A RATIONAL LOOK AT RENEWABLE ENERGY

AND THE IMPLICATIONS OF INTERMITTENT POWER

By Kimball Rasmussen | President and CEO, Deseret Power | November 2010, Edition 2.0

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There seems to be a common misperception, that wind turbines provide an inexhaustible supply of cheap energy—after all, the fuel is free, isn't it? Why don't we simply build more and more renewable energy and achieve low-cost energy independence, while at the same time creating millions of new jobs to fuel a green economic recovery? What's not to like about that? Unfortunately for all of us, the real world poses limits on renewable energy technology, and with those limits come costs—relatively high costs (financial and otherwise), as will be shown in this paper—that must be paid to integrate even a modest amount of renewable energy into the power supply portfolio.

This paper will explore wind and solar energy in terms of their environmental, operational and economic attributes. We will then place these in context to form a rational look at renewable energy and the implications of intermittent power—the not-so-obvious operational challenges that have to be addressed when large quantities of intermittent energy must be accommodated on the electricity grid.

This analysis is based on the current state of wind and solar technologies. Further research and development efforts of these technologies may produce breakthroughs, which could mitigate some of the impediments to high penetrations of wind and solar power to the electric grid, but as yet these impediments remain significant, and no economical mitigation is on the immediate horizon.

FORWARD

Wind and solar energy—two of the most popular sources of renewable energy—are sometimes touted as the answer to the world's energy challenges. Some advocates of these energy sources want us to believe they can solve a plethora of problems, ranging from avoiding the disastrous 2010 oil leak in the Gulf region to materially reducing global climate change. Wind and solar energy are also routinely promoted with the promise of green jobs, which will lead to a green technology revolution while improving the environment—and making us "energy independent" to boot. But how well do wind and solar energy solutions actually perform on these promises? Let's take a rational look.

WIND ENERGY

Wind energy is becoming a significant consideration in the planning and development of the modern electric system. In the past decade, [the] United States (U.S.) wind energy output grew [as a sector] 10 times faster than [the combination of] all other sources of electric energy.[1] The growth in wind turbines is remarkable, given that the U.S. wind industry installed more than 60 percent of all existing turbines in just the past four years. We are truly in a wind boom. This is attributable to a number of factors, including the fact that wind projects are much quicker to design, permit and construct than traditional coal or nuclear plants, and wind energy tends to be one of the least expensive renewable energy options. As a result, the U.S. now leads the world in total wind energy connected to the grid, surpassing nations such as Germany and Denmark. Where we go from here depends on how much we choose to subsidize this alternative, as well as on some specific attributes of wind and the systems required to deliver it.

FUNDAMENTAL ISSUE: INTERMITTENCY

Despite robust wind development in the U.S., wind faces a nearly insurmountable issue: intermittency. Simply put, the intermittent nature of wind makes it difficult to harness effectively on a power grid that is finely tuned to deliver electricity around the clock, matching demand second-by-second. The down side of this intermittency is clearly evident in the actual performance data of wind turbines already installed. Wind performs poorly across all traditional utility metrics for generating resources. For reliability, stability, forecast ability, proximity to load centers, dispatch ability and economics, wind power is a poor choice for large-scale power production.

NAME-PLATE RATING VERSUS ACTUAL ENERGY DELIVERY

For the sake of this discussion it's important to know that all power producing equipment comes with an output rating stating how much power the facility will produce. This is referred to as name-plate capacity and it is expressed in kilowatts (kW) or megawatts (MW).[2] For large utility grade generators the customary expectation is that once installed, they will deliver the name-plate output, on demand, when supplied with sufficient fuel. Additionally, they will operate, if required, around the clock. In the case of wind energy installations this is simply not the case. The output over time is only a small fraction of name-plate rating because of the intermittency of the fuel resource (moving air). The ratio of actual output divided by maximum potential output is defined as capacity factor. The entire sector of U.S. wind energy is currently operating at a capacity factor of only 30 percent.[3]

It is troubling that we see some astonishingly simplistic reports in the media which assert the number of homes that a given "wind farm" will allegedly supply. When reliability, expressed as capacity factor, is taken into account, the serviceability of wind is much lower than advertised. Our modern understanding of supplying electricity to a home is that a fully sufficient amount will be made available 24/7/365. In reality, it would be rare that any wind development could actually supply fully sufficient electricity to even a single home 24/7/365. Such misleading claims by developers may contribute to the sentiment that renewable energy can easily replace fossil fuels—it cannot.

[1] U.S. DOE Energy Information Administration, Net Generation by Energy Source, (2010), http://www.eia.gov/electricity/monthly/index.cfm. Wind data shown in [on] Table 1.1.A. Net Generation by Other Renewables: Total (All Sectors), 2000 through July 2010. Based on a comparison of 2010 versus 2000, wind energy output expanded by 1600 percent, natural gas electric generation grew 63 percent, nuclear grew seven percent, coal declined six percent and hydroelectric declined seven percent. The entire electric mix from all sources grew a total of eight percent.

[2] One megawatt is equal to one thousand kilowatts.

[3] U.S. DOE Energy Information Administration, Electric Power Monthly, Table 1.1.A, *Net Generation by Other Renewables*, www.eia.gov/electricity/monthly/index.cfm. Annual capacity factor is calculated by dividing 2010 wind generation by the monthly average of installed capacity.

WIND IS WEAK AT PEAK

The intermittent and unpredictable nature of wind is further compounded by the fact that the wind tends to be weak during electrical peak load conditions. Wind blows most consistently and creates the best generation opportunities during off-peak hours, cooler days and evening hours. Unfortunately, this is directly opposite the electric customer demand profile. This disparity is a natural consequence of the climate forces that determine wind: daily and seasonal temperature differentials.

For example, on the hottest days of the summer the wind tends to be low or non-existent when air conditioning demands are at their peak. Then when it gets windy, the temperatures will naturally moderate and air conditioning loads drop off just in time for the wind energy to pick up. So wind supply and user demand are out of sync. The same phenomena can be demonstrated to occur during winter peak conditions. The very coldest days are also the days when the wind is not blowing. For this reason, utility-scale balancing regions simply do not plan for significant contribution of wind at peak demand periods. This can be amply demonstrated in real-world, large scale examples from Texas, California, the Pacific Northwest region, and the entire western United States.

TEXAS

Texas is home to the largest collection of wind generation facilities in the nation. More than one out of every four wind turbines in America is found in Texas. The Electric Reliability Council of Texas (ERCOT) only plans for 8.7 percent of wind name-plate rating as the "dependable contribution to peak requirements" (also known as Capacity Value), in accordance with ERCOT's stakeholder-adopted methodology.[4] This means that more than 91 percent of Texas wind turbines are expected to be off-line when it matters most—at peak load periods.

CALIFORNIA

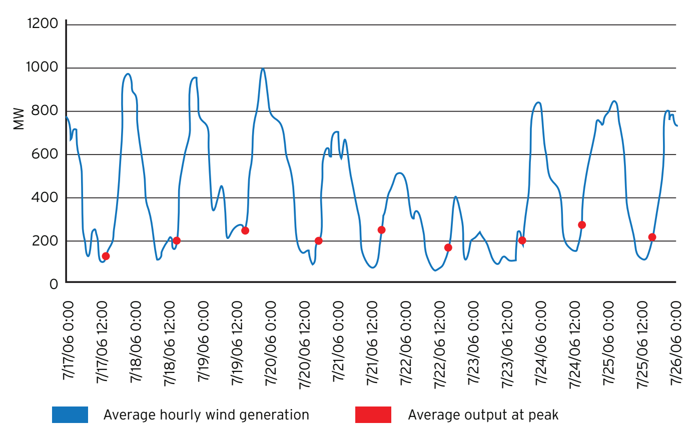
The State of California ranks third in the U.S. for total installed wind energy (behind Texas and Iowa). California is also the third largest state geographically (behind Alaska and Texas). According to the California Independent System Operator (CAISO),

> *"California is a national leader in the development of renewable resources. Because California has large quantities of renewable resources already on-line, a significant amount of historical data is available to accurately model and forecast future performance of the various types of renewable resources."*

> *"Wind generation presents . . . significant operational challenges. Wind generation energy production is extremely variable, and in California, it often produces its highest energy output when the demand for power is at a low point."*[5]

CAISO's graph demonstrates its summer wind generation and average variation by hour:

2008 SUMMER LOADS & RESOURCES
OPERATIONS PREPAREDNESS ASSESSMENT



[4] Kent Saathoff, ERCOT *Expects Adequate Power Supplies for Summer*, ERCOT, May 12, 2010, www.ercot.com/news/press_releases/2010/nr-05-12-10.

[5] 2008 Summer Loads and Resources Operations Preparedness Assessment, Figure 5, Grid Assets, California ISO Version 1.0, April 28, 2008.

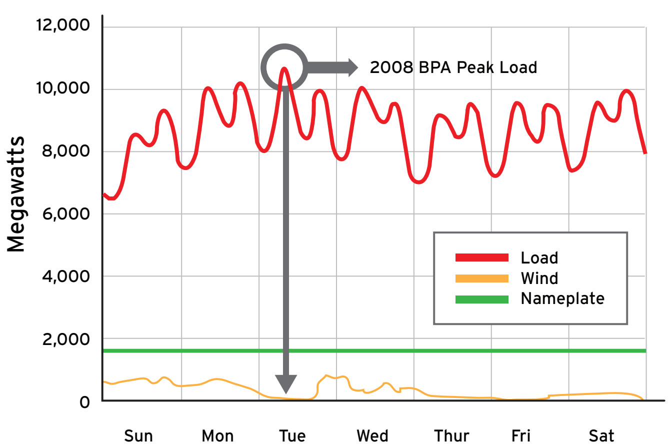
The wind capacity available at California peak demand times is about 200 MW. The name-plate capacity of California-based wind generators is about 2,600 MW. Hence, the wind power available at peak is less than 10 percent, which is very similar to the Texas experience. In other words, about 90 percent of California wind turbines cannot be depended on to be producing at peak load conditions.

Note that Texas and California are both summer-peaking systems. Let us consider a vast winter-peaking region—the Pacific Northwest—to see how wind energy performs in that situation.

THE PACIFIC NORTHWEST

Oregon and Washington rank fourth and fifth in the U.S. for total installed wind energy. The prominent Federal Power provider in the region—the Bonneville Power Administration (BPA)—is a winter-peaking system with about 10,000 MW of load.

BONNEVILLE POWER ADMINISTRATION[6]
ACTUALS - WEEK DECEMBER 14, 2008



Data: Bonneville Power Administration

On Tuesday December 16, 2008, the BPA system reached its peak for the entire year, with a demand of 10,762 MW. At the time of peak demand, the output of the entire fleet of wind resources, with a name-plate value of 1,599 MW, was only 116 MW, or about seven percent of the name-plate potential. This is very similar to the Texas and California wind experience, only in this case about 93 percent are not producing at the winter peak.

THE WESTERN UNITED STATES

Now let us consider an even broader region—all eleven western states, from Montana to New Mexico, from Washington to California, and everything in between. This vast area is served as a single "reliability" region known as The Western Electricity Coordinating Council (WECC). During the heat wave of July 2006, the WECC system reached its peak on Monday, July 24, 2006. The hottest day was actually July 23, 2006, but this was a Sunday so total loads did not peak until Monday. On the hottest day, the capacity factors for wind resources through most of WECC were well under five percent, and on the peak day, which was a slightly cooler day, the wind capacity factors were less than 10 percent.[7] Again, this is very similar to Texas, California and the Pacific Northwest.

These real-world lessons illustrate a grave shortcoming of wind. Approximately 90 percent of wind turbines can be expected to NOT PRODUCE power at peak load periods, even when distributed over broad geographic areas.

Incidentally, I recently had a conversation with a trustee of a large mid-western utility that is home to 450 MW of wind generation. He asked me to guess how much of the 450 MW of wind was actually producing during their system peak. I responded, "Probably between 30 and 40 MW." He gasped, "How did you know? That is exactly what we are seeing!" Yes, wind is weak at peak.

[6] Bonneville Power Administration, http://transmission.bpa.gov/Business/Operations/Wind/default.aspx.

[7] WECC, *Wind Capacity Issues,* Working Draft, March 17, 2010.

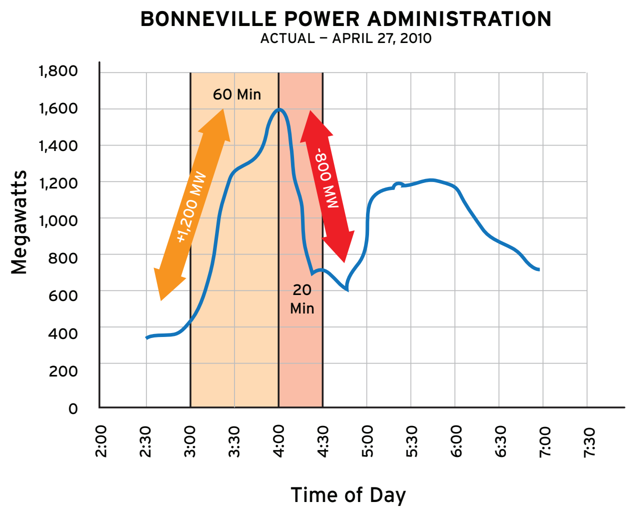
ENTER THE "TWILIGHT ZONE"– A CONTROL AREA[8] NIGHTMARE

The demonstrated low performance of wind energy during peak load conditions is only one side of the coin. The other side occurs during off-peak periods when unscheduled, unanticipated wind energy comes booming onto the system ready to serve loads that are nowhere to be found.

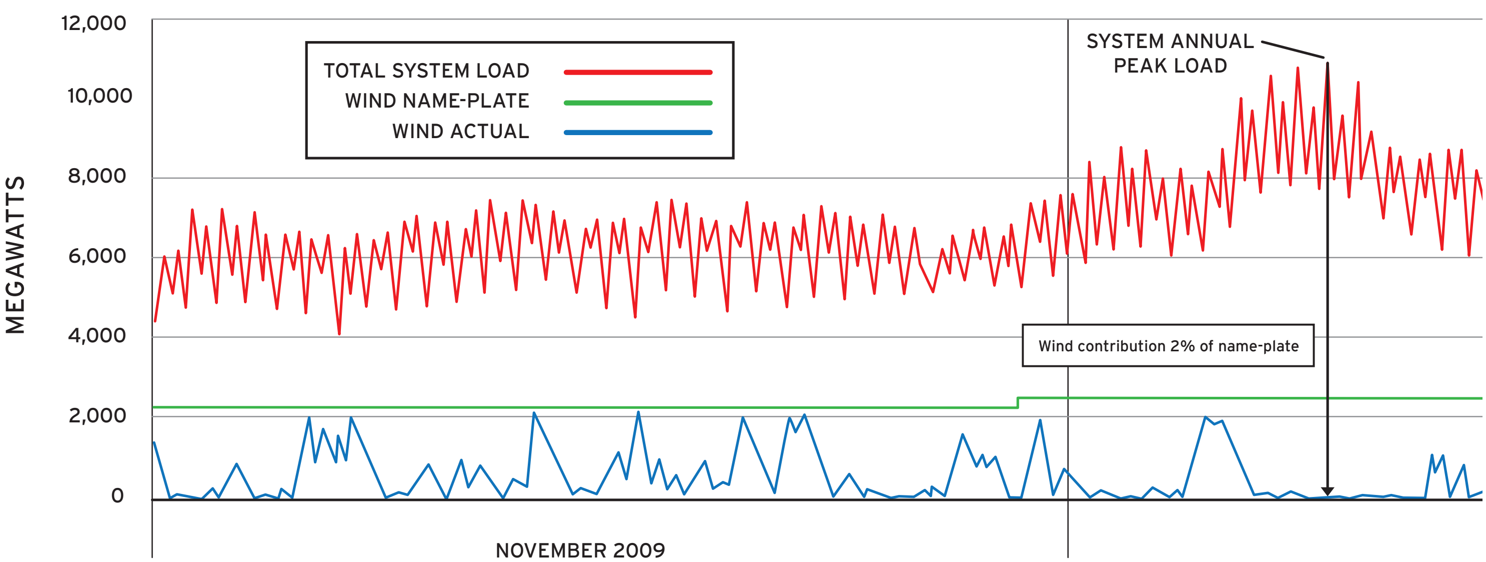
This can easily happen because of the physics of wind energy: the power output of a wind turbine accelerates at a much faster rate than the simple change in wind speed. For instance, if the wind speed changes from 10 to 20 mph (a doubling of the wind speed) the associated power output will change by a factor of eight.[9]

An actual case with the BPA brings the control area problem into perspective. On April 27, 2010 about 3:00 a.m., wind generation on the BPA system ramped up by 1,200 MW in only one hour, and then down 800 MW in only 20 minutes. Such rapid changes cause extreme stress to a control area and in many cases result in market price distortions and environmental degradation.

CONTROL AREA/TWILIGHT ZONE IN ACTION:[10]



BONNEVILLE POWER ADMINISTRATION 2009/10 TOTAL SYSTEM LOAD AND WIND CONTRIBUTION



[8] Control Area - A power generation regulation region that maintains and balances its power load and power interchanges with other control areas. See also, Control Area Concepts and Obligations, North American Electric Reliability Council, 1992.

[9] Note that the physics of wind energy is such that the change in power of a wind turbine is proportional to the cube of the change in wind speed. This means that if the wind speed cuts in half, the power output will cut to one-eighth. See also, Wind Systems Power Calculation, http://wind-power.generatorguide.net/wind-speed-power.html.

[10] Bonneville Power Administration, http://transmission.bpa.gov/Business/Operations/Wind/default.aspx or ibid.

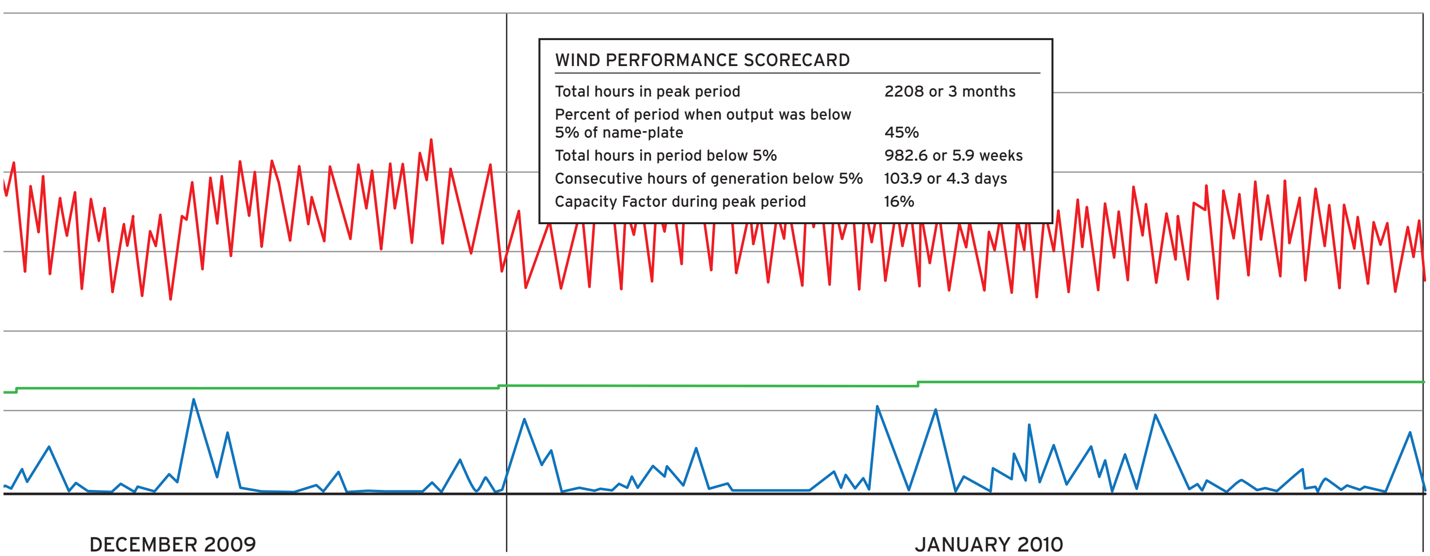
Such erratic changes in generation run directly counter to the needs of utility operators who select from a pool of different traditional generators to provide the right amount of power at the instant it's required. In a normal day they blend the outputs of traditional power plants that include coal, nuclear, natural gas, and in some regions hydroelectric to work in concert to minimize operating costs while maintaining reliability.

Now we have the advent of wind. The use of wind energy creates an unprecedented challenge, which can easily launch utility power systems into an off-peak condition, something that can be described as the "twilight zone."

Consider an event that occurs during off-peak or twilight hours. The various utilities are operating with all of the peaking plants off line and many of the intermediate resources off line. Still running are base-load, coal-fired generators but they have been reduced to minimum-load status. The nuclear plants are running because they remain in "must-run" condition for safety and economic reasons. The wind turbines are cruising along at a modest output.

Now assume that a sudden, unanticipated, change in the weather brings with it a rapid ramping of wind energy output. This can result in a large block of several thousand MW of unplanned energy that, when combined with the operating status just described, can easily swamp out the total load requirements of the utility—meaning there's literally no place for the energy to go.

Now the utility is forced to make quick and drastic decisions to balance loads and resources. I call this the twilight zone—a control area no-man's land. One option might be to enact the costly decision to shut down a base-load resource, such as a nuclear



WIND PERFORMANCE SCORECARD

Total hours in peak period	2208 or 3 months
Percent of period when output was below 5% of name-plate	45%
Total hours in period below 5%	982.6 or 5.9 weeks
Consecutive hours of generation below 5%	103.9 or 4.3 days
Capacity Factor during peak period	16%

or coal unit, and then subsequently face a high cost "re-start" with its attendant unusual wear and tear on the affected units. In the case of a coal-fired unit, emissions will increase as the unit and its pollution control equipment ramp up during the few hours after startup. Another significant problem with this choice is illustrated in the BPA example above. If a base-load source like coal is shut down, and then the wind supply suddenly drops, it will not be possible to re-energize the base-load facility quickly enough to compensate for the wind loss. This could result in rolling blackouts—which puts us out of the twilight zone and into an electric abyss.

Another twilight zone choice is to try to sell the "hot potato" energy to a neighboring utility or to another control area authority. What if the neighbor already is operating at (or close to) optimum balance—a likely scenario. The choices are quite limited and whatever option is chosen there will be a substantial losses incurred by the wind energy utility (i.e. ratepayer).

In the first case the electricity is sold at a substantially discounted price (e.g. what costs the utility $135/MWh is sold for $20/MWh).[11]

In the second case the market price for electricity can plunge so low that the price actually goes negative. The host utility might actually have to pay a neighboring utility to accept the surplus schedule and allow delivery onto its system. This absurd result is a reality in a system that has a high percentage of wind generation installed and can be very costly to the host utility.[12]

Do you think the twilight zone problem is insignificant? Is this just a remote hypothetical? Think again. Many utilities have found themselves in precisely this situation. For this reason some system operators are now requiring wind turbines to be equipped with a "cut out" switch that disconnects the wind farm from the grid by remote control. But it doesn't end there as the wind developers still want to get paid for the energy they might have been able to deliver. When they are denied this payment, they sue.[13] No matter what the result of such a suit, there is an obvious waste of money and energy.

THE SHADOW GRID—THE FOSSIL FUEL STAND-IN FOR NO SHOW WIND

Wind's unpredictable nature tends to provide energy that does not match user demand. As noted in the examples of ERCOT, California and the Pacific Northwest, wind volatility makes it unsuitable for electricity planners to rely on wind energy to meet peak demand needs. The same applies to base-load and load-following demands. In order to mitigate these negative effects, the grid operators and planners must construct a shadow grid, typically consisting of fossil-fueled power plants (particularly fast responding gas-peaking units). This shadow grid stands as reserve generation for those times when wind has unexpected supply variations, which are inherently a daily matter. This augmentation needs to be distinguished from the former backup of conventional sources built into the grid, which was primarily designed to deal with demand variations. Expressed another way, conventional sources have a Capacity Value of well over 90 percent, while wind energy's Capacity Value is under 10 percent. This is a profound difference.

[11] FPComment, *Ontario's Power Trip: Power Dumping*, http://opinion.financialpost.com/2011/07/20/ontarios-power-trip-power-dumping/.

[12] Knowledge Problem, *Frequent Negative Power Prices in the West Region of ERCOT Result from Wasteful Renewable Power Subsidies*, http://knowledgep-roblem.com/2008/11/20/frequent_negati/.

[13] United States of America Before the Federal Energy Regulatory Commission, *Complaint and Petition for Order Under Federal Power Act Section 211A Against Bonneville Power Administration Requesting Fast Track Processing*, http://www.bpa.gov/corporate/agencytopics/columbiariverhighwatermgmnt/otherdocs/2011-06-13_complaintagainstbpa.pdf.

Typically, we build new fossil-fueled peaking power plants (usually natural gas) to augment the wind resources that were intended to eliminate fossil-fueled resources in the first place.

This duplication of costs is forced onto consumers, who must pay for both the wind turbine and the back-up generator.

THE LOS ANGELES DEPARTMENT OF WATER AND POWER (LADWP) recognizes the need to back up wind with gas in order to maintain capacity and reliability. Consider the following statement from the LADWP's executive summary of its 2010 Draft Integrated Resource Plan:

> *"There is ongoing debate regarding the level of on-peak reliability of renewable resources. However, the renewable resources were added mainly to satisfy Renewable Portfolio Standard (RPS) target requirements, while natural gas resources were incorporated to ensure system reliability."*

In other words, the LADWP overtly recognizes that the wind projects on the system are only meeting the legislatively mandated RPS as they provide intermittent energy. But to actually operate a reliable system, with capacity and energy, LADWP must install additional natural gas generation resources. In spite of the purported environmental objective of wind energy, the shadow grid of gas generation will result in consequential air emissions, including carbon dioxide. To meet the fast-acting needs of their wind partner, many such generators are "simple cycle" peaking units, which tend to be less efficient and have the highest emissions among gas-fired generators.

The need to develop a shadow grid has also resulted in the actual filing of new tariffs to charge for the cost of such a grid. Puget Sound Electric has recently filed a tariff with a proposed charge of $2.70 per kilowatt-month to offset the carrying cost of a shadow grid of gas turbines that are required to stabilize the volatility of wind.[14] This can result in an energy charge of one- to two-cents per kWh—or an additional 10 to 20 percent (or more) tacked onto the already high cost of a wind turbine in order to integrate it operationally into the grid.

INCREASE IN CARBON DIOXIDE FROM WIND POWER—IT IS POSSIBLE

In addition to the obvious investment and operating cost of the shadow grid, there is another unintended consequence of this fossil-fueled backstop system: CO_2 [carbon] emissions. As discussed above, a significant penetration of wind turbines into an electric grid can cause base and intermediate resources to be fired up and energized onto the grid or dispatched at levels where design efficiencies are very poor. This results in increased CO_2 emissions from what might otherwise be expected.

Think of it like this: suppose that you were going from one part of a city to another, where you are required to maintain an average speed of 30 mph. In the base case you take an unobstructed route where you can set the car on cruise control at 30 mph. Now consider if another equally long road you took had stoplights and periodically congested traffic—which would result in unpredictable stops or slowdowns. To maintain the same 30 mph you would have to rapidly accelerate to 50 mph+ for certain intervals. Clearly there would be much higher fuel used in the second case. This is more or less what happens to an electric system that attempts to accommodate a high percentage of wind resource into the grid.

[14] Energy News Data, *California Energy Markets*, July 16, 2010, No. 1087, 11-12.

The concept and conclusion is as valid as it is alarming:

Wind power does not produce all of the claimed benefits of reductions in fossil fuel consumption and CO_2 emissions when the fuel consumption and related emissions of the shadow grid of gas-fired resources are taken into account.

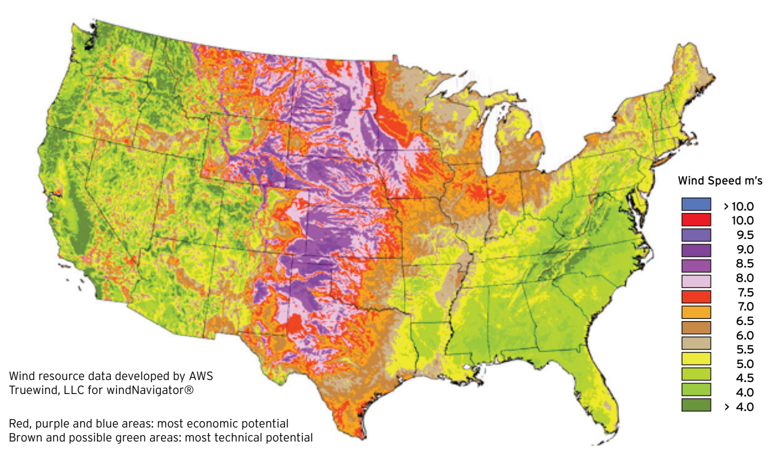
The actual benefits are much less. When real world efficiency losses and additional emissions from the gas turbines are taken into account, the perceived environmental savings of wind energy are greatly diminished.[15]

GOT TRANSMISSION? ANOTHER MISSING COST ELEMENT

No matter where you live, or how windy you think it is, some regions of the country see relatively little sustained wind at all. Below is a basic map of the United States' wind energy potential.[16]

Note that the regions of maximum wind potential (the areas of red, purple and blue) do not coincide with the areas of dense population. The wind speed and duration are generally the greatest in the least populous areas far away from the big cities on either coast. This mismatch between resource and population is one of the reasons that developers of wind energy are challenged to find and exploit locations close to existing high-voltage transmission lines that can carry electricity from wind turbines to big city distribution lines. As more of these locations become occupied, adding more wind generators can only happen in locations where new additional transmission corridors are cleared and constructed, to carry out the delivery process from high wind zones to urban centers. Obviously the lack of new transmission adds a significant hurdle when considering wind development. Too often this substantial component of cost gets overlooked in discussing the relative costs and benefits of wind energy.

The western continental United States is home to eight of the largest states, in terms of land area (with Alaska and Texas completing the top 10). Of these eight states, only California ranks in the top 10 in terms of population. The relatively sparse population in the vast, open areas calls for lengthy, and therefore costly, transmission lines. There can also be significant line losses.



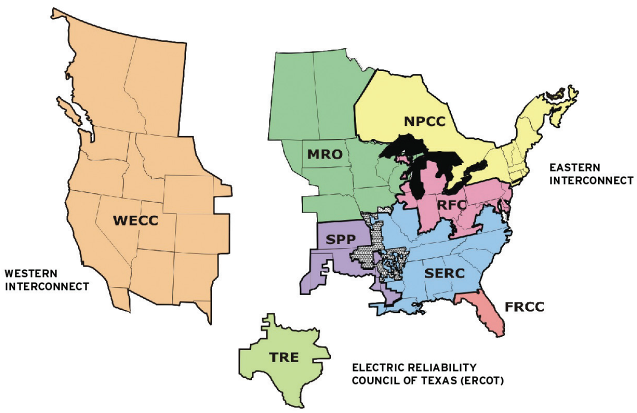
[15] Benteck Energy, *How Less Became More—Wind, Power and Unintended Consequences in the Colorado Energy Market*, http://docs.wind-watch.org/BENTEK-How-Less-Became-More.pdf.

[16] U.S. Department of Energy, *Wind Powering America*, http://www.windpoweringamerica.gov/wind_maps.asp.

THE ELECTRIC CONTINENTAL DIVIDE

The United States electric delivery system does not operate as a single grid, but rather as three separate grids as shown on the map below:

NORTH AMERICAN ELECTRIC RELIABILTY CORPORATION (NERC) REGIONS



Because electric energy is instantaneously generated and consumed, the operation of these three grids requires a coordinated balancing of generation and consumption of power within each grid. Control Area Operators (CAOs) perform this function, as well as other important tasks, that allow the interconnected electric power systems and their components to operate together both reliably and efficiently. There are approximately 150 Control Areas in the nation. Most are run by the dominant large investor-owned utility in a geographic area defined by an interconnected transmission grid and power plant system. The CAOs dispatch generators from a central control center with computerized systems in such a way as to balance supply and demand and maintain the transmission system safely and reliably. This also protects the sensitive electronics to which we've grown accustomed by providing a consistent voltage, 24/7/365.

The Western Interconnect boundary (WECC) consists of 30 such "Control Areas" that include most of Montana, Colorado, New Mexico and all states to the west. The Eastern Interconnect includes everything east of this border, with about 120 individual Control Areas. And Texas? I guess you don't mess with Texas! They do their own thing down there.

These three grids operate independently from one another. Since the three large grids are not in synchronous operation with one another, they cannot be interconnected with one another through traditional "alternating current" (AC) transmission lines. The only possible means of interconnection is through "direct current" (DC) and this is very costly. Consequently there are only six DC ties connecting the Western Interconnect and the Eastern Interconnect in the United States and one additional DC tie in Canada. The capacity of these ties is quite limited (due to cost). The current interties, being already in service, have little excess capacity to move new renewable power. Six or seven interties of several hundred MW will simply not get the job done especially when compared to the million megawatt size of our electric system.

The aforementioned transmission challenges create a virtual wall between east and west and Texas. Unfortunately, the greatest natural source of wind energy is electrically trapped in the Midwest. It is virtually impossible, or at least very cost prohibitive, to consider transmitting this resource to the west. It is also impractical and cost prohibitive to transmit this energy to the east coast population centers that are, in some cases, more than a thousand difficult miles away.

Just as precipitation will naturally drain within a continental divide, in similar manner the nation's wind energy resources are virtually constrained to remain within the three "electric continental divides" of the West, the East and Texas. What happens in the east stays in the east, what happens in the west stays in the west and what happens in Texas, stays in Texas.

WIND ENERGY STORAGE—NOT READY FOR PRIME TIME

What if we could just store the wind energy when it is produced (and not needed) and then call on it in times of need? Consider this statement from the North American Electric Reliability Corporation (NERC):[17]

> *"Unlike water or gas, electricity cannot be stored. It must be generated as it is needed, and supply must be kept in balance with demand. Furthermore, electricity follows the "path of least resistance," so it generally cannot be routed in a specific direction. This means generation and transmission operations in North America must be monitored and controlled in real time, 24 hours a day, to ensure a consistent and ample flow of electricity. This requires the cooperation and coordination of hundreds of electricity industry participants."*

Storage of electricity would, indeed, answer many of the operational concerns raised when it comes to renewable energy. In the above statement saying electricity "cannot be stored" would be better phrased as "cannot be practically and economically stored, at this time." To fill this perceived need, there is much effort underway to develop new storage technologies. An ideal storage mechanism would be able to economically capture very large quantities of electricity, at a near instantaneous rate of charge and discharge on demand. It would also be able to safely hold a large charge for long periods of time, with little or no losses. Unfortunately, as of today, this dream set of criteria is a fantasy, with nothing on the horizon likely to be even close. Unfortunately, the wave of new, wind and solar energy sources can only function properly in a world that has optimized such near-ideal energy storage opportunities.

It is true that devices have been invented to store bulk electric energy. These tend to be miniscule in scale, and expensive to acquire and operate.

One particular state-of-the-art storage device consists, essentially, of a high-speed flywheel (30,000 rpm) that is suspended (or levitated) above cleverly designed magnets, resulting in a storage that is almost frictionless. Such a device can begin charging (or discharging) in a fraction of a second—it is clearly able to respond to any sudden changes in wind or solar output. It is recommended by the developer of this technology that about 2.5 MWh of storage capacity (at a cost of $1.4 million) will accommodate a wind turbine of about one MW name-plate rating. The one MW wind turbine, according to EIA data,[18] would come with an installed cost of about $2.4 million. Storage, in this case, therefore adds about 60 percent to the installed cost of wind. Such a storage device is capable of offsetting any unanticipated effects of the wind system for a period of at least

[17] North American Electric Reliability Corporation, *About NERC: Understanding the Grid*, http://www.nerc.com/page.php?cid=1|15.

[18] U.S. DOE Energy Information Administration, *Updated Capital Cost Estimates for Electricity Generation Plants*, November 2010, http://www.eia.gov/oiaf/beck_plantcosts/pdf/updatedplantcosts.pdf.

2.5 hours, or longer. This gives the utility system more opportunity to operate with more predictability; it also mates some capacity with the wind energy. The storage does not, however, mitigate wind's nationwide annual average capacity factor of only 30 percent, or provide for reliability or dispatch ability on a par with our conventional sources.

Based on the above estimates, storage would add about 4.7 cents per kilowatt-hour to the cost of wind. It is doubtful that such a system is economically justified, but it is quite interesting nonetheless. Such exotic storage systems are typically reserved for the most rare of applications—remote islands, arctic outposts, etc., or for research and development pilot projects. None of these technologies currently exist with sufficient supply and at a low enough cost to make a meaningful difference to the bulk power system.

Not every region or location is suitable for the most promising storage opportunities. It should also be noted that storage technologies always come at not only a capital cost to develop and acquire the storage mechanism, but also an operating cost or storage penalty (essentially the execution of thermodynamic laws). There is always some amount of energy loss associated with storage. The flywheel system previously described claims a storage penalty of about five percent, including transformation, while hydroelectric pumped storage (the only large-scale storage mechanism built to date) requires about 30 percent more energy to fill the storage pond than can be extracted upon retrieval. The energy output of storage is always net negative.

WIND TURBINES CAN CONSUME ELECTRICITY

One of the little known ironies about utility scale wind turbines is that they require an external source of grid-provided electricity in order to run numerous functions.[19] For example, particularly in cold climates, where much of the best wind resources can be found, these units must be heated to maintain proper viscosity in lubricating fluids and to protect vital components from damage. Even more of a draw is that blades need to be periodically de-iced. When it's cold in Wyoming and up into the Dakota badlands where the calm night air drops to below-zero, it will be the fossil-based fuel from gas and coal-fired power plants in the region that are called upon to warm the massive wind turbines towering hundreds of feet above the windswept plains. These considerations need to be factored into not only wind economics but also the actual amount of CO_2 saved.

As we gather more and more real-world data in the production of wind energy, it is apparent this resource has a long way to go before becoming a viable contributor to the world's energy needs. While there may be a worthy role for subsidies and taxpayer support of wind, the inescapable fact is that wind is unlikely to ever be more than high-cost/low-benefit supplemental resource, which must be backed up by natural gas plants and/or energy storage technology.

[19] AWEO, *Energy Consumption in Wind Facilities*, http://www.aweo.org/windconsumption.html.

VALUE OF POWER— DEMAND VERSUS ENERGY

Commercial and industrial electric power is typically priced and valued based on two components: demand and energy. Demand, or capacity, is the ability to supply electricity at the very instant it is needed. Energy refers to the amount of electricity that is actually delivered and used over the course of time (such as a monthly billing period, typically in kWh). Depending on the utility rate structure, the demand charge component can be as large as or larger than the energy charge component. This reflects the fact that the utility must purchase, construct and have available all of the generating and transmission resources necessary to meet peak demand needs, as well as the cumulative energy needs measured over a period of a month or a year.

Satisfying demand is closely associated with the notion of dependability or reliability.

Consumers want the power to be there the very instant that it is demanded.

Having electricity intermittently available, at unpredictable times and quantities, is not acceptable in today's modern electric system.

A practical example will help illustrate this point. When it comes to our automobiles, we have a tendency to demand cars be reliable and to meet our wants and needs at our beck and call. Consider a choice between two automobiles: one gets 50 miles per gallon, but only runs intermittently about 25 percent of the time; the other car gets about 20 miles per gallon, but it runs all of the time. How would you value each of these cars?

If the first car had low fuel cost, but also low reliability, how much would you pay for such a car? Note that when considering the cost, you would certainly also add in the cost of frequently calling a taxi when your car stalls half way down the road to town (or on the middle of your cross-country vacation), the cost of the tow truck to return your vehicle, the cost of your lost time, the cost of lost business, etc. It doesn't take much thought to see that a focus on the fuel economy (as an accurate indicator of overall cost) is an illusion, as the real cost of such a vehicle is considerably more than the conventional options. And who wants a car that only runs on its own schedule?

Some wind proponents say that the reliability will be equivalent to our conventional sources if we join together several wind facilities, spread over a very wide area. In our analogy that would be like buying multiple undependable cars hoping one of them would likely work at any time. Clearly the cost (e.g. multiple insurance policies, etc.) and nuisance would far exceed the expense of one reliable vehicle. Empirical evidence doesn't support this claim either. See the earlier discussion, "Wind is Weak at Peak."

This "value of power"concept is very relevant to a discussion about renewable energy. A claim might be made, for instance, that a certain wind turbine can produce power at a cost in terms of cents per kilowatt hour (kWh) that approximates the cost of coal or gas. But energy cost is only half the story. The actual value of such power is properly assessed by considering both the demand and energy provided by any given resource, and the related dependability.

WIND POWER COMPARED TO NATURAL GAS POWER

Suppose we are weighing the pros and cons of a decision to add a new resource. The two finalists are (1) a 100 MW wind farm, and (2) a 100 MW combined-cycle gas plant. Our goal is to offset emissions from an existing 100 MW coal plant that is nearing retirement.

Our target coal plant is currently operated a little less than 67 percent of the time, primarily due to the fact that the coal plant is dispatched, or operated to conform to load requirements. Our plant runs about the same as the entire fleet of U.S. coal plants. It normally runs at very high availability rates—in excess of 90 percent—but is scheduled to match consumer load requirements. Our prospective gas plant can easily take the place of the retiring coal unit as it performs with similar characteristics. It can be sited flexibly near load. It depends on a combustion resource and therefore can be operated to match the consumer load requirements at any time.

Our prospective wind resource on the other hand, can only be scheduled according to the operator's best estimate of forward-looking weather patterns. The primary challenge of wind is the intermittency of the supply. Unless it is backed up with another peaking resource (usually gas turbines), we cannot use the wind by itself as a complete coal replacement. But, the obvious allure of wind is the promise of low emission electricity (e.g. carbon dioxide, sulfur dioxide, nitrous oxides, particulates, etc.).

So, how well does wind energy perform? The national average output efficiency for wind is slightly less than 30 percent.

This means, for instance, that a 100 MW wind farm will average only 30 MW of output. This might come in the form of near 100 percent output for 30 percent of the time, and 0 percent output during nearly 70 percent of the time, with numerous iterations in between. But, over time, the average will be about 30 MW. Thus, the ability of wind to displace our coal is energy limited because of the intermittent actual output.

Since our target coal unit operates with 67 average MW, the maximum replacement (albeit highly unlikely or even impossible) that we can get from the wind farm is 30 of the 67 average MW, or a 45 percent displacement. We are unavoidably left with at least 37 average MW of coal that must operate when the wind is not blowing. But, in fairness, 45 percent coal displacement is an extreme upper limit of what wind can do. In actuality, the wind farm is likely to produce some of its energy (probably about 30 percent of the time) during periods when the coal plant is not operated at all. In addition, wind tends to be strongest during off-peak periods—the same periods when the coal plant is most likely to be scaled back to minimum load. And, if the wind energy comes on during these periods, the coal plant cannot be further reduced, unless it is taken completely off line (which would subsequently incur restart costs and ramping challenges). Therefore, the wind will most likely displace some other resource, such as gas or possibly hydro. Obviously, the carbon reductions from wind will be much lower, or even nonexistent, in this circumstance. So, the range of coal displacement that can be accomplished by wind is somewhere in the range of 20 percent to 45 percent, with 30 percent as a reasonable central estimate.

Now, let's consider the gas alternative.

Combustion of natural gas produces about 45 percent less carbon dioxide emissions than combustion of coal. Further, gas units are more efficient than their coal counterparts, and when this efficiency is accounted for a combined-cycle gas plant can be expected to produce about 60 percent less carbon dioxide than coal.[20]

[20] According to the Energy Information Administration, as a national average, coal-fired power plants emit 210.6 lbs. CO2 per MMBTU. Gas, on the other hand, emits 117 lbs. CO2 per MMBTU. So, comparing these two fossil fuels, gas emissions are about 55 percent of the coal counterpart. This means that there would be a 45 percent savings—but this is only part of the story. These emission rates are further adjusted by equipment efficiency. The term used in industry for this efficiency is heat rate, where a lower heat rate constitutes a more efficient machine (the machine produces more electrical energy per unit of heat or BTU input). The national average heat rate for coal is 10,355 BTU per kWh, while the national average heat rate for gas is 7,620 BTU per kWh. When we combine heat rate with the emission attributes, we find that natural gas-fired emissions are about 59 percent lower than coal-fired emissions per unit of energy, as shown in this formula: [(210.6 X 10,355) – (117 X 7,620)] / (210.6 X 10,355) = 59 percent. When we employ the same formula for an efficient combined-cycle unit with a heat rate of 7,000 BTU/kWh, can demonstrate CO2 reductions of 64 percent.

Because gas can be run essentially all of the time, and can easily ramp up or down to match consumer loads, it is a natural operational substitute for coal. Therefore, if we were to install a new 100 MW combined-cycle, gas-fired plant (instead of the 100 MW wind farm in our example), this would result in a net carbon dioxide emissions reduction of about 60 percent, compared to coal.

Consider the significance of this analysis. With the same installed capacity, a combined-cycle gas turbine can provide net reductions in carbon dioxide that are greater than wind—approximately double the benefit. In addition, wind is significantly more costly when compared to gas. A new wind farm can be expected to have an installed cost that is about double the price of a new combined-cycle gas turbine.[21]

Emissions Reductions using Natural Gas to Replace Coal

Nitrogen Oxides	-85.20%
Particulates	-99.80%
Sulfur Dioxide	-100%
Mercury	-100%

(Assumes gas heat rate of 7,620 BTU/kWh and coal heat rate of 10,355 BTU/kWh)

In the above example, we were focused solely on carbon dioxide. How does the example pan out in terms of other pollutants? Gas performs even stronger when considering other forms of emissions. Gas yields an 85 percent reduction in nitrogen oxides versus coal. And, gas-fired power plants have virtually no particulate emissions, and no sulfur dioxide or mercury, compared to coal.[22] So, in these regards, it is impossible for wind to outperform gas.

Conclusion: gas outperforms wind in all emission-reduction categories when balanced against average wind performance across the U.S. Further, gas can run with the same reliable profile as a viable replacement for coal. If the national policy is to reduce emissions from coal-fired units, policy makers should abandon so-called "renewable portfolio standards" that mandate wind and solar, and consider policies to promote the use of natural gas as the preferred alternative.

SOLAR ENERGY

There is significant national and international interest in the development of new solar energy. While this is obviously an energy source that has more applicability to regions with high levels of sunshine, it is a promising technology for many reasons. The single greatest challenge to solar power is the immutable fact that the sun is only available, at best, half of the time, no matter how ideal other conditions may be.

A well-designed and situated solar project will typically provide available energy about 20 percent of the time. At this low availability, solar energy can never be more than a supplement to a larger portfolio of power generating resources.

And like wind, solar energy begs for supplemental storage in order to provide a degree of reliability to the grid.

NOT ALL SUNSHINE IS EQUAL

Photovoltaic cells, or PV solar, are by far the most common application for electric generation from solar energy. Although there are other forms of solar renewable projects, given the availability and popularity of PV, we will focus on it first.
PV panels are made from materials such as crystalline silicon and cadmium telluride, which convert photons from the sun's rays into electric

[21] Calculations based on JEDI model found in U.S. Department of Energy, Wind Powering America, www.windpoweringamerica.gov/economics_jedi.asp and www.20percentwind.org.

[22] Energy Information Administration—EIA, Voluntary Reporting of Greenhouse Gases Program Fuel Emission Coefficients, 2012.

energy. To make use of the energy produced by these cells, an inverter is attached to a PV array to create alternating electric current. Some PV panels are small, roof top applications, and a few are larger, utility scale facilities. PV solar panels have no moving parts. Hence the operations and maintenance consists largely of a careful cleaning from time to time with glass cleaner. But even a very large PV solar project will have a fairly modest output.

The entire United States' output of PV solar for the year 2009 was 807,988 MWh, about one-tenth of one percent of the U.S. nuclear output.

HOW EXPENSIVE IS PV SOLAR?

Apart from the day/night cycle of solar power, which can't be avoided, another disadvantage of PV solar is its high cost. California provides robust rebates and incentives under its California Solar Initiative and has produced some valuable benchmarks for the cost of solar power. According to a study produced for the California Public Utilities Commission in 2009, the price of installed PV under the California program averaged $7,090 per kW for large industrial customer installations, and $8,490 per kW for residential installations.[23] Assuming a 20 percent capacity factor, a cost of capital of six percent and a life of 25 years, the cost per kWh of these installations would run from 32 to 38 cents per kWh.

This example helps to explain why solar energy is only a miniscule resource in the United States. Still, solar is a growth industry and significant improvements in both design and cost are forthcoming. Indeed there are anecdotal evidences of less costly solar installations—as little as $4,000 per kW—but even at that installed cost, the bottom line energy cost to the consumer would be in the range of 15 to 20 cents per kWh. To be competitive, solar would need to cut even further, probably another 50 to 70 percent below even these levels.

LARGE PV SOLAR

Three years ago the much-publicized PV solar facility at Nellis Air Force Base was the largest such facility in North America, and the third largest in the world. It sits on 140-acres and produces about 30,000,000 kWh per year. Yet this amount of production is only equivalent to one day's output of a 1,200 MW coal-fired plant. If we were to attempt to replace the entire fleet of coal-fired electrical generation in the United States with large PV solar projects, we would have to install a Nellis-sized facility each month for each of the next 5,000 years.[24] Indeed we are a long way from accomplishing much with PV solar energy. With growth in the solar industry, there are now three other PV solar facilities in the United States that are larger than the Nellis facility, and 40 larger PV facilities in the world.

Given the inefficiencies of scale associated with PV solar, it is not realistic to envision the entire electric system consisting solely of such distributed units. Homes cannot run entirely from PV solar panels without some form of backup or battery storage. Even large arrays on commercial buildings are almost always tied into the electric grid because of the various shortcomings in PV systems, and large scale utility systems require enormous tracts of land while providing only modest energy output.

CONCENTRATED THERMAL SOLAR

PV technology directly converts solar energy into electrical energy through panels. Concentrated thermal solar, on the other hand, uses parabolic

[23] Energy News Data, *California Energy Markets*, July 2, 2010.

[24] Based on the United State's coal-fired electrical generation of 2 billion MWh per year compared to Nellis' advertised annual output of 30,000 MWh per year. (2 billion / 30,000) / 12 months = 5,555 years.)

mirrors, or similar technology, to focus solar energy into heating a fluid that then goes through a heat transfer process that is not unlike a traditional gas- or coal-fired steam electric turbine. In fact, many concentrated solar facilities will have natural gas-based generation as a backup or supplement. Concentrated solar installations tend to cost around two-thirds, or less, compared to the cost of a PV installation. This is a significant step in the right direction, but still very expensive power compared to traditional base load resources.

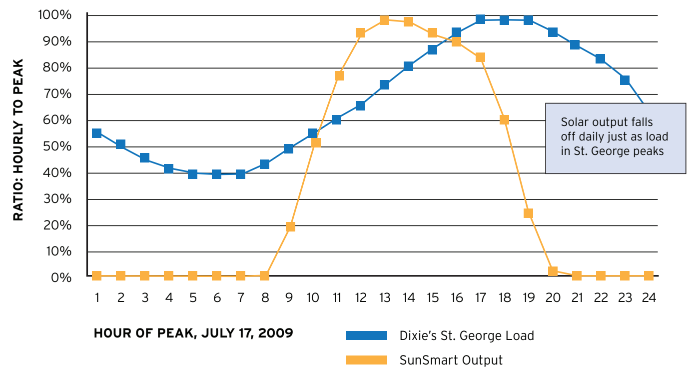
Nevada Solar One boasts one of the newest and largest concentrated solar facilities in the United States. This project delivers 64 MW of capacity and approximately 134,000 MWh of energy per year. Gilbert Cohen, vice president of Engineering and Operations for Solargenix, said the project installation costs are somewhere in the range of $220 to $250 million. At that price, the power is more expensive than most wind power projects, but less expensive than typical PV projects. Energy from Nevada Solar One currently costs about 13 cents per kWh.[25] The developers of Nevada Solar One believe that a target of seven cents per kWh will be achievable in the future. At that price, concentrated solar would be fairly competitive as a viable, utility grade source of power.

SOLAR DEMAND VERSUS SYSTEM PEAK

A desirable attribute of solar energy is that it is produced during hours that roughly coincide with utility system peak loads. The coincidence is not perfect, but much better than wind. The chart in the following column is an actual output profile of the 100 kW SunSmart project in St. George, Utah.

The solar output shown in yellow tends to ramp up around 10 a.m. and then ramps down in the afternoon. The shape of the output curve is very predictable, barring the unpredictable effects of intermittent cloud cover. If solar panels are spread over a wide enough area, some of the cloud cover effect can be mitigated through diversity. However, even in the best case the peak solar output tends to occur prior to the time of peak load for the utility shown in blue.

ST. GEORGE CITY PEAK LOAD VS. SUNSMART'S OUTPUT:



Based on the graphic, about 30 to 60 percent of the solar peak was useful during the peak hour. The fit between solar-produced energy and the demand curve for electricity usage is not as close as one might expect, and certainly not as good as one would hope. This can be significantly mitigated and improved if the solar project is combined with an energy storage facility, but that would add to the cost. A similar result can be demonstrated across a much larger system. Last year, CAISO reported peak demand of 45,994 MW, which occurred at 3:00 p.m. on September 3, 2009. In that hour, even though California had installed PV capacity of nearly 250 MW, that was operational and online on the state's electric grid, only about 144 MW of solar energy was being generated to help serve the peak demand, or around 58 percent of the amount that the installed solar units were capable of producing. By contrast, as of noon that same day, the PV solar units reached their maximum capacity factor at about 72 percent, which is the typical peak

[25] Jesse Broehl, Renewable Energy World.Com, *A New Chapter Begins for Concentrated Solar Power*, (2006), www.renewableenergyworld.com/rea/news/article/2006/02/a-new-chapter-begins-for-concentrated-solar-power-43336.

performance for the California PV system. What happened to all the rest of the capacity that should have been available? The report submitted to the California Utility Commission indicates that dust and dirt affect the performance of PV panels in the afternoon, and panels do not perform at top efficiency above temperatures of 68°F, which is commonly exceeded on summer afternoons in California.[26] And frankly, the sun is on its way down in the afternoon at the same time electric loads are picking up.

It is also ironic that summer PV solar output is not markedly better than spring or fall. While summer days are longer, they are also hotter and unfortunately solar panels lose efficiency in the heat.

THE VALUE OF SOLAR POWER—DEMAND VERSUS ENERGY

Solar power can be used to offset the fuel costs of traditional power plants, but it is expensive. For traditional production, energy-only costs tend to be in the range of 1.5 to four cents per kWh, hence, most utilities would view the 13.5 cent cost of solar energy as quite expensive—coming with a premium of 200 to 800 percent in terms of raw energy value.

Solar is generally the most expensive form of renewable energy.

THE SOLAR SYNOPSIS

Solar energy, while costly, is grid friendly. Indeed the general rate of change of the solar output curve is as calm as a morning sunrise or as smooth as an evening sunset. The peak solar output precedes a typical system demand peak, with only about 60 percent of the solar maximum still available at the time of actual utility demand peak. Compared to wind, the solar output shows a significant advantage as a fairly reliable peak-period supplier, especially when combined with a reasonable investment in complementary storage and/or backup resources.

The major hurdle with solar is cost. It is generally the most expensive form of renewable energy. However, significant strides are being made to bring down the cost and increase the reliability. Solar is not "in the money" yet, but with continued support from taxpayer subsidies and incentives, solar is likely to be a capable and significant resource of the future, at least in some regions of the country.

THE RENEWABLE PORTFOLIO STANDARD (RPS) OR HOW 20 PERCENT CAN EASILY BECOME 100 PERCENT OF A UTILITY'S PLANT INVESTMENT

There is significant political pressure for states and/ or the Federal Government to adopt a Renewable Portfolio Standard (RPS) which mandates utilities to acquire an arbitrary portion of their energy requirements from renewable sources such as wind, solar, biomass, and geothermal energy, by some arbitrary date. Note that the so-called RPS, or RES (Renewable Energy Standard) as it is sometimes called, is generally spun as a "standard." In reality it is not just a standard, but a legally enforceable "mandate." RPS mandates are proposed across the board, even when some utilities have relatively little access to renewable energy, or only very expensive alternative generation sources available. The RPS mandate trumps market-based choices, which is its intention.

While a 20 percent RPS (for example) may sound modest, the resulting effect on the rate base can be much larger than one might think. There are two underlying facts that support the materiality of this concern. First, renewable resources have an intermittent output that renders low capacity factors—typically in the range of 20 percent to

[26] Energy News Data, *California Energy Markets*, July 2, 2010.

40 percent of full name-plate rating for wind, and 15 percent to 25 percent for solar. Coal, gas and nuclear power, on the other hand, will typically achieve capacity factors of 70 percent to 95 percent. Renewable energy projects tend to produce about one-third the energy of comparable name-plate quantities of coal, gas and nuclear power. So a 20 percent "energy" RPS really looks more like a 60 percent RPS in terms of the actual installed name-plate quantity that is required to meet the energy mandate.

The second area of pricing concern has to do with the installed cost of new, renewable resources versus the depreciated book value of existing resources. The installed cost of new wind generation, according to the DOE Jobs and Economic Development Impact model[27] default values discussed earlier, is about $2,300 per kW. The installed cost of solar capacity is in the range of $5,000 to $8,000 per kW. Compare this to a "Production Plant" depreciated book value of about $700 per kW for a typical utility.[28] The new renewable "capacity" comes at an installed cost that is at least triple, quadruple, or even more than the existing "Production Plant" book value of existing resources.

Now combine these two effects: the 20 percent RPS which acts like 60 percent in terms of installed name-plate capacity, and the "new versus used" differential of installed cost of $2,300 versus $700. These two effects, when combined, can easily more than double the dollars of rate base for installed generation of a utility. This will result in significant rate increases—much more than suggested at face value by a 20 percent RPS.

It is worth noting that this evaluation does not include the substantial expense and challenges of building additional transmission that almost inevitably would have to be built to interconnect the new RPS portfolio. Nor does it include the "shadow grid" of gas resources that would be required to "firm" the supply of our new book of intermittent resources. It also does not include any planning or operating reserve margins that would be imposed on the utility. And finally, it does not include any margin for underperformance of the RPS portfolio. If the utility, in good faith, acquires a block of wind and solar resources, but for unforeseeable reasons these resources underperform, what sort of liability or penalties would the utility face for its failure to meet the RPS mandate? All of these questions need to be addressed as well.

Proponents of the RPS standard will invariably appeal to the jobs creation aspect of such a program. But as previously discussed, the jobs impact will be net negative—we can expect to lose 1.5 to 2.7 traditional jobs for every new "green" job created. In addition the local and general economy will feel the negative impacts in response to the price increases that will result from the RPS implementation.

An RPS of 20 percent may sound harmless or benign, but just the opposite will likely occur. A Renewable Portfolio Standard of 20 percent can easily compel a utility to more than double its rate-base investment in generating plant with only modest increases in capacity and energy production.

Inevitably, rates will increase for the end user—and that includes businesses. Essentially every economic analysis done concludes as a business' costs go up, the number of employees they can afford to have goes down. So, higher electricity costs logically

[27] National Renewable Energy Laboratory, *About JEDI Models*, http://www.nrel.gov/analysis/jedi/about_jedi.html.

[28] The "Total Production Plant Investment, $/kW" reported in the G&T Trend 2009 by the National Rural Utilities Cooperative Finance Corporation is $697 per kW, averaged across all Generation & Transmission Cooperatives in the United States. This represents a sample of 51,885 MW of generation. Many of the units in the sample are jointly owned with investor-owned utilities.

mean job losses. Yet, we continue to march forward with empty promises of economic expansion, job growth and a new era of green prosperity while concurrently ignoring the realities of higher energy costs forced upon consumers due to renewable energy mandates and net job losses. This does not make sense.

Furthermore, not all RPS mandates are equal. As if 20 percent were not enough, some states have legislated even more aggressive targets. Colorado has ushered in legislation requiring utilities to generate 30 percent of their electricity from renewable energy sources by 2020.[29] This requirement is the second highest renewable energy standard in the nation and is surpassed only by California, which has laid out a goal to reach 33 percent renewable energy by 2020.[30]

At a time when California is experiencing a serious corporate exodus, in large part because of higher energy costs and other government mandates, it is likely that enormous deficits and higher and higher tax burdens will dampen the state's economy for the foreseeable future. For Colorado to adopt a similar scenario at this time seems like a recipe for economic disaster.

SUMMARY

Wind energy has a highly intermittent output that significantly mismatches demand and delivers energy largely when it is less needed. Wind cannot satisfy the demand requirements of a utility unless it is backed up with fossil fuel plants and/or energy storage projects. This results in duplication of resources and additional costs, with little, if any, carbon mitigation. Further, the steep increases and declines in power delivery of wind put the reliability of the grid in question. The tactic of switching off excess wind supply only diminishes the already weak pattern of intermittency and adds to the per kWh cost of wind. Typically, wind resources are located far away from where the power is needed and require significant additional costs of building new transmission. Intermittency, duplication and grid operations all significantly increase the already high cost of wind energy.

Wind becomes even more questionable when proven solutions like natural gas can deliver even greater reductions in emissions at half the cost.

While solar power is much more grid friendly than wind, it is generally the most expensive form of renewable energy. Solar energy quasi-matches system peak load periods, but the peak solar output significantly misses actual electric system load peaks. In addition, solar facilities still produce only about 18 to 25 percent of the time. Without electricity storage, solar energy will not be able to do more than serve as a supplement to other forms of energy. It is not currently a full-scale alternative to baseload energy.

A Renewable Portfolio Standard, or mandate of 20 percent, can result in a utility-scale duplication of net investment in generating plant of 100 percent or more. The mandate can also cause the wide variation of rate impacts, depending on availability of renewable energy projects and other utility specific parameters.

An RPS program makes as much sense as does a government mandate that 20 percent of our vehicles be horse-drawn in five years. The justification would be that such a change would substantially reduce fossil fuel, and (unlike with wind and solar) so it would. It could also be claimed that many new jobs would be created. Again (and unlike with

[29] Lynn Bartels, *Ritter Signs Bill Requiring Greater Use of Renewable Energy by 2020*, Denver Post, (March 23, 2010), www.denverpost.com/search/ci_14735606.

[30] Executive Order S-14-08, http://gov.ca.gov/executive-order/11072/.

wind and solar) so it would. But what would be the impact on citizens and on the forward progress of our country? We abandoned horsepower to become a modern society. Likewise we abandoned wind mills. As with horses, so far there is no proven legitimate reason to regress here.

All of this comes down to one inescapable conclusion: the process of how we got into this quagmire is severely flawed. Our representatives should redefine the process for approving such guaranteed-to-fail programs as RPS. The methodology that will work is to ask a very simple question when solicited by promoters of such ideas: "Before we can implement any of your suggestions, we need to see genuine scientific proof that what you are proposing is cost-beneficial."

EYES WIDE OPEN

As our nation embarks on the path of a green policy, we should recognize the U.S. electric sector, built over the last 100 years, has been successfully engineered for plentiful and reliable low-cost energy. It has served us exceedingly well and has made a major contribution to our standard of living in virtually all areas of modern life.

As we consider how best to transition to a greener energy economy, we must move forward intelligently and recognize that such a transition will take years, if not decades. After all, how can we expect to reinvent in a few years what took over a hundred years to build in the first place?

Renewable energy can be helpful to meet improved environmental targets, but we the people must recognize that the environmental benefits will come at a high price: an increase in electric rates, an increase in capital requirements, a challenge to grid reliability and net job losses. Only with our eyes wide open can we strike an informed balance and adopt a science-based energy policy without hype and pretense.

SPECIAL THANKS

Kimball Rasmussen wishes to express his sincere thanks John Droz and George Taylor for their thoughtful input that helped bring about the 2.0 edition of this paper. Their input has clarified a number of earlier concepts and in the process prompted updating some of the statistics presented.

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