

Testimony of Robert J. Michaels: Subcommittee on Water and Power **(<http://www.instituteforenergyresearch.org/2011/09/22/testimony-of-robert-j-michaels-subcommittee-on-water-and-power/>)**

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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 2,800. 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 other House committees.

II. Background and Purpose

The Committee today is exploring the economics that underlies H.R. 2915, and in particular the consequences of repealing the Western Area Power Administration's (WAPA) \$3.25 billion borrowing authority under The American Reinvestment and Recovery Act of 2009. That Act authorizes borrowing to construct new or upgraded transmission lines interconnected with WAPA, and specifically mentions lines "delivering or facilitating the delivery of power generated by renewable energy resources."^[1] [\(#_ftn1\)](#) Numerous individuals and agencies have alleged that the increased investment in "renewable" sources of power is a worthwhile national objective on two grounds:^[2] [\(#_ftn2\)](#) [1] it will provide environmental and climate benefits that outweigh their higher costs, and [2] these investments will favorably impact employment, particularly in a time of recession. If these statements were even approximately true, they could justify support and subsidization of renewable power. Unfortunately, they are not.

My testimony addresses the realities of renewable electricity. It first addresses the very minor contribution of renewables to the nation's power supply, and how that contribution reflects subsidies and regulations rather than market factors. It continues with a summary of the actual subsidies to various power sources, showing that some renewables receive highly disproportionate treatment that is unjustifiable on economic grounds. The third part questions the logic behind any policy that purports to "create jobs." Even if government can create them, energy policy is one of the poorest possible vehicles with which to do so. Renewables are seldom sources of durable jobs, and their actual importance for the nation's employment is negligible. On closer examination, most of the millions of frequently touted "green" and "clean" jobs have little to do with either existing or proposed energy policies. I conclude that federal policies

toward renewables are due for a complete rethinking, and that the WAPA authorization may be a useful starting point for that process.

III. Renewables and reality

A. Renewables in the U.S. power supply

Exhibit 1 shows the amounts of the nation's power coming from various sources. In 2010, 44.9 percent came from coal, 23.8 percent from natural gas, 19.6 percent from nuclear, and 4.1 percent from renewables (excluding hydropower).^[3] (#_ftn3) Note the recent drop in production from coal, the longer-term increase in production from gas and the remarkable constancy of nuclear generation. Renewable power is a small fraction of today's total, but its contribution was even smaller in the past — 2.1 percent in 1990 and 2.2 percent in 2005, when its current growth began. Exhibits 2 and 3 show that the mix of renewable sources has changed substantially over the past 20 years. In 1991, over 95 percent of renewable electricity was from geothermal sources, biomass and waste burning. These technologies were viable because their unsubsidized power was (and still is) competitive with fossil-fuel generation in a few areas. They were also dispatchable, operable when their power was valuable and left idle when it was not. All three of them have since stagnated. In 1992 they produced 70.5 million kilowatt-hours (gigawatt hours or gwh) and in 2009 slightly more, 72.2 gwh. Solar power remains a minor presence despite its substantial subsidies. Its 1993 output of 0.45 gwh grew to only 1.29 gwh in 2010, under 1 percent of renewable power and 0.03 percent of all U.S. power. Exhibit 4 shows that the growth of renewable electricity since 2000 has been almost entirely in wind power, which by 2010 accounted for over half of all renewable generation capacity. Explaining that growth is our next task.

B. Costs of power and costs of reliability

Wind power is both intermittent and expensive, and official expectations are that it will remain so. Exhibit 5 shows the U.S. Energy Information

Administration's (EIA) projections of the levelized cost per megawatt-hour (mwh) of various technologies (including fuel where applicable) for plants expected on-line in 2016 (in 2009 dollars). The three most costly sources are solar thermal (\$312/mwh), offshore wind (\$243) and solar photovoltaic (\$211). The cost of onshore wind is \$97/mwh. Compared with a conventional (not an advanced) combined cycle gas-fired generator (\$66/mwh) the cheapest intermittent source is almost 50 percent more expensive. Intermittent renewables are even likely to be poor investments under a carbon tax or cap-and-trade system. The costs of carbon capture and sequestration (CCS) technology are still highly uncertain, but EIA estimates that adding it to a combined cycle gas unit still leaves it 8 percent less expensive per mwh than the cheapest wind turbine. At carbon prices typically projected for cap-and-trade regimes the wind plant still loses.

Technology and economics both tell us that intermittent wind capacity carries costs that will likely exceed those the same dispatchable fossil-fueled capacity. Small amounts of wind can easily be integrated into a regional grid because a sudden calm is operationally indistinguishable from a minor outage. Larger amounts of wind capacity, however, require costlier backup arrangements, including operating reserve generators. In most regions wind blows most strongly when its power production is least valuable. 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 (over the diverse northern and southern climates) was 256 MW.^[4] (#_ftn4) 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 for planning purposes.^[5] (#_ftn5)

Because wind requires fossil-fuel generation as backup we cannot simply conclude that a mwh of wind power eliminates the pollutants in a mwh of conventional power. Research by gas marketer Bentek Energy found that in some areas additional wind power has strikingly perverse consequences. Bentek found that large increases in Texas and Colorado wind capacity indeed led to less coal-fired generation. Emissions of EPA "criteria

pollutants” from these plants, however, actually increased, and CO₂ emissions were unchanged.[6] (#_ftn6) Operating data showed that wind’s variability required numerous quick adjustments by coal-fired units, which were responsible for the added pollution. Bentek’s controversial conclusion was that the total load in the area could have been served with lower total emissions had the wind units never existed.

C. Who gets what subsidies?

Subsidies and regulations can explain wind power’s rise quite graphically. The American Reinvestment and Recovery Act (ARRA) extended wind’s sporadic production tax credit (PTC, now also applicable to some other renewables) through the end of 2012. Before the PTC’s first enactment in 2000, only 67 megawatts (MW) of wind capacity were built. That figure grew to 1,697 MW during its initial year of 2001. For 2002 (credit not in effect) and 2003 (in effect) the figures are 446 and 1,687 MW; and for 2004 (off) and 2005 (on) they are 389 and 2,431 MW.[7] (#_ftn7) Many other factors influence investment, but total investment in years with the tax credit was 544 percent greater than in years without it. (We cannot go beyond these years because subsequent extensions have included retroactivity provisions that investors may have come to expect.) There is, however, no evidence of changes in market conditions that would diminish the importance of subsidies, as was recently noted by the American Wind Energy Association (AWEA). In mid-2010 it claimed that ARRA’s subsidy provisions (which included an investment tax credit option) had been responsible for an increase in small turbine installations:

“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...”[8] (#_ftn8)

Alongside such subsidies, renewable portfolio standards (RPS) and related regulations in approximately half of the states require utilities to obtain certain quantities of power from renewable sources. Although

quantification is difficult it is likely that some wind investments have been made solely for RPS compliance, rather than because they were cost-effective choices.

Energy subsidies are a sensitive issue in part because they have no generally agreed-upon definition. For fiscal 2010 the U.S. Energy Information Administration (EIA) produced what are the currently authoritative estimates. Its authors took particular care in calculating the effects of subsidies to various fuels on the actual amounts of power they produced. Thus a subsidy to the oil industry will only be relevant to the extent that it affects the (negligible) amount of oil used to generate power. Exhibit 6 presents the basics. Per mwh of power that it actually produced, wind received a subsidy of \$56.29 and solar received \$775.64. Wind gets 88 times more funds per mwh than coal, and the same multiple more than gas and oil.[\[9\]](#) ([#_ftn9](#))

Taken by themselves, these figures alone cannot determine the desirability of subsidies. For example, the newness of renewable technologies might provide an economic rationale for subsidies to fund basic research that if successful could render them truly competitive. (Justifying the subsidy, however, also requires a demonstration that renewables somehow differ from other leading-edge industries in their unique needs for support.) Even if so, the current form of the subsidy is inappropriate. A targeted research subsidy might make sense, but one that simply lowers prices paid by purchasers of renewables or reduces the taxes of investors is harder to rationalize. EIA's report states that "tax expenditures" (i.e. reductions) to the coal industry (including those for coal not used to produce power) were \$561 million in fiscal 2010, while R&D subsidies (possibly necessary if we are to have "clean coal") were \$663 million. Tax expenditures for renewables were \$8,168 billion, primarily the production tax credit for wind, while the R&D that might make them competitive was only \$1,409 million for renewables as a group with \$166 of that going to wind.[\[10\]](#) ([#_ftn10](#))

IV. Renewables and employment

A. “Green jobs”

It is rapidly becoming apparent that renewable energy is failing to produce the promise of painless prosperity embodied in “green jobs” that will simultaneously decrease unemployment rates and reduce pollution. Begin with some principles:[\[11\]](#) ([#_ftn11](#))

1. *The proper goal of energy policy is to support the efficient provision of energy.* The lower the cost of energy to the economy, all else equal, the higher will be job creation and economic growth *outside of* the energy sector. Raising energy costs by forcing the use of uneconomic technologies that create more job slots will have exactly the opposite effect. Put simply, more workers in energy reduce the production of non-energy goods and services.

2. *Any analysis of job creation by green energy must consider the simultaneous effect of job destruction.* Policies that raise the cost of energy to households and businesses must leave them with fewer funds to spend elsewhere. Such policies include the spending of tax revenues to support green activities instead of other government purchases or returning the funds to taxpayers. To a first approximation the net effect of such programs on employment will be zero. This is particularly important here because the new job slots are often visible, while the losses are dispersed among the thousands of goods and services that households and businesses will spend less on. Jobs that cost more to create will generally have higher costs in terms of lost jobs elsewhere.

3. *Double counting of jobs and unrealistic assumptions about labor markets.*

Although they seldom say so explicitly, the models that underlie most studies of green energy and job creation assume that there is a limitless pool of idle laborers with just the right skills to fill the job slots created by the spending. As always happens in labor markets, many such jobs will in fact be filled by already-employed workers, whether the nation is in prosperity

or recession. Even if green policies moved massive amounts of labor between jobs they would have little impact on the national unemployment rate.

B. How Government Models Job Creation

Much federal research on both the technology and economics of renewables is in the hands of the National Renewable Energy Laboratory (NREL), where a now-standard computer model of the economic impact of renewable projects originated and continues to be maintained. During my appearance at a 2010 hearing before the House Energy and Environment Subcommittee the discussion turned to what was known about the effects of renewables on unemployment. After a representative of NREL testified about the optimistic findings of that standard model, known as JEDI (Job and Economic Development Impact), I commented that its use was entirely inappropriate. I noted that JEDI is structured, by NREL's own admission, in a way that makes any outcome other than job creation mathematically impossible.^[12] (#_ftn12) It is thus a worthless tool for analyzing the actual employment effects of renewables, because it can only produce favorable ones. NREL's representative disputed my statement, and that person and I agreed to submit supplemental testimony on the matter.^[13] (#_ftn13)

As I detail in that testimony, JEDI is one of a large class of "input-output" models that analyze the effects of a project by examining the payments its owners make to workers and suppliers of materials. The monies they receive will in part be respent on other goods, and a "multiplier" effect brings further increases in incomes, outputs and employment across potentially many industries. I noted that

"[t]here is nothing in the model that could conceivably decrease employment or output in other sectors of the economy. Any project consider by JEDI, no matter how efficient or inefficient as a source of electricity, will show a positive effect on employment. That increase may be large or small, but we can be certain that it will not be negative."^[14] (#_ftn14)

I further noted that most of the effects will be transitory, since most of the positions created will be in construction rather than operation.

JEDI's creators appear to have consciously chosen to avoid discussing the sources of the workers or the funds for projects under study. Even if there is a vast pool of unemployed workers in the project area who just happen to have the right skills, we can say nothing about its effect on overall employment. JEDI does not net out jobs lost due to taxes paid by consumers and businesses elsewhere that they cannot spend as they wished to. Even if the project is funded by private or public bond issue, alternative projects with their own employment consequences could have been undertaken. It is not even enough to have workers in the project area with the right skills, because net increases in employment usually happen only if those persons have also been suffering long-term unemployment.

NREL's disregard of elementary economics and continued reliance on this model is remarkable, particularly in light of its' creators' acknowledgments of its inadequacies:

On occasion [the creators] have cited the works of others who use more complex models capable of forecasting both job creation and job destruction. Such models can incorporate factors that include responsiveness to higher power prices, reductions in employment in conventional power, and the 'crowding out' of other capital spending by increased investment in renewables. Sometimes such models produce negative effects on employment in the long run. NREL's researchers are thus aware that other models that capture important complexities are available (or they could surely create their own). For unknown reasons, they instead persist in using a model that can produce only the single result of job creation from renewables.^[15] (#_ftn15)

The "green jobs" claim is logically insecure at best, and models like JEDI mask that insecurity by invariably finding that the jobs are created. Interestingly, however, I am aware of no published research in which the predictions of JEDI or a similar model for some project have been compared

with the actual results. Apparently the model's own creators also take its claims on faith, and that faith appears to be without foundation.

C. Which jobs are green?

Even if there were a usable model to analyze job creation, we are left with the problem of identifying which jobs are actually “green.” A renewable project can result in the employment of technical personnel trained to specialize in operating or maintaining its technology (whom we presume are green), as well as additional bartenders who will help the workers to enjoy their evenings (harder to classify as green). The matter is important because any type of governmental or private spending might open up slots for bartenders. Renewable technologies, however, have been viewed as the foundation for a massive increase in skilled workers whose human capital will provide them with higher lifelong earnings.

Two recent studies point up that the choice of definitions can affect estimates of the green workforce, and show that an extremely small fraction of jobs defined as green are in renewables. The Brookings Institution recently estimated 2.7 million jobs associated with the “clean economy.” The categories include “Agricultural and Natural Resources Conservation” (18.9 %), “Regulation and Compliance” (5.3%), “Energy and Resource Efficiency” (31.0%), and “Greenhouse Gas Reduction, Environmental Management, and Recycling” (39.6%).^[16] (#_ftn16) The clean economy expands its bounds by creative classification. Thus we find that energy efficiency includes 350,000 people in public mass transit, mostly bus drivers, and environmental management includes 386,000 people in waste management, formerly known as trash disposal. The researchers chose not to use an alternative definition that would have been far more helpful to most readers: how many clean jobs have (or will) come into being as a result of recent and proposed energy, environmental and climate regulations? (And, of course, how many others will vanish.)

Some additional insight is possible when we consider the Brookings’ final category. “Renewable Energy” contains 138,000 clean jobs, only 5.1

percent of the total. If we subtract the 55,000 of them in hydropower, which most data sources class as nonrenewable, the figure is down to 84,000, or 3.1 percent of all clean jobs. 29,000 of this remainder are in solar (thermal and photovoltaic), which accounts for under 1 percent of actual renewable power production. 24,000 more are in wind (17.4 percent of renewable power workers and under 1 percent of total clean workers).[17] (#_ftn17) Even if we are willing to assume very large “multipliers” from renewable power, its impact on employment will be trivial, whether taken as a fraction of all energy, clean economy jobs, or the entire labor force.

As a check on those figures we examine Washington State, where environmental awareness is high and renewable energy (non-hydro) is a significant presence. Its four base categories are [1] Increasing energy efficiency, [2] Producing renewable energy, [3] Preventing and reducing environmental pollution, and [4] Providing mitigation or cleanup of pollution.[18] (#_ftn18) Again, a significant fraction of its green workers are bus drivers, trash handlers and the like. The Washington data show that renewable energy occupies 3,464 workers, 3.5 percent of the state’s 99,979 green jobs.[19] (#_ftn19) Its current wind capacity is 2,357 MW, ranking it sixth among the states.[20] (#_ftn20) Washington is one of the most active states in wind investment and production, but still only a small percentage of its green workforce works with renewables, including wind. The Washington study’s authors further note that “construction-related industries and occupations, as well as professional and technical services occupations, accounted for the majority of all [renewable] positions.[21] (#_ftn21) The majority of these jobs are in manufacturing and construction. Per project, both are short-lived, and once in operation “most renewable energy facilities operate with a relatively small number of operations and maintenance employees.... The proportion of part-time positions is higher for renewable energy than for any other private-sector core area (35 percent).”[22] (#_ftn22)

Both the Brookings and the Washington data tell similar stories. Green or clean jobs are not objectively definable, and cases like the bus drivers tell

us that they are easy to inflate. Under both studies' definitions, renewable power jobs are small fractions of the total, and most will be short-lived construction work performed in the main by people with skills that are usable in almost any type of project. Washington's wind units produce a higher fraction of the state's power than those of most other states, but their existence has not created any discernible difference in Washington's labor market performance. Similarly, it appears that most of the solar work force is in construction, where opportunities will diminish with the growth of installations. The past three years have led many to question the federal government's ability to create new employment and the odd logic that lies behind that hope. The data, however, should make it clear to both believers and nonbelievers that renewable power is a singularly inappropriate and ineffective way to increase employment.

V. Summary and Conclusions

The reality of most renewable electricity, particularly from intermittent sources, is easy to summarize. It is expensive, undependable and environmentally problematic. Some renewables such as biomass and geothermal are exceptions, often capable of passing market tests that wind and solar cannot. Unchallenged data from the Energy Information Administration show that the subsidies per kwh actually generated by wind and solar power are over 80 times those received by non-nuclear conventional sources, and over 15 times those for nuclear power. Most subsidies to wind and solar are politically-inspired wealth transfers, rather than tools to incentivize improvements in their competitiveness. In all but the most extreme scenarios, the Department of Energy projects that they will be uncompetitive with conventional resources, even if carbon policies come into being.

The economic theory behind claims that renewables will increase employment applies (if at all) to an economy that hardly resembles today's. Advocates of job creation almost invariably fail to note the concomitant destruction of jobs in industries whose products are no longer bought because consumers must pay taxes or higher prices for the renewable

power. The National Renewable Energy Laboratory's models of job creation are curiosities devoid of policy relevance, mathematically structured to render any possible job destruction an impossibility. Even if we only look at jobs in renewables, their impacts on employment are minimal. The Brookings Institution estimates slightly over 80,000 renewable energy jobs, many of which are short-term construction work. The millions of "clean" or "green" jobs mentioned in the media are overwhelmingly positions that would be filled even if all renewable electricity vanished — bus drivers, refuse workers, and some building trades, to name a few. Calling these workers part of the "clean" economy can only mislead the public about the likely effects of energy and climate policy.

Any choice by government to financially support one energy source over another is by definition an exercise in picking winners. All too often such spending generates forces that make it very difficult to abandon the non-winners. The stories of synfuels and ethanol are back today in wind and solar power, which have many friends in Washington. Whatever happens there, the real future of energy has already arrived, and the winner was picked by the market, with virtually no help from the District of Columbia. Independent risk-takers devised ways to access shale gas for the simplest of reasons — there was profit to be made by alleviating a scarcity of conventional gas. Shale is competitive on costs, compliant with environmental rules and in the main within state jurisdiction, under which it is producing prosperity. The jobs shale creates are the kind that have always powered the country, and their finance comes from the voluntary savings of households and businesses. The nation is looking at centuries of low-cost, clean, secure fuel that creates the kind of jobs that are really worth creating — in the making of goods and services that people voluntarily trade because doing so makes both sides better off. Wind and solar largely exist because government can coerce payments for them.

The subject matter of this hearing is a seemingly minor provision in a far larger and more pervasive law. ARRA and many other recent laws contain

language that prioritizes facilities associated with renewable power in ways that I believe are unwarranted. This testimony has summarized some facts about renewable energy in order to shed light on its true costs, benefits, and labor market effects. These facts clearly show that this committee must rethink ARRA's statement that WAPA pay particular attention to renewable energy. I am not testifying about the organization or performance of WAPA, or about the costs and benefits of any specific transmission project. Rather, I am stating that power from renewable sources should compete for transmission resources on the same terms as power from conventional ones.

[1] (#_ftnref1) 42 U.S.C. § 16421a.

[2] (#_ftnref2) There is no generally accepted definition of "renewable" sources, but popular usage includes biomass, geothermal, wind and solar facilities. The U.S. Department of Energy has sometimes included hydroelectric generation and some states include still others, e.g. Pennsylvania's inclusion of waste coal as a renewable source.

[3] (#_ftnref3) All figures are from various reports from the U.S. Department of Energy's Energy Information

Administration. Data and references are available upon request from the author.

[4] (#_ftnref4) 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. Similarly low wind power production can be seen in real time on most warm days at the ISO's web site. <http://www.caiso.com/Pages/TodaysOutlook.aspx> (<http://www.caiso.com/Pages/TodaysOutlook.aspx>)

[5] (#_ftnref5) 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>
(<http://www.ercot.com/news/presentations/2006/RenewablesTransmissi.pdf>)

[6] (#_ftnref6) 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> (<http://docs.wind-watch.org/BENTEK-How-Less-Became-More.pdf>) Criteria pollutants include ozone and oxides of nitrogen and sulfur. Bentek’s findings have yet to be challenged.

[7] (#_ftnref7) 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
(http://www1.eere.energy.gov/ba/pdfs/39684_app_E.pdf)

[8] (#_ftnref8) 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
(http://www.awea.org/smallwind/pdf/2010_AWEA_Small_Wind_Turbine_Global_Market_Study.pdf)

[9] (#_ftnref9) Institute for Energy Research
<http://www.instituteforenergyresearch.org/2011/08/03/eia-releases-new-subsidy-report-subsidies-for-renewables-increase-186-percent/>

[\(http://www.instituteforenergyresearch.org/2011/08/03/eia-releases-new-subsidy-report-subsidies-for-renewables-increase-186-percent/\)](http://www.instituteforenergyresearch.org/2011/08/03/eia-releases-new-subsidy-report-subsidies-for-renewables-increase-186-percent/)

[10] (#_ftnref10) EIA, Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2010 (2011), <http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf> (<http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf>)

[11] (#_ftnref11) Some of these are adaptations of statements that originally appeared in Robert Michaels and Robert Murphy, *Green Jobs: Fact or Fiction?* (Institute for Energy Research, Jan. 2009).

[12] (#_ftnref12) The model and some applications are discussed in detail at <http://www.nrel.gov/wind/news/2011/1574.html> (<http://www.nrel.gov/wind/news/2011/1574.html>)

[13] (#_ftnref13) See Supplemental Testimony of Robert J. Michaels, PhD, June 28, 2010. I have not seen any comparable submittals from NREL.

[14] (#_ftnref14) *Id.* at 3.

[15] (#_ftnref15) *Id.* at 5, one footnote omitted. It is also noteworthy that the model has never appeared in the peer-reviewed economics literature. As best I can discern, its basic structure was developed by urban planners rather than economists.

[16] (#_ftnref16) Mark Muro, *et al*, *Sizing the Clean Economy: A National and Regional Green Jobs Assessment*, (Brookings Institution, 2011).

[17] (#_ftnref17) Brookings' authors note (at 12) that the American Wind Energy Association claims 30,000 "direct" workers and the Solar Energy Industries Association 24,000, roughly the same as the Brookings figures.

[18] (#_ftnref18) Washington State Employment Security Department, *2009 Washington State Green Economy Jobs* (Mar. 2010), 5. Brookings notes (at 14) that its total is approximately 19 percent higher than its own on a per capita basis.

[19] ([#_ftnref19](#)) Calculated from Washington State Employment Security Department, 15 and 21.

[20] ([#_ftnref20](#)) American Wind Energy Association, *Wind Energy Facts: Washington* (Aug. 2011). Washington has very little non-wind renewable capacity. <http://www.awea.org/learnabout/publications/upload/Washington.pdf> (<http://www.awea.org/learnabout/publications/upload/Washington.pdf>)

[21] ([#_ftnref21](#)) Washington State Employment Security Department, 7.

[22] ([#_ftnref22](#)) Washington State Employment Security Department, 30.

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