U.S. House Committee on Science and Technology
Energy and Environment Subcommittee

Testimony of Robert J. Michaels, PhD

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I. Introduction

My name is Robert J. Michaels. I am Professor of Economics at California State University, Fullerton and an independent consultant. I hold an A.B. Degree from the University of Chicago and a PhD from the University of California, Los Angeles, both in economics. My past employment as an economist includes the Institute for Defense Analysis and affiliations with consulting firms. I am also Senior Fellow at the Institute for Energy Research and Adjunct Scholar at the Cato Institute. I attach a biography to this testimony. The findings and opinions I am presenting today are entirely mine, and they are not the official views of any of my professional or consulting affiliations.

For over 20 years I have performed research on regulation and the emergence of markets in the electricity and gas industries. My findings have been presented in peer-reviewed journals, law reviews, and industry publications and meetings. I am Co-Editor of the peer-reviewed journal *Contemporary Economic Policy*, an official publication of Western Economic Association International with a circulation of 2,500. I am also author of *Transactions and Strategies: Economics for Management* (Cengage Learning, 2009), an applied text for MBA students and advanced undergraduates. My consulting clients have included state utility regulators, electric utilities, independent power producers and marketers, natural gas producers, large energy consumers, public interest groups and governments. My services have at times entailed expert testimony, which I have presented at the Federal Energy Regulatory Commission, public utility commissions in California, Illinois, Mississippi and Vermont, the California Energy Commission, and in two previous appearances before other House committees.

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II. Background on renewables

A. Purpose of testimony

The Committee today explores questions pertinent to the fuller integration of renewable generation into regional power grids. The achievement of important energy and environmental policy goals may require additional research within this Committee's jurisdiction to support new technologies and operating practices that may be necessary if grids are to operate efficiently and reliably. I intend that my testimony provide the Committee with guidance on factors that it should consider when evaluating the research that others are presenting today, and its relevance for future policy. The most important such research is contained in a study completed last month by General Electric Energy for the National Renewable Energy Laboratory (NREL).[1] Its authors claim that new technologies and changed operating practices could enable some regions (in particular, the area covered by WestConnect, an association of transmission-owning utilities that cover parts of seven western states) to obtain as much as 35 percent of their power from wind (30 percent) and solar (5 percent) generators. Reliability considerations currently put considerably lower limits on the power that grid operators can safely obtain from such sources. Most of the witnesses on today's panel are probably strong supporters of increasing renewable resources and integrating them more strongly into existing grids. I hope that my testimony will bring some balance to the discussion, and perhaps strike a cautionary note. At the outset I wish to make clear that I do not object in principle to federal support of research in this or other areas. There may well be cases in which such support is economically warranted. My testimony will instead put the recent rush toward renewables into perspective, and conclude that recent experience in the U.S. and elsewhere requires rethinking their role in our electrical future.

B. Generation: history and choices

The desirability of integrating wind and solar resources on a large scale depends on both the costs of new infrastructure and the costs of the resources themselves. Those of renewables continue to disappoint the long-held expectations of their advocates. Instead of passing market tests that would indicate their worth, wind and solar continue to live on subsidies and state-level requirements that require utilities to procure increasing percentages of their power from

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[1] GE Energy, *Western Wind and Solar Integration Study*, May 2010.

renewables. In 2009, 44.6 percent of the nation's power was generated from coal, 23.2 percent from natural gas, 20.0 percent from nuclear, and 3.6 percent from renewables, generally defined as including biomass and waste conversion, geothermal, wind and solar sources.[2] Until very recently, their percentage contribution to the nation's power supply was even less important. In 1990 they produced 2.0 percent of it, and 2.2 percent in 2005, before beginning their recent growth to 3.6 percent in 2009. The reasons for the change are important. In 1990, 95 percent of renewable power came from biomass, waste burning and geothermal sources. These were viable power sources because, then as now, their unsubsidized costs made them competitive against fossil fuel generation in some markets. These resources had the added virtue of dispatchability – they could be run when they could lower the system's costs and left idle when they could not. Their fuel could be stored in anticipation of when their power would be most useful.

For the next 20 years, biomass, waste and geothermal power remained viable but their outputs did not grow. In 1992 they produced 70.5 gigawatt hours (gwh or million kilowatt-hours) of power, and in 2009 their output was about the same, 69.5 gwh. The growth of solar power has been surprisingly modest. In 1993 it produced 0.45 gwh, which by 2009 had grown to 0.81 gwh (below the 2008 figure). This was 0.6 percent of all renewable power in 2009, and one-fiftieth of one percent of all U.S. power. The growth in renewables since 2000 has been almost entirely in wind, to the point that by 2009 it accounted for over half of all renewable generation.

Intermittent power is expensive power, and official expectations are that it will remain so. The accompanying figure shows the U.S. Energy Information Administration's projections of the levelized cost per megawatt-hour output of the most common electrical technologies. They apply to plants expected on-line in 2016, and are expressed in 2008 dollars. The four most costly sources are, by rank, solar photovoltaic ($396/mwh), solar thermal ($256), offshore wind ($191) and onshore wind ($149). Compared with a conventional (not an advanced) combined-cycle gas plant ($83/mwh) the cheapest intermittent source is 80 percent more expensive. Nor are intermittent resources necessarily good investments if a carbon tax or cap-and-trade system is on the horizon. Adding carbon capture and sequestration (CCS) technology (whose cost is still quite uncertain but is likely to fall) to a combined cycle gas plant still leaves it 32 percent less expensive per mwh than the cheapest wind plant. At prices for carbon predicted by many models, the wind plant still loses. Note also that biomass and geothermal are expected to remain competitive with gas on a cost basis.

[2] All figures are from various documents of the U.S. Department of Energy's Energy Information Administration. A set of graphics and data are available upon request from the author.

Subsidies explain investment in wind generation. Although the 20 percent production tax credit on wind energy is now (probably) permanent, earlier in this decade it was on-again off-again. In 2000 (off) 67 MW of wind capacity were built, rising to 1,697 MW in 2001 (on). Between 2002 (off) and 2003 (on) the figures are 446 and 1,687 MW; and between 2004 (off) and 2005 (on) they are 389 and 2431 MW.[3] Many other factors influence investment, but total investment in years with the tax credit was 544 percent greater than in years without it. There is no evidence that the costs of wind turbines have fallen sufficiently since 2005 to invalidate this relationship. The American Wind Energy Association (AWEA) is aware of the importance of subsidies. As recently as last week (June 8) it explained a recent upswing in installations of small wind turbines as due to the 2009 American Recovery and Reinvestment Act (ARRA), which expanded the federal Investment Tax Credit (ITC) for small wind turbines to 30 percent.

> "The ITC was perhaps the most important factor in last year's growth …[it] helped consumers purchase small wind systems during a recession when other financing mechanisms were hardest to obtain. The enactment of the ITC [was] the industry's top priority…"[4]

The issue of subsidies is a sensitive one, with problems that hinge on what a subsidy is, etc. About the most comprehensive study of U.S. energy subsidies is a 2007 document by the U.S. Energy Information Administration. The document is unique in that its authors took the pains to examine how they applied to fuel actually used to produce electricity, which is the issue before this Committee. Thus a subsidy to the oil and gas industry, for example from some particular tax rule, is only relevant to the extent that it affects the oil and gas used to generate electricity. Specializing to fuels used in electricity, the attached graph presents the basics. Per megawatt-hour of power it produces, wind receives a subsidy of $23.37 and solar receives a dollar more. Wind gets 53 times more funds per mwh than coal, and 93 times more than gas and oil.

Note that these facts do not by themselves say much about the desirability of these transfers. Since renewables are a relatively newer industry than fuels, there might be an economic rationale for subsidies that fund basic research in them that if successful could render them truly competitive. A subsidy that simply discounted prices to purchasers of renewables or

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[3] U.S. Department of Energy, Energy Efficiency and Renewable Energy (DOE/EERE), GPRA07 Wind Technologies Program Documentation (2007), App. E at E-6.
http://www1.eere.energy.gov/ba/pdfs/39684_app_E.pdf

[4] AWEA Small Wind Turbine Global Market Study, Year Ending 2009, 4.
http://www.awea.org/smallwind/pdf/2010_AWEA_Small_Wind_Turbine_Global_Market_Study.pdf

reduces their taxes would be harder to rationalize. According to the Energy Information Administration, "tax expenditures" (i.e. reductions) to the coal industry (including those for coal not used to produce power) were $264 million in 2007, while R&D subsidies (possibly necessary if we are to have "clean coal") were $522 million.[5] Tax expenditures for renewables were $724 million, primarily the production tax credit for wind, while the R&D that might make them truly competitive was only $108 million.

III. U.S. renewables, present and future

As the U.S. and other nations accumulate experience with wind generation, its virtues and its shortcomings are becoming evident. Small amounts of wind power are easily integrated into existing grids because a sudden calm is operationally no different from a small outage. Wind, however, blows the most when it is not needed, and increasing grid sizes and wind resource concentrations will not completely resolve the basic problems of intermittency. In 2006, California had 2,323 MW of wind capacity and was operating under record loads in early summer. Wind's average on-peak contribution (scattered over the diverse northern and southern climates) was 256 MW.[6] For system planning purposes, ERCOT, the Texas grid operator, currently sets a wind turbine's "effective capacity" at 8.7 percent of its nominal amount.[7] The costs of more wind will include that of transmission that links it with consuming areas, which will usually operate at only a fraction of its capacity. When it is fully loaded, however, however, markets supplied by wind behave oddly. Texas' wind capacity is mostly far from load centers, and its power is priced by market bidding. As they compete for access to the constrained transmission lines, prices are bid to lower levels. In Texas, however, those prices are quite frequently becoming negative, 14 percent of all hours in 2008.[8] This growing problem

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[5] Federal Financial Interventions and Subsidies in Energy Markets 2007 (2008), 105. http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/pdf/subsidy08.pdf

[6] Robert J. Michaels, "Run of the Mill, or Maybe Not," *New Power Executive*, July 28, 2006, 2. The calculation used unpublished operating data from the California Independent System Operator.

[7] Lawrence Risman and Joan Ward, "Winds of Change Freshen Resource Adequacy," *Public Utilities Fortnightly,* May 2007, 14 -18 at 18; and ERCOT, *Transmission Issues Associated with Renewable Energy in Texas, Informal White Paper for the Texas Legislature*, Mar. 28, 2005 at 7. http://www.ercot.com/news/presentations/2006/RenewablesTransmissi.pdf

[8] Peter Hartley, Some Preliminary Comments on Wind Generation in ERCOT, presentation graphics, Rice University, n.d. http://www.rice.edu/energy/research/carbonsolutions/Hartley%20Presentation%20Aug09Workshop-SECURE.pdf

is indicative of both a need for transmission and strong evidence on the effects of subsidies. Wind generators will pay to put power into the grid because subsidies are high enough that they retain a small profit after making that payment.

Some might view negative prices in Texas as curiosities, or as an embarrassing consequence of an otherwise desirable subsidy system. Newer research has found that increasing the scale of wind operations sometimes produces a strikingly perverse outcome. Gas marketer Bentek Energy examined a seeming paradox in Texas and Colorado: Large increases in wind power production were responsible for decreases in the output of coal-burning generators, but emission of pollutants from those plants had had actually increased, and CO_2 emissions were unchanged.[9] Operating data showed how wind's variability meant that coal units had to make many quick output adjustments, and that those adjustments were responsible for the added pollution. Bentek's controversial conclusion was that the total load in the area could have been produced with lower total emissions had the wind units never existed.

Another possible problem for wind's expansion stems from the country's dual regulatory system for power. State regulators have the lion's share of authority over permits for and siting of generation and transmission that move power between states. An increasing number of them are unwilling or politically unable to ensure that construction of renewable generation and transmission will take place. Local intervenors who formerly blocked the construction of conventional generation and transmission are becoming adept at doing the same for renewables. Utilities in a growing number of states are becoming unable to comply with their own "renewable portfolio standard" (RPS) requirements. Once lauded for its progressive policies, California now exemplifies how to obstruct them. A 2002 law required its large utilities to obtain 20 percent of their energy from renewables by 2010. All of its utilities are currently out of compliance, and now expect to meet the standard by 2014 or later. In 2008, California got a smaller percentage of its power from renewables than it did in 2001. Other states are encountering similar problems, and these will become more stringent as compliance levels increase.[10] Through all of the questions about renewable investment, the U.S. Department of

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[9] Bentek Energy, How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market (April 10, 2010).

[10] Massachusetts utilities have largely complied with their state's RPS by obtaining generation credits from biomass plants in Maine (which has no RPS), and difficulties in siting the Cape Wind project have become national news. Many other states have maintained compliance in the same way. Maryland's utilities have done so with small hydro projects in Pennsylvania, but the start of that state's RPS will eliminate this alternative. Arizona is 25 percent compliant with its RPS, Nevada 35 percent, and similar records are appearing elsewhere.

Energy's National Energy Modeling System has demonstrated that for at least the next several decades the preponderance of new generation will continue to be in fossil-fuel plants.[11]

IV. Operations and economics

A. Operational realities

Any possible increase in U.S. commitment to wind power should be viewed in light of recent European experience, and it should be viewed in both economic and political terms. Denmark's vaunted ability to obtain 20 percent of its electricity from wind helps make its power costs the highest in Europe, and they can use only about half of that output. The country can maintain its mix of power sources only thanks to geography. It owns a small part of a large, centrally dispatched grid that covers Scandinavia, whose power sources are mostly hydroelectric and nuclear, and whose systems always have capacity to handle imports from or exports to Denmark, whose wind facilities are a minor part of the regional total. Denmark is relevant here not only for its economics, but for the underlying politics. The WestConnect region is only a fraction of a considerably larger grid that covers the western U.S. The bulk of the nation's hydroelectric capacity is in the Pacific Northwest, and is equivalent to approximately 22 nuclear powerplants. The ability to redirect some of this power out of that region appears to be of great importance if NREL's plan is to be feasible. As practical politics, the Pacific Northwest has long fought tenaciously to keep as much cheap hydropower as possible for its own use, and governments in that region appear unlikely to cede control over it to facilitate NREL's scenario.

B. Economic realities

America's economic performance over the past two years gives little encouragement to those who believe that government spending can generate substantial and sustained increases in employment. But even if one believes in the efficacy of a stimulus package renewables are probably a poor choice for the creation of job slots. Most jobs in that industry are in the production and construction of durable equipment and installations, with relatively few long-term operating positions. Wind advocates and critics have produced many studies on the stimulus approach, but there is a fundamental flaw in one of the most widely-used models that favor job creation. As an example of a critical study, a recent one from Spain purports to show that

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[11] See any recent volume of the Energy Information Administration's Annual Energy Outlook. I and others have criticized the model elsewhere, but the text is a consensus finding that does not depend on details of its assumptions.

governmental support for renewables actually destroys jobs rather than creating them, because renewables have surprisingly high capital requirements per worker. If so, investing elsewhere will create more employment slots, although not necessarily better-paying ones.[12] For uncertain reasons, NREL subsequently took the initiative in critiquing this study, documenting how its "JEDI" computer model showed that that pro-renewables policies in fact created new employment.[13] Calzada's study is open to criticism, but ironically NREL's model cannot possibly be the tool to make those critiques. NREL admits that JEDI is constructed in a way that renders job destruction mathematically impossible, i.e. it preordains a pro-renewables finding of job creation regardless of the data being analyzed.

V. Summary and Conclusions

The value of funding the changes that the Committee is considering depends critically on an assumption that requires far more thorough examination than it has thus far received – that wind power will be an economic choice for the nation's electrical future. Almost all of the evidence points in the opposite direction. There are two types of renewable resources: ones like biomass, waste and geothermal generators that have long occupied a small niche in markets where they have long stood on their own. The other resources, primarily wind, have yet to pass market tests and instead thrive because of subsidies and regulatory requirements that utilities purchase their output. Official data show clearly that the costs of electricity from wind and solar units are well above those of every fossil fuel, and are expected to remain high. We have seen wind's sensitivity to subsidies in the pattern of investments with and without its production tax credit, and in the statements of its trade association about the importance of those subsidies. Further, claims that all energy sources are subsidized can be quite misleading. Looking at fuel actually consumed in power production, a megawatt-hour of wind power receives 90 times the subsidy of one produced from natural gas. Most of wind's subsidy takes the form of tax breaks for producers rather than direct allocations of funds for research.

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[12] Gabriel Calzada Alvarez, Study of the Effects on Employment of Public Aid to Renewable Energy Sources, Universidad Rey Juan Carlos, March 2009. Calzada's non-peer reviewed study concluded that since 2000 each "green job" created in Spain cost €571,000, with subsidies of over €1 million for each wind industry job.

[13] Eric Lantz and Suzanne Tegen, NREL Response to the Report *Study of the Effects on Employment of Public Aid to Renewable Energy Sources* from King Juan Carlos University (Spain), White Paper NREL/TP-6A2-46261 (Aug. 2009).

Other problems are still matters for research, but as they arise they suggest that government think twice before it continues to rush electricity into heavier dependence on wind power. Wind's useful contributions to capacity are weather dependent, and wind often produces the least when it is the most needed. Integrating wind into regional markets will require substantial transmission investments, and preliminary results of work on wind power's actual impact on fossil fuel emissions are not encouraging. Regional political factors and electrical geography may further render some planned operational changes difficult or impossible to implement. Finally, as an engine of "job creation," wind power is probably a poor choice

It is always hazardous for a non-expert (or for that matter an expert) to predict policy trends. Unfortunately, this Committee will have little choice but to do so when considering the GE / NREL study. Public opinion is in flux, but absent national carbon control and / or renewables requirements, the value of implementing its recommendations will fall precipitously. Markets are also changing in ways that bring up further questions. Over the past few years wind power has grown strongly, largely fueled by subsidies and regulatory requirements. Over that same period a revolution in fossil fuels has taken place, but without such subsidies or regulations. The technologies to access natural gas in shales, tight sands and coal seams have come of age. They can now reach hitherto unimagined volumes located all around the nation at current prices, and with what most agree are minor environmental impacts. The nation's gas reserves are massively increasing, and the history of oil and other minerals strongly suggests that early estimates of reserves will turn out to have been far too low.[14] America can probably look forward to literally centuries of its own clean, safe, competitively produced, and truly secure fuel. Looking forward also means looking backward. Abundant gas means less need for power from coal and uranium, and from uneconomic renewables as well. Gas-fired generation is cost-effective, fuel-efficient, environmentally acceptable almost everywhere, and already an integral part of almost every utility's power supply. The future belongs to the efficient, and it is time to abandon the mistaken belief that efficiency and renewable are synonyms.

I thank the Committee for the opportunity to present these views, and welcome any questions or comments.

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[14] Proved U.S. gas reserves rose from 4.74 trillion cubic meters in 1999 to 6.93 million in 2008. *BP Statistical Review of World Energy*, June 2010, 22.