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Committee on Space, Science, and Technology

Hearing Assessing the Efficiency and Effectiveness of Wind Energy Incentives

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Testimony of Robert J. Michaels, PhD

I. Introduction and Purpose of Testimony

A. Biographical

My name is Robert J. Michaels. I am Professor of Economics at California State University, Fullerton. I am also Senior Fellow at the Institute for Energy Research and Adjunct Scholar at the Cato Institute. I am also an independent consultant in electricity and natural gas. 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 Staff Economist at the Institute for Defense Analyses and affiliations with various consulting firms. The findings and opinions I am presenting today are entirely mine and not the official views of any of my professional or consulting affiliations. I attach a current biography to this testimony.

For over 20 years I have engaged in research on regulation and the emergence of markets in the electricity and gas industries. My findings have been published in peer-reviewed journals, law reviews, industry publications, and at professional and industry meetings. I am also author of *Transactions and Strategies: Economics for Management* (Cengage Learning, 2010), 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, environmental organizations, 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 three previous appearances before House committees and one previous appearance before this one. Of particular relevance for today's testimony are appearances before the Vermont Public Service Board and the Washington State Energy Facilities Siting Committee, both on behalf of environmental organizations critical of proposed large wind installations.[1] My testimonies discussed in some detail the economics of wind energy in

[1] *Deerfield Wind*, Vermont Public Service Board Docket No. 7250 (2008), Testimony on behalf of Save Vermont Ridgelines; and *Whistling Ridge Energy*, Washington Energy Facilities Site Evaluation Council Docket No. 2009-01 (2009), Testimony on behalf of Friends of the Columbia Gorge.

the context of electric system operation, planning and power markets. They also examined the environmental consequences of increased reliance on wind and the results of studies purporting to show that the projects would create new employment opportunities. Today's testimony also examines several of these issues in a national context.

My testimony today is presented on behalf of the Institute for Energy Research (IER), a nonprofit organization that conducts research and analysis on the functions, operations and government regulation of global energy markets. IER articulates positions that respect property rights and promote efficient outcomes for energy consumers and producers. The organization was founded in 1989 as a public foundation under Section 501(c)3 of the Internal Revenue Code. Its funding comes from tax-deductible contributions of individuals, foundations and corporations.

B. Purpose of Testimony

This testimony responds to the Committee's request that followed the March release of Government Accountability Office (GAO) Report GAO-13-136 ("GAO Report," cited as "GAO") on federal financial support for wind-generated electricity.[2] That report enumerates and quantifies existing policy incentives, their costs, and possible rationales for their existence. These topics are important in light of the federal role in wind power's growth, which will have consequences for consumers' power bills, reliability of regional power grids, and the environment. GAO confines its report to wind technology, but some aspects of its study may also be relevant for other renewables, particularly those that can only operate intermittently such as solar generators. My testimony is also confined to federal support and deals only in passing with state financial support and "Renewable Portfolio Standards" (RPS) that set quotas on renewable power that utilities must distribute.

Putting the GAO Report in perspective requires some background on wind power and its place in U.S. electricity. Investment in wind turbines has grown substantially since the late 1990s. Today they produce 3.0 percent of the nation's electric energy, a

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[2] GAO, *Wind Energy: Additional Actions Could Help Ensure Effective Use of Federal Financial Support*, GAO-13-136 (March 2013).

higher percentage than any other non-hydroelectric renewable source. (GAO, 1) There are many possible sources of that growth, including technologies that have become more efficient, a relative abundance of sites for wind installations, active competition among producers of turbines, environmental regulations that pose lower barriers to wind than other renewables, state-level RPS laws, and the federal incentives that are the subject of GAO's report.

This testimony begins with a discussion of electric system reliability and the effects of increasing use of intermittent power resources such as wind. I document the operational problems that have arisen because wind turbines are not dispatchable by system operators, which are aggravated by the fact that wind in many areas produces the most power when power is least valuable. I then compare the costs of wind and fossil-fuel generation and consider recent findings of shorter useful lifespans for wind generators than originally expected. Further growth of wind in many areas will also require investments in transmission whose only use is to move wind power from isolated facilities to consuming areas. Unlike most other transmission facilities, such lines neither reduce the cost of delivered power nor improve reliability. I then consider the environmental effects of wind's growth, which need not be better than those of alternative generators despite the fact that wind turbines do not burn fossil fuels. I go on to discuss how once-popular reasoning that favored wind as a way to "diversify" generation are becoming irrelevant with the growth of unconventional gas production and increases in gas and oil reserves. Finally, I consider and find reason to reject the frequent claims of wind advocates that federal support policies have brought such macroeconomic benefits as job creation and rising incomes.

With these facts as background I then consider the potential significance of GAO's data on federal support for wind power, an activity entailing at least $4 billion in direct grants to producers and tax expenditures (i.e. selective reductions), as well as loan guarantees and other programs. I then examine how strongly GAO's economic arguments support its stated belief that these programs will bring the economic benefits of improved wind generation technologies. I find that the report's data is likely to be inconsistent with these arguments, and that neither the data nor the arguments provides a sound rationale for the programs under investigation. Specifically, less than one percent of these funds are spent on development activities that could potentially improve wind generation technologies, and the remaining 99 percent do no more than support deployment of established technologies. This testimony is in no way intended as a criticism of GAO's findings or methods. I am an economist with no expertise in federal auditing, and I understand that the scope of the report requested from GAO is in some ways narrower than subsumed in my comments. GAO's data are important and useful, but any conclusions that the Office might reach on the basis of a wider study need not necessarily match those I have reached in this testimony.

II. The Value of Wind Energy

A. Operational Costs

Any electric system should operate as economically and reliably as possible. Excepting some industrial users who will pay low prices for interruptible supplies, most households and businesses place a high value on reliability. The integration of wind energy into an electrical grid poses peculiar and costly problems because wind turbines only produce power when the wind blows. The physical properties of electricity greatly complicate the operation of an electrical system whose resources include substantial amounts of generation capacity that produces only intermittently. Maintaining area-wide reliability requires at all times that the amount of power being produced equal the amount users wish to consume. Mismatches of less than one second will produce region-wide blackouts, whether production exceeds consumption (which overloads lines) or the reverse (which destabilizes power flows). Storing large amounts of power is prohibitively costly (except behind hydroelectric dams) and researchers have yet to produce economical batteries or other storage devices on the necessary scale. A system operator is also constrained by the fact that electric grids have no "valves" that could be used to control power flows along individual lines. This complicates operations because it means that reliability also depends on which particular generators are operating and their individual output levels.

Nonstoreability and uncontrollable flows complicate the planning of a power system's operations over a day. Reserve generators must be operating or in readiness to meet high loads that are expected in late afternoon and early evening. The grid operator must have access to resources that respond to both predictable and unpredictable events. These include operating generators ("spinning reserves") that can instantaneously make up for the unexpected loss of other generators or transmission lines, e.g. from lightning strikes. These inescapable engineering and operating problems point up the importance of generators that the operator can dispatch to cope with whatever specific difficulties might arise. A wind turbine whose output cannot be directly controlled complicates operations by adding new risks associated with wind's unpredictability. Our abilities to forecast wind over intervals that are relevant for reliability are still quite weak, and the general characteristics of wind further aggravate the problems. In most wind-rich regions the ability to generate wind power is greatest when that power is least valuable (late at night) and least during the late afternoon hours when it would be most valuable.

Wind power's inability to increase production at times of high power demand means that the most inefficient (and often most polluting) fossil-fuel generators must operate to maintain reliability and cannot be replaced by wind units. Even if wind turbines are widely dispersed around a region, the operator cannot expect with near-certainty that high wind power output in one subregion will make up for low wind power output elsewhere. California was early to put in place a substantial base of wind generation, dispersed over the differing climates of its north and south. Early in the summer of 2006 (and on later occasions as well), California faced record heat conditions that strained its ability to meet peak daily demands of 50,000 megawatts (MW). The resources included 2,323 megawatts (MW) of wind capacity. Wind's average on-peak contribution over the month of June was only 256 MW, barely 10 percent of potential production had capacity been fully utilized.[3] Data on installed wind capacity are of little or no value in predicting the actual power the system can get from it at peaks. The California Independent System Operator has on many occasions expressed concerns about its ability to maintain reliability in the face of a 33 percent RPS for 2020 that will require a tripling of wind and solar power production.[4] Likewise, the nonprofit Electricity Reliability Council of Texas (ERCOT) is responsible for dispatching the state's

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[3] 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.

[4] California Independent System Operator, *Reliable Power for a Renewable Future, 2012-2016 Strategic Plan.* http://www.caiso.com/Documents/2012-2016StrategicPlan.pdf

generation, administering its energy markets, and monitoring the adequacy of resources to meet growing demand. For planning purposes ERCOT treats a megawatt of wind capacity as equivalent to only 8.7 percent of a megawatt of dispatchable fossil-fueled capacity.[5]

Exhibit 1 illustrates the intermittency problem from several perspectives.[6] The green line in its top panel shows average monthly output of wind power as a fraction of ERCOT system load between June 2011 and June 2012. (The red and blue lines are maximum and minimum percentages attained over the month.) The seeming steadiness of the green line vanishes when we examine the daily averages of hourly production shown in Exhibit 1(B). From day to day the average percentage of ERCOT load served by wind often varies from nearly zero to over 25 percent. Exhibit 1(C) shows another aspect of unpredictability. It breaks down wind power production as a percentage of load for individual hours during May and June of 2012. Randomness is so pervasive that even hour-to-hour responses to wind availability and changing loads are difficult to predict. Given the variability of wind shown in this exhibit, further additions of wind capacity are likely to increase rather than decrease the necessary adjustment in the outputs of non-wind generation, further worsening the system's operational problems.

B. Planning for Wind Power

Many windy areas are isolated and require transmission to consuming areas. A gas-fired generator can be located (near a pipeline) where it contributes the most value to the grid, but a wind generator must be located where the wind blows and the rest of the system must accommodate itself to that locational constraint. A radial line that links a consuming area to an isolated windy site has no other uses than transmitting that power and makes only a minimal contribution to reliability. A line to a baseloaded generator will be fully loaded for more of the time with more kilowatt-hours (kwh) to

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

[6] Graphics are from ERCOT, System Planning Monthly Status Report, June 2012.

spread its capital cost over than a line to a wind source with a lower load factor.[7] The costs of wind-related transmission can be quite substantial. Over the next five years ERCOT plans on building $8.7 billion of new high-voltage transmission, approximately $5 billion going to facilities that will be solely used to transmit wind power from central and western Texas to consuming areas.[8]

Adding wind power need not require that reserves stand ready to compensate for every kwh of wind power produced, and there is some predictability that a system operator can use to economize on scheduling conventional generation. Any saving in operating costs from wind generation, however, comes with an increase in capital costs. As shown in Exhibit 2, The U.S. Energy Information Administration's forecasted levelized [i.e. annualized] capital costs of new generation for 2018 show that advanced gas-fired plants will have costs per megawatt-hour (MWh) approximately 24 percent lower than onshore wind units. The capital cost and capacity factor disadvantages of wind power are so substantial that the per-MWh total cost, including fuel, of a modern gas-fired unit is lower. Even if we could control the output of the wind unit its full cost per kwh produced would exceed that of a conventional plant. In reality the wind unit's value to the grid is considerably lower because it cannot be depended upon.[9] The difference depends on particulars of the situation, including the prices of fuels and the abilities of consumers to shift their power use over the day, as some will have with the expansion of the smart grid.[10]

As experience with wind generation has accumulated some researchers in the United Kingdom and Denmark have found that the life-cycle productivity of wind turbines

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[7] If winds across a region are highly correlated, then several wind installations in a particular locale will bring the same operating problems as if they comprised a single installation.

[8] "Nearly $8.7 billion in transmission projects planned over next five years," ERCOT Press Release, Jan. 16, 2012. Total transmission investment in ERCOT between 1999 and 2012 was approximately $6.6 billion. http://www.ercot.com/news/press_releases/show/475

[9] Perhaps paradoxically, this reasoning gives solar power an availability advantage over wind. While it too is of little use on cloudy days, the sun is always potentially available during afternoon hours when demand is likely to peak. A full analysis of solar power is beyond the scope of this testimony.

[10] See e.g. Paul L. Joskow, "Comparing the Costs of Intermittent and Dispatchable Electricity Generation Technologies," MIT, (Revised version Feb. 2011) for some numerical comparisons.

has been overstated. A typical onshore wind turbine in the UK starts with a normal load factor (operating hours as a fraction of total hours) of around 25 percent. After five years the average factor is 15 percent, after ten years it is 10, and after 18 years it is 2 percent. Most cost-benefit calculations of wind units have assumed economic lifespans of 20 to 25 years and slower declines in productivity. If these figures continue to hold, a fifteen-year economic lifespan would substantially raise wind's capital cost above its already high figure.[11] Offshore data are more limited and its technologies are newer, but available evidence suggests that rates of productivity decline for offshore wind turbines in Denmark exceed those of onshore installations.[12]

III. Wind Power and the Environment

Reliable electricity and a clean environment are both desirable, and both are costly to obtain. Wind power's operating costs are indeed negligible and wind turbines do not burn fossil fuel, but these facts alone cannot suffice to make a case for it. Economic analysis requires consideration of both the costs and benefits of wind power, and comparisons between them and relevant alternatives. Those costs include both the direct use of materials and labor to build and install turbines, and support costs that include additional fuel for reserves, new transmission lines, etc. As noted above, the per-MWh capital costs of wind exceed all-in (capital plus fuel) costs of modern gas-fired plants, even if we do not include the support costs necessitated by wind's intermittency. The capital costs of wind are incurred in manufacturing processes that, like those for fossil-fuel generators, can also release emissions that are costly to eliminate or mitigate.

Any environmental case for policies that favor wind power requires a showing that the value of additional power from wind net of all its costs exceeds the corresponding figure for dispatchable powerplants. Intermittency raises the cost of wind power by necessitating costly support to maintain reliability, a requirement that is lower

[11] Gordon Hughes, *The Impact of Wind Power on Household Energy Bills*, Global Warming Policy Foundation, 2012.

[12] Gordon Hughes, *The Performance of Wind Farms in the United Kingdom and Denmark*, Renewable Energy Foundation, 2012.

for dispatchable powerplants. Fossil-fuel plants, on the other hand, must bear the added cost of pollution controls that are necessary to reduce health risks from their operation. As a practical matter, these costs (at least for gas-fired plants) remain quite manageable.[13] [14]

In most of the U.S. wind power displaces power generated from gas. Coal-burning generators remain largely base-loaded, while gas-fired units adjust the system to both predictable and unpredictable changes in load. Gas produces relatively small amounts of EPA "Criteria Pollutants" (including particulates and oxides of nitrogen and sulfur) that substantially raise the costs of mitigating coal-based pollution. It also emits less carbon per kwh generated and does not have the long-term disposal issues of nuclear energy. If wind generation proliferates and gas-fired capacity is limited a system operator must use coal-fired units to balance the grid, as happens at times in Colorado, Texas and elsewhere. Gas marketer Bentek Energy recently found that using coal-fired generators instead of gas for this purpose has actually led to increases in emissions of Criteria Pollutants (and no reduction in greenhouse gases), even after netting out the emissions reductions due to wind. Bentek's controversial conclusion was that total load in these areas could have been served with lower total emissions of these pollutants had the wind units never existed.[15]

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[13] Whether they will remain manageable in the event carbon control becomes national policy is a question beyond the scope of this testimony.

[14] For additional details, see Robert J. Michaels, "National Renewable Portfolio Standard: Smart Policy or Misguided Gesture?" *Energy Law Journal* 29 (No. 1, 2008), 79-119; and Robert J. Michaels, "A National Renewable Portfolio Standard: Politically Correct, Economically Suspect," *Electricity Journal* 21 (April, 2008), 9-28.

[15] Bentek Energy, *How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market* (April 10, 2010). http://docs.wind-watch.org/BENTEK-How-Less-Became-More.pdf The American Wind Energy Association's attempt to refute the Bentek findings is at http://www.awea.org/newsroom/realstories/upload/110720-The-Facts-about-Wind-Energy-and-Emissions.pdf.

IV. Wind Power in Changing Energy Markets

At best, wind power is questionably economic, but that value depends on market conditions beyond those for electricity. Federal programs like those discussed in the GAO Report could (but need not necessarily) affect the energy sector's future development. Even if the programs succeed in advancing wind technology, the value of those advances is already falling. Policies favoring renewable electricity have long been justified with claims that they would ease the nation's adjustment to widely expected changes in energy markets and environmental policies. In particular, fostering wind development would help the economy adjust to ever-dwindling hydrocarbon supplies and their international complications. It could also aid in implementing climate policies that reduce carbon use.

Today, there is growing agreement that America's energy future has definitively changed for the better with the development of technologies for extracting natural gas and liquids from hitherto-inaccessible shales and tight sands. These technologies are cost-competitive with existing ones and environmentally acceptable. Renewables policies were based in large part on an expectation that the end of inexpensive gas and oil was near. Instead of exhaustion, the nation now looks forward confidently to centuries of clean, inexpensive and secure energy. Instead of a "bridge fuel" to a renewable future, shale-based hydrocarbons are now the future. When the end of natural gas appeared in sight, renewable power subsidies could have had a role to play in facilitating adjustment to it. It is now time to write them out of the drama.

Resource abundance is advancing and at the same time technological changes are expanding the roles of energy efficiency and the abilities of consumers to adjust to changes in power prices. As supplies become more abundant so do our abilities to respond to market changes. Even small users are gaining the ability to respond in real time to changes in energy prices that they could not even observe prior to smart grid and telecom technologies. In all of this, the presence of costly and intermittent wind power will convey even less value to users with new abilities to control and plan their consumption. Wind adds a costly and random element to energy prices that can only make it difficult for many customers to make rational decisions about how to use power.

V. Wind Power and the Economy

Wind power's costs must eventually turn up in consumers' monthly bills, or if not, then certainly in their future tax burden. A tax that consumers must pay to buy something of low value inflicts harm on their budgets and produces benefits for those interests that succeeded in getting it enacted. Additional federal support for otherwise uneconomic technologies cannot possibly produce "green jobs" and prosperity. How could it possibly happen if that support raises energy prices for everyone? Quite simply, taxing Person A and spending the money to employ a new green job holder must at the same time destroy a job held by Person B who would have otherwise received the taxed-away income.[16] It does not matter whether the tax takes the form of a higher power price or a collection by the IRS.

In my research I have analyzed (to my knowledge) every existing argument that attempts to link support for renewables to green jobs. In every case I have found the arguments sadly lacking, both in logic and in any measured effects.[17] I have also submitted testimonies to state regulators (on behalf of environmental groups) showing that the job creation arguments of wind advocates fail, as matters of logic, as quantitative predictions, and in actual results. DOE's National Renewable Energy Laboratory (NREL) utilizes a computer model ("JEDI") which uses input-output analysis to estimate additional employment that will result from a given renewable project. The model was discussed during my 2010 testimony before this Subcommittee, when Dr. David Mooney of NREL responded to a member's question by discussing JEDI's favorable predictions for wind investments. I responded that NREL's model is constructed so that any renewable project *must* create jobs, i.e. it is mathematically impossible for a user of that model to ever find adverse effects of wind power on employment. I also noted that NREL had as of that time had yet to compare any predicted employment effects with what actually happened. At the Committee's request, I submitted supplemental testimony on this subject, which I have attached to this

[16] I acknowledge that there are many technical complications to this reasoning in economic theory, but the sentence in the text suffices to make my point.

[17] See Robert Michaels and Robert Murphy, *Green Jobs: Fact or Fiction*, Institute for Energy Research, Washington D.C., Jan. 2009; also references in note 14 above.

testimony. The Committee also invited Dr. Mooney to submit testimony in support of his assertions about job creation. I have no record that such testimony was ever submitted.

VI. The GAO Report

A. Introduction

This background on wind power allows us to examine the GAO Report in greater depth. The Report describes and measures the various mechanisms for federal support that GAO compiled. This support includes [1] direct grants to developers including the Treasury's recently expired Section 1603 program; [2] "tax expenditures" including the Production Tax Credit (PTC) and accelerated depreciation; [3] loan guarantees, including Treasury's Section 1705 programs; and [4] research-related grants and minor programs. The report enumerates 82 distinct activities, describes them and discusses their interactions and redundancies where applicable. GAO also noted the lack of a well-defined process to assess the funding needs of grant recipients and loan guarantees, as well as the need for documentation of criteria used to determine the winners.

These initiatives "supported a range of wind issues that included siting, expediting permits, offshore wind installations, and, most commonly, utility scale and distributed land-based wind." (GAO, 10) The superficially diverse activities are in reality quite concentrated. A single tax expenditure (the Production Tax Credit) and a grant initiative, both at Treasury, accounted for nearly all federal financial support." (GAO, 10) Total 2011 actual and estimated obligations were $2.90 billion, of which the Treasury's Section 1603 grant program (no longer in existence) accounted for $2.7 billion (94 percent). (GAO, 13-14) In addition, tax expenditures accounted for "at least $1.1 billion for activities specifically related to wind," (GAO, 10) almost all from the PTC of 2.2 cents per kwh generated by qualifying installations.[18] On April 3, 2013, indexation raised the credit to 2.3 cents per kwh, a 5 percent increase.

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[18] There are smaller but similar credits for other renewables including landfill gas and small hydroelectric facilities. Most solar technologies are eligible for their own investment tax credits. (GAO, 18)

GAO acknowledges that its 2011 calculation of $4 billion in outlays and tax expenditures is incomplete because other important programs provide only totals over several sources rather than allocations specific to wind power. For example, wind is responsible for an unknown percentage of the $350 million in tax expenditures that result from accelerated depreciation. Disregarding the PTC, total tax expenditures from programs identified by GAO as potentially affecting wind power are $1.75 billion, but non-wind energy producers are also eligible for some of these benefits.[19]

B. Outlays and Tax Expenditures Under The Programs

Since the early twentieth century economists have theorized about the possible value of governmental research funding and attempted to measure its actual consequences. We are all familiar with claims that governmental support was essential for the rise of digital technology and the Internet, but numerical evidence that might verify these conclusions is largely missing. For every claim about its importance (or unimportance) counter-examples seem easy to find. Was governmental support necessary to bring about the Internet? Was the development of hydraulic fracturing achieved with little or no governmental research funding?

GAO makes no claim that absent these policies wind technology development would be at a standstill. It made no attempt to value of the programs' accomplishments with the amounts spent.[20] The Report, however, contains some assertions about value, along with references to economic theory that could support a case for the efficacy of the programs. GAO listed the activities that could support innovation as including "basic research, applied research, demonstration, commercialization and deployment," (GAO, 7) before restating established economic logic:

> … [U]nless the government intervenes, the amount of research and development (R&D) that the private sector undertakes is likely to be inefficiently low from society's perspective because firms cannot easily capture the "spillover

[19] GAO, 80. This total includes $350 million from accelerated depreciation, which GAO says is the upper limit on that category.

[20] Because ideas take time to become marketable technologies, there is also the possibility that the policies discussed in the document will be long-term successes. There is no evidence either way on this.

> benefits" that result from it. That is particularly true at the early stages of developing a technology. Such research can create fundamental knowledge that can lead to numerous benefits for society as a whole but not necessarily for the firms that funded that research; thus government funding can be beneficial. (GAO, 6 – 7)

This theory could be a foundation for governmental support, but the case for it depends critically on the types of programs being funded and the incentives they provide for recipients. In particular, both the PTC and formerly available Section 1603 grants appear quite unsuitable as rewards for innovation. Instead of being directed to research the PTC is given to existing wind installations (roughly) in proportion to their output rather than being based on superior efficiency (e.g. as in incentive-based utility regulation). Likewise, Section 1603 funds were an alternative to the PTC whose payments did not bear any relation to the actual efficiency of a plant. Some programs discussed by GAO probably do incentivize the development of new technologies. An actual count of inventions and improvements generated by this funding apparently does not exist, and there are also no available calculations of the overall effect of the programs on the costs of producing wind power. The fact that newer turbines are more efficient than older ones cannot possibly suffice for a conclusion that the funds in question have spurred technological progress. It is important to note that while R&D-specific funding is more likely to advance technology than deployment subsidies there has been no demonstration of the former's cost-effectiveness. Nothing in this testimony should be construed as support for such funding.

Another look at the data casts additional doubt on that case. The Report's calculations show that in 2011 the PTC and Section 1603 accounted for all but a few percent of total federal support for wind. Disregarding the PTC, total Treasury obligations (which it has little discretion about paying) were $2.7 billion of a $2.9 billion federal total. (GAO, 10) Further, "less than half of the [remaining] initiatives [i.e. the $0.2 billion difference] supported other types of recipients such as public and private researchers or individuals." (GAO, 10) Thus approximately 99 percent of the payments discussed in the report went to support deployment. Without additional evidence GAO cannot justifiably claim that deployment itself is a "technology advancement activity" (GAO, 18) In summary, GAO argues on theoretical grounds that the programs serve to advance technology, but almost all of the funds in these programs go to activities that are very unlikely to generate such advances.[21]

Likewise, GAO presents well-known data showing that in years when the PTC was in effect investment in wind was high, and the opposite for those years when it was not. (GAO, 8) This too cannot possibly demonstrate the value of the programs since it is simply a statement that investors will increase their commitments when assured of higher returns by the PTC. More importantly, it is hard to classify the PTC as a “federal investment," (GAO,8) since the credit goes to any qualified wind facility that chooses it over a Section 1603 payment.

I conclude that GAO has produced no evidence that links improvements in wind technology to the outlays and tax expenditures compiled in its Report.

VII. Conclusions

1. GAO has produced a useful summary and breakdown of federal activities to support wind energy development. Economic theory suggests that to support technological progress in the development of wind power technologies funds should be allocated directly to those who are attempting to invent better technologies, rather than to support production by existing wind operators. In reality, approximately 99 percent of total federal support takes the form of subsidies to deployment rather than investment in basic or applied research. There is no evidence that these subsidies have played any important role in advancing the technology.

2. The question of federal support for wind generators should be reconsidered in light of what is known about the limited contributions that wind power actually makes, and the high cost of obtaining them in light of wind’s intermittency.

[21] GAO cites as possible support the 2011 *Wind Technologies Market Report* issued by the Department of Energy’s Energy Efficiency and Renewable Energy Division, which it says shows that "recent improvements in the cost and performance of wind energy technologies contributed to the growth of wind energy in 2011." (GAO, 9) I can find no statements in that report that link the programs under discussion with improvements in cost and performance.

3. Wind power's effects on the environment are not necessarily benign, even if the production of wind power burns no fuels directly. Wind requires additional backups in the form of generators that burn fossil fuel, the capital costs of wind generators are higher than those of comparable gas-fired units, and supplementary investments in transmission are frequently necessary to connect wind generators.

4. Wind's value depends on the costs and benefits of alternative sources of power. The revolution in hydrocarbon technologies that began quite recently eliminates any rationale for continuing to support wind power on grounds that natural gas and oil are being rapidly exhausted.

5. Wind cannot be supported on grounds that it produces "green jobs." There is no evidence that it does so and no theoretical support in economics for claims regarding green jobs. Existing methods of estimating green jobs are in fact one-sided contrivances whose only possible prediction is that building renewables must increase employment. The conclusion is not based on observations, but is built into the mathematics that underlies the prediction.

Exhibit 1(A)

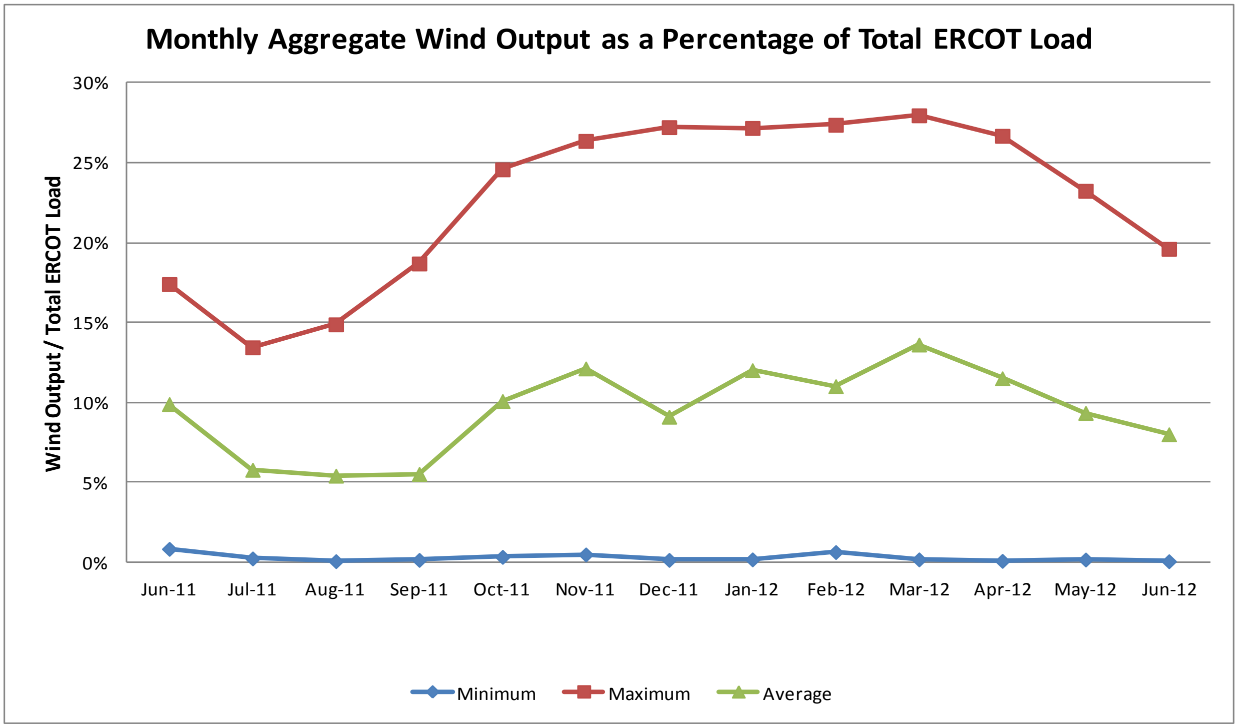

Exhibit I (B)

One-hour average of total wind power output as a percentage of ERCOT load.

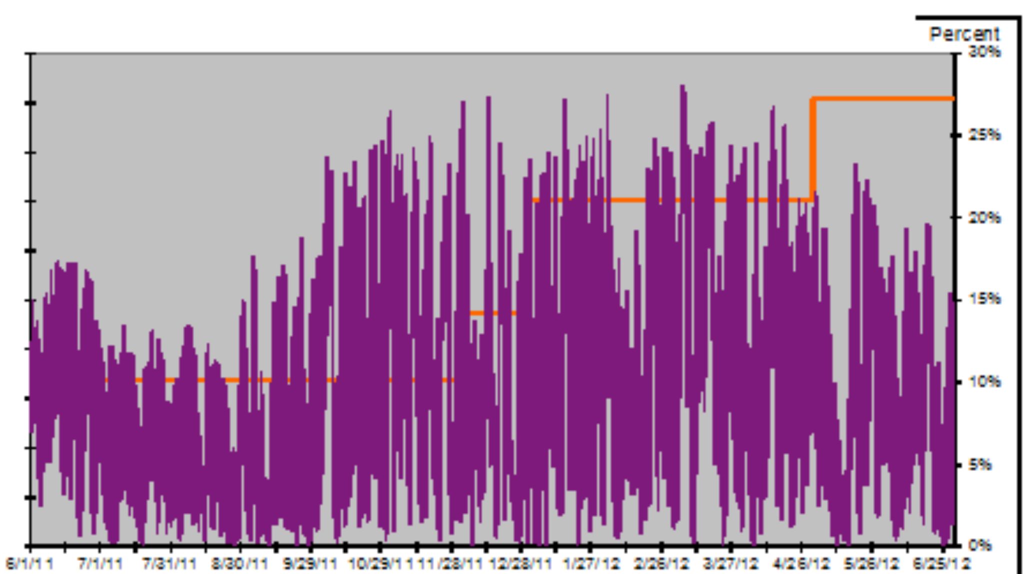

Exhibit 1 (C)

Hourly ERCOT Wind Generation as Percent of Load (Detail)

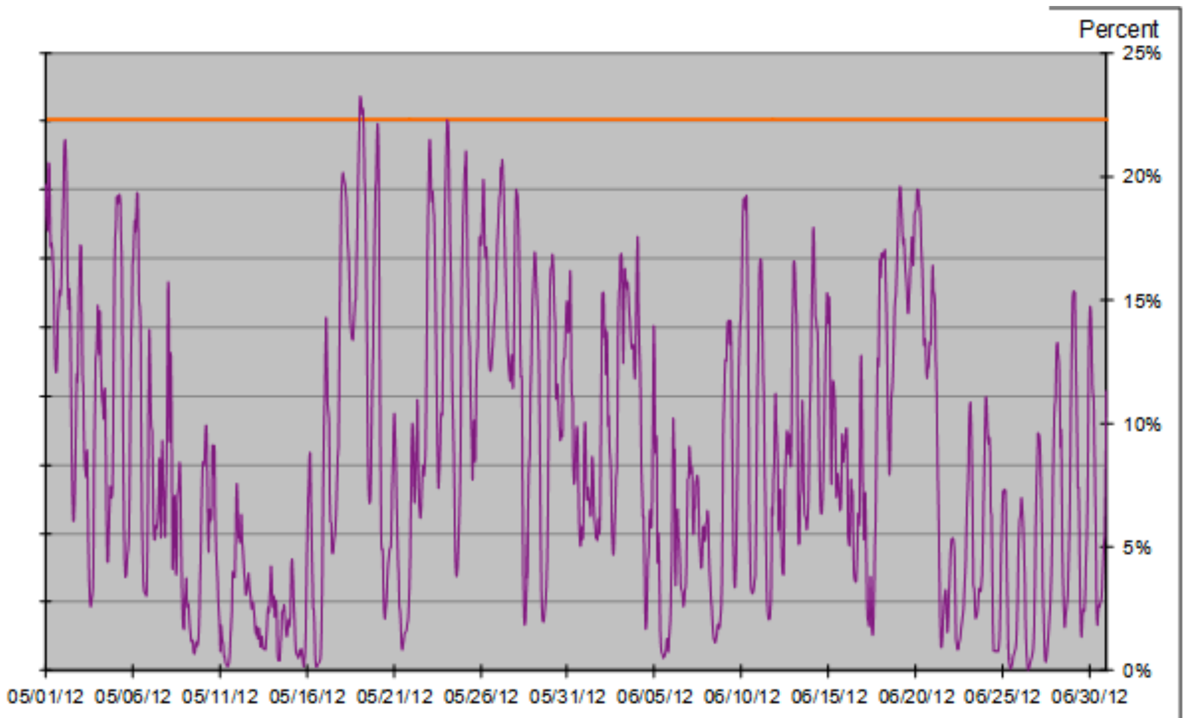

Exhibit 2. Estimated levelized cost of new generation resources, entering service in 2018, $/MWh

Plant type	Capacity factor (%)	Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total system levelized cost
Dispatchable Technologies						
Conventional Coal	85	65.7	4.1	29.2	1.2	100.1
Advanced Coal	85	84.4	6.8	30.7	1.2	123.0
Advanced Coal with CCS	85	88.4	8.8	37.2	1.2	135.5
Natural Gas-fired						
Conventional Combined Cycle	87	15.8	1.7	48.4	1.2	67.1
Advanced Combined Cycle	87	17.4	2.0	45.0	1.2	65.6
Advanced CC with CCS	87	34.0	4.1	54.1	1.2	93.4
Conventional Combustion Turbine	30	44.2	2.7	80.0	3.4	130.3
Advanced Combustion Turbine	30	30.4	2.6	68.2	3.4	104.6
Advanced Nuclear	90	83.4	11.6	12.3	1.1	108.4
Geothermal	92	76.2	12.0	0.0	1.4	89.6
Biomass	83	53.2	14.3	42.3	1.2	111.0
Non-Dispatchable Technologies						
Wind	34	70.3	13.1	0.0	3.2	86.6
Wind-Offshore	37	193.4	22.4	0.0	5.7	221.5
Solar PV[1]	25	130.4	9.9	0.0	4.0	144.3
Solar Thermal	20	214.2	41.4	0.0	5.9	261.5
Hydro[2]	52	78.1	4.1	6.1	2.0	90.3

[1]Costs are expressed in terms of net AC power available to the grid for the installed capacity.
[2]As modeled, hydro is assumed to have seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season.
Note: These results do not include targeted tax credits such as the production or investment tax credit available for some technologies, which could significantly affect the levelized cost.
Source: U.S. Energy Information Administration, *Annual Energy Outlook 2013*, December 2012, DOE/EIA-0383(2012).