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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, Adjunct Scholar at the Cato Institute and Senior Fellow at the Texas Public Policy Foundation. 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 professional or consulting affiliation. I attach a current biography to this testimony.

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 published in peer-reviewed journals, law reviews, industry publications, and presented 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 four previous appearances before House committees.

Of particular relevance for today's discussion are my testimonies 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 analyzed wind energy in the contexts of electric system

[1] 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.

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 employment opportunities. Today's testimony also examines these matters 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 for my views on the potential extension of the wind energy production tax credit (PTC). Initiated in 1992, the credit has engendered substantial controversy, most recently regarding its 2013 extension and recently issued IRS rules on compliance with it. The PTC has been extended five times and been allowed to sunset on four occasions. Beginning at 1.5 cents per kilowatt-hour (kwh) in 1994 – 1999, it has been adjusted for inflation to its current level of 2.3 cents/kwh. My broad conclusion is that the PTC has far outlived any limited usefulness that it may once have had in stimulating wind power development, and that it should be permanently terminated as soon as possible.

Like numerous other tax preferences and subsidies, the PTC was originally enacted to spur development of a technology that may have required research and experience to become competitive with more established power sources. Even in those early times, however, the structure of the worldwide market for wind generators rendered "Infant industry" arguments questionable. Today wind accounts for a large part of new generation investments and there are no discernible links between a continuing PTC and possible future technological improvements. If there is in fact a plausible case for support of emerging technologies, that support should take the form of direct allocations to research. Instead the PTC provides tax savings to owners of all eligible wind turbines on the basis of their production volumes. The emergence of Renewable Portfolio Standards (RPS) in a majority of states has further weakened any infant industry rationale for the PTC. Utilities in RPS states represent a large and stable market for wind generation that will provide steady demand for it over a long horizon. Below I provide evidence that it is RPS rather than the PTC that has been responsible for the strong and sustained growth of investments in wind power, although the intermittency of the PTC has been responsible for significant inter-year fluctuations.

Federal data and forecasts show that the all-in cost of wind turbines has and will be higher than that of gas-fired plants, inclusive of their fuel costs. These comparisons, however, still overstate wind's possible benefits to power distributors and users. Wind power is by nature intermittent and can only be integrated into a regional grid if other generation is instantly available to compensate for wind's variability. Adding a controllable generator to an electric grid generally increases reliability. By contrast, wind is a power source that can put reliability at risk as dependence on it increases. "Must-take" rules in many regional power grids shift the cost of maintaining wind power's reliability away from wind generators to ratepayers. Since 2008 the growth of wind generation in isolated areas has been responsible for approximately $22 billion in new transmission facilities. Many of them are financed by ratepayers and would have been unnecessary absent wind power. In some areas it has become a significant presence that has led to reliability concerns. As wind grows, it is also affecting outcomes in competitive energy markets, where it randomly exerts significant downward pressure on energy prices that will reduce investment in conventional generators needed to maintain reliability. The PTC further complicates market operation because its certainty of payment allows generators to bid power into the grid at negative prices and still profit.

Wind's other benefits are either overstated or ephemeral. The "zero emissions" associated with a kilowatt-hour of wind power are generally far from zero. They must be netted against the emissions from plants that must operate to maintain reliability in the face of wind's intermittency. On a life-cycle basis, production of the materials and services used to construct a wind generator also entails pollution and carbon emissions. Few people view any type of powerplant as a scenic treasure, and wind has become less of an exception as the size of turbines grows.

Finally, there is no substance to claims that the PTC is desirable because wind power's effects on employment in the economy make it part of an "industrial policy." So-called "green jobs" are arbitrary classifications (one list includes bus drivers). Jobs in renewable electricity are a small fraction of any assumed total, and those in wind power are a small fraction of that fraction. Advocates often use computer models to substantiate claims that investment in wind, stimulated by the PTC, will generate extensive employment opportunities in other activities. In reality, these benefits have yet to be demonstrated. Funds expended on wind projects are unavailable to spend on the outputs of other industries, so to a first approximation the net effect of gained jobs in wind and lost jobs elsewhere is zero. Oddly, these computer models do not estimate lost jobs in these other industries, which makes their seemingly favorable findings on wind-related employment meaningless.

II. POSSIBLE RATIONALES FOR THE PTC

A. Public goods and infant industries

Two interrelated rationales for governmental activities in private markets originally dominated debate about the PTC. Despite great changes in technology and markets they remain frequently cited. The U.S. Government Accountability Office's (GAO) March 2013 report on federal financial programs and incentives affecting wind power restated the canonical "public goods" reasoning:

> [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 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.[2]

Beyond these theoretical assertions, GAO made no efforts to assess the possible relevance of this reasoning to wind power and the PTC.

GAO did, however, enumerate "basic research, applied research, demonstration, commercialization and deployment" as activities where federal intervention might be warranted. (GAO, 7) The PTC, however, is ill-suited to incentivize all but the last of these activities. Tax preferences under it are quite unlike direct support payments to basic researchers such as those from National Science Foundation and national energy laboratories.

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

The PTC is directed entirely to owners of already-built generators. It reduces taxes in proportion to their power output during the first ten years of operation, regardless of whether a plant embodies new technologies or established ones. The case for the PTC stimulating basic research is unproven, and such research might be better supported by direct incentives. The PTC may in fact stimulate deployment, as do state-level renewable portfolio standards (RPS), a topic to which I return below.

The other activities listed by GAO are equally speculative rationales for the PTC. Today's wind power industry is large, technologically sophisticated and competitive. When the PTC was enacted in 1992 wind accounted for a negligible percentage of total power production.[3] The PTC remained in effect during most of the succeeding years, and by 2011 wind capacity in the U.S. had grown to over 45,000 megawatts (MW), whose output was 3.2 percent of total U.S. generation.[4] In 2012 wind capacity increased by more than any other type of generation.[5] Wind may once have been an "infant industry" but it is no longer so. Over the past twenty years, however, the relative benefits of the PTC have increased. Between 1990 and 2010, the levelized cost per megawatt-hour (mwh) of U.S. wind power fell from approximately $170 to $80 (in 2010 dollars).[6] Between 1992 and 2010 the PTC was indexed to stay roughly constant in real terms. Hence the per mwh subsidy in real terms associated with the PTC has roughly doubled over the period.

The market for wind turbines in the U.S. has become significantly more competitive. In 2005 four manufacturers accounted for 99 percent of U.S. installations, a figure that grew to 12 manufacturers in 2012. The U.S. market shares of the three largest suppliers added up to 72 percent in 2012, and two of those suppliers were European corporations.[7] Wind turbine manufacturers and operators have developed new products and operating methods that have substantially reduced costs. Average operation and maintenance costs were $55 per kilowatt-

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[3] U.S. Energy Information Administration (EIA),
Table 8.2a Electricity Net Generation: Total (All Sectors), 1949-2011.

[4] *Id.,* and Table 4.3. Existing Capacity by Energy Source, 2011.

[5] U.S. Department of Energy, 2012 Wind Technologies Market Report, 5.

[6] Eric Lantz *et al*, *IEA Wind Task 26: The Past and Future Cost of Wind Energy,* National Renewable Energy Laboratory, 2012, 16. The figure reached a minimum of approximately $50 in 2005 and subsequently rose.

[7] 2012 Wind Technologies Market Report, 15.

year for projects built in the 1990s. For those built after 2010 the figure was $25.[8] Both large manufacturers and small producers of turbine parts have been responsible for technological advances, whose revenue streams are often protected by patents. There are no discernible links between any of these advances and the continuation of the PTC.

Whatever the rationale and economic value of the PTC, wind power remains both intermittent and expensive. The most recent forecasts from the U.S. Energy Information Administration expect little further progress. Exhibit 1 contains projections of levelized cost including fuel and maintenance expenses (in 2011 dollars) per mwh for generators expected to go on-line in 2018.[9] The three most costly sources are solar thermal ($261.5/mwh), offshore wind ($221.5) and solar photovoltaic ($144.3). The cost of onshore wind is $86.6/mwh. An advanced combined cycle gas-fired generator's cost is $65.6 per mwh, 76 percent of wind's cost. Even under a carbon tax or a cap-and-trade system wind barely passes a market test. The costs of carbon capture and sequestration (CCS) technology are still uncertain, but EIA estimates that adding it to a combined cycle gas generator leaves that unit at only an eight percent cost disadvantage to wind. If gas prices remain steady or rise by slightly less than EIA's projection, the gas unit is the economic choice.

B. The PTC and state renewable portfolio standards

At first glance the PTC appears to have been a major cause of the wind industry's growth, since investment has been substantially higher in years when it was in effect than in years when it was not.[10] Given the PTC's uncertainty and intermittency it is hardly surprising that investors bunched their activities in this way. Although technologies were available, the 1992 enactment of the PTC resulted in very little activity through 1996. Significant growth began only in 1998. States began enacting RPS in the late 1990s and the number trended upward until about 2007, after which few states joined them. RPS laws typically qualified a

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[8] *Id*. at 39.

[9] EIA, Levelized Cost of New Generation Resources in the Annual Energy Outlook 2013 (Jan. 28, 2013) http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

[10] 2012 Wind Technologies Market Report, 55.

number of technologies as renewable, but in most states wind accounted for over 90 percent of compliance investments. By one estimate, if future RPS requirements were to be fulfilled by wind, its capacity would rise from today's 60,000 MW of today to about 130,000 MW by 2030.[11]

Nearly all state RPS programs have remained as enacted, in the face of large changes in the costs of both wind generation and conventional power. In practice, RPS requirements appear to provide a near-guarantee of wind market size that is independent of the PTC or its absence. As regional markets grow wind turbine owners can further supplement their incomes by selling renewable energy credits in other states that are unwilling or unable to build their own wind units. Given the stability of RPS and uncertainty of the PTC, the former may have a greater value to wind entrepreneurs.

III. WIND POWER, PRICES AND RELIABILITY

A. Operations and intermittency

Wind advocates often describe a project as producing (e.g.) "enough power to light 20,000 homes." Residential use is only about 1/3 of total consumption, but whatever that value the statement is at best misleading and at worst outrightly false. Any power system operates under a fundamental constraint: at every second, power production must exactly equal consumption. Any difference between production and demand (whether positive or negative) will trigger a region-wide blackout. Meeting the constraint requires a mix of generation. There will be baseload units (often nuclear and coal) producing near capacity at all hours, intermediate units (often gas) that respond to predictable inter-day variation, and units that only run at peaks. Reserve generators must also be operating, to instantly step in if another generator or transmission line fails. The need to respond quickly to both predictable and unpredictable events indicates that a generator's value to the grid does not simply depend on its operating cost. It also depends heavily on whether the operator can control its output to help maintain the balance between production and consumption.

The controllability ("dispatchability") of conventional generators (as well as renewables like biomass burners and geothermal units) means that bringing them into operation strengthens the reliability of the grid. Adding wind generators whose output is unpredictable

[11] David E. Dismukes, *Removing Big Wind's "Training Wheels:" the Case for Ending the Federal Production Tax Credit*, Institute for Energy Research, 2012, 8.

and uncontrollable does the opposite. Regional grids often operate under "must take" rules that prohibit the operator from refusing an offer of wind power except in extraordinary situations. This constraint raises required reserves and their fuel costs, and the greater wind's variability the higher the cost of accommodating it. In many systems, the additional costs are distributed to various customers by regulatory rules ("socialized") rather than borne by wind generators responsible for them. In some operational situations the extra reserves required by wind's intermittency must suffice to instantaneously adjust to a complete loss of wind. Even an extensive grid cannot rely on wind fluctuations at different locations to balance out and thereby provide the equivalent of a single reliable generator. Exhibit 2 shows the variability of hourly wind output as a percentage of system load over a year in ERCOT, the Texas regional grid. There is no pattern to the fluctuations, and their amplitude is very high. The variability becomes even more apparent at higher resolution over the two months graphed in Exhibit 3. As noted above, there are times at which wind generation falls to zero, sometimes followed within hours by operation of virtually all available turbines, with accommodation required by "must-take" rules.

Adding to the operational difficulties, in most regions the wind is more likely to blow when the power it generates is least valuable. It is typically strongest at night, when baseload generators (which can take over a day to restart) must continue to operate at lower outputs in anticipation of tomorrow's load. It is weakest during peak hours of the mid-afternoon. Seasonally, in many areas wind is typically (but not always) weakest in summer when most grids reach their annual peaks. The upper panel of Exhibit 4 shows the average percentage of ERCOT load met by wind power at different hours of the day, averaged over a year. Its lower panel shows average monthly percentages of load supplied by wind.

Wind is typically weakest during periods of extreme temperature (both hot and cold) during which a system's gas-fired generation capabilities are at greatest risk of reaching their limits.   During high-temperature peak load periods, the fraction of California wind capacity that actually produces power averages only 5 percent of the installed amount.[12] Texas has the nation's largest installed wind generation capacity, scattered over a wide area of the state. For planning purposes ERCOT sets a wind turbine's "effective capacity" at 8.7 percent of its

[12] Testimony of Yakult Mansour, President of the California Independent System Operator, California State Senate Committee on Governmental Operations, Aug. 9, 2006.

nominal amount.[13] All of these operational difficulties are likely to be aggravated if policies such as the PTC lead to further increases in the amount of wind investment.

B. Investment and intermittency

Wind's effect on operating costs also impacts capital costs. As wind grows in the generation mix its randomness and seasonality will bring a need for additional generation capacity, which will increase costs regardless of whether it is owned by regulated utilities or independent power producers. The effects also extend to transmission, where we already have strong evidence on costs. The efficient locations for fossil-fuel generation are often convenient to railroads or pipelines that deliver their fuel, and close to loads where they can contribute more to reliability. In the U.S. the best opportunities for wind development tend to be far from loads and often necessitate dedicated transmission. Investment induced by PTC or RPS can require the building of additional transmission at high cost. Since 2008 the Federal Energy Regulatory Commission (FERC) has approved over $15 billion in transmission to reach wind generation, and another $7 billion is under construction in Texas, which is exempt from FERC jurisdiction.[14] Because these are often radial extensions from a denser network they will contribute less to reliability than interconnected lines. Intermittency implies that these lines will operate below capacity much of the time. The average "capacity factor" for U.S. wind turbines from 2006 through 2012 was 32.1 percent, very low relative to fossil-fuel units.[15]

Larger volumes of wind generation, induced in part by the PTC, can decrease the efficiency of regional grids and distort investment decisions in other ways. In grids operated by Regional Transmission Operators, an important fraction of many generators' revenue is obtained from short-term (day- or hour-ahead) energy sales into their markets, where prices are determined by supply and demand at the time. The presence of increased wind capacity has the effect of lowering those prices and the revenues obtained by all generators whose

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[13] 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, 7. http://www.ercot.com/news/presentations/2006/RenewablesTransmissi.pdf

[14] Dismukes, *Op. Cit*. at 15.

[15] 2012 Wind Technologies Market Report, 42.

sales are linked to the market. The significant revenue reductions reduce investors' profit expectations and deter them from new investments.[16] Paradoxically, the growth of wind power discourages investment in the generation that is needed to maintain reliability. Given the regional nature of the grid, the consequences can also be borne by interconnected states that do not have RPS policies.

As the volume of wind generation grows, its effects on energy market prices have become even more perverse in some regions. When transmission between wind areas and load centers iscongested generators must bid for access to the lines. The winners are those willing to receive the smallest netbacks. In a competitive market with conventional powerplants this result is desirable – those with the lowest operating costs will be the winning bidders. Where wind power has a significant presence the PTC at times allows its owners to bid *negative* prices and still earn a profit. A wind generator will pay any amount below its PTC savings for access to the lines, since it can still earn the difference between what it pays and the tax savings. Even if the negative bid does not set the market price, it further reduces the returns to fossil-fuel generators whose minimum operating limits are critical for reliability.[17]

IV. WIND POWER'S ENVIRONMENTAL EFFECTS

Reliable electricity, inexpensive electricity, and a clean environment are all desirable. Unsurprisingly, all are also costly. Wind turbines are durable, have low operating costs and do not burn fossil fuel, but these facts alone do not clinch either the economic or environmental case for wind. Wind power carries costs of its own, including materials and labor to build and install turbines, as well as support costs that include fuel for added reserve generation, new transmission lines, etc. Fossil-fuel plants must incorporate pollution control technologies that wind units do not need. As noted above, the per-MWh capital costs of wind exceed all-in (capital plus fuel) costs of modern gas-fired plants by over 30 percent, even if we do not include the support costs associated with intermittency.

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[16] Chi-Keung Woo *et al*, "Blowing in the Wind: Vanishing Payoffs of a Tolling Agreement for Natural-Gas Fired Generation in Texas," *Energy Journal* 33 (2012), 207-229.

[17] For graphics that show the growth of negative pricing in four wind-rich RTOs, see the NorthBridge Group, *Negative Electricity Prices and the Production Tax Credit* (2012), 10.

Manufacturing either a conventional generator or a wind turbine requires raw materials whose extraction and assembly release emissions that are costly to mitigate. Wind units, however, require larger volumes than fossil units of some raw materials commonly associated with high pollutant and carbon emissions. Estimates of life-cycle costs are sensitive to technical details, but one fairly representative comparison found that a megawatt of coal-fired capacity requires 98 metric tons of steel and 160 cubic meters of concrete (cement manufacture emits carbon), while a megawatt of gas generation capacity requires approximately 3 metric tons of steel and 27 cubic meters of concrete. A megawatt of wind capacity, by contrast, requires 460 metric tons of steel and 870 cubic meters of concrete.[18]

In most of the U.S. wind power displaces gas generation. Coal units are base-loaded, while gas units adjust the grid to both expected and unexpected 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 emissions. It also emits less carbon per kwh generated. If wind generation proliferates and gas-fired capacity is limited, the operator must use coal-fired units to balance the grid, as happens at times in Colorado, Texas and elsewhere. Controversial research by gas marketer Bentek Energy recently analyzed operating data to discover the consequences of using coal plants as wind backup in the absence of gas-fired capacity, a situation that sometimes prevails in Colorado and Texas. Bentek found that the use of coal actually increased emissions of Criteria Pollutants (and did not reduce carbon), even after netting out the emissions reductions due to wind. Bentek concluded that loads in those areas could have been served with lower total emissions had the wind units never existed. The American Wind Energy Association has challenged Bentek. The issue remains undecided, but there will be important consequences for wind power whichever side wins.[19]

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[18] James Conca, "Is the Answer, My Friend, Blowing in the Wind?" *Forbes*, July 1, 2012. http://www.forbes.com/sites/jamesconca/2012/07/01/is-the-answer-my-friend-blowing-in-the-wind/

[19] Bentek Energy, *How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market* (April 10, 2010). http://docs.windwatch.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

V. WIND POWER AND EMPLOYMENT

A. How many jobs are green?

Since the initiation of the PTC we have heard numerous assertions that subsidizing wind power results in the creation of "green jobs." These opportunities simultaneously improve worker incomes and bring relief from unemployment, all while improving energy efficiency and cleaning the environment. Green jobs, however, provide no rationale for extending or gradually eliminating the PTC. Instead one can make a case that more economic benefits will stem from its abandonment than from its perpetuation. To see why, I first examine the nature of green employment. I follow by critically evaluating claims that investment in wind power will send ripples of prosperity through the entire economy.

Two recent studies illustrate the inherent arbitrariness of classifying jobs as green. In 2011 the Brookings Institution estimated 2.7 million jobs in the "clean economy."[20] 18.9 percent were in "Agricultural and Natural Resources Conservation," 5.3 percent in "Regulation and Compliance," 31.0 percent in "Energy and Resource Efficiency," and 39.6 percent in "Greenhouse Gas Reduction, Environmental Management, and Recycling." All are exercises in creative classification. Energy efficiency includes 350,000 workers in public mass transit (mostly bus drivers) and environmental management includes 386,000 people in trash disposal. The authors chose not to use an approach that most analysts would have found far more helpful: how many clean jobs have (or will) come into being as a result of various regulations? And how many will vanish?

The Brookings researchers counted only 138,000 positions in renewable power, 5 percent of their clean job total. After subtracting 55,000 jobs in hydropower (commonly viewed as nonrenewable), they are left with 84,000, i.e. 3.1 percent of all clean jobs. Of these, 29,000 were in solar, (which generates under 2 percent of renewable power) and 24,000 (under one percent of clean jobs) are in wind. Similar research in Washington State (where wind is a significant presence) found a total 3,464 workers in renewable energy, 3.5 percent of the state's green jobs. Its authors noted that "construction … [and] professional and technical

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[20] Mark Muro, *et al*, *Sizing the Clean Economy: A National and Regional Green Jobs Assessment*, (Brookings Institution, 2011). It is possible that growth in residential photovoltaics since its publication would raise the totals.

services accounted for the majority of all [renewable] positions."[21] The majority of jobs are in manufacturing and construction, and both are generally short-lived. After they open, "most renewable energy facilities operate with a relatively small number of operations and maintenance employees…[t]he proportion of part-time positions is higher for renewable energy than for any other private-sector core area (35 percent).[22] Both the Brookings and the Washington studies tell us that green jobs are not objectively definable, that it is easy to inflate their numbers, and that they do not differ significantly from non-green positions that require similar qualifications. Whatever the definitional details, wind power has a minimal presence in labor markets.

B. Are there economy-wide effects?

Green jobs may be few, but advocates frequently claim "multiplier" effects that create many additional jobs when the original green workers respend their incomes in the community. In reality wind power's costs must eventually turn up in consumers' monthly bills (or possibly in their future taxes). A tax that forces consumers to buy needlessly expensive power when cheaper (and clean) power is available inflicts harm on their budgets, while benefitting those interests that succeeded in enacting the tax. Seen in this light, increases in government support for uneconomic technologies cannot possibly produce "green jobs" and prosperity. How could it possibly happen if that support brings the nation higher energy costs and no countervailing benefits? 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 funds as income.[23] It does not matter whether the tax takes the form of a higher power price or a direct governmental tax collection.

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[21] Washington State Employment Security Department, *2009 Washington State Green Economy Jobs* (Mar. 2010), 5.

[22] *Id.* at 30.

[23] 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.

In previous 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.[24] 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.[25] DOE's National Renewable Energy Laboratory (NREL) utilizes a "social accounting matrix" computer model ("JEDI") 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 forecasts of job creation from investments in wind power. I responded that NREL's model is constructed so that any project it examines *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 yet to put its model through the most rudimentary test – comparing the predicted employment effects against reality. At the Committee's request, I submitted supplemental testimony on this subject, which I have attached to this 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.

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[24] A summary appears in Robert Michaels and Robert Murphy, *Green Jobs: Fact or Fiction*, Institute for Energy Research, Washington D.C., Jan. 2009. Also 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.

[25] In the Matter of Whistling Ridge Energy Project, LLC, Application No. 2009-01, Supplemental Prefilled Testimony of Robert J. Michaels, PhD, Dec. 14, 2010.

VI. SUMMARY AND CONCLUSIONS

At its inception the PTC was a minor addendum to legislation affecting a then-tiny industry. It was a product of politics, rationalized by economic arguments that few took any interest in verifying. In the national haste to increase power production from renewables, wind became a clear winner. It seemed to produce power for free, emitted few if any pollutants and was producible in many parts of the country. Until the recent rise of solar, “renewable” was in effect a synonym for wind. Renewables have a considerably longer history than wind, and one worthy of a brief review. Biomass has long been an economically viable fuel in some areas, and until quite recently geothermal power made up the largest share of California’s renewables. Biomass and geothermal probably escaped notice for two reasons: they could stand on their own economically, and they could be dispatched as integral parts of a power system. These renewables were like fossil-fuel plants, whose presence strengthened reliability and lowered the cost of delivered power.

Wind changed renewables from useful assets into problematic ones. When wind turbines were a small fraction of generation they created minimal problems because small doses of intermittency required few extraordinary actions or investments. At the same time wind’s cost characteristics and the environmental acceptability of smaller-scale projects rendered it the renewable of choice to meet RPS requirements. The PTC only strengthened a rush to wind whose consequences could hardly have been foreseen when wind was a footnote. The PTC itself led a complex life, with intervals of dormancy and complex legislative bargains over it. The time has come to end that life, and to do so as quickly as possible.

The original “public goods” and “infant industry” justifications for subsidizing wind vanished long ago with the growth of advanced turbine technologies and a competitive world market for them. Even if further growth will stimulate more progress, state RPS requirements (and national ones elsewhere) will ensure a long-lived market for the generators. Wind’s effects on system operating costs will be with us for a long time, aggravated by rules that prioritize its operation. Wind’s presence is becoming a major influence on market prices, and its further growth is likely to distort far more costly decisions on generation and transmission investment. Perhaps new operating technologies and superior ways to forecast wind will be able to alleviate these problems. Their solution, however, can only be more difficult as the installed base of wind turbines grows with continuation of the PTC.

People can understandably dispute the effects of recent economic stimulus policies in bettering (or perhaps worsening) macroeconomic performance. The PTC has been a relatively small (relative to the federal budget) experiment in the difficulties and unintended consequences of applying economic stimuli. It has rewarded those who invested in wind power, while its longer-term effects on operating costs and the future of electric reliability are only appearing at this rather late hour. And if the PTC does not even meaningfully increase employment, the case for ending it is even more transparent.

Exhibit 1. Estimated Levelized Cost of New Generation Resources Entering Service in 2018, 2011 $/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).

Exhibit 2

Hourly Wind Output in ERCOT (Texas) as a Percentage of Load

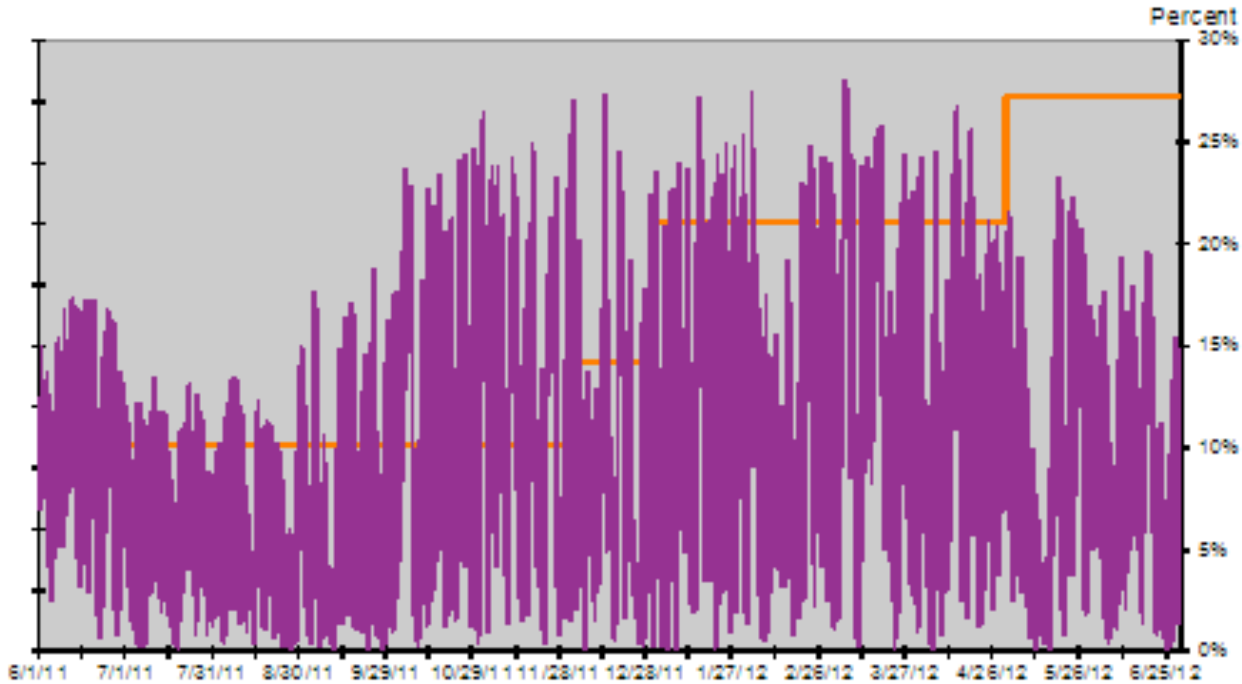

Exhibit 3

Hourly Wind Output in ERCOT (Texas) as a Percentage of Load (Detail)

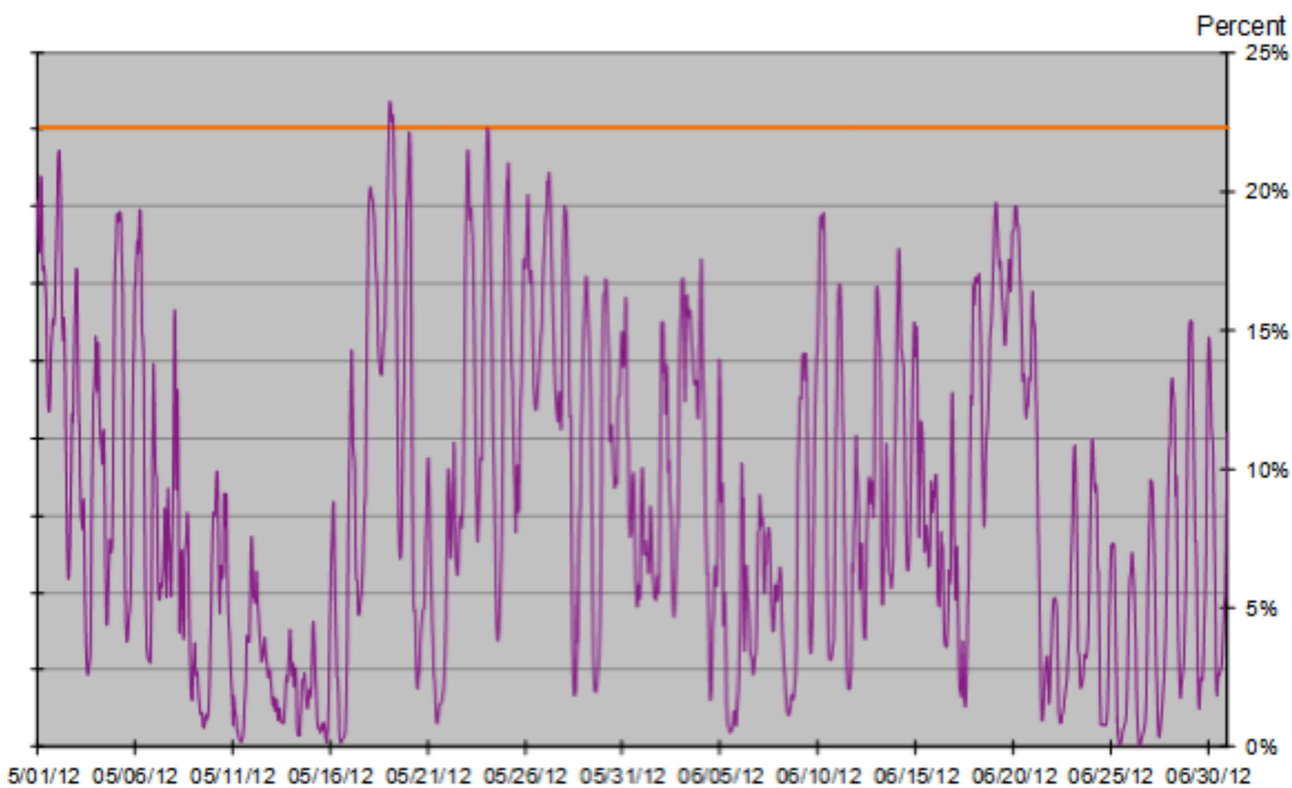

Exhibit 4

Average proportion of Wind in ERCOT Load by Hour of the Day and by Month