Engineering and Operational Considerations for VG Integration

Energy Information Administration

Variable Renewable Energy Workshop

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What is UVIG?

- Non-profit corporation established by 6 utilities in 1989 with support from EPRI and DOE/NREL
- Expanded scope from wind to include solar PV in 2011, now Utility Variable-Generation Integration Group (UVIG)
- Over 180 members, including ISOs, utilities, developers, manufacturers, consultants, government organizations
- Focus on technical issues
- Mission: To accelerate the development and application of good engineering and operational practices supporting the appropriate integration of solar and wind power into the electric system

Outline of Topics

- Recent Industry Trends and Findings
- Flexibility and Forecasting
- Capacity Value and Adequacy
- Reliability and VG Integration
- Market Design and VG Integration
- Implications for the Future

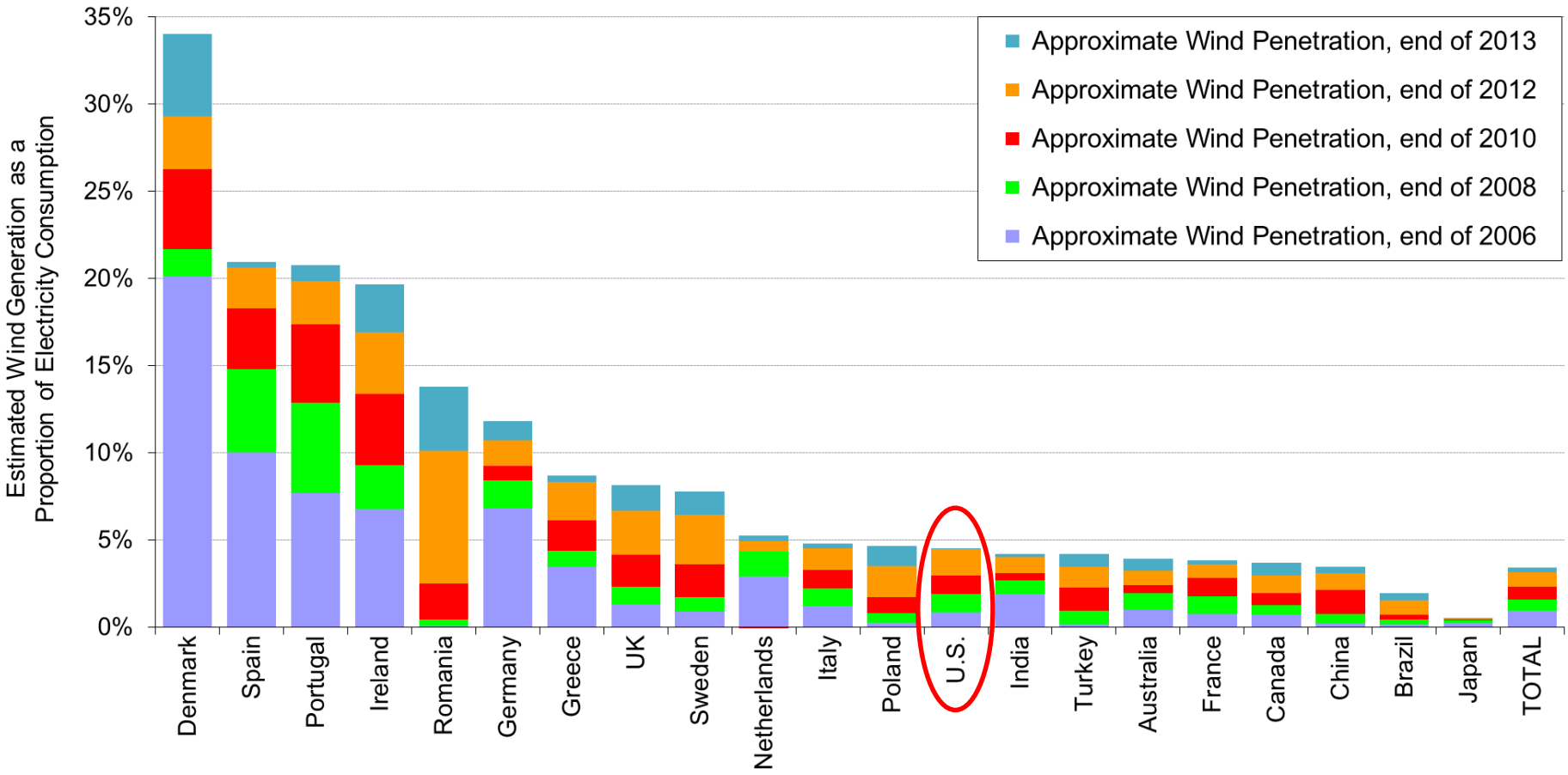
Recent Industry Trends

- NERC Essential Reliability Services Task Force (ERSTF) highlights:
  - Growing interdependence between gas and electricity markets
  - Concern over coal plant retirements
  - Increased levels of wind and solar
  - Maintaining future system reliability
- Cost of renewables continues to drop
- Low marginal cost of renewable energy continues to drive concern for capacity adequacy
- Capacity flexibility issue gaining attention

Renewable Energy is Very Competitive

- Lazard reports on lowest unsubsidized energy costs for:
  - Rooftop residential solar: $180/MWh
  - Simple Cycle GT $165/MWh
  - Nuclear $97/MWh
  - Coal $65/MWh
  - Combined Cycle GT: $52/MWh
  - Utility scale solar: $50/MWh
  - Wind energy: $32/MWh
- Other reports from industry pubs on recent PPA prices:
  - Utility scale solar $37-$50/MWh
  - Wind energy $18-$30/MWh

Relative Position of Major Wind-Producing Countries

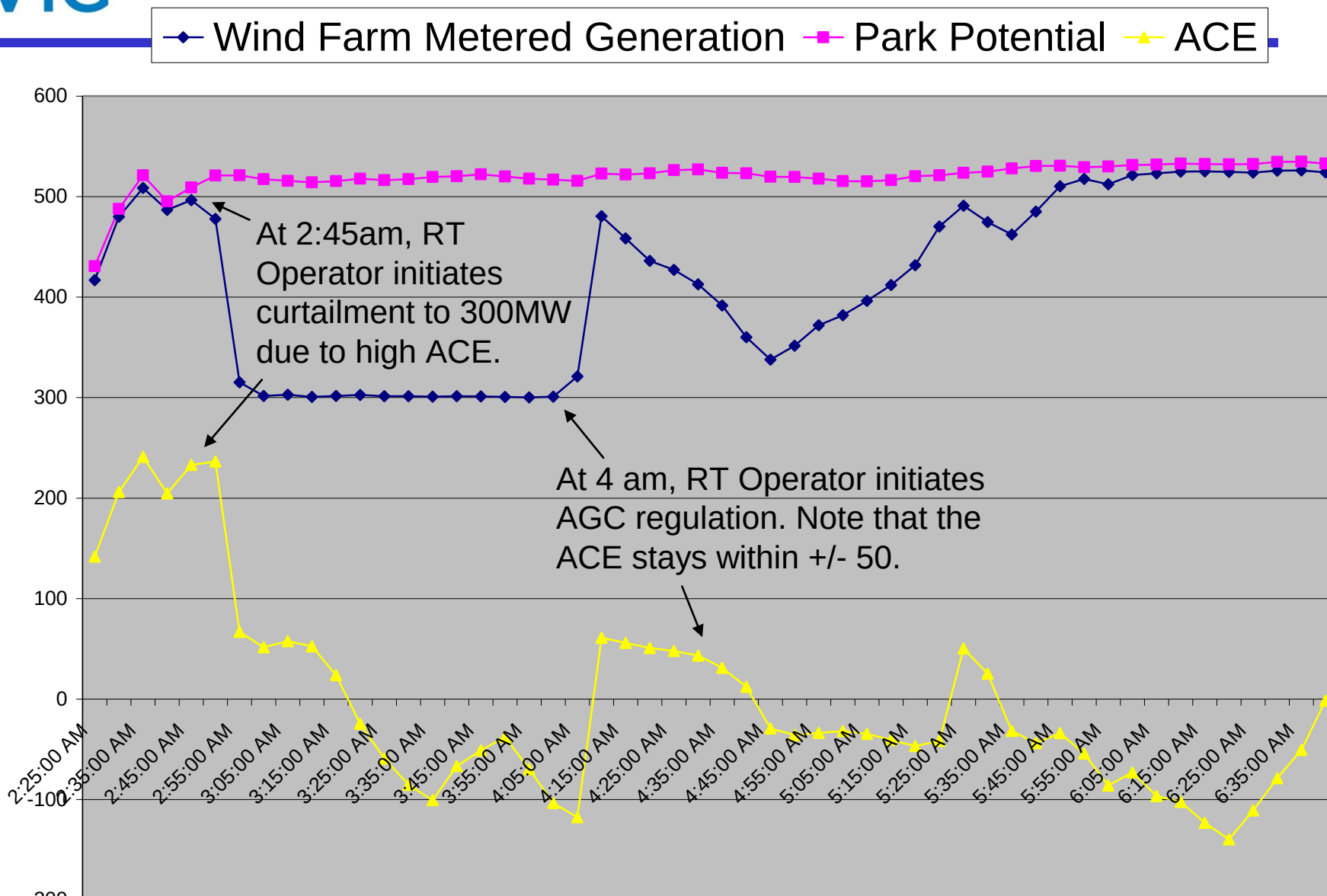


Note: Figure only includes the countries with the most installed wind power capacity at the end of 2013

Operational Flexibility in the US

- Flexibility - the ability to change output rapidly to accommodate rapidly changing system conditions.
- Flexibility measures
  - short start up time
  - ability to ramp up or down quickly
  - more daily start-up and shut down cycles
  - high turn-down ratio
- Sources of flexibility
  - Flexible thermal and hydro
  - VG, DR, and storage
  - 5 min dispatch
  - Co-optimization of energy and A/S in competitive markets
- **ERCOT rethinking entire ancillary service market design**

Xcel Wind Plant on AGC



Operational Flexibility from Forecasting

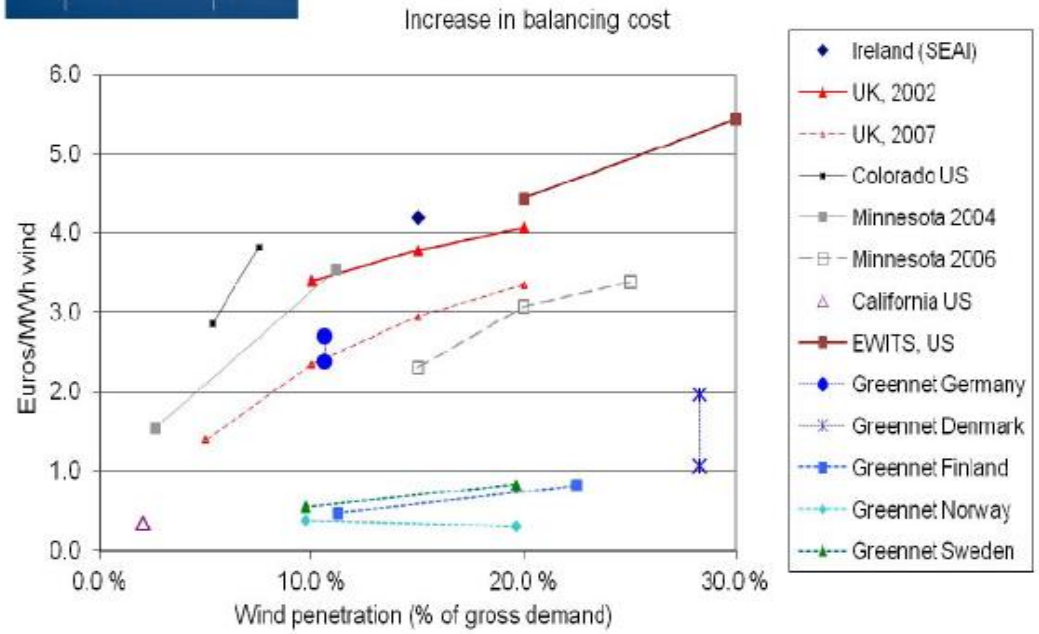
- Most ISO/RTO systems now include wind in Day Ahead Unit Commitment and Security Constrained Economic Dispatch
- Wind dispatch done with a 10-minute-ahead forecast or faster
  - Using the current telemetered value (a fast "persistence" forecast)
    - NYISO, ERCOT, SPP
  - Using a rolling five-minute forecast ("persistence + model" forecast)
    - MISO, PJM, IESO
- Not a markets issue (markets can help, but this works anywhere)
  - Forecast wind into day ahead unit commitment
  - Dispatch the entire system (including wind) every five minutes using a very short term wind forecast or the current telemetered output value
- **Dispatch is not arbitrarily telling a generator what to produce, but rather knowing what is available for the dispatch period, and optimizing the system as a whole.**

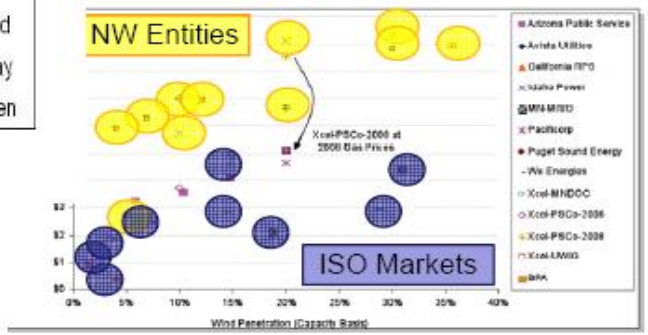
Balancing Cost- Summary of Results

Task 25 Design and Operation of Power Systems with Large Amounts of Wind Power

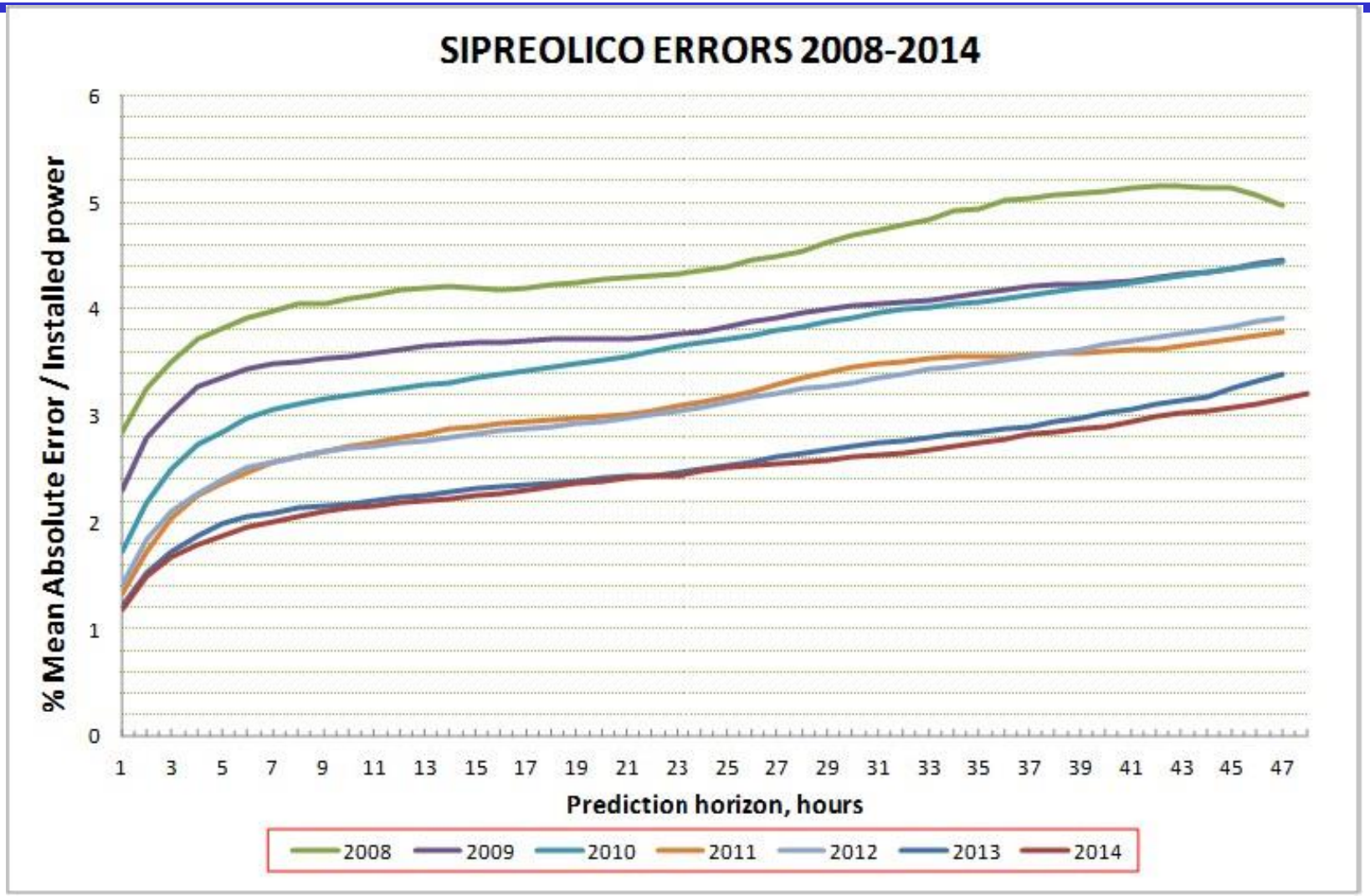
iea wind

Balancing cost – summary of results





How Low Can You Go?



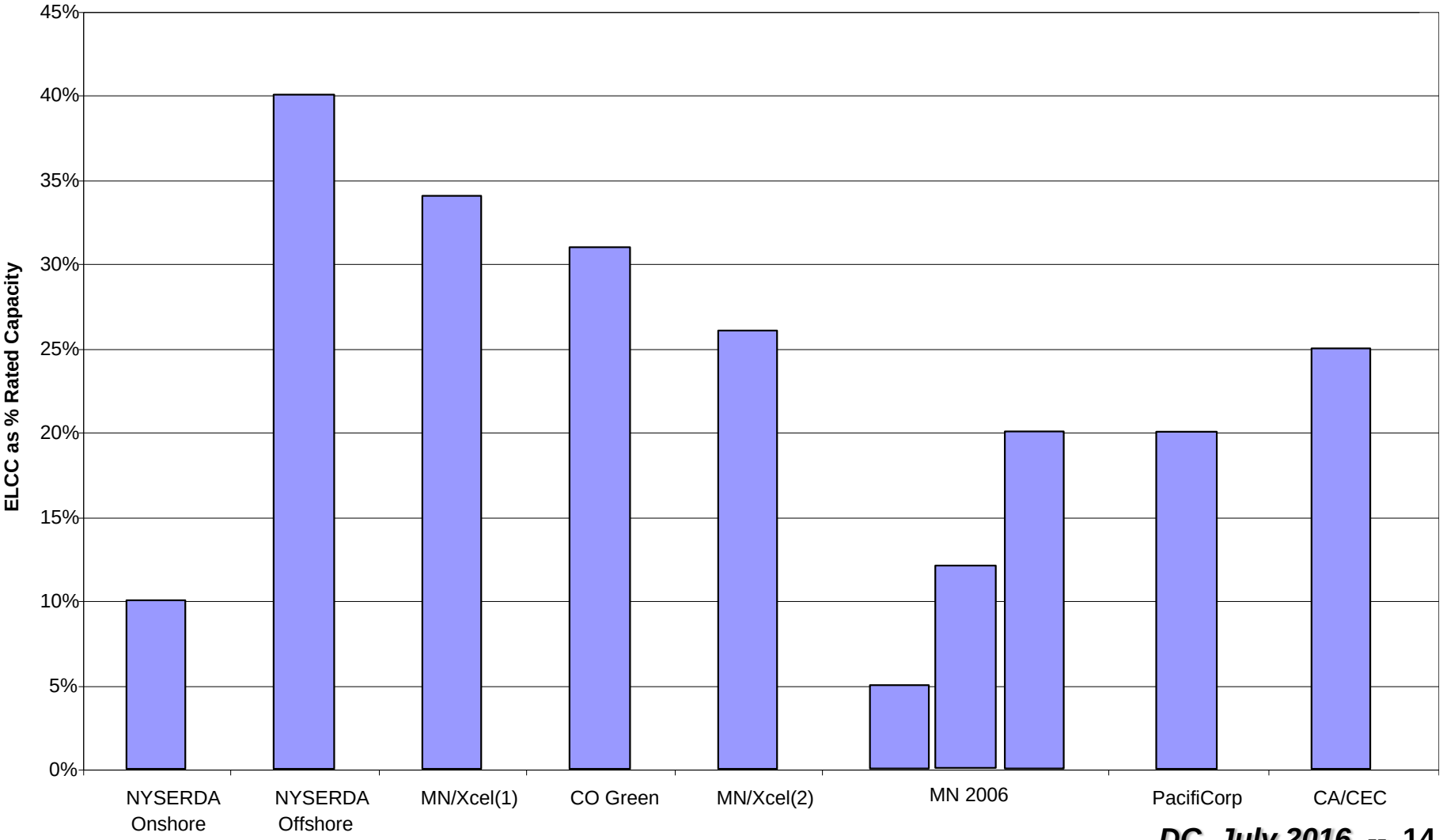
What To Do When the Wind Doesn't Blow

- Good question!
- Must deal with energy resource in a capacity world
- Dealt with through probabilistic reliability methods used to calculate Effective Load Carrying Capability (ELCC)
- Contribution may be large (40%) or small (<5%)
- Once the ELCC is determined, get on with the job of designing a reliable system
- And that means adding more flexible capacity in the future!

Wind Capacity Valuation Simplified

- Provides a measure of the contribution of a plant to meeting system peak load
- For example, in PJM, Manual 21 specifies the approach to calculating capacity value of WPP
- Onshore plants range between 24-26%
- Offshore plant calculations yield 31-34%
- On average, the offshore plants are 30% higher
- Wind plants historically price takers in capacity market, but this option eliminated in May 2017
- Only Capacity Performance resources accepted in subsequent auctions

An Energy Resource in a Capacity World



Wind and Solar Plants are Power Plants

- **Dispatchable**
  - Easy if done right, high errors if "fuel characteristics" are ignored
- **Ride through disturbances**
  - Wind ride-through requirements exceed those of conventional generators per FERC Order 661A and exceed NERC Standard PRC-024 requirements
- **Provide frequency response and voltage control**
  - Implemented for wind in ERCOT and other regions
- **Impressive ramping and active power control**
  - Very fast and accurate response over entire capability range

Utility-scale solar plants can support similar capabilities

Mark Ahlstrom, UVIG, 2015

General Recommendations

- Require all new power plants to have the capability of providing essential reliability services i.e. voltage regulators and governors
  - All plants should be capable of contributing to system reliability
  - Operational use of plants to provide services will vary based on economics (need for service, value of service, opportunity cost)
  - Not every plant needs to provide every reliability service at all times, but we can't perfectly predict future needs or values
  - All power plants should ride through disturbances
- Leave it to tariffs and markets to compensate generators for their services
- Wind and PV must participate in the markets
- Requirements should be technology-neutral to the extent possible
- We will learn and adapt as the generation mix, load characteristics and markets evolve and change

Resource Adequacy and Market Design

- The organized markets are similar in their energy and ancillary service market designs,
  - Sub-hourly energy markets
  - Co-optimized energy and ancillary service markets
  - Large systems with aggregation benefits for generation and load

  but vary widely in approaches for resource adequacy
- The two primary market alternatives are
  - energy-only market with capacity costs recovered in the energy and ancillary service market (e.g. ERCOT)
  - energy market with a parallel capacity market to recover some portion of the capacity cost (e.g. PJM, NYISO, ISO-NE)
- Either may have additional regulatory capacity planning margin requirements that require LSEs to contract for capacity

A New Paradigm for Future Capacity and Flexibility Adequacy?

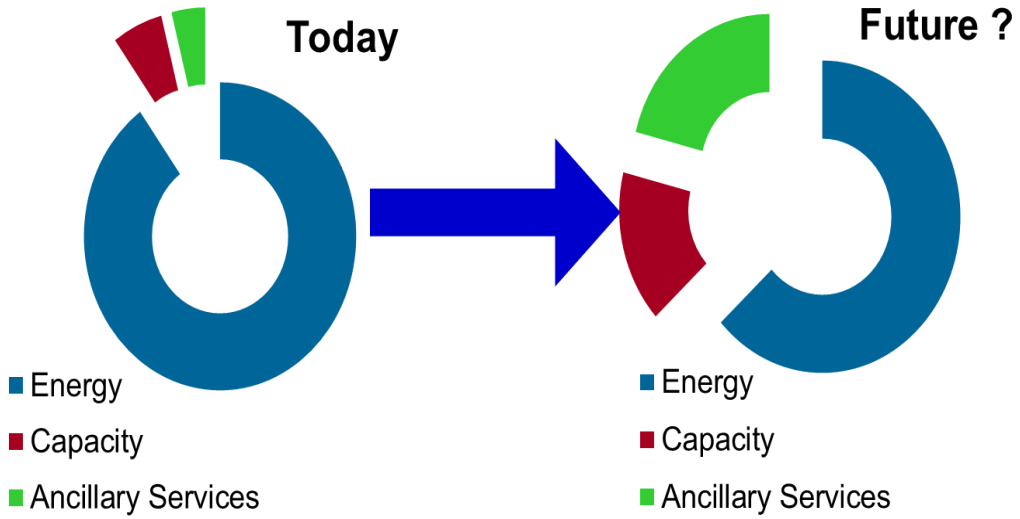


Figure courtesy of EPRI

Revenue mix will change, but paths and values are uncertain

- Capacity markets vs. long-term contracts vs. rate-based plants…
- Ample supplies of services may lead to low values
- New sources of services and flexibility are likely

Markets are a critical part of the future!

Mark Ahlstrom, UVIG 2015

Outlook for Wind and Solar

- In spite of the stay issued by the Supreme Court in the implementation of the CPP …
- Corporate America is on board with renewable energy
- The expectation is that there is no turning back the clock
- Low cost renewables and customer demand are driving increasing interest in carbon-free electricity
- A lot of experimentation is going on in markets to understand the value of flexibility from DR, storage and other new sources. VG should be included.
- Markets provide an opportunity to let all resources compete on a level playing field and help market participants understand the value of new services, including flexibility

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