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Wind Energy and Energy Storage

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Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Wind Energy by the Numbers

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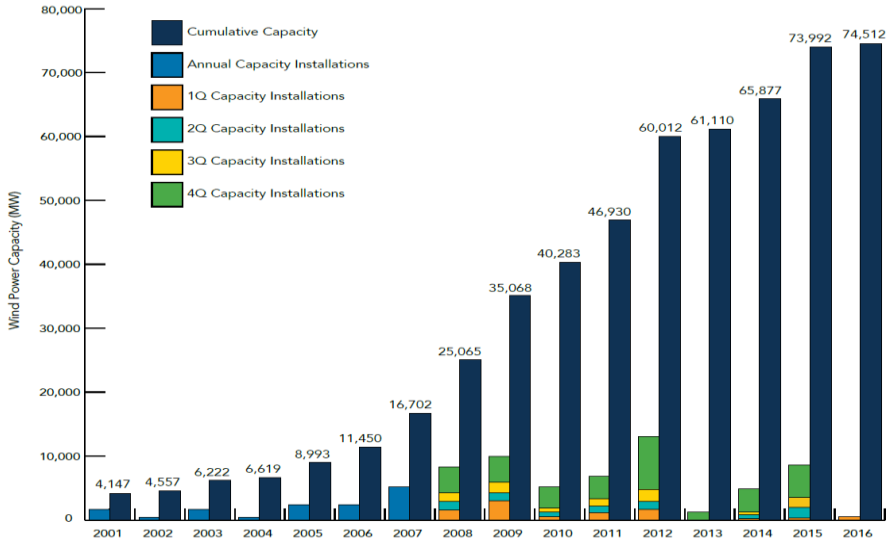
74,512 MW Total U.S. installed wind capacity, through end of 2016 Q1

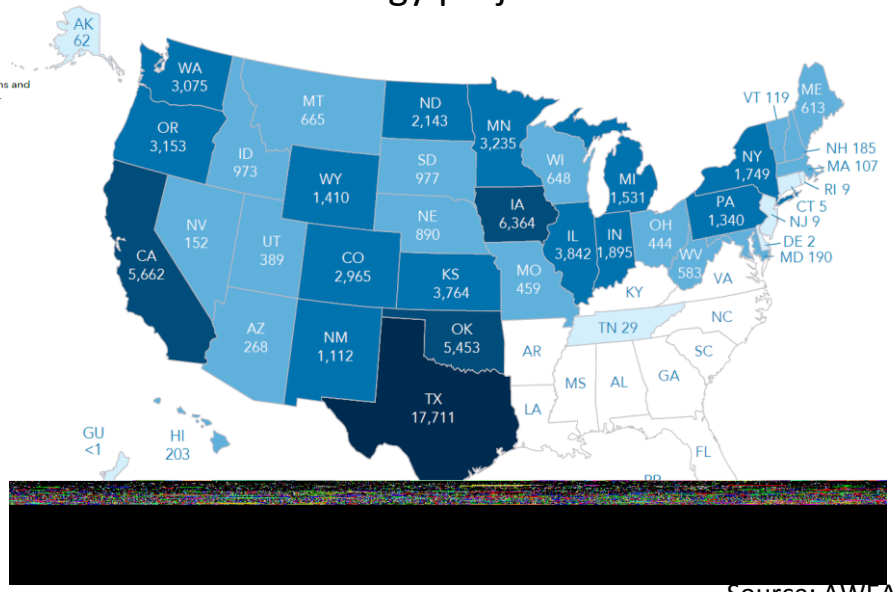


Note: Utility-scale wind capacity includes installations of wind turbines larger than 100-kW for the purpose of the AWEA U.S. Wind Industry Quarterly Market Reports. Annual capacity additions and cumulative capacity may not always add up due to decommissioned, uprated and repowered wind turbines. Wind capacity data for each year is continuously updated as information changes.

>4% U.S. electricity production annually

>48,800 Total number of operating utility-scale wind turbines

40 plus Puerto Rico & Guam Number of U.S. states with operating utility-scale wind energy projects



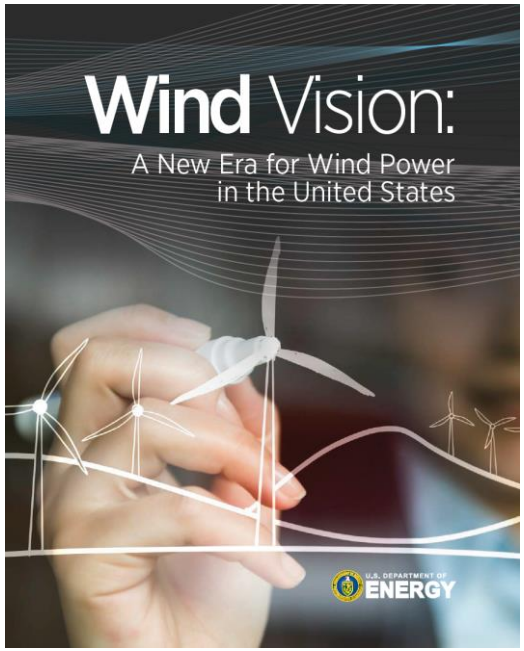
41% Wind energy's percentage share of power capacity additions in 2015

11 States where wind power exceeds 12 percent total electricity production

>10% Percentage of total electricity production in Texas (ERCOT)

Source: AWEA

The DOE Wind Vision



- Updated and expanded upon the *20% Wind Energy by 2030* report
- Analyzed scenarios of wind power supplying:
  - 10% by 2020
  - 20% by 2030
  - 25% by 2050
- Wind Integration and Delivery Challenges:

  Wind energy is:
  - Variable & Uncertain
  - Location Dependent

  This leads to:
  - Increased level of operating reserves
  - Transmission constraints result in curtailment
- Wind Integration and Delivery Solutions:
  - Improving power system flexibility can come from:
    - Changes to grid operating practices
    - Changes in market design
    - Physical changes to power system resources, **including storage options**

The Need for Power System Flexibility

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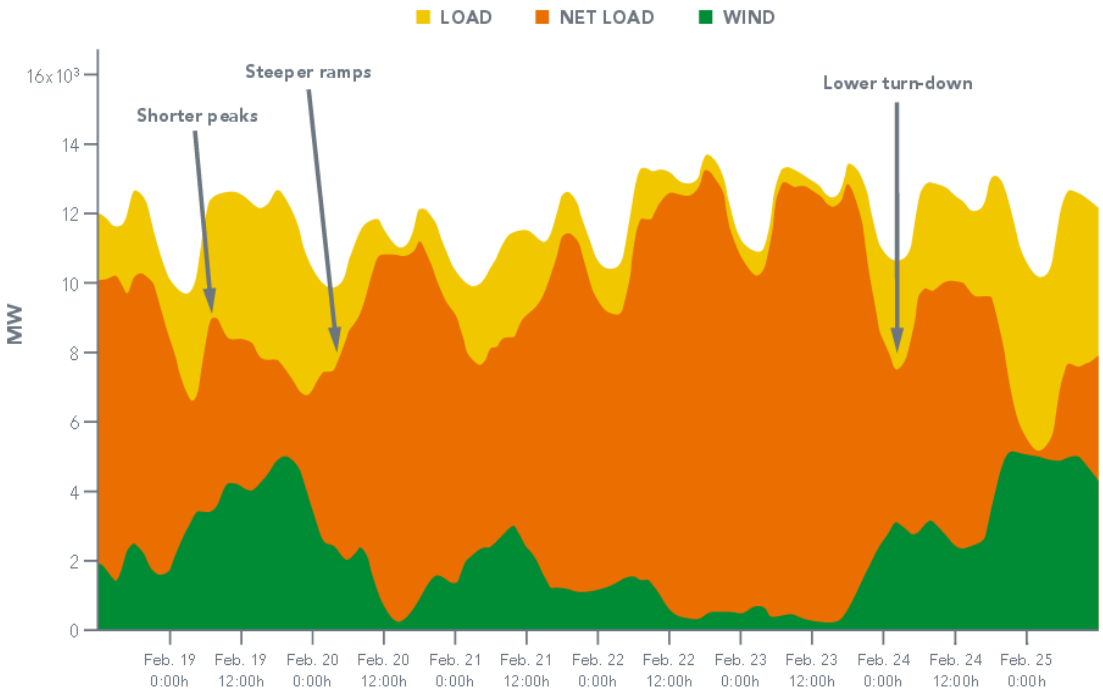
Wind generation can lead to:

- Steeper ramps

  Rate of change in dispatchable generation to follow demand changes
- Deeper turn-downs

  Operation of dispatchable generators output to low levels and remain online
- Shorter peaks

  Periods when wind is high resulting in fewer operating hours for conventional plants



Power System Flexibility to accommodate wind (& solar):

- Flexible generation

  Power plants that can ramp up and down quickly and run at low output levels
- Flexible transmission

  Networks with sufficient capacity and include sharing between neighboring power systems. Smart network technologies that better optimize transmission usage
- Flexible demand-side resources

  Incorporation of demand response and storage technologies
- Flexible system operations

  Improved forecasting, market changes to accommodate for decision making closer to real time, increased collaboration between neighboring systems

Source: NREL: http://www.nrel.gov/docs/fy14osti/61721.pdf

ESS & Flexibility

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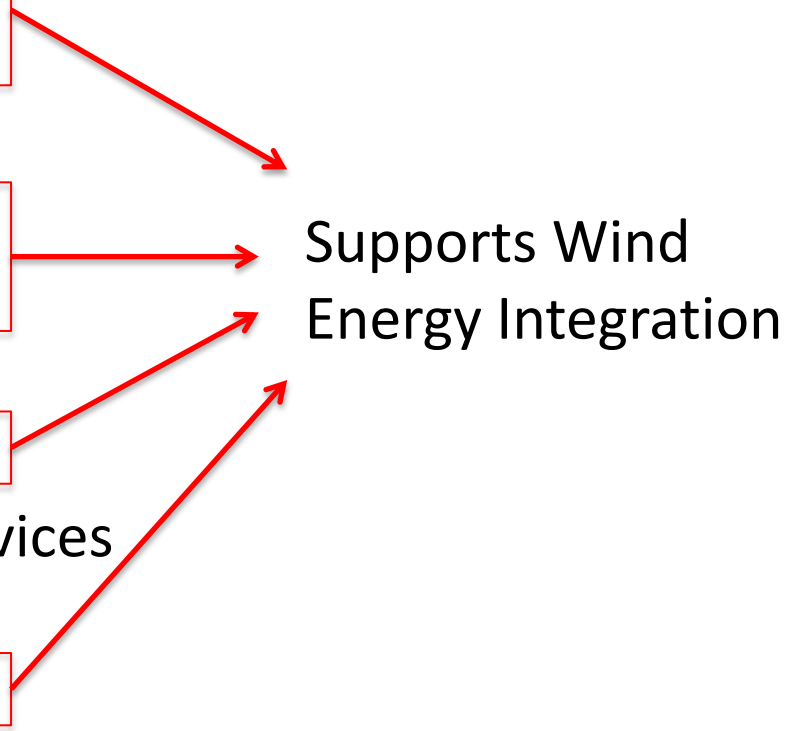
Grid Services that Energy Storage can Provide:

- Bulk Energy Services
  - Energy Arbitrage or Time-shifting
  - Capacity
- Ancillary Services
  - Regulation
  - Spinning, Non-Spinning Reserves
  - Voltage Support
  - Black Start Capability
- Transmission Infrastructure Services
  - Upgrade Deferral
  - Congestion Relief



Challenges

- Research focused on renewable energy production does not usually emphasize integration with the grid
- Primary customers (e.g. DOE/EERE and DOE/OE) have limited resources and diverse motivations -- making it challenging to co-sponsor or collaborate on RE/Grid/Storage R&D activities
- RDT&E facilities with combined RE/Grid/Storage capabilities are not common
- Energy Storage guys don’t often go to Wind workshops, conferences, etc. (and vice versa)

SWiFT & ESS Opportunity

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Sandia's Scaled Wind Farm Technology (SWiFT) Facility at the Reese Technology Center (RTC) in Lubbock TX is a collaboration with Texas Tech University (TTU), Vestas, Group NIRE, and many others

Group NIRE and TTU commissioned a 1MW/1MWH Battery at the RTC Oct 18, 2013

- Group NIRE and TTU are also working on development of a PV farm and a microgrid at RTC
- Activities are underway to link capabilities at RTC/SWiFT to other SNL test facilities

Thank you!

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