefits for most of these technologies. So the technologies themselves, in this case, are perfectly functional. What prevents their use is a larger, social, political, cultural, and economic issue.

Mark Levine, Environmental Energy Technologies Division Director, Lawrence Berkeley National Laboratory: I see at least four. First, there is the general lesson of how slow technologies actually come into the market. There is no such thing as a quick fix to anything. Products take a long period of time to make things better, and in some instances can also make things worse. Some of the energy technologies are, in themselves, very dangerous technologies. Nuclear power plants were thought never to be at risk of explosion and permitting large amounts of radioactivity to be released. We can see the same thing with air pollutants, mercury, etc. The environmental footprint of energy technologies is also very high. No matter what the economists say, though, the time of diffusion for new technologies is long.

Second, we have also learned that with a concerted effort, we can do a remarkable job reducing the environmental impact of energy technologies. Tokyo serves as a good example, and the Japanese have done a great job with their technology.

Third, one of the hardest things is how to perfect policy. In general, the technologies under development now in our national laboratories won't be in the market for at least fifteen to twenty years. How do we predict their impacts? I see the major barriers to doing the right thing not as finding out the one thing is right for the country, but in pushing many things forward in the direction that they are needed.

Fourth, and finally, many non-sensical energy solutions have been bought by politicians who didn't know any better. A good sales person can cause the country to waste immense resources. Here we see the clearest example as to how energy technologies can invoke a clash of values: the opportunity of capitalism and selling technologies and the opportunity of conservation, harmony, and balance with the environment.

Paul DeCotis, Director of Energy Analysis, New York State Energy Research and Development Authority: I view energy technology as fundamentally different from most other technologies. Energy technology in particular is productivity-based – consuming energy and receiving some service, *e.g.*, light, heat, etc. I think of most other technology as enabling and facilitating, and making things possible that have intrinsic value or personal value, or free up time or allow us to get more satisfaction than something else, like information technology, for example. For the most part, I think society has learned that information technology and entertainment technology offer greater value to investors than energy technology.

Rodney Sobin, Innovative Technology Manager, Virginia Department of Environmental Quality: I see two. First, the problems of politics and expertise. Most Americans don't have any idea what has to happen so that electricity is delivered to their home. Thus they oppose wind turbines because they may ruin, in their mind, the view of a mountain top, but they never actually consider that the alternative to that turbine is more smokestacks, cooling towers, and even fly-ash and acid rain, which ultimately end up hurting the mountain much more. People don't campaign against birds hitting windows, cars, or cell phone towers, but they will campaign against birds hitting wind turbines. I think it demonstrates a lack of understanding of context and tradeoffs. It may also be something about how we perceive risks. This is true of many things—e.g., worrying more about a landfill's impacts than that of the exhaust from the trucks going to the landfill, fearing flying more than driving, and so on.

And second, I see the larger issue of external costs and assigning worth. Energy policymakers in this country tend to immediately defer to supply-side, technological solutions to energy problems, rather than longer-lasting, demand-side practices. I mean, the cheapest and cleanest power plant is the one you never have to build. But instead, we assign more worth to supply-side technologies, and we also assign more worth to cheaper priced electricity, even if that cheaply priced electricity exacts larger, social costs in terms of environmental destruction and human suffering. Our error bars and our studies need to be different. Sure, it's hard to predict and estimate external costs, but it is better to be roughly right than precisely wrong.

Ryan Wiser, Staff Specialist in Renewable Energy Systems, Lawrence Berkeley National Laboratory: This may not be a unique lesson, but many intermediaries exist between energy technologies like a wind turbine generating electricity and an inducted customer. Those intermediaries, in the form of electric utilities, have immense impact on the types of technologies that can be developed and deployed. In the energy sector, the influence of utilities has been and continues to be profound. This seems unlike any other

technological system, since the separation between technology and the end user is so great.

Sam Fleming, Former Program Manager for Renewable Energy Systems, Nextant Incorporated: Well, I think in terms of policy, no brand-new energy technology has or will make it on its own without some assistance from government sources in early stages of development, in my view. This was true of, nuclear energy, petroleum production and renewables. Each of these required significant government support, initially, to get off the ground. If you want to incentivize the development of new technologies, I think the lesson is that you need to (1) really bear down on the projected economics, taking the false optimism out of it, and make sure that you are rigorous, self-disciplined, and never overestimate potential in your projections; and (2) recognize that there are multiple criteria for energy systems. Take new nuclear technology as an example: the requirements embrace all of safe design, security (proliferation resistance), good economics, start-to-finish responsibility for the fuel cycle. And that means addressing and estimating the impacts of those systems requires a cradle-to-grave analysis that includes the entire system. Three out of the four criteria is not enough, we need all four!

Historically, we have tended to exclude the measurement of externalities. Today we cannot ignore those externalities, and it takes tremendous discipline to see the whole fabric, the advantages and potential downsides of different energy technologies. So it's a great challenge, and good people are now looking at the whole chain triggered by the possible adoption of a new technology. So while it maybe hasn't been done all that well in the past, it must and is being done today.

Steffen Mueller, Senior Research Economist, Energy Resources Center at the University of Illinois at Chicago: There is a total indirection between technology development, deployment, and the regulatory directions those technologies face. The energy industry is a great example of that where you have left over utility monopoly structures impeding the deployment of more modern, efficient, smaller systems.

Tommy Thompson, Energy Manager, Virginia Department of Mines, Minerals, and Energy: That is a rather involved question. The first thing that comes to mind is that there is no simple solution, no free lunch, no magic spell, no silver bullet to society's energy problems. Everything has an associated cost, and you can either pay for it up front or pay for it later. We can do something with cleaner fuels, or we can then fight the pollution that falls from the sky. One way or another, there are costs for every type of technology, every type of energy. Who ends up paying that cost, and when, is very much part of the problem. Virginia has a lot of coal, but most of it is high sulfur, nobody wants you to burn it here, so you send it overseas and import low sulfur coal. It's a question of how you do it, where you pay the cost. With every fuel source and technology, there are costs, and the most difficult are those that are long term and difficult to attach a monetary value to.

Toben Galvin, Senior Energy Analyst, Vermont Energy Investment Corporation: I think one lesson learned from energy efficiency is that it is incorrect to market the

benefits of a given technology based on a sole attribute. It seems you need to give equal and sustained attention to the marketing of technologies based on a variety of attributes, such as health, comfort, ease of use, and cost savings, to name a few. For technologies to be widely used, they must have a user friendly interface and an element of universality. Look at compact fluorescent fixtures: so many types exist, which makes it complicated for retailers and general customers to figure out what is going on. If you want technology to be widely adopted, there must be an element of consistency to it.

Vikram Budhraja, Former President of Edison Technology Solutions, Edison International Company: No one technology is ever going to be a complete winner. We need a diversified basket of technologies.

Also, I think people, especially in the policy arena, overlook a fundamental fact in the production of electricity. That is almost all systems require the input of some type of fuel. And that's the beauty of renewable energy: no fuel input. Otherwise, when we talk about CHP, fuel cells, and so forth, all of these technologies have fuel input, and the competitiveness of those technologies rises and falls on the basis of efficiency differentials. In short, with non-renewable technologies, we can never get rid of the fuel requirement. And I think we will see renewables grow in favor, especially with natural gas prices continuing to rise. Look at the cost of electricity now, for instance. With natural gas prices at $6 to $8 million BTU, the cost of production for electricity is around $70 to $80 per MWh. The capital component of that is only around $20. You can reduce the capital by half and go from 20 to 10, but you still need to address the 80% of the cost tied to the fuel. With natural gas prices spiking to $15 per million BTU as it did in January 2006, the cost of electricity increased to $150 per MWh. That is why having renewables to diversify the fuel mix, stabilize prices and reduce price volatility is a very critical factor.

Appendix 3: Political Support for Renewable Energy Technologies

In addition to their environmental, financial, and social benefits, renewable energy technologies have benefited from a variety of political incentives—often in the form of tax credits and government procurement. While such support has been significant over the past thirty yeas, the incentives for renewable energy have been implemented in a piecemeal manner by federal and state governments. Like overall energy policy in the United States, legislation dealing with renewable energy has never taken a comprehensive nor integrated perspective. Therefore, the incentives that exist often resulted due to the special interest of certain parties and policymakers or as unintended consequence of neglected pieces of legislation.

This appendix is designed to accomplish two tasks. The first is to provide those interested in renewable energy with the knowledge of how they can take advantage of current political incentives should they wish to build or deploy their own renewable or distributed energy resource. The second is to demonstrate that the spotty record of incentives can be seen in federal legislation, which has created several incentives that were later rescinded or allowed to expire, creating a further (and ironic) disincentive towards renewable energy. Some federal incentives remain, though their on-again/off-again nature has contributed to boom and bust cycles of construction of renewable facilities (especially wind turbines). Furthermore, uncertain or inconsistent incentives, such as ones that may depend on annual reauthorization or appropriation, serve as disincentives to businesses because electrical generation projects—renewable or nonrenewable—generally require several years to plan and implement and depend on predictable long-term cash flow estimates.

General Federal Incentives

Largely as a result of the "energy crisis" of the 1970s, federal and state governments instituted a variety of policies for encouraging renewable energy technologies. Presidents Nixon and Ford hoped that concerted efforts would yield "energy independence," which generally meant the end of reliance on unstable foreign supplies of energy (largely oil). Going beyond rhetoric and some modest legislation, President Carter proposed an aggressive energy policy that included incentives for increased domestic production of energy (including the use of renewables) and energy efficiency. Seriously watered down by Congress, his policy nevertheless provided several valuable incentives for renewables. President Reagan allowed provisions of many of the energy laws to expire, along with them incentives for renewable energy and energy efficiency. Market forces, which he encouraged, and the collapse of OPEC discipline, led to more than a decade of relatively low energy prices, which diminished interest in alternative energy technologies. In contrast, the recent rise in energy prices may serve as an incentive to entrepreneurs and homeowners to pursue renewable energy and energy efficiency.

Policies supportive of renewable energy consisted of legislative mandates—one in particular—that enabled novel technologies to be used within the formerly regulated

electric utility industry. More commonly, legislation offers financial incentives (such as tax credits) to encourage development and installation of renewable technologies.

Legislative Mandate

The major legislative mandate spurring work on renewable energy technologies consisted of the Public Utility Regulatory Policies Act (PURPA) of 1978 (P.L. 95-617). Passed as one of five diluted measures of President Carter's national energy plan, the law primarily encouraged electric utility companies to reform rate structures so customers would reduce wasteful consumption of power. But one part of the law also had wide-ranging effects on companies and individuals that sought to use nontraditional sources of energy to produce electricity: it required power companies to purchase electricity produced by nonutilities if generated from highly efficient cogeneration plants and from renewable energy facilities.[1] Previously, utilities could decline to purchase such power created by these small-scale, decentralized producers, or they could offer low prices. PURPA, on the other hand, mandated that utilities purchase this power at rates that equaled their own cost of producing electricity.

In some states, regulators set these rates at high levels as a way to encourage production from renewable and cogenerating plants. By doing so, they motivated large research and development efforts on the technology, which contributed to huge declines in the cost of producing power. Largely because of the stimulation of PURPA, for example, entrepreneurs developed small wind turbines (between 0.05 to 0.5 MW) for use in clusters, with the amassed electricity sold to utilities. Costs dropped throughout the 1980s and into the 1990s such that wind turbines now produce larger amounts of power (up to 3 MW per turbine) at costs comparable to fossil fuel (including natural gas) in some parts of the country, and cheaper than other non-hydro renewable resource. Solar cell technologies also saw major improvements under the impetus of PURPA: costs per kWh dropped from about 90 cents in 1980 to about 20 cents in 1995.

The effect of PURPA has been limited by subsequent legislation. While the law remains in force (despite efforts to repeal it by those who believe it encourages expensive and unneeded power), the Energy Policy Act of 1992 has created a new class of independent generators (known as exempt wholesale generators) that sell power into an open wholesale (and sometimes retail) market.[2] Moreover, some states have seriously weakened the incentives offered to generators that took advantage of PURPA's provisions. The Energy Policy Act of 2005 further amended PURPA and limits the ability of some nonutility generators to sell power to the grid.[3]

Financial Incentives

[1] The term "cogeneration" is now commonly referred to as combined heat and power (CHP), and refers to any electrical generator that also generates useable heat (or chilling) in addition to electricity.
[2] Much of these paragraphs on PURPA draw on Richard F. Hirsh, Power Loss: *The Origins of Deregulation and Restructuring in the American Electric Utility System* (Cambridge: MIT Press, 1999).
[3] P.L. 109-304, signed 8 August 2005. Section 1253 of the Energy Policy Act of 2005, "Cogeneration and Small Power Production Purchase and Sale Requirements."

Many pieces of legislation provided direct and indirect support of renewable resources over the years. For example:

- **Energy Tax Act of 1978** (P.L.95-618). The law offered income tax credits (30 percent of the first $2,000 and 20 percent of the next $8,000) to residential users of solar and wind-powered technologies. Businesses earned a 10 percent tax credit in addition to a 10 percent investment tax credit on solar, wind, geothermal, and ocean thermal technologies. Many of the law's credits were allowed to expire between 1982 and 1985, during the Reagan administration.

- **Crude Oil Windfall Profits Tax Act of 1980** (P.L.96-223). Augmenting the terms of the Energy Tax Act of 1978, this legislation boosted the residential tax credit for solar, wind, and geothermal energy technologies to 40 percent for the initial $10,000 in costs. Businesses also saw their tax credit for renewable energy technologies grow from 10 to 15 percent, while extending the credits until the end of 1985. Other terms allowed for tax-exempt interest to be paid on industrial development bonds for waste-to-energy, hydroelectric, and renewable energy facilities.

- **Economic Recovery Tax Act of 1981** (P.L.97-34). An early piece of legislation during the Reagan administration, this law permitted accelerated depreciation of capital for renewable energy equipment. It also offered a 25 percent tax credit for spending on research and development.

- **Tax Equity and Fiscal Responsibility Act of 1982** (P.L.97-248). This law ended further acceleration in the depreciation formula created by the 1981 Economic Recovery Tax Act.

- **Tax Reform Act of 1986** (P.L.99-514). Though it repealed the 10 percent investment tax credit that benefited investors of renewable (and nonrenewable) energy technologies as well as the tax-free status of some industrial development bonds and other credits, it extended the business tax credits for some renewable technologies. For the first time, renewable energy technologies owned by public utilities could be depreciated on an accelerated basis. However, the business energy tax credit for wind powered systems was not extended; it expired at the end of 1985.

- **Energy Policy Act of 1992** (P.L.102-486). A major piece of legislation that sought to employ market forces to spur energy production and energy efficiency, the Energy Policy Act contained several provisions for renewable energy technologies. It gave a 10 percent business tax credit for purchases of solar and geothermal equipment. Perhaps most importantly, it offered a 10-year production tax credit of 1.5 cents per kWh for wind projects and biomass plants installed before mid-1999. The law also provided some tax credits for business investments in solar and geothermal facilities. The production tax credits were

extended by Congress annually until the end of 2003. Congress did not re-extend the credit until October 2004, with another expiration set for the end of 2005. (See Energy Policy Act of 2005, below, for more information on the production tax credits.)

- **Tax Relief Extension Act of 1999** (P.L. 106-170). As some of the terms of the Energy Policy Act of 1992 were about to expire, Congress passed this legislation, which extended and modified the production tax credit for wind turbine projects and some biomass facilities. Installations of these facilities needed to be completed before the end of 2001.[4]

- **Energy Policy Act of 2005 (P.L. 109-58).** Passed by Congress after years of debate, the law provides several incentives for renewable energy, partly in return for extensive incentives for fossil and nuclear fuel technologies. Wind power entrepreneurs celebrate the fact that the law extends the production tax credit (at a rate of 1.9 cents per kWh) until the end of 2007.[5] Previously, Congress allowed the tax credit to expire before renewing it. By providing continuity, the boom and bust cycle of investment in wind turbine technology will likely diminish. The law also requires purchase of power produced by ocean (current, tidal, or wave) technologies. Moreover, the new act provides federal tax credits for solar energy homes. According to the Department of Energy, homeowners and businesses will receive a credit of up to thirty percent of the cost of installing a solar power, solar hot water, or solar thermal system. The solar energy tax credit is capped at $2,000 for each type of system and applies to systems installed during 2006 and 2007.[6] Finally, the energy bill reauthorizes the Energy Savings Performance Contract Program, which allows private contractors to help federal agencies improve the energy efficiency of their facilities by installing more efficient technologies such as renewable energy systems.[7]

Beyond the incentives discussed above that generally subsidized the cost of producing electricity with renewable energy facilities, the federal government established programs that sought to encourage technologies by eliminating market barriers and by offering incentives to create markets for them. These included:

- Residential Energy Conservation Subsidy Exclusion (for businesses)
- Renewable Energy Systems and Energy Efficiency Improvements Program
- Tribal Energy Program Grant
- Value-Added Producer Grant Program

[4] L Mark Gielecki, Fred Mayes, and Lawrence Prete, "Incentives, Mandates, and Government Programs for Promoting Renewable Energy," *Report to the Energy Information Administration*, (February, 2001) available at http://www.eia.doe.gov/cneaf/solar.renewables/rea_issues/incent.html.
[5] American Wind Energy Association, "Energy Bill Extends Wind Power Incentive through 2007" 29 July 2005, available at http://www.awea.org/news/energy_bill_extends_wind_power_072905.html.
[6] Department of Energy, "Net Metering, Tax Credits for Solar Energy Included in Energy Act," August 9, 2005, available at http://www.eere.energy.gov/news/.
[7] See White House Press Release, "Energy Security for the 21st Century," August 8, 2005, available at http://www.whitehouse.gov/infocus/energy/.

- Energy Efficient Mortgage
- Energy Star Financing and Mortgages
- Residential Energy Conservation Subsidy Exclusion (Personal)
- Conservation Security Program Production Incentive
- U.S. Department of Energy's Alternative Fuels Data Center
- Federal Government's Green Power Purchasing Goal

Federal Energy Programs

In addition to providing incentives via legislative mandate and tax credits, the United States federal government also manages a number of related energy programs. A recent 2005 Government Accountability Office (GAO) report charged with "identifying major federal energy related energy efforts" and determining "the extent to which resources associated with federal energy-related efforts have changed" found more than 150 energy program activities and 11 tax preferences. The GAO grouped these incentives into eight major energy activity areas: energy supply, energy's impact on environment and health, low income energy consumer assistance, basic energy science research, energy delivery infrastructure, energy conservation, energy assurance and physical security, and energy market competition and education. These programs are managed by 18 federal agencies, including the Department of Energy, Department of Agriculture, and Department of Health and Human Services.[8] Incentives that directly affect renewable energy come from two of these areas: energy supply, and basic energy science research.

According to the GAO, energy supply programs and related income tax preferences accounted for more than $6 billion of the federal resources devoted to energy programs. Energy supply measures are managed by six different federal agencies that conduct in excess of sixty-five program activities. The estimated budget authority for those programs addressing renewable energy tended to emphasize research and development, which consumed $349 million in fiscal year 2003. In addition, two income tax preferences – a new technology credit and exclusion of interest on facility bonds – support renewable energy at an estimated outlay of $510 million.[9]

The second program area – basic energy science – consists of general energy related research within the Department of Energy's Basic Office of Science. While the Office of Science's Basic Energy Science Program for fiscal year 2003 had more than $1 billion allocated to it, the majority of its research focused on advancing hydrogen production, high power batteries, and nuclear fuel purification and reprocessing efforts, some of it – the GAO does not quantify exactly how much – was aimed at improving existing models for solar energy conversion and for "other energy sources."[10]

Technology-Specific Incentives from the Federal Government

[8] See Government Accountability Office, "National Energy Policy: Inventory of Major Federal Energy Programs and Status of Policy Recommendations," *United States GAO Report to Congress* (June, 2005) (GAO-05-379), pp. 1-5.
[9] Ibid, pp. 7-10.
[10] Ibid, pp. 14-15.

The incentives mentioned above (and a few highly specific measures) can be re-categorized (and supplemented) according to the technologies they support.

Wind Energy

- Public Utility Regulatory Policies Act of 1978
- Economic Recovery Tax Act of 1981. This law allows renewable energy systems to be depreciated within five years, which is a great benefit for wind energy developers. However, many restrictions exist that often diminish the value of the rapid depreciation.[11]
- Energy Policy Act of 1992
- Energy Policy Act of 2005
- Farm Security and Rural Investment Act of 2002 (P.L. 107-171). The law offers funding assistance to farmers, ranchers, and small rural businesses that purchase renewable energy systems. Approximately $23 million was made available annually for fiscal years 2003 through 2005 as grants and loan guarantees.[12]
- Wind Powering America program. Managed by the Department of Energy, this initiative provides information for installing wind turbine facilities in rural areas and on Native American lands.[13]
- Environmental Protection Agency's Green Partnership Program. Established in 1992, the program provides free technical assistance and training for those homeowners and small businesses who wish to employ renewable resources in their community.

Photovoltaic Systems (Solar Panels)

- Renewable energy production tax credit, provision of Energy Policy Act of 1992, and renewed, most recently, to expire at the end of 2005.[14]
- Million Solar Roof Initiative. This Department of Energy program supports efforts between private companies and government bodies to install photovoltaic cells on one million roofs by 2010. The program offers workshops, information, and other resources for helping to overcome market barriers and to increase the market for solar energy.[15]

Biomass and Waste-to-Energy

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[11] Restrictions include individuals who must pay alternative minimum tax rates, for example. Also, non-tax-paying entities, such as municipalities, cannot exploit the accelerated depreciation benefit. See Edwin Ing, "Full Use of Federal Tax Incentives," *North American Windpower* 2 (No. 7, August 2005), pp. 24-27.
[12] U.S. Department of Energy, "Wind Energy Provisions in 2002 Farm Bill," at http://www.eere.energy.gov/windandhydro/windpoweringamerica/ag_farm_bill.asp.
[13] U.S. Department of Energy, "Wind Powering America," at http://www.eere.energy.gov/windandhydro/windpoweringamerica/.
[14] Union of Concerned Scientists, "Renewable Energy Tax Credit Saved Once Again, but Boom-Bust Cycle in Wind Industry Continues" (December 2004), available at http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=121.
[15] U.S. Department of Energy, "Million Solar Roofs," at http://www.millionsolarroofs.org/.

- 1992 Energy Policy Act tax incentives.
- Executive Order 13134, 12 August 1999. Issued by President Clinton, the order seeks to promote biobased energy products through a comprehensive strategy of research, development, and incentives.[16]
- Agricultural Risk Protection Act of 2000 (P.L.106-224). Included in this law are provisions for grants for research and development on biomass. Title III of the law is entitled the Biomass Research and Development Act of 2002.[17]
- Farm Security and Rural Investment Act of 2002 gives discount loans and grants for closed loop biomass electricity.
- Alcohol fuels tax credit. The federal tax code contains several incentives benefiting alcohol fuels derived from biomass. Among them is a partial exemption of the excise tax paid on gasoline, a credit of $0.51 cents per gallon for converting biomass to ethanol and $0.60 per gallon for fuel other than ethanol.[18]
- 2005 "Billion Tons of Biomass" program from the United States Department of Agriculture. This program provides low interest loans, technical assistance, and public workshops for those wishing to generate bioelectricity or combined bio-fuel and bioelectricity.

Virginia Incentives for Renewable Energy Technologies

The Commonwealth offers only a few incentives for renewable energy technologies.[19]

- **Local Option Property Tax Exemption for Solar Facilities**. Enacted in 1977, this provision permits counties, cities, or towns to give total or partial exemptions

[16] The text of the order can be found at http://ceq.eh.doe.gov/nepa/regs/eos/eo13134.html. Also see U.S. Environmental Protection Agency, "Executive Orders," at http://www.energystar.gov/index.cfm?c=pt_reps_purch_procu.pt_reps_exec_orders.

[17] The text of title III can be found at http://www.bioproducts-bioenergy.gov/about/bio_act.asp.

[18] Salvatore Lazzari, "Tax Incentives for Alcohol Fuels," *CRS Report for Congress 95-261* (9 February 1995), available at http://www.ncseonline.org/NLE/CRSreports/energy/eng-12.cfm?&CFID=13165225&CFTOKEN=61811498; Internal Revenue Service, "Alcohol Fuel Mixture Credit," at http://www.irs.gov/publications/p378/ch04.html.

[19] Not included in this list is a program run by the Tennessee Valley Authority, a federal government power program that has a small presence in the state. TVA's Green Power Switch Generation Partners Program, designed for residential and small commercial customers, allows producers of power from solar photovoltaic and wind turbines to sell their output to the TVA at a rate of $0.15 per kWh. Customers must produce a minimum of 0.5 kW and a maximum of 50 kW. Residential producers can receive a TVA grant of $500 to defray construction costs. Other limits and conditions apply. The authors note it here only because the Database of State Incentives for Renewable Energy (at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1) lists it as a program available to Virginians. However, one of the authors contacted the program administrators, who noted that only certain power distributors of TVA electricity participate in it. The sole Virginia cooperative that buys TVA power, the Powell Valley Electric Cooperative, which serves three counties, does not participate in the program. E-mail correspondence from Angela R. Hamlin , Product Manager, Green Power Switch, to Richard Hirsh, 5 August 2005.

from local property taxes for the use of solar energy or recycling equipment. Twenty-one of the state's 135 counties currently offer this exemption.[20]

- **Solar Manufacturing Incentive Grant Program**. Offered since 1996 (and scheduled for expiration at the end of 2007), this program authorized up to $4.5 million annually to encourage the manufacturing of solar photovoltaic panels. Managed by the Virginia Department of Mines, Minerals, and Energy and the Virginia Economic Development Partnership, the fund pays up to $0.75 per watt (up to a maximum of 6 MW) for the first year, declining to $0.25 in the final two years (of a six year program). Since the program began in 1995, two firms built plants in Virginia, though they have since closed.[21]

- **Virginia Small Wind Incentives Program.** Administered by James Madison University's Virginia Wind Energy Collaborative, this program offers grants of up to $10,000 for landowners who install small wind turbine systems (generally producing less than 20 kW each) in 2004 and 2005. Support is limited to ten projects.[22]

Additionally, the state legislature and Virginia State Corporation Commission have enacted some rules that seek to ease the burden of the small producer of power from renewable resources. These include:

- **Net metering rules**. Among the thorniest problems for the small producer of power is receiving payment for their output (PURPA notwithstanding). Virginia's net metering law, effective in 2000, enables residential producers of power (up to 10 kW) and commercial producers (up to 500 kW) to earn credits against their consumption on a net basis. For example, if customers buy 1,000 kWh of electricity from a utility and produce 250 kWh in a month, they only pay for 750 kWh. Several restrictions still apply, and customers need to ensure that their equipment interconnects safely with the utility's equipment subject to standards established by several organizations.[23]

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[20] Va. Code § 58.1-3661, Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1, and U.S. Census Bureau, State and County QuickFacts, at http://quickfacts.census.gov/qfd/maps/virginia_map.html. Few other tax incentives could be found during a search of the Virginia Department of Taxation web site, which contains a searchable tax policy library. For example, from 1983 through 1987, the commonwealth offered tax credits for individuals and businesses that employed renewable energy technologies. Tied to federal incentives, those credits were not renewed. 23 VAC 10-120-190 amd Va/ Code § 58.1-331. Office of Tax Policy website: http://www.policylibrary.tax.virginia.gov/OTP/policy.nsf.

[21] Va. Code § 45.1-392. Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1.

[22] Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1, and JMU Virginia Small Wind Incentives Program website, http://vwec.cisat.jmu.edu/vswip_program.htm.

[23] Va. Code § 56-594, and Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1.

- **Interconnection standards**. The State Corporation Commission established simplified interconnection rules for small residential (up to 10kW) and commercial (up to 25kW) customers so they could exploit the net metering rules, noted above. Customers still need to meet many technical standards and must pay for inspections and insurance.[24]

Incentives in Other States for Renewable Energy

Compared to some other states, Virginia offers few incentives for renewable energy technologies. Elsewhere, policy makers have created at least two major mechanisms to encourage development and use of renewable energy technologies. These mechanisms were often established (or promised to be established) during legislative negotiations that led to the partial deregulation of the states' electric utility networks. Advocates of environmentally preferable technologies sometimes played major roles in the restructuring legislation, enabling them to win concessions for support of renewable technologies after state regulation ended. They argued that, in the absence of state regulation, nothing would encourage power companies to stimulate use of energy-efficiency and renewable energy technologies.

The most common mechanisms for increasing renewable energy production consist of the public benefit fund (PBF) to support development of new technologies and the renewable portfolio standard (RPS).

Public Benefits Funds

Public benefit funds (also called system benefit funds) originated in the 1990s, at a time when state policy makers considered electric utility restructuring legislation. Afraid that gains made in pursuing research, development, and implementation of environmentally preferable renewable energy technologies would end after regulators lost their sway, advocates of the novel technologies in some states won concessions for a new funding mechanism for high risk or long-term projects. The funds' income came from a small addition to the price of electricity paid by customers of companies that distributed power to them. It could not be avoided simply because customers bought power from a nonutility company in a deregulated system.[25] First implemented in Washington State in 1994, the charges were endorsed by the Federal Energy Regulatory Commission in 1995 as a way to fund services that had previously been included in customers' bills of regulated utility companies.[26] As part of the negotiations for California's restructuring

[24] Regulation 20 VAC 5-315-40 , Va. Code § 56-578 , and Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1.
[25] Eric Hirst, Ralph Cavanagh, and Peter Miller, "The Future of DSM in a Restructured US Electricity Industry," *Energy Policy 24* (April 1996), p. 311.
[26] Washington Utilities and Transportation Commission, DSM Tarrifs UE-941375 and UE-941377, Olympia, WA, 1994, and FERC, "Promoting Wholesale Competition Through Open Access Non-Discriminatory Transmission Services by Public Utilities and Recovery of Stranded Costs by Public Utilities and Transmitting Utilities, Notice of Proposed Rulemaking and Supplemental Notice of Proposed Rulemaking, Docket Nos. RM95-8-000 and RM94-7-001, Washington, DC, 1995, cited in Hirst, "The Future of DSM."

law, environmental advocates won a provision for a public benefit fund that would expend at least $872 million on energy-efficiency work from 1998 to the end of 2001. For renewable energy programs, the fund would allocate $540 million.[27] To develop renewable energy technologies and other programs that would likely wither after deregulation, the California Energy Commission created its Public Interest Energy Research program, which initially drew about $62 million annually from the state's PBF.[28]

By mid-2003, twelve states had created PBFs. Seventeen organizations that administer the funds, which are scheduled to total $3.5 billion in a decade, collaborate through a nonprofit organization, the Clean Energy States Alliance. Seeking to expand the use of clean energy technologies (with special emphasis on solar, wind, and fuel cells), the organization sponsors original research and collects information and analyses. It seeks to increase the efficiency of the research of state organizations by eliminating duplication of efforts and by providing forums for the states to share knowledge and insights.[29]

Virginia, it should be noted, is not one of these twelve states. It currently has no means for setting aside funds for research and development on new and renewable technologies. These technologies may benefit the public interest, but they may not immediately provide financial benefits to utility companies or independent generators.

Renewable Portfolio Standards

Along with public benefit funds in some cases, eighteen states and the District of Columbia have established "Renewable Portfolio Standards" (also known as renewable electricity standards) that seek to increase the amount of environmentally friendly generation capacity.[30] Simply put, the RPS is a legislative mandate that requires all producers of power in a state to employ renewable energy technologies to produce a certain percentage of capacity by a fixed date. Generating companies have the option of either building renewable facilities themselves or buying credits from other companies that own them. By giving companies this choice, the RPS creates a market for credits in a way similar to the federal trading of emissions credits under the Clean Air Act amendments of 1990. It therefore blends the benefits of "command and control" with the free market approach.

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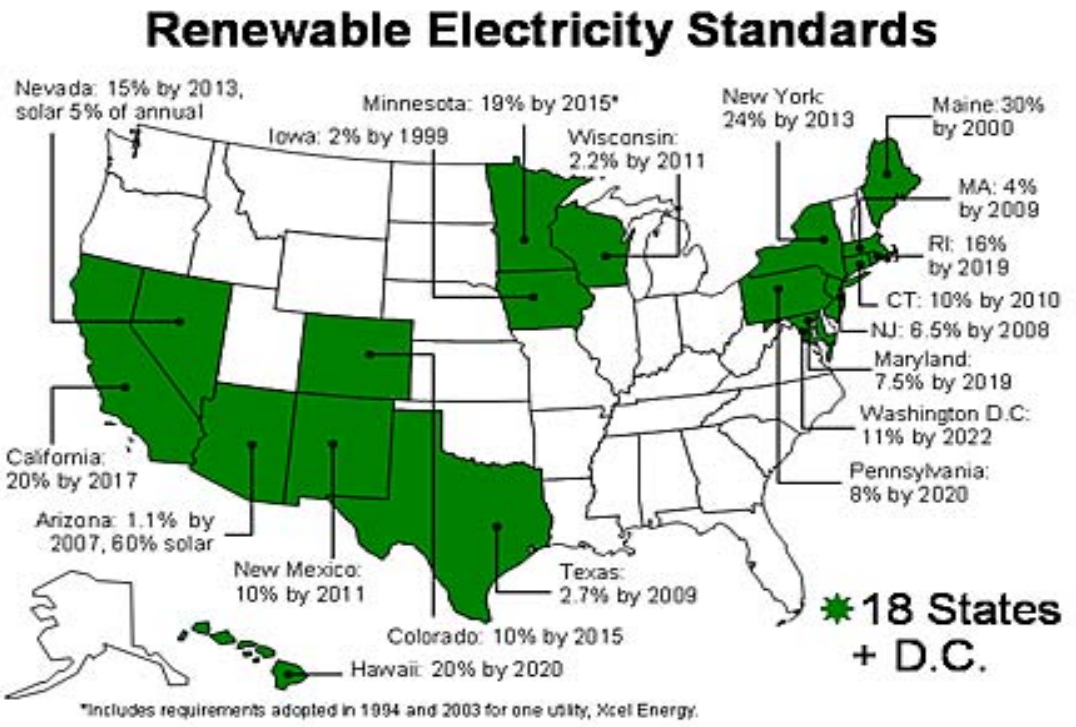
[27] California bill, AB 1890, Article 7, Research, Environmental, and Low-Income Funds, Section 381(c)(1) to (c)(3). The law also mandated utility funding of low-income programs at 1996 levels or higher. Ibid., Section 382. See also R. Wiser, S. Pickle, and C. Goldman, "California Renewable Energy Policy and Implementation Issues--An Overview of Recent Regulatory and Legislative Action," Report LBNL-39247, UC-1321, September 1996. Recommendations on how to allocate funds for renewable technologies are included in California Energy Commission, Renewables Program Committee, "Policy Report on AB 1890, Renewables Funding," no date, but an accompanying letter was dated 7 March 1997.

[28] An overview of the PIER program can be found at http://www.energy.ca.gov/pier/.

[29] Clean Energy States Alliance, at http://www.cleanenergystates.org/index.html.

[30] This datum comes from the Union of Concerned Scientists, which has prepared a thorough overview and analysis of current RPS programs.



(Source: Union of Concerned Scientists and the Oak Ridge National Laboratory)

Advocates of the RPS approach argue that the mechanism creates a market for renewable energy technologies and therefore spurs research, development, and implementation of the facilities. It also demonstrates to policy makers the practicality, cost-effectiveness, and non-financial benefits (such as lower pollution) that these technologies provide. As the market for renewable energy technologies grows, manufacturers gain experience and further drive down the cost of clean electricity production.

Each state that has developed an RPS defines renewable energy slightly differently.[31] Moreover, states have chosen different amounts of renewable capacity to be used by various dates. Iowa, for example, set a goal of 2% of capacity to be implemented by 2011. New York and California, by contrast, have set goals of 24% and 20% by 2013 and 2017 respectively. Since these states have large established bases of power, these percentages would yield huge amounts of renewable power. The Texas RPS has often been cited as a huge success. Governor George W. Bush signed legislation establishing the RPS in 1999, requiring 2,000 MW of renewable energy to be constructed by 2009.[32] But because of the good renewable resources in the state (largely wind) and improving

[31] Union of Concerned Scientists, "Renewable Electricity Standards at Work in the States" at http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=47

[32] Ryan Wiser and Ole Langniss, "The Renewables Portfolio Standard in Texas: An Early Assessment," *Lawrence Berkeley National Laboratories Report LBNL- 49107* (2001).

technology, producers had already installed 1,293 MW by the end of 2004, most of it consisting of wind turbines.[33]

Virginia does not have a renewable portfolio standard. An RPS had been included in the Senate version of the long-debated federal energy bill. It would have required 10% of the nation's power to come from renewable technologies by 2020.[34] However, legislators deleted the provision of the RPS before final passage of the Energy Policy Act of 2005.[35]

Energy Efficiency Portfolio Standards

Perhaps one of the most innovative techniques for promoting more efficient electricity generators comes from new legislature requirements enacted in Texas. Texas is the first state to promulgate energy efficiency portfolio standards (EEPS) for its distribution utilities, thereby mandating reductions in load growth. While similar to systems benefit funds, EEPS establish small funds set in terms of tenths of a cent, or mills per kWh, that are assessed as a non-bypassable charge on the utility's transmission and distribution service. All customers in an affected area or class pay the same charge, with the fines collected then distributed to cover a variety of resources (from financial assistance for low-income residents to mandatory renewable generators). In contrast to systems benefits funds, EEPS set an energy savings target rather than a distinct systems benefit charge level. An independent study undertaken by the American Council for an Energy Efficiency Economy estimated that EEPS could save the country 74.2 TBtu by the year 2020.[36]

In 1999, the Texas Legislature restructured the state's electric utility industry and in the same bill required that its distribution utilities meet 10% of its projected load growth through a portfolio of energy efficiency programs. The projects are self selected based on Standard Offer and Market Transformation programs approved by the Public Utility Commission. In the deregulated sector of Texas, which is about 70% of total load, the distribution/wires companies can choose to implement Standard Offer Contracts with an Energy Efficiency Service Provider (EESP). The EESP receives a standard payment based on the amount of energy and peak demand savings attributed to end-use customer sites where the measures are implemented. The Standard Offer or incentive payment is 50% of the avoided cost (for the next gas-fired power plant and associated energy costs)

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[33] David Garman, "Diversification of Power Generation," *Hearing Before the House Committee on Energy and Commerce* (March 8, 2005) The American Wind Energy Association, a lobbying group for wind power technologies, noted that the cost of power from the new wind farms in Texas is lower than electricity produced from new natural gas plants. See AWEA, "The Renewables Portfolio Standard: Recent Experience," at http://www.awea.org/pubs/factsheets/nyrps001.pdf.

[34] "Senate Adds RPS, but not Climate Change Provisions, to Energy Bill," Foster Electric Report (22 June 2005), report no. 412, p. 1, online version; and "Energy Policy: Senate Energy Debate Might Last Beyond Next Week," Environment and Energy Daily (17 June 2005), online version.

[35] Senator Patrick Leahy (I-Vermont) commented that the Senate bill would have done more to solve the nation's energy problems than the compromise bill that emerged from the House-Senate conference. "The Senate sent a good energy bill to conference," he said, "and we got back a frog." Discussion of Conference Report of Energy Policy Act of 2005, *Congressional Record—Senate* , 29 July 2005, 109th Congress, 1st Session, 151 Cong Rec S 9335, Vol. 151, No. 106, p. S. 9339.

[36] Prindle et al. 2003.

for residential and 35% of the avoided cost for commercial energy efficiency measures. Funds for achieving the energy efficiency goal will be included in each service area's transmission and distribution rates.[37]

International Incentives for Renewable Energy

As a final comparison, it is worth noting that renewable energy technologies have been successfully promoted with government policies in other countries. Wind turbines have been the most popular renewable technology, largely because of their cost effectiveness. At the end of 2004, Germany led the way with the highest total amount of installed wind power capacity (16,629 MW), providing about 6% of the country's total power consumption. Spain followed in second place (with 8,263 MW), followed by the United States (6,740 MW), Denmark (3,117 MW), India (3,000 MW), Italy (1,125 MW), and the Netherlands (1,078 MW).[38] Germany's success has resulted, in part, from legislation that guarantees a minimum price paid for electricity generated from wind turbines. A German federal law also sets the goal of increasing the wind power share of the market to at least 20% by 2020.[39] The long term of the incentive helps provide the security and predictability appreciated by entrepreneurs.

[37] Public Utility Commission Of Texas, "Substantive Rule, Chapter 25. Electric., Preamble Proposal for Adoption at 2/24/00, (02/23/00)" See: http://www.puc.state.tx.us/rules/rulemake/21074/022300pre.pdf Also see: http://www.puc.state.tx.us/rules/rulemake/21074/21074.cfm "Energy EfficiencyPrograms Project #21074", for other pertinent documents.

[38] "Global Wind Power Continues Expansion," news release from Global Wind Energy Council, Brussels, 4 March 2005.

[39] "The German Wind Energy Industry," Renewables Made in Germany website, http://www.renewables-made-in-germany.com/index.cfm?cid=1461.