October 10, 2014

Office of Energy Policy and Systems Analysis
EPSA-60
QER Meeting Comments
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585-0121

Submitted via email to: QERComments@hq.doe.gov

Dear Quadrennial Energy Review Task Force:

The American Wind Energy Association (AWEA)[1] appreciates this opportunity to comment on the first ever Quadrennial Energy Review (QER)[2], which is focused on the transportation, transmission, distribution and storage of energy, including electricity. AWEA applauds the QER Task Force for undertaking this important effort and for the extensive public outreach to date.

As you know, electricity is the lifeblood of the modern U.S. economy. Being able to get electrons from where they are generated to where they are consumed is essential to virtually everything Americans do on a daily basis (including drafting these comments and submitting them to you). Yet, our electricity grid is aging and needs sustained attention and investment in order to continue to provide reliable, affordable service to consumers. In addition, because the grid was built to serve existing energy technologies, little to no transmission has been built in the areas of the country with the best wind energy resources. Effective transmission planning, cost allocation, and siting policies are essential for meeting the nation's clean energy and climate goals, as a strong transmission system is critical if we are to cost-effectively put America's world-class renewable energy resources to use. It is AWEA's hope that the QER planned for release in January 2015 will serve as a catalyst for such sustained focus by policymakers and other stakeholders on what's working and what needs improvement in order to facilitate a rapid and orderly upgrade and expansion of our nation's electric transmission infrastructure, along with how the grid itself is operated.

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[1] AWEA is a national trade association representing a broad range of entities with a common interest in encouraging the expansion and facilitation of wind energy resources in the United States. AWEA's members include wind energy facility developers, owners and operators, construction contractors, turbine manufacturers, component suppliers, financiers, researchers, utilities, marketers, customers, and their advocates.

[2] Presidential memorandum, Establishing a Quadrennial Energy Review, January 9, 2014, available at: http://www.whitehouse.gov/the-press-office/2014/01/09/presidential-memorandum-establishing-quadrennial-energy-review

Upgrading and expanding our nation's aging electric transmission grid benefits consumers and lowers costs by improving reliability (and thus reducing the frequency of blackouts and associated economic losses), reducing congestion, and providing access to lower-cost generation resources, among other benefits. Expanding the grid and improving grid operations is also essential to the continued rapid growth of wind energy, which is a necessary element of achieving the President's energy and climate protection goals.

These comments will summarize the following key issues related to electric transmission and the integration of wind energy:

- The benefits of transmission upgrades and expansion;
- How wind energy is being reliably integrated into the U.S. electric grid at a low cost to consumers;
- Grid operating reforms that improve reliability, lower costs to consumers and facilitate the integration of wind energy;
- The capability of modern wind turbines to provide services to the grid to enhance reliability;
- Policies necessary to facilitate expanded transmission and improved grid operations, including planning, paying for, and permitting transmission; and,
- The appropriate role for storage.

AWEA is also providing links to additional resources with greater detail than can be covered in these comments that may be helpful to the Task Force as you draft the QER.

At the end of each section, AWEA provides specific recommendations for how the QER should address the issues raised.

Thank you for your careful consideration. Please don't hesitate to contact AWEA if we can provide any clarifications or additional information.

Sincerely,

Tom Vinson
Vice President, Federal Regulatory Affairs
American Wind Energy Association

## Background on Transmission and Wind Energy

President Obama has called for 80 percent of our nation's electricity to come from clean and renewable resources, including wind energy, by 2035.[3] In addition, in his Climate Action Plan released in June 2013, the President proposed to again double the deployment of renewable energy by 2020, building on the doubling of renewable generation that was achieved during his first term.[4] The Clean Power Plan[5] proposed by the U.S. Environmental Protection Agency (EPA) in June 2014 to regulate carbon emissions from existing power plants, provides states with the opportunity to expand their deployment of wind energy as a compliance tool for achieving their state targets. And, the Department of Energy is in the process of updating the 20 percent wind energy by 2030 vision.[6] None of this can be achieved without upgrading and expanding our nation's transmission infrastructure.

AWEA has long been concerned that the development of new transmission infrastructure is not keeping pace with the goals set forth in various public policies that call for greater renewable energy development.[7] Indeed, if the considerable wind and other renewable resources of the United States are to be utilized to meet our energy and climate goals, it will require a significant amount of new transmission, including high-capacity, high-voltage interstate transmission lines, such as HVDC lines, in order to move this utility-scale renewable energy from where it would be generated to where it will be consumed.

At the end of 2013, more than 114 gigawatts (GW) of wind power projects were in interconnection queues of various transmission grid operators around the country.[8] There were also 15 near-term transmission projects pending as of the end of 2013, which if all built could carry an estimated 60 GW of additional wind power capacity, or enough to more than double the currently installed base of wind power in the U.S.[9]

The deployment of wind energy supported by an upgraded and expanded transmission grid will have significant and measurable benefits for the economy and the environment.

With respect to the economy, the wind industry invested $5 billion into the U.S. economy in 2013.[10] Over the past five years, the industry has invested an average of $15 billion annually in new wind energy projects. The industry currently supports more than 50,000 jobs, and has supported more than 80,000 in some years. During 2013 there were at

[3] Available at: http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address.
[4] Available at: http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.
[5] Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule
[6] Available at: http://energy.gov/eere/wind/new-vision-united-states-wind-power
[7] See, e.g., 2009 AWEA-SEIA Report on Green Power Superhighways: Building a Path to a Clean Energy Future available at: http://www.awea.org/files/FileDownloads/pdfs/GreenPowerSuperhighways.pdf.
[8] AWEA Annual Market Report for the Year Ending 2013, page 85. Available at: http://www.awea.org/amr2013
[9] Ibid. p. 85
[10] All statistics in this paragraph come from the AWEA Annual Market Report for the Year Ending 2013.

least 580 manufacturing facilities producing products for the wind industry across 44 states.

With respect to the environment and public health, based on AWEA analysis using the Environmental Protection Agency's AVERT model, the currently installed wind energy fleet in the U.S. avoids nearly 115 million metric tons of carbon dioxide annually, equivalent to over 5 percent of power-sector carbon emissions, or taking 20 million cars off the road.

Wind energy also reduced emissions of sulfur dioxide by 347 million pounds per year and $NO_x$ emissions by 214 million pounds in 2013, and saved at least 36.5 billion gallons of water that would have been consumed at conventional power plants. This is the equivalent of roughly 116 gallons per person in the U.S., or 276 billion bottles of water, which is increasingly important given sustained droughts in many parts of the country.

Increased investment in expanding transmission capacity and continuing progress in improving grid operations are necessary precursors to sustaining these economic and environmental benefits.

**The Benefits of Transmission Upgrades and Expansion**

Investing in transmission provides significant benefits to the U.S. economy. For example, in a May 2011 report[11] for the Working Group for Investment in Reliable and Economic Electric Systems (WIRES), The Brattle Group found a likely annual investment range of $12 billion to $16 billion in transmission through 2030 would stimulate $30 billion to $40 billion in economic activity and support 150,000 to 200,000 full-time jobs per year.

The Brattle Group wrote another study[12] on behalf of WIRES in July 2013 that provides a comprehensive overview of the many other benefits of upgrading and expanding the transmission grid. Table ES-1 of the report is published below documents the various benefits of transmission investments identified by Brattle:

| Benefit Category | Transmission Benefit |
|---|---|
| 1. Traditional Production Cost Savings | Production cost savings as traditionally estimated |

[11] Available at: http://www.wiresgroup.com/images/Brattle-WIRES_Jobs_Study_May2011.pdf
[12] Available at: http://wiresgroup.com/docs/WIRES%20Brattle%20Rpt%20Benefits%20Transmission%20July%202013.pdf

| | |
|---|---|
| 1a-1i. Additional Production Cost Savings | a. Reduced transmission energy losses<br>b. Reduced congestion due to transmission outages<br>c. Mitigation of extreme events and system contingencies<br>d. Mitigation of weather and load uncertainty<br>e. Reduced cost due to imperfect foresight of real-time system conditions<br>f. Reduced cost of cycling power plants<br>g. Reduced amounts and costs of operating reserves and other ancillary services<br>h. Mitigation of reliability-must-run (RMR) conditions<br>i. More realistic representation of system utilization in "Day-1" markets |
| 2. Reliability and Resource Adequacy Benefits | a. Avoided/deferred reliability projects<br>b. Reduced loss of load probability or<br>c. Reduced planning reserve margin |
| 3. Generation Capacity Cost Savings | a. Capacity cost benefits from reduced peak energy losses<br>b. Deferred generation capacity investments<br>c. Access to lower-cost generation resources |
| 4. Market Benefits | a. Increased competition<br>b. Increased market liquidity |
| 5. Environmental Benefits | a. Reduced emissions of air pollutants<br>b. Improved utilization of transmission corridors |
| 6. Public Policy Benefits | Reduced cost of meeting public policy goals |
| 7. Employment and Economic Development Benefits | Increased employment and economic activity;<br>Increased tax revenues |
| 8. Other Project-Specific Benefits | Examples: storm hardening, increased load serving capability, synergies with future transmission projects, increased fuel diversity and resource planning flexibility, increased wheeling revenues, increased transmission rights and customer congestion-hedging value, and HVDC operational benefits |

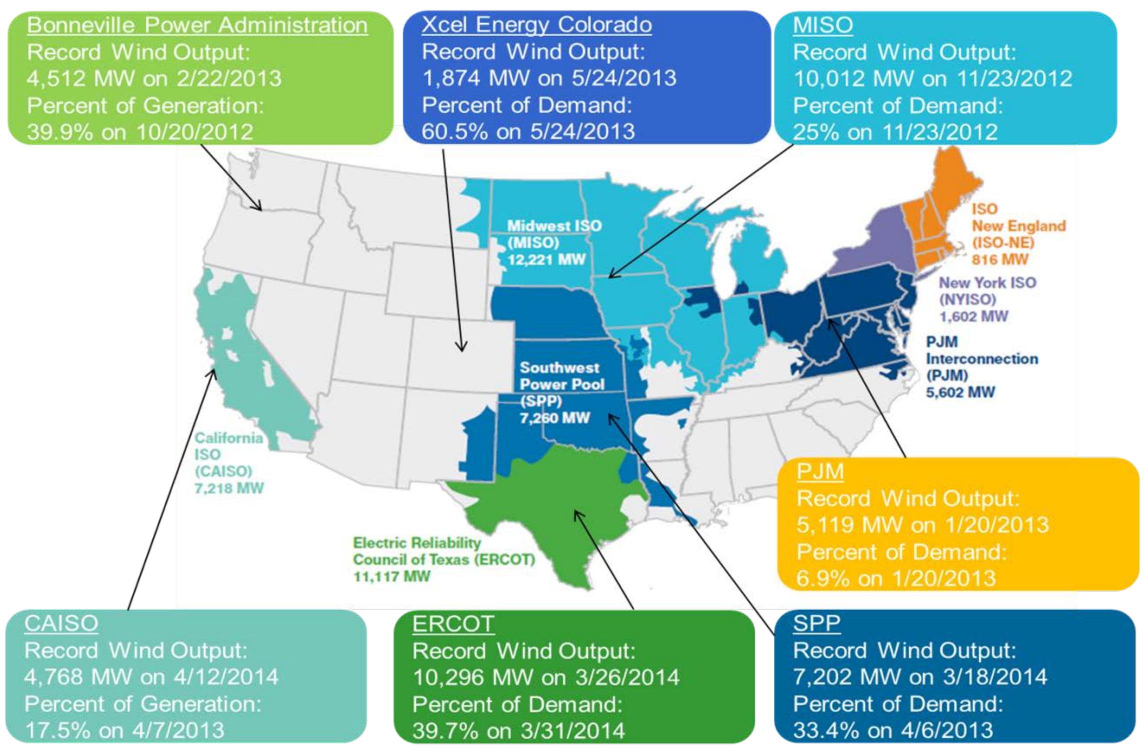
***AWEA Recommendation:*** The QER should discuss and endorse the myriad benefits of investing in transmission infrastructure and support efforts at the Federal Energy Regulatory Commission, state regulators, grid operators and others to get these full range of benefits recognized in transmission planning and cost allocation.

## How Wind Energy is Being Reliably Integrated at a Low Cost to Consumers

Grid operators across the United States are already reliably integrating large amounts of wind energy.

U.S. wind energy provides enough electricity to power the equivalent of over 15 million homes. On an average annual basis, Iowa and South Dakota produced more than 25% of their electricity from wind last year, with a total of nine states above 12% and 17 states at more than 5%. At times, wind has supplied more than 60% of the electricity on the main utility system in Colorado, and nearly 40% of the main Texas power system, all without any reliability problems.

At certain times of the year, even larger percentages of wind generation have been reliably integrated. The graphic below shows wind generation records as a percent of demand or generation over the last couple of years.




Source: AWEA

More than a dozen utility and independent grid operator studies[13] have found wind can reliably provide an even larger share of our electricity. For example, PJM just studied the impacts of increasing its use of wind energy by a factor of 15, and found the "PJM

[13] Available at: http://variablegen.org/resources/ and http://variablegen.org/resources/#!/3700/u-s-regional-and-state-studies

system, with adequate transmission and ancillary services in the form of Regulation, will not have any significant issue absorbing the higher levels of renewable energy penetration considered in the study."[14]

The Eastern Wind Integration and Transmission Study[15] (EWITS) found that 20% and 30% wind penetration scenarios in the eastern U.S. were technically feasible with an expanded transmission grid. The study also found that expanded transmission "helps reduce the impacts of the variability of the wind, which reduces wind integration costs, increases reliability of the electrical grid, and helps make more efficient use of the available generation resources."

The Western Wind and Solar Integration Study[16] (WWSIS) showed it is operationally possible to accommodate 30% wind and 5% solar energy in the western U.S. if utilities substantially increase their coordination of operations over wider geographic areas and schedule their generation and interchanges on an intra-hour basis.

How is it possible to accommodate significant penetration levels of wind energy when the wind doesn't blow all the time? Every day, grid operators constantly accommodate variability in electricity demand and supply by increasing and decreasing the output of flexible generators – power plants like hydroelectric dams or natural gas plants that can rapidly change their level of generation. Thus, the water kept behind a dam or the natural gas held in a pipeline may be thought of as a form of energy storage, with operators using this energy when it is needed and "storing" it when it is not.

Grid operators have always kept large quantities of fast-acting generation in reserve to respond to abrupt failures at large conventional power plants, a challenge and cost that is far greater than accommodating any incremental variability added by the gradual and predictable changes in the aggregate output of a wind fleet. Grid operators use these same flexible resources to accommodate any incremental variability introduced by wind energy that is not canceled out by other changes in electricity supply or demand. Therefore, the incremental impact to consumers is very low.

The ERCOT (Texas) and MISO (Upper Midwest) grid operators each reliably accommodate more than 10,000 MW of wind energy on their power systems. These significant levels of wind penetration are being accomplished with limited amount of reserves, with ERCOT finding that amount of wind is reliably accommodated with less than 50 MW of additional fast-acting reserves.[17] Similarly, MISO explains that the incremental need for those reserves due to wind is "little to none."[18]

[14] http://www.pjm.com/~/media/committees-groups/committees/mic/20140303/20140303-pjm-pris-final-project-review.ashx, page 12
[15] Available at: http://energy.gov/eere/wind/downloads/eastern-wind-integration-and-transmission-study-executive-summary-and-project
[16] Available at: http://www.nrel.gov/electricity/transmission/western_wind.html
[17] http://variablegen.org/wp-content/uploads/2012/12/Maggio-Reserve_Calculation_Methodology_Discussion.pdf
[18] http://variablegen.org/wp-content/uploads/2012/12/Navid-Reserve_Calculation.pdf

By a large margin, the most expensive challenge for grid operators is accommodating the abrupt failures of large conventional power plants, not integrating renewable energy.

PJM currently holds 3,350 MW of expensive, fast-acting reserves 24/7 in case a large fossil or nuclear power plant unexpectedly breaks down. For comparison, PJM's renewable study found that adding 28,000 MW of wind would only increase the need for fast-acting reserves by 340 MW.[19] In addition, the largest hourly changes in electricity demand are 10 times larger than the largest hourly changes in wind energy output for PJM.[20]

The story is similar in Texas.  The cost of reliably integrating large conventional power plants onto the power system in Texas is more than 17 times larger than the cost of reliably integrating wind energy, based on AWEA analysis of data from the state's independent power grid operator.

This analysis rebuts one of the most widely-held misconceptions about how wind energy is reliably integrated onto the power system. While it is true that wind energy's variability does slightly increase the need for the balancing reserves that grid operators use to keep supply and demand in balance, all forms of energy impose integration costs on the power system.[21]

In fact, Texas grid operator data show that the integration costs for conventional power plants are far larger than the integration costs for wind generation, even though Texas has more wind energy than any other state and one of the highest levels of wind generation for a U.S. grid operator. Because changes in wind output occur gradually over many hours and can be predicted, while failures at conventional power plants occur instantly and without warning, more reserves and more expensive reserves are required to reliably integrate conventional power plants. For example, the Texas grid operator ERCOT holds[22] 2800 MW of fast-acting reserves 24/7/365 to keep the lights on in case one of the state's large fossil or nuclear power plants experiences an unexpected failure, as all power plants do from time to time.

The following table compares the reserve costs for wind versus other sources of variability on the ERCOT grid.

[19] http://www.pjm.com/~/media/committees-groups/committees/mic/20140303/20140303-pjm-pris-final-project-review.ashx, page 111
[20] http://www.pjm.com/~/media/committees-groups/task-forces/irtf/20130417/20130417-item-05-wind-report.ashx, and http://www.pjm.com/markets-and-operations/energy/real-time/loadhryr.aspx
[21] Available at: http://www.nrel.gov/docs/fy11osti/51860.pdf, pages 11-16.
[22] Available at: http://www.ercot.com/content/news/presentations/2012/Dumas_IPPSA_March13.pdf

| Factor | Total annual cost (million $) | % of total reserve cost | Cost per electric bill |
|---|---|---|---|
| **Conventional power plant failures** | **$239.690** | **67%** | **76 cents** |
| **Wind** | **$13.740** | **4%** | **4.3 cents** |
| **Conventional and demand deviations** | **$103.359** | **29%** | **33 cents** |

The table above is directly calculated from the following ERCOT data. The first three rows in the following table list ERCOT data[23] on the incremental amount of reserves it holds to accommodate various sources of variability, while the fourth row lists the average cost of those reserves in 2013, also calculated from ERCOT data.[24] The last three rows use this data to calculate the total reserve cost for each source of variability.

| | Regulation down | Regulation up | Responsive reserves | Non-spinning reserves |
|---|---|---|---|---|
| Contingency reserves for conventional power plant failures (MW) | | | 2,800 | |
| Incremental reserves for wind (MW) | 14 | 42 | | 328 |
| Electricity demand variability and deviations at conventional power plants (MW) | 476 | 508 | | 1,474 |
| **Cost of reserve ($/MW)** | **$4.89** | **$8.57** | **$9.77** | **$3.47** |
| Annual reserve cost for conventional power plant failures (million $) | | | $239.690 | |
| Annual reserve cost for wind (million $) | $0.585 | $3.159 | | $9.996 |
| Annual reserve cost for electricity demand variability and supply deviations at conventional power plants (million $) | $20.372 | $38.126 | | $44.860 |

[23] Available at: http://variablegen.org/wp-content/uploads/2012/12/Maggio-Reserve_Calculation_Methodology_Discussion.pdf

[24] Data available at http://mis.ercot.com/misapp/GetReports.do?reportTypeId=13091&reportTitle=Historical%20DAM%20Clearing%20Prices%20for%20Capacity&showHTMLView=&mimicKey

As the table shows, the cost of additional reserves to accommodate wind accounts for about 4.3 cents out of a typical Texas household's $128 monthly electric bill[25], or 1/30,000th of a typical electric bill. In contrast, the $240 million annual cost of reserves to accommodate conventional power plant failures works out to about 76 cents per monthly electric bill. In other words, the total cost of contingency reserves for conventional power plant failures is more than 17 times larger than the cost of all wind-related reserves.

On a per-MWh of energy produced basis, wind's reserve cost is still about half as large as conventional power plants' reserve costs. Wind's reserve cost is about $0.37/MWh of wind when allocated across the wind MWh generated in ERCOT last year, which equates to roughly 1% of the typical cost of wholesale electricity. In contrast, the cost of contingency reserves was $.65/MWh when allocated across all MWh generated in ERCOT last year, and even higher if only allocated to generation from the larger conventional power plants that cause the need for contingency reserves.[26]

The low cost of reliably integrating wind energy is confirmed by the results of dozens of wind integration studies conducted by grid operators and government entities in the U.S. and Europe.[27] For example, a study for utilities in Nebraska calculated that the whole Southwest Power Pool region could reliably obtain 40% of its electricity from wind energy at an additional operating reserve cost of only $2/MWh of wind energy, or 80 cents per typical household monthly electric bill.[28]

Wind's contribution to reserve needs and cost is small because many changes in wind output are canceled out by opposite changes in electricity demand, resulting in only a small incremental increase in total reserve needs. In addition, because changes in wind output occur gradually, incremental wind variability is mostly accommodated using low-cost non-spin reserves, which cost about 1/3 as much as the expensive fast-acting reserves used to accommodate conventional power plant failures.

The role of wind in maintaining electric system reliability can also be found in last winter's severe cold weather snaps.

In January 2014, the Nebraska Public Power District met record winter electricity demand with wind providing about 13% of its electricity. The utility explained that "Nebraskans benefit from NPPD's diverse portfolio of generating resources. Using a combination of fuels means we deliver electricity using the lowest cost resources while maintaining high reliability for our customers." The utility also noted that "NPPD did not operate its natural gas generation because the fuel costs were up more than 300 percent over typical prices."[29]

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[25] Available at: http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf
[26] For more background on these calculations, see http://aweablog.org/blog/post/fact-check-winds-integration-costs-are-lower-than-those-for-other-energy-sources
[27] http://variablegen.org/resources/
[28] http://www.nepower.org/Wind_Study/final_report.pdf
[29] http://www.nppd.com/2014/nebraska-customers-set-time-winter-peak-nppd/

PJM's wind output was around 3,000 MW when the grid operator faced challenges due to the unexpected failure of 20% of its conventional generation across all fuel types.[30] Similarly, wind output was very high when the New York grid operator faced record winter demand.[31]

As "a shortage of natural gas triggered by extreme cold weather" affected California in February, wind energy provided the state with around 2,000 MW at the time of peak demand, with wind output above 2,500 MW for most of the rest of the evening.[32] The state grid operator noted that this wind output allowed it to avoid calling an energy emergency alert.[33]

NERC just released its Polar Vortex Review[34] last month. This report identified fuel deliverability issues, natural gas pipeline outages, gas service interruptions, and frozen electricity and gas equipment as key factors for generator unavailability during the vortex, which threatened system reliability in multiple regions. While wind turbines did occasionally trip offline due to the cold weather, the vast majority of the generators that failed to perform were conventional power plants.

The story was the same in February 2011, when ERCOT noted wind energy's role in keeping the lights on when a cold snap caused many conventional power plants to fail.[35]

These events illustrate that all energy sources experience failures, so a diverse mix of resources is critical for reliability.

***AWEA Recommendation*:** The QER should accurately present how grid operators balance the various generation resources providing power to the grid along with demand, the role of reserves in integrating both conventional and renewable resources, and the relative cost of doing so.

## Grid Operating Reforms that Lower Costs to Consumers, Improve Reliability, and Facilitate the Integration of Renewable Energy

The grid operating reforms that facilitate the integration of renewable energy also provide major net benefits to consumers and improve reliability, so they can be implemented at negative cost and should be done anyway.

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30 http://www.pjm.com/~/media/documents/reports/20140113-pjm-response-to-data-request-for-january%202014-weather-events.ashx

31 http://www.nyiso.com/public/webdocs/media_room/press_releases/2014/NYISO%20-%20Frigid%20Temperatures%20from%20Polar%20Vortex%20Drive%20Record%20Winter%20Demand%20-%2001_09_14%20-%20FINAL.pdf

32 http://www.caiso.com/Documents/ISOissuesStatewideFlexAlert.pdf

33 SNL Energy article, Christine Cordner, "CAISO: Wind, demand response helped avoid February emergency alert," March 21, 2014

34 Available at: http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf

35 Available at: http://www.texastribune.org/2011/02/04/an-interview-with-the-ceo-of-the-texas-grid/

Reports by NREL[36] and the Western Governors Association[37] provide an overview of the helpful grid operations practices, including:

- Better coordinating regional grid operations, such as through RTOs/ISOs or shared markets like an energy imbalance market
- Consolidated (i.e. larger) balancing authorities
- Faster scheduling and dispatch intervals
- Better integrating wind energy forecasting into grid operations
- Establishment of ancillary services markets that incentivize flexible resources such as demand response and more flexible generation

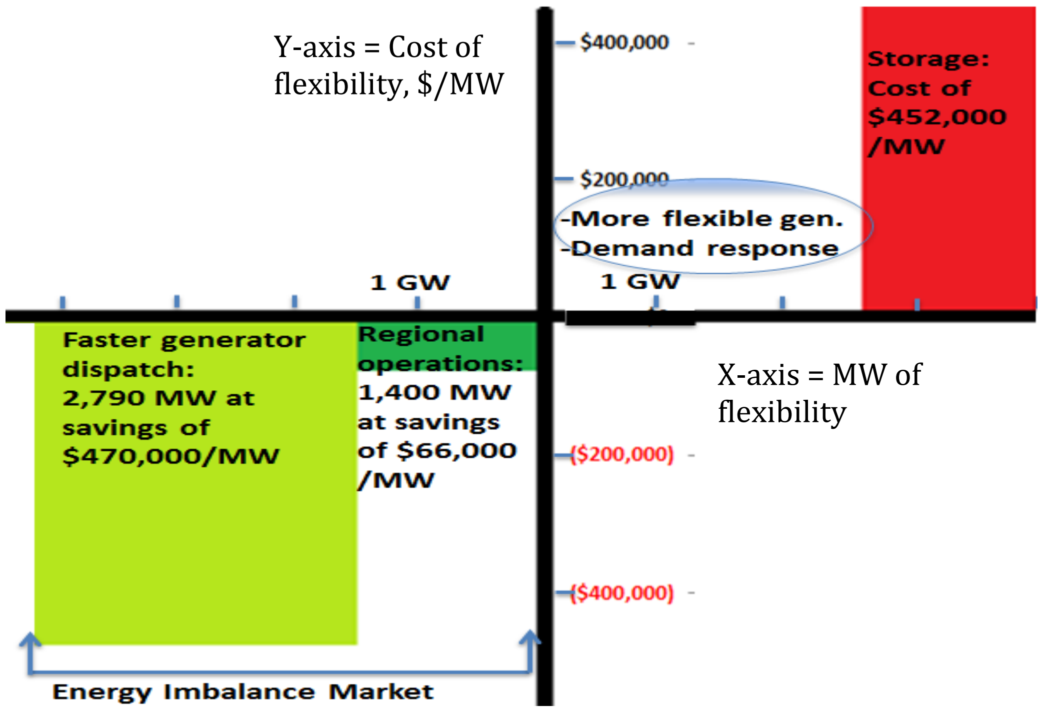
Many studies have documented the sizeable net benefits of grid operating reforms like an Energy Imbalance Market, with benefits not limited to reducing consumer cost and facilitating the integration of renewable energy by allowing more efficient operations, but also improving electric reliability through greater grid operator situational awareness and increased opportunity for sharing operating reserves. In particular, these studies have examined potential grid operating reforms in the Western U.S., where hourly generator dispatch is still the norm and there has been significant discussion about the opportunity to move to an Energy Imbalance Market.[38]

Grid operating reforms like an Energy Imbalance Market (EIM) are by far the lowest-hanging fruit for making the power system more flexible, and in fact can be done at a negative cost to consumers. AWEA has compared study results on the costs and benefits of grid operating reforms like an EIM, versus the costs and benefits of other flexibility solutions. The results are presented in the chart and table below, in an attempt to quantify where these options would fall on the "flexibility supply curve."

[36] Available at: http://www.nrel.gov/docs/fy09osti/46273.pdf, http://www.nrel.gov/docs/fy13osti/60451.pdf and http://www.nrel.gov/electricity/transmission/energy_imbalance.html

[37] Available at: http://www.westgov.org/component/docman/doc_download/1610-meeting-renewable-energy-targets-in-the-west-at-least-cost-the-integration-challenge-full-report?Itemid=

[38] See http://westernenergyboard.org/energy-imbalance-market/documents/, http://www.westgov.org/PUCeim/documents/07-12-13EIMgu.pdf




| | Faster dispatch | Regional coordination | Storage |
|---|---|---|---|
| Benefit/year ($M) | $1,312 | $146[39] | $0.05[40] |
| Cost/year ($M) | | $54.16[41] | $0.50[42] |
| MW of flexibility per unit cost | 2790 | 1397[43] | 1 |
| Annual cost per MW of flexibility | ($470,250.90) | ($65,740.16) | $452,000.00 |

[39] Annual benefits of $1.312 billion from faster dispatch and additional regional coordination benefits of $146 million from region-wide EIM, http://www.nrel.gov/docs/fy13osti/57115.pdf, page xviii

[40] $50/kW-year increase in the economic value of pumped hydro storage at 30% wind, http://emp.lbl.gov/sites/all/files/lbnl-6590e.pdf, page 44

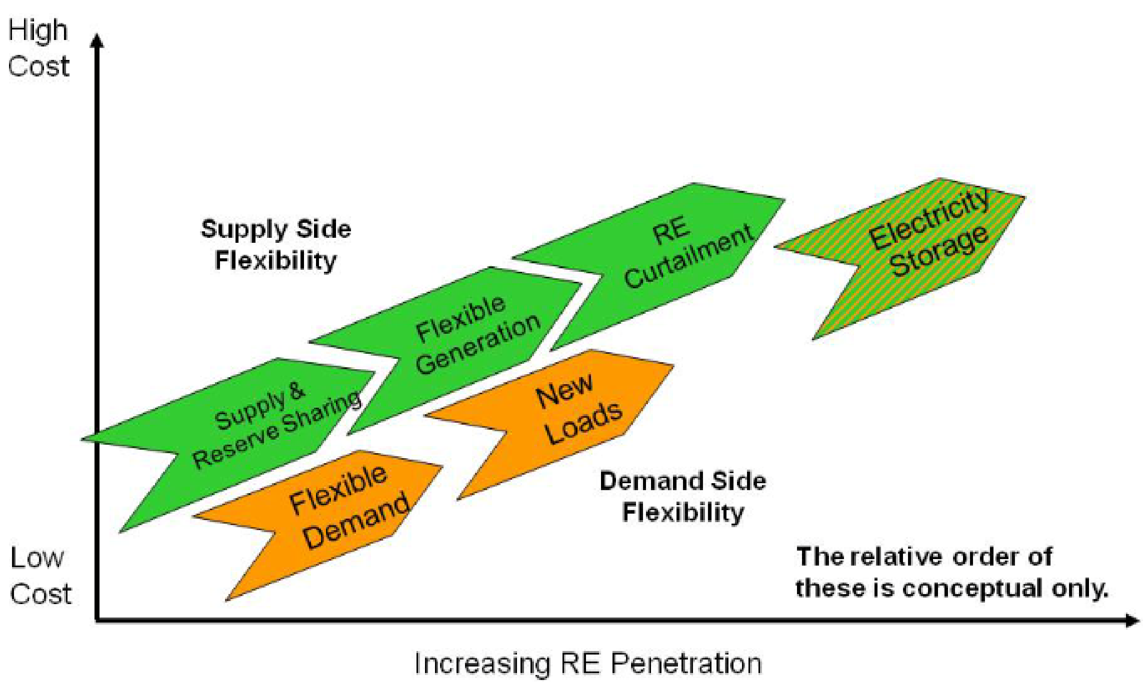
[41] This is the estimated annualized cost of an EIM, which would encompass both faster generator dispatch and regional coordination on grid operations. The annualized cost was calculated by taking the sum of SPP's estimated start up first year cost for the EIM operator and the average of NWPP's low and high estimates of EIM participant startup costs for all BAs in the West, and annualizing them. That number was added to ongoing costs, which were derived from SPP's ongoing EIM operator cost estimate plus the average of NWPP's low and high estimates of EIM participant ongoing costs. Sources include http://www.nwpp.org/user_documents/040313_EIM_Preliminary_Quantitative_Results.pdf, http://www.westgov.org/PUCeim/meetings/2013sprg/briefing/present/m_milligan.pdf, http://www.westgov.org/PUCeim/documents/07-12-13EIMgu.pdf, http://www.westgov.org/PUCeim/documents/03-15-13WECCrcp.pdf

[42] Annualized capital cost of $700/kW-year for pumped hydro, minus $198/kW-year benefit to the power system in the absence of renewable energy. http://emp.lbl.gov/sites/all/files/lbnl-6590e.pdf, page 44

[43] Average reduction in flex reserve needs from fast dispatch and regional coordination from http://www.nrel.gov/docs/fy13osti/57115.pdf, page 46

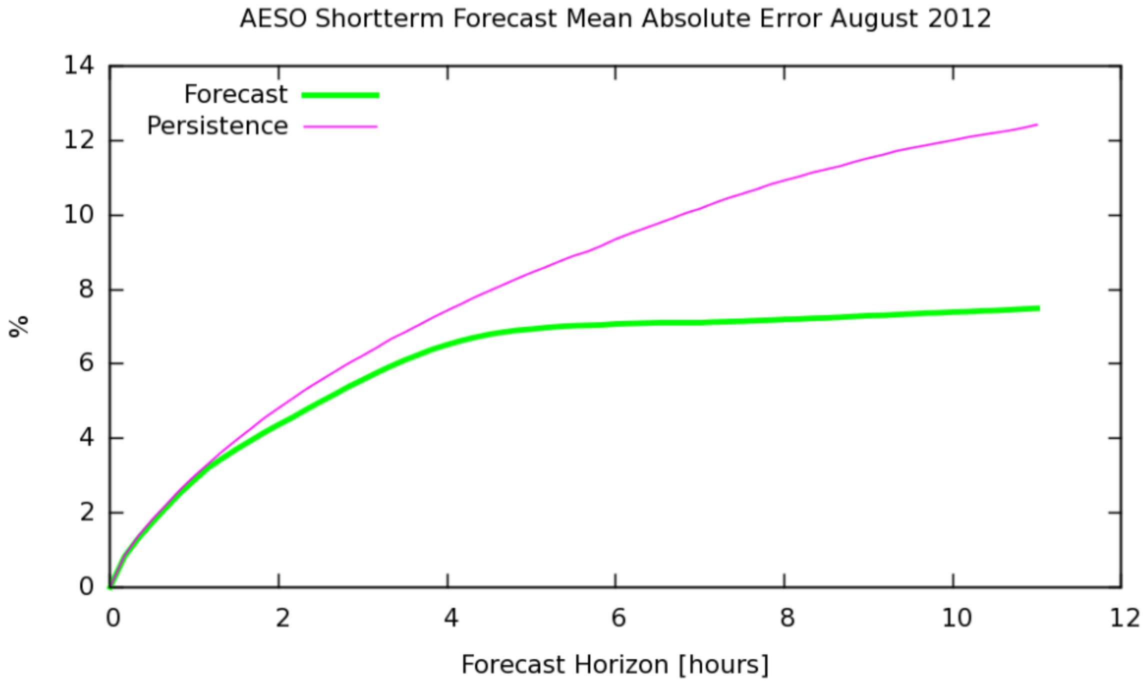
These results show that grid operating reforms are by far the lowest hanging fruit for improving power system flexibility, particularly the fast generator dispatch and regional grid coordination provided by an Energy Imbalance Market. These two reforms encompassed in an EIM reduce power system costs by hundreds of millions of dollars by improving power system efficiency, repaying for the cost of implementing these reforms many times over. In contrast, energy storage is a far more costly option for power system flexibility. Data was gathered on the costs and benefits of demand response and more flexible generation (both new generation as well as making existing generation more flexible), which indicated that the net costs per MW of flexibility placed it somewhere between $0 and the cost of storage.

The concept of a "flexibility supply curve" has been frequently discussed by NREL and other wind integration experts. For example, the following chart was a conceptual effort to list and roughly rank some of the grid resources that are available to provide flexibility, in order of increasing cost.[44] Its results are consistent with the findings presented above, namely that supply and reserve sharing is one of the lowest cost options for providing flexibility, far lower than the cost of energy storage. Grid operating reforms that achieve greater utilization of existing flexibility while more than paying for themselves by improving power system efficiency should be the highest priority in any effort to make the power system more flexible.




[44] http://www.nrel.gov/docs/fy10osti/47187.pdf

Reducing the generation dispatch interval from one hour to 10 minutes, and setting generation schedules at 10 minutes or less before the operating hour, both of which are accomplished under an EIM, are the single most important steps for improving the efficiency of power system operations and facilitating the integration of renewable energy. Setting schedules as close to real-time as possible greatly reduces the cost and reserve need for integrating wind energy because wind energy forecast error falls drastically as one gets closer to real-time, as shown in the chart below.[45]

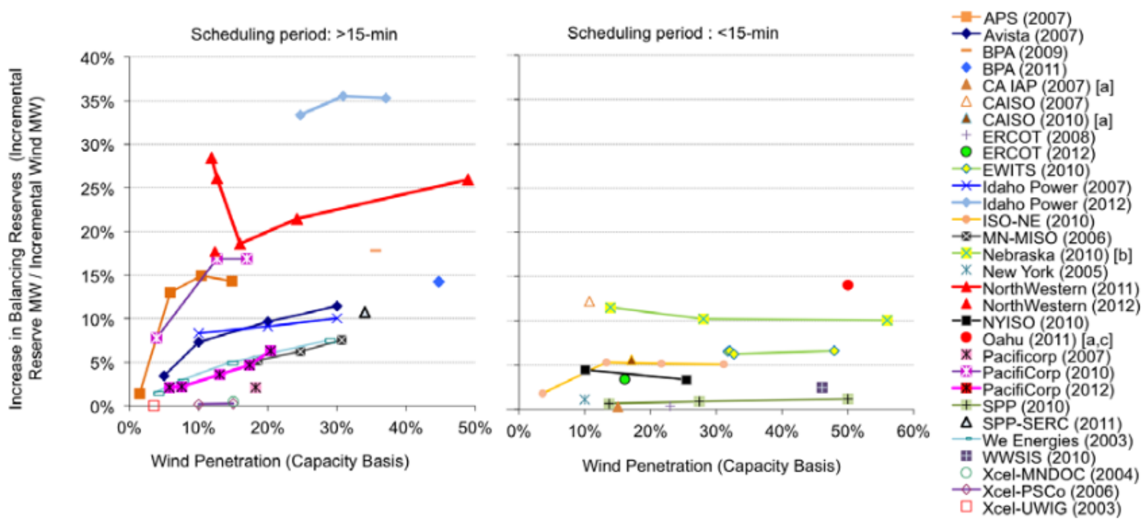



Setting generation schedules at 10 minutes or less before the operating hour is now standard practice in most of the country. Hourly generation schedules and long lead times for setting generation schedules are a relic of an era before computers and modern communications equipment when generation schedule changes had to be communicated by telephone, and these obsolete practices have no place in the 21st Century.

Concerns about the reliable and cost-effective integration of wind energy are now almost exclusively relegated to the parts of the Western U.S. that continue to use outdated dispatch and scheduling practices. As described above, grid operators that use efficient practices, such as MISO and ERCOT, have found wind's impact on the need for operating reserves and integration costs to be trivially small, even with more than 10,000 MW of operating wind generation.

[45] http://www.nrel.gov/docs/fy14osti/61035.pdf, page 4

The following chart from the DOE/Lawrence Berkeley National Laboratory Annual Wind Technologies Market Report also illustrates the value of efficient grid operating practices for greatly reducing the incremental operating reserve need and cost associated with integrating wind energy. Regions with efficient grid operating practices see much smaller integration costs, as shown in the chart below illustrating that regions with fast sub-hourly scheduling (on the right) have much lower wind-related operating reserve needs than regions with hourly scheduling.[46]




***AWEA Recommendation***: The QER should acknowledge the importance of improved grid operations not just for integrating renewable energy, but for the broader benefits they provide to consumers and with respect to reliability, and the report should encourage wider adoption of such grid operation practices. More importantly, grid operating reforms and other low-hanging fruit for increasing power system flexibility to reduce consumer costs and facilitate wind integration should be prioritized over higher cost flexibility solutions.

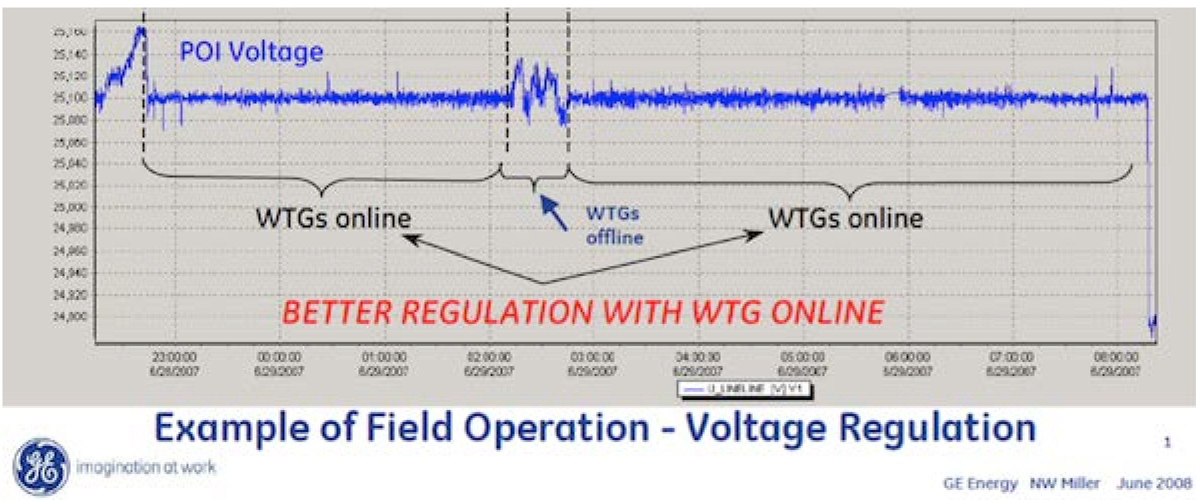
## **The Capability of Modern Wind Turbines to Provide Services to the Grid to Improve Reliability**

Wind turbine technology has matured significantly over the last decade. According to the North American Electric Reliability Corporation (NERC), the entity responsible for the reliability of the electric grid in the United States in conjunction with FERC and regional reliability organizations, modern wind turbines provide equivalent or better capabilities[47] for supporting power system reliability needs as conventional power plants in almost every category.

[46] https://www1.eere.energy.gov/wind/pdfs/2012_wind_technologies_market_report.pdf, page 64
[47] See this NERC report: http://www.nerc.com/docs/pc/ivgtf/IVGTF_Report_041609.pdf, at page 22

As explained by NERC, modern wind turbines “may provide voltage regulation and reactive power control capabilities comparable to that of conventional generation.”[48] Wind plants meet a higher standard and far exceed the ability of conventional power plants to “ride-through” power system disturbances, which is essential for maintaining reliability when large conventional power plants break down.[49]

All modern wind turbines have sophisticated power electronics that allow the turbine to provide significant voltage and reactive power control at all times, even when the wind turbine is not producing electricity. As compellingly illustrated by the actual power system data[50] presented in the chart below, wind turbines can significantly improve power system voltage stability, indicated by the fact that power system voltage is much better regulated when wind turbine generators (WTGs) are online than when they are not.




Recent analysis by WECC, the entity responsible for power system reliability in the Western U.S., found that in a scenario with very high renewable penetration across the West, “the system results did not identify any adverse impacts due to the lower system inertia or differently stressed paths due to the higher penetration of variable generation resources.”[51]

Analysis conducted for the California grid operator identified no major concerns for frequency response in a transition to a high renewable future, finding that “None of the credible conditions examined, even cases with significantly high levels of wind and solar generation (up to 50% penetration in California), resulted in under-frequency load

48 NERC, “Accommodating High Levels of Variable Generation,” April 2009, available at http://www.nerc.com/docs/pc/ivgtf/IVGTF_Report_041609.pdf, page 22
49 http://www.ferc.gov/whats-new/comm-meet/052505/E-1.pdf
50 Miller, N., GE Presentation, June 2008
51 Available at http://www.wecc.biz/committees/StandingCommittees/PCC/RS/RPEWG%20-%20RS%20Meetings8-21-13/Lists/Minutes/1/VGSStudy7-15-13.doc

shedding (ULFS) or other stability problems."[52] Adding wind generation can increase total power system frequency response by causing conventional power plants to have their output reduced, which provides them with more range to increase their output and provide frequency response.[53]

In addition, new techniques employing wind plants' sophisticated controls and power electronics enable wind plants themselves to provide fast-acting frequency response. NREL recently released in-depth analysis that concluded "wind power can act in an equal or superior manner to conventional generation when providing active power control, supporting the system frequency response and improving reliability."[54] The report further documented how major utilities like Xcel Energy are using this capability of wind plants in some hours to provide all of the frequency response and regulation needed to maintain power system reliability, which has enabled Xcel's Colorado power system to at times reliably obtain more than 60% of its electricity from wind energy.

NREL also did a study[55] on frequency response in the eastern interconnection, including in scenarios with high wind energy penetration, which found adding wind generation is unlikely to significantly reduce frequency response and can actually improve it.

***AWEA Recommendation***: The QER should accurately characterize the extensive capabilities of modern wind turbines to support the reliability of the grid, and accurately portray the causes of and solutions to potential concerns about the provision of frequency response and other reliability services.

**Putting Storage in the Appropriate Context**

Some of the most common questions about wind power revolve around the role of energy storage in integrating wind power with the electric grid. It is important to understand that very large amounts of wind energy can be reliably integrated at low cost without a need for energy storage, and that energy storage provides a variety of services, of which benefits to renewable energy are a very small subset, and is therefore best viewed as a power system resource and not a resource for wind energy or any other individual resource.

The reality is that, while several small-scale energy storage demonstration projects have been conducted, the U.S. has been able to add more than 60,000 MW of wind power to the grid without adding any large-scale energy storage. Similarly, European countries like Denmark, Spain, Ireland, and Germany have successfully integrated very large amounts of wind energy without having to install new energy storage resources. In the U.S., numerous peer-reviewed studies have concluded that wind energy can provide 20% or more of our electricity without any need for energy storage.

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[52] Available at http://www.caiso.com/Documents/Report-FrequencyResponseStudy.pdf
[53] http://web.mit.edu/windenergy/windweek/Presentations/GE%20Impact%20of%20Frequency%20Responsive%20Wind%20Plant%20Controls%20Pres%20and%20Paper.pdf
[54] Available at http://www.nrel.gov/docs/fy14osti/60574.pdf
[55] Available at: http://www.nrel.gov/docs/fy13osti/58077.pdf

The ability to do so lies in using the sources of flexibility that are already present on the electric grid. As discussed earlier in these comments, every day, grid operators constantly accommodate variability in electricity demand and supply by increasing and decreasing the output of flexible generators – power plants like hydroelectric dams or natural gas plants that can rapidly change their level of generation.

This flexibility was built into the power system to accommodate large and abrupt swings in electricity supply and demand. Demand for electricity can vary by a factor of three or more depending on the time of day and year, which nationwide translates into hundreds of gigawatts of flexibility that are already built into the power system. Because these power plants and other sources of flexibility have already been built, it is almost always much cheaper to use this flexibility than to build new sources of flexibility like energy storage facilities.

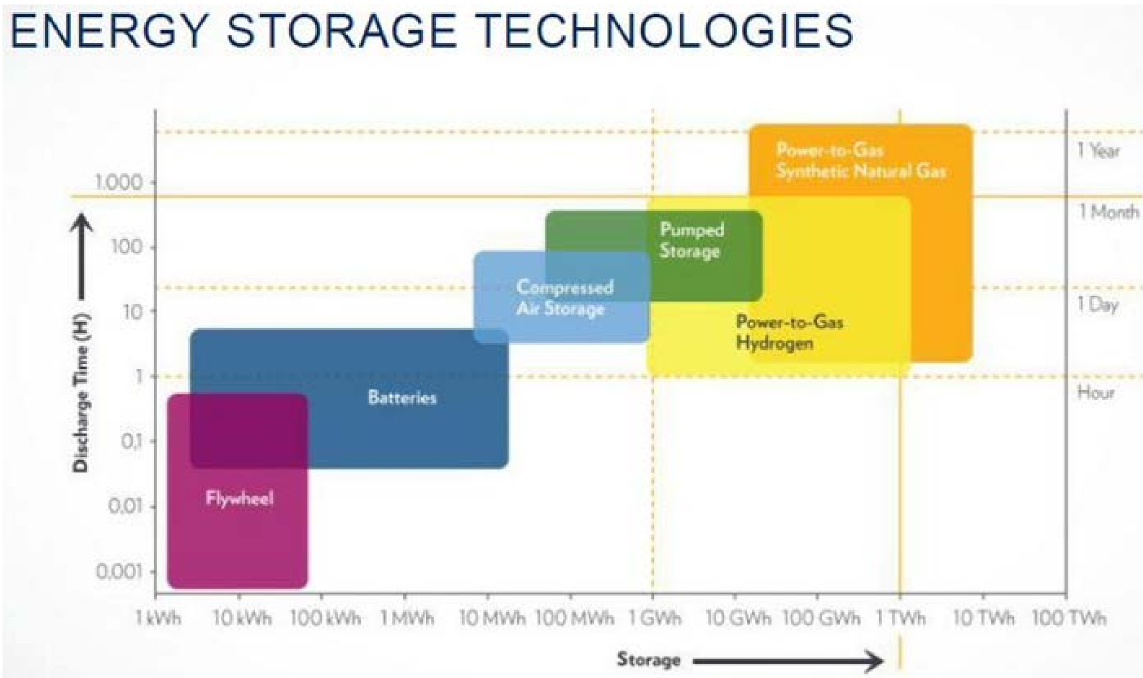
While continuing advances in energy storage technology can make it more economically competitive as a provider of grid flexibility, and improving the performance and reducing the cost of battery storage remains critical for enabling greater electrification of the transportation sector, it is important to remember that resources like wind energy can already be cost-effectively and reliably integrated with the electric grid without energy storage. As described in an earlier section, the key is using sources of flexibility that are already present on the power system, including implementing grid operating reforms that provide greater access to that flexibility.

The high cost of energy storage relative to other sources of flexibility, including those on the existing power system, is the chief reason why it is not more widely used today. In addition, many types of energy storage are poorly suited to help accommodate the specific type of variability that wind energy adds to the electric grid. Wind energy output shows very little variability over the minute-to-minute timeframe, with significant changes in output only tending to occur over time periods of 30 minutes or more. Fortunately, it is much cheaper to provide flexibility over these longer time periods using existing resources; as illustrated in the ERCOT data provided earlier, slower-acting reserves can be obtained at a fraction of the cost of faster-acting reserves. Some energy storage technologies, such as flywheels and advanced batteries, can be cost-effective for accommodating demand variability on the second-to-second time frame, but such technologies provide little to no value for wind integration.[56]

While energy storage technologies cannot currently compete with conventional sources of flexibility, there are also fundamental limits to most energy storage technologies for providing the services needed at very high penetrations of wind energy, such as those in excess of 50% annual penetration by energy. As illustrated below, no energy storage technologies in current widespread use are of sufficient scale to move dozens or even hundreds of GWh of energy hours or even days in time.[57] Pumped hydroelectric

[56] See, for example, http://emp.lbl.gov/sites/all/files/lbnl-6590e.pdf
[57] http://www.itm-power.com/energy-storage/power-to-gas-energy-storage-solution/

storage, with its ability to store large amounts of energy for long durations, is the only energy storage technology that is currently available that comes close to providing this type of service.




Some people incorrectly assume that wind output must be "firmed," i.e. have its variability leveled out, to make it valuable to electric utilities or system operators. In reality, there is no need for individual power plants to provide constant power output; this is a good thing, as all power plants experience unexpected outages fairly frequently. As previously discussed, significant variability is already present on the electric grid due to changes in electricity demand and supply as consumers turn appliances on and off and power plants unexpectedly go out of service. Many changes in wind output actually cancel out opposite changes in electricity demand or supply. Therefore, attempting to "firm" wind can actually add to the total variability on the electric grid. Instead, it makes more sense for energy storage to be viewed as a system resource that can help even out the aggregate variability of all generators and all demand on the electric grid, and not used as a dedicated resource for a single generator or load.  As a result, at or near a wind plant is seldom the optimal location for deploying energy storage.

In certain rare situations, it could make sense to site energy storage near a wind plant. If a constraint on the transmission grid prevents a wind plant or group of wind plants from selling their full output on a consistent basis, it could be economical to store electricity that would otherwise have been curtailed. However, this type of application is a short-term fix; building out the transmission grid is typically the more optimal long-term solution to a transmission constraint.

In addition, it is important to keep in mind that while energy storage can be an economically attractive option in certain niche applications, such as small island power systems, this does not indicate that energy storage is an economic option on large mainland power systems. Small island power systems, due to geography and fuel mix, often lack low-cost sources of flexibility such as an ability to exchange power with neighboring grid operators. In contrast, mainland U.S. power systems can far more cost-effectively manage variability from all sources by exchanging power with a neighboring power system.

While energy storage is not needed to integrate wind energy with the electric grid and is often not cost-effective, in some cases having certain types of energy storage on the grid can modestly reduce the cost of integrating wind. In some cases, energy storage has been found to provide negative value for the integration of wind energy, even if the energy storage was provided at no cost.[58] Regardless, given the low cost of using existing flexibility to integrate wind energy, and grid operating reforms that enable far greater use of existing flexibility at negative cost, it is difficult for energy storage technologies to compete economically.

The only form of energy storage that is currently operational on a large scale in the U.S. is pumped hydroelectric storage, with a little over 20 GW of installed capacity. In an illustration of that fact that storage is best viewed as a system resource, much of this storage was built to accommodate the significant increase in nuclear generation that occurred during the 1960's, 70's, and 80's. Just as it is difficult for wind plants to increase their output in response to grid demands, it is very difficult for nuclear plants and even coal plants to increase or decrease their output in response to commands from the grid operator. Changing the output of a nuclear or coal plant requires changing the amount of heat traveling through the plant's steam system. The resulting temperature fluctuations can cause thermal stress to plant equipment, significantly increasing maintenance expenses and causing safety concerns.
Thus, all inflexible generators benefit when other sources of flexibility, including energy storage, can relieve them of having to accommodate changes in electricity supply and demand. In fact, studies in the Netherlands[59] and Ireland[60] found that coal plant owners were the primary beneficiaries of energy storage as it allowed coal power plants to run more at night, with this low-cost energy being stored and used to displace more expensive natural gas generation during the day, interestingly causing a net increase in electric sector carbon dioxide emissions.

While energy storage technologies may currently have difficulty competing economically with conventional sources of flexibility – especially over the time frame most relevant for wind integration – continuing advances in energy storage technology can make energy

[58] http://emp.lbl.gov/sites/all/files/lbnl-6590e.pdf

[59] http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=4463799&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D4463799

[60] http://econpapers.repec.org/article/eeeenepol/v_3a39_3ay_3a2011_3ai_3a4_3ap_3a1965-1974.htm

storage more competitive as a provider of grid flexibility. For example, there is significant potential for the batteries of plug-in hybrid electric vehicles to be used as energy storage for the grid, particularly by simply altering the rate of charging of these batteries and therefore avoiding any cycling-related impacts to battery life, because the expense of their batteries would largely be covered by the fuel savings they provide to the vehicle owner. While the potential of such technologies is exciting, it is important to remember that resources like wind energy can already be cost-effectively and reliably integrated with the electric grid without energy storage.

***AWEA Recommendation*:** The QER should avoid discussing or making recommendations related to energy storage in the context of integrating renewable energy. Energy storage should be discussed as a system resource that serves as a tool for the transmission and distribution of all sources of energy and is capable of smoothing out all sources of variability, including changes in demand and the failure of conventional power plants. Energy storage should also be put in its proper context along with other sources of flexibility already available to grid operators, including grid operating reforms that reduce the need for operating reserves and allow greater utilization of existing flexibility, and compared on cost.

**Policies necessary to facilitate expanded transmission and improved grid operations**

AWEA has referred to the policies necessary to facilitate an upgraded and expanded transmission grid as the three "Ps": planning, paying for, and permitting. As noted, policies to gird operations are equally important as they can also facilitate expanded deployment of renewable energy, improved reliability and consumer savings.

There has been significant progress over the last several years related to how transmission is planned and paid for (cost allocation), as well as with respect to implementation of improved grid operations. A sampling follows:

- FERC Order 1000 on regional and interregional transmission planning and cost allocation;
- FERC Order 764 on integrating variable energy resources;
- The Competitive Renewable Energy Zone (CREZ) transmission buildout in Texas, which has emerged as a success story due to the rapid subscription of the transmission lines by new low-cost wind generation and the lines' contribution to meeting unforeseen reliability needs;[61]
- Implementation of an energy imbalance market parts of the western U.S.;
- MISO's multi-value project (MVP) transmission planning and cost allocation effort, modeled on the successful CREZ combination of pro-active transmission planning and broad cost allocation;

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61 http://www.ercot.com/content/committees/board/keydocs/2014/ERCOT_Monthly_Operational_Overview_201407_Revision_2.pdf

- SPP's highway/byway transmission planning and cost allocation effort;
- The positive impact transmission build out has had on reducing curtailment of wind generation;[62]
- Implementation of MISO's dispatchable intermittent resources (DIR) program; and,
- The Western Area Power Administration's (WAPA) decision to join SPP.

However, there has been very little progress on improving the permitting process, particularly with respect to large interstate transmission lines. In this area, the U.S. Department of Energy has an important role to play.

In a September 2011 letter to then-Energy Secretary Chu, AWEA supported a proposal to unify, by a delegation from DOE to FERC its authority under section 216 of the Federal Power Act, the currently bifurcated federal siting authority. FERC has a long history of siting energy and, therefore, is the appropriate agency to carry out that task. Moreover, the end result would be a single siting proceeding at a single agency rather than consecutive proceedings at two separate agencies, improving the efficiency of the federal siting process.

AWEA has also supported improving the corridor designation process under Section 1221 of the Energy Policy Act of 2005, including by allowing transmission corridor designations by request and by clarifying and expanding the criteria for designation, including by adding fuel diversity, energy security, and access to renewable energy resource areas (i.e. similar to the CREZ process in Texas).

In a 2009 report[63], and in a handful of bills introduced in Congress, AWEA has supported enhanced federal siting authority along the lines of FERC's authority to permit natural gas pipelines.

One more recent proposal to improve the functionality of federal backstop siting authority comes from a February 2013 report[64] by the Bipartisan Policy Center titled "Policies for a Modern and Reliable Electric Grid." BPC recommends:

- Congress should enact a new, targeted backstop siting authority that allows the Federal Energy Regulatory Commission (FERC) to issue a federal permit approving multistate HVDC or 765+ kV AC transmission projects if:
  - A state siting authority has denied the project without offering an alternative route that is consistent with relevant state law, or has not issued a decision within 18 months of receiving a completed application, or has insufficient authority to grant such an application; and
  - The project has been approved by a state siting authority in another state.

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62 See wind curtailment data on page 51, http://emp.lbl.gov/sites/all/files/2013_Wind_Technologies_Market_Report_Final3.pdf
63 Available at: https://www.awea.org/files/FileDownloads/pdfs/GreenPowerSuperhighways.pdf
64 Available at: http://bipartisanpolicy.org/sites/default/files/Energy_Grid_Report%5B1%5D.pdf

AWEA has also supported DOE utilizing its Section 1222 authority to participate with other entities in constructing and owning new or upgrade transmission facilities.

In addition, while federal power marketing administration like Bonneville and WAPA have taken some helpful steps to build out the transmission grid and integrate renewable energy, there is more they can do to lead in this effort.

***AWEA Recommendation***: The QER should acknowledge the importance of policy with respect to getting transmission planned, permitted and paid for, should support the progress that has been made as discussed above, and should encourage wider adoption of successfully demonstrated policies. The QER should also discuss options for improving the permitting of high voltage interstate transmission lines, where less progress has been made.