The Brattle Group

Wind Integration Services

Summary of Industry Practices in North America

Prepared for NorthWestern Energy

In Docket No. EL11-006
Before the Public Utilities Commission of the State of South Dakota

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Exhibit 1 to the Affidavit of Philip Q. Hanser
EL11-006

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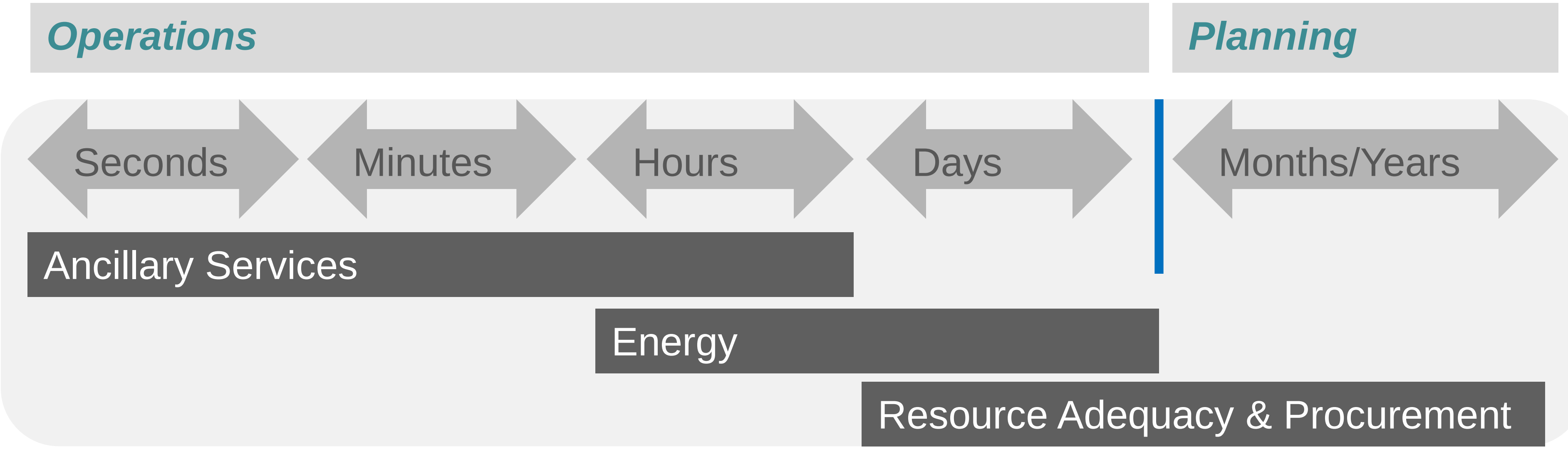
Integrating Renewable Energy Involve Compensation at Various Time Frames



The challenges and tools for wind integration vary greatly with the timeframe

- ***Intra-hour timeframe.*** The focus is on the ability to compensate unpredictable variations with durations in seconds to tens of minutes. In the U.S., the compensation is performed through the use of Ancillary Services (A/S) and intra-hour energy and transmission scheduling (more details in coming slides).
- ***Hours-to-days timeframe.*** The focus is on the ability to cope with uncertain wind forecasts, addressed by changes in the commitment and dispatch of controllable resources .
- ***Days to years timeframes.*** The focus is on having sufficient capacity to meet peak demands over timeframes of months to years. (Wind plants typically have low output during peak load conditions in the U.S. As such, the capacity value of wind tends to be low, so resource adequacy is ensured through other resources.)

Integration of Renewable Energy Has Required Changes to Operational and Planning Rules

- Rules are changing in both the operations and planning horizons, including changes to procuring and pricing services/products
  - Frequency regulation, load following and ramping
  - Allowing and encouraging entry of new technologies and demand resources
- Increasing balancing area coordination
  - Creation of residual energy imbalance market with dynamic interchange schedules
  - Coordinate intra-hour scheduling across areas
- Improve wind forecasting
- Improving interconnection and transmission planning processes, in response to high renewables expansion

Overview of Wind Integration Practices

- The short-term (second to tens of minutes) operational challenges are mostly met by the use of Ancillary Services
  - All jurisdictions provide Ancillary Services to compensate intra-hour fluctuations.
  - Organized markets use Ancillary Service and Real-time Energy markets to integrate renewable energy
    - Day-ahead markets provide the ability to hedge against real-time price uncertainty. However, wind generators bear the risk for real-time deviations from day-ahead schedules, limiting their incentives to participate in day-ahead markets.
  - Jurisdictions without organized markets provide intra-hour ancillary services at costs (included in the standard transmission tariff).
    - The costs of these ancillary services are assessed on wind plant owners in a few jurisdictions.
- *To date, formal "integration services" include all of the services (and costs) necessary to compensate the intra-hour variability and uncertainty associated with Variable Energy Resources (VERs)*
  - Wind plants outputs are typically not made firm beyond an hour, unless the wind plant owner or a third-party aggregator controls a pool of resources including controllable resources *(e.g.,* Iberdrola operates thermal and hydro resources, besides wind).

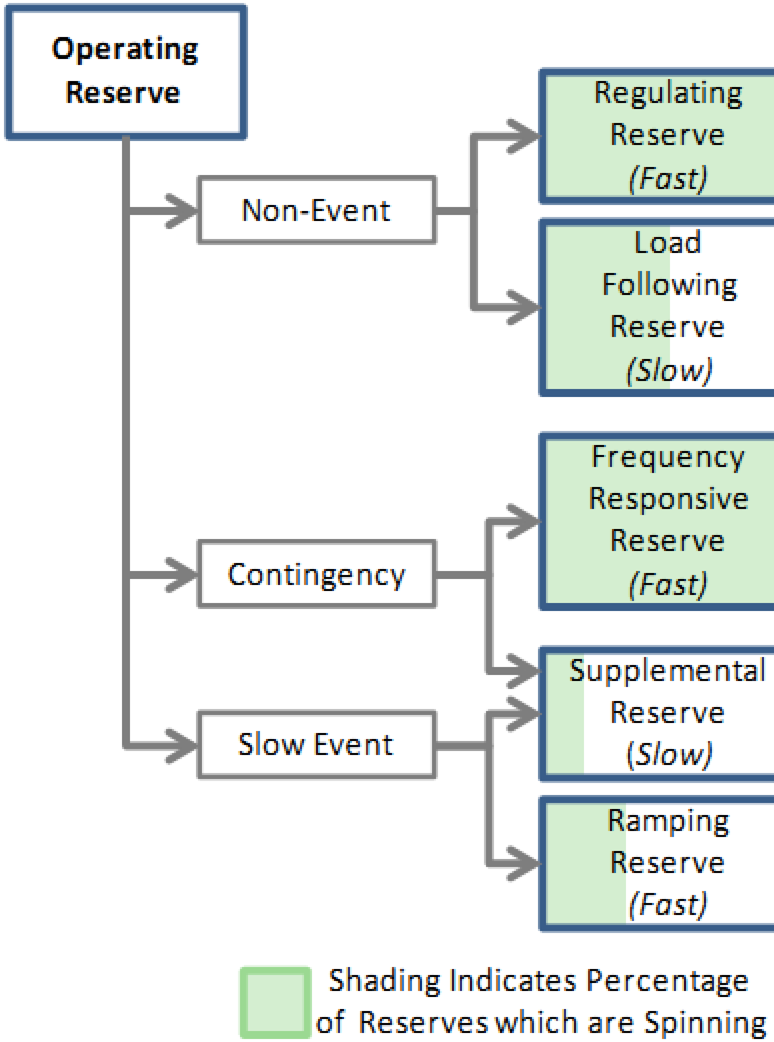
Definition of Ancillary Service (contained in Standard OATT)

- FERC Order No.888-A defined Ancillary Services as follows:

  "Those services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the Transmission Provider's Transmission System in accordance with Good Utility Practice."

- Ancillary services (A/S) exist to ensure system reliability and can be categorized into several functional categories (see next slide for details):
  - Scheduling, system control and dispatch
  - Reactive supply and voltage control from generation
  - Energy imbalance
  - Regulation and frequency response
  - Operating reserve—spinning and supplemental (non-spinning)
  - Generator imbalance
- A/S can be differentiated over several dimensions:
  - Technical requirements:
    - Automatic Generation Control capability must be met for regulation service provision.
    - Upward and downward available capacity reserve must be maintained to follow the AGC signal or provide sub-hourly load following.
    - Response times within the sub-hourly intervals and ability to quickly ramp generation in upward and downward direction is increasingly important.
  - Time domain of application—seconds, minute, sub-hourly, hourly, multi-hourly, etc.

Taxonomy of Ancillary Services



- **Operating Reserve:** Capability above firm system demand required to provide for regulation, load forecasting error, equipment forced and scheduled outages and local area protection. It consists of spinning and non-spinning reserve.
- **Regulating Reserve**: An amount of reserve responsive to Automatic Generation Control (AGC), which is sufficient to provide normal regulating margin.
- **Frequency Response**: The ability of a system or elements of the system to react or respond to a change in system frequency.
- **Frequency Regulation**: The ability of a Balancing Authority to help the Interconnection maintain Scheduled Frequency. This assistance can include both turbine governor response (primary response) *and* AGC.

Sources: NERC "Operating Reserves and Wind Power Integration: An International Comparison Preprint," October 2010; NERC "Glossary of Terms Used in NERC Reliability Standards," Feb 2013; NREL "Eastern Wind Integration and Transmission Study," January 2010

Taxonomy of Ancillary Services, Bonneville Power Authority

- Additional Ancillary Services terms, as defined by Bonneville Power Authority (BPA), are:[1]
  - Regulation: The moment-to-moment variations in generation.
  - Load-Following: The longer timeframe variations over 10 minutes.
  - Imbalance: The total hourly deviation between actual and scheduled output.
- Imbalance Services can be further split into incremental (*inc*) or decremental (*dec*) reserves.[1]
  - *Inc* reserves are provided from generators that can increase generation (or loads that can reduce consumption) when loads increase or other generation decreases.
  - *Dec* reserves are provided from generators that can reduce generation when loads decrease or other generators increase.

1 *BPA, Testimony of D. H. Fischer et al. on GENERATION INPUTS POLICY*, BP-14-E-BPA-21.

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U.S. Federal Regulatory Requirements for Renewable Integration

- FERC Order 888, Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities (1996)
  - Requires that open access be provided to transmission systems
  - Requires unbundling of A/S; some areas have recently included in their tariffs A/S specific for the integration of variable energy resources (VER)
  - Requires the possibility to self-supply ancillary services by transmission customers
- FERC Order 764, Integration of Variable Energy Resources (2012), sets basic requirements to improve operational procedures to facilitate VER integration
  - Requires each transmission provider to offer intra-hourly transmission scheduling
  - Requires interconnection customers whose generating facilities are variable energy resources to provide meteorological and forced outage data to the transmission provider for the purpose of power production forecasting.

Intra-hour Wind Integration Cost Assessment: Organized Markets vs. Other Jurisdictions

There is a difference in the assessment of the costs associated to VER integration services between organized markets and other jurisdictions

- Organized markets do not specifically levy a wind integration charge on wind generators – the integration of VERs is *de-facto* paid by all purchasers of power from the pool in MISO, PJM, NYISO, ISO-NE, ERCOT, and CAISO.
- Two balancing areas in the Pacific Northwest have set a precedent for charging for wind integration services to *exporting wind resources* by specifying a dedicated VER integration services and associated charge in their tariffs: BPA and Puget Sound (wind resources can also procure the services from other parties)
- NaturEner (wind developer) created its own balancing area (NaturEner Powerwatch LLC) to manage wind integration costs internally
  - Located in Montana, it consists of two wind plants (Glacier Wind I and II) with a total of approx. 200 MW
  - NaturEner Powerwatch LLC has contracted with hydro power plants for provision of regulation (outside of the balancing area)

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Wind Plants Participate as Dispatchable Resources in U.S. RTOs

- As newer wind turbines are capable of controlling their output according to dispatch instruction, markets are treating wind as a dispatchable resource in their real-time energy market.
  - NYISO: since 2009 wind must participate as a dispatchable resource.
  - MISO: since 2013 wind must participation as a dispatchable resource but it can change its Forecast Maximum Limit up to which MISO can dispatch the resource.
  - PJM: wind may offer into the Real-time market as a dispatchable resource, but it can change it's the maximum limit to which it can be dispatched can be changed only once per hour.
  - ERCOT: wind generators are dispatchable, failure to generate within the required range may result in a deviation charge.
  - Alberta: exploring how wind can participate in the energy market, has found it beneficial for the grid and for the wind farm: 2 wind farms have participated as a pilot project (~130MW), allowing restatement period of 20 min prior; allow dispatch tolerance of +/- 5 MW.

Wind Participation in Real-Time Energy Market

- Integrating wind generation into real-time dispatch provides several benefits.
  - More efficient congestion management – system operator is better able to curtail the minimum amount of wind for the shortest durations needed to relieve congestion.
  - Minimizes the need for less efficient, out-of-market actions to maintain reliable operations.
  - More efficient price signals –Incorporates wind plant dispatch instructions into energy market clearing price.
  - Wind plants can indicate their economic willingness to generate.
  - Maximizing wind generation without compromising reliability.
  - Reduces the probability of minimum generation emergencies (low-load & excess generation).
  - Wind is treated in a manner more comparable to conventional generation, including the eligibility for make-whole payments (to cover fixed costs, *e.g.*, start-up costs, not covered by market prices).

Wind Participation in Day-Ahead Energy Market

- Participation in Day-Ahead Energy Markets
  - In U.S. RTOs with DA markets, wind is usually allowed to participate under the same terms as other types of generators.
  - Real-time wind deviations from the day-ahead schedule result in imbalance charges, therefore wind has less incentives to bid into the DA market.
    - In two-settlement markets, virtual bidding can help converge DA and RT prices even when wind is underscheduled in DA.
    - Virtual bidding is open to any market participant.
    - There is some evidence that virtual bidders are taking advantage of price divergence caused by wind underscheduling.

Other Issues for Wind in the Energy Market

- Other Energy Market Issues
  - Balancing area coordination – geographic diversity helps to mitigate volatility of wind; however, intra-hour scheduling between balancing areas is just beginning to be tested.
  - Transmission service is still being scheduled on an hourly basis. This may be a source of inefficiency, especially in markets that are surrounded by renewable-rich regions (*e.g.,* California).

Current Practices of Ancillary Services Procurement

- Market design and quantitative analyses of Ancillary Service products, procedures and policies are complicated by several factors:
  - There is no unique mapping of Ancillary Services across all markets.
  - By design, Ancillary Services are intended to assist in maintaining system reliability.
  - Control area operators are focused on reliability metrics, which can be met with a variety of similarly defined reserves, often dictated by established historical practices.
- Depending on system characteristics, dispatch procedures, and other operating factors, some areas might procure a smaller set of Ancillary Service products than another.
  - Some Ancillary Services, like Frequency Response, have been required of all synchronized conventional generators and are not procured as stand-alone market products.

Current Practices of Ancillary Services Procurement

- Other ancillary services, like Load Following, are implicitly obtained from Real-time generation resources in organized markets and are not readily distinguished from energy or balancing.
- The significant addition of VER in markets like ERCOT and CAISO is driving the need to increase the Ancillary Services requirements as well as efforts to consider the definition of new Ancillary Services such as Ramping.
- Additional Ancillary Services needs are always considered for the entire pool of resources, rather than just for VER, *e.g.,* Regulation requirements are system wide, and not split between VER and non-VER requirements (although integration analyses often differentiate the need of the VER and load separately).

Case Study: Supply of Ancillary Services from MH to Midwest ISO using HVDC ties

In MISO, Ancillary Services may be procured from a non-synchronously connected resource (situation analogous to the request from BEMI to provide integration services to HQD from NYISO).

> *"External Asynchronous Resource (EAR) is defined as a DC tie between the synchronous Eastern Interconnection (EIC) grid and an asynchronous grid that is represented within the MISO Region through a Fixed Dynamic Interchange Schedule Import Schedule."* [1]

- Manitoba Hydro is a coordination member of MISO, bound by a Coordination Agreement and a Seams Operating Agreement.[2]
- Manitoba Hydro resources in Northern Manitoba, connected to the EIC via two bi-pole HVDC ties, qualify as EARs in the Midwest ISO markets.[3]
  - The converter stations can be dynamically scheduled every 5 minutes.
  - MISO's real-time telemetry requirements are met by MH.

1 Midwest ISO, *Energy and Operating Reserve Markets Business Practices Manual*, BPM-002-r12, Feb 2013, p. 79, 152.
2 MISO, MISO-Manitoba Hydro Coordination Agreement, Jan 2012
3 Potomac Economics, *MISO 2011 State of the Market Report, p. A-9.*

Case Study: Supply of Ancillary Services from MH to Midwest ISO using HVDC ties

- EARs can supply regulation and other reserves, and participate in the MISO real-time markets (effectively providing load following and balancing services).[1]
  - MH gets paid the market price for products cleared in the real-time and ancillary services markets.
- The total amount of ancillary services provided by EAR is limited.
  - Regulation purchases from EARs cannot exceed 20% of the Midwest ISO-wide regulation requirement. [2]
  - Currently EARs can only supply Ancillary Services when they are net energy suppliers into MISO (although there is an initiative to eliminate this condition). [3]

1 Midwest ISO, *Energy and Operating Reserve Markets Business Practices Manual*, BPM-002-r12, Feb 2013, p. 79, 152.
2 Midwest ISO, MISO Tariff MODULE C ENERGY AND OPERATING RESERVE MARKETS, Version: 1.0.0, 4/1/2011 , p. 74.
3 Midwest ISO Issue ID MSC054, created Jan 2013.

Wind Participation in Capacity Markets

- Capacity markets are employed by some RTOs to ensure resource adequacy
- North American RTOs with centralized capacity markets allow wind to participate as a capacity resource, however, nameplate wind capacities are significantly derated because wind output tends to be low during peak hours. Currently used capacity values as % of nameplate capacity.
  - PJM: For existing wind: 3-year rolling average capacity factors during peak periods in the summer;
    - Default value for new wind without operational history: 13%
  - MISO: For existing wind: based on historical capacity factors; for new wind MISO uses an ELCC probability based method to estimate system-wide credit, which is allocated pro-rata using the ‘period metric’ for each CPnode.
    - Currently system-wide 12.9%; current capacity values range from 0% to 31.8% for individual nodes.
  - NYISO: For existing wind: based on resource’s historical capacity factor
    - Current average of about 22.1%.
  - ISO-NE: based on median historical output during summer and winter peak hours and shortage events.

Selection and Compensation of Wind Integration Services Providers in the Organized Markets

- Organized markets effectively use the Regulation and Real-time Energy markets to integrate renewable energy intra-day
  - Most North American markets have co-optimized Energy and Ancillary Services markets that clear between real-time and hour-ahead – PJM, NYISO, MISO, ISO-NE, CAISO, ERCOT
  - Real-time markets usually clear every five minutes, ten minutes ahead, thereby providing load following and energy imbalance services.
  - Regulation is one of the Ancillary Services procured through formal market mechanisms in the Organized Markets
  - Resources capable of providing Regulation submit an offer to supply the service, together with an offer to supply energy in the real-time markets. The regulation offer is in $/MW for a specified amount of time (usually an hour), and the energy offer is in $/MWh. Resource constraints are included in the offer (resource max and min capacity, ramp limitations, storage efficiency for storage resources, etc.)
  - Market results include the least-cost Energy and Ancillary Services dispatch and the resulting service prices. Resources that provide Regulation (or other Ancillary Services) are paid/pay the real-time energy prices for energy supplied/absorbed while providing the Ancillary Service

Wind Energy Penetration in the Organized Markets

- In the US Organized Markets, overall wind penetration factors tend to be low, with the exception of ERCOT.

Market	Penetration Factor	Peak Load (MW)	Installed Capacity (MW)
ERCOT ISO	9.16%	66,548	9,838
IESO (Ontario)	3.27%	24,636	1,511
Midwest ISO	6.20%	98,399	12,270
New England ISO	0.93%	25,553	516
PJM ISO	1.60%	154,339	5,500

* Penetration factor calculated using energy produced

1 Penetration Factor & Peak Load from Energy Velocity Data and Analysis
2 Installed Capacity numbers come from organizational websites:
ERCOT: http://www.ercot.com/news/press_releases/show/495, Accessed March 28, 2013
IESO: http://www.ieso.ca/imoweb/media/md_supply.asp, Accessed March 28, 2013
MISO: https://www.midwestiso.org/WhatWeDo/StrategicInitiatives/Pages/GrowthofWindCapacity.aspx,, Accessed March 28, 2013
ISO-NE: http://www.iso-ne.com/trans/celt/report/index.html, Accessed March 28, 2013
PJM: http://www.pjm.com/~/media/training/core-curriculum/v-wind-ops/wind-gen-in-pjm.ashx, Accessed March 28, 2013

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Wind Integration in Jurisdictions without Organized Markets

- Transmission providers are required to offer unbundled Ancillary Services to *all* transmission customers serving load in the area[1]
- Most Balancing Areas have no provisions for VER-specific Ancillary Services yet, and do not assess costs of basic ancillary services to VER. However this area is evolving
    - In most areas, the impacts on the level of Ancillary Services needed for integrating VERs is very small, and the VER are procured to serve load under the RPS requirements (and as such the costs of ancillary services are assessed to load customers)

1 FERC Order 888.

Wind Integration in Jurisdictions Without Organized Markets

- Two large balancing areas in the Pacific Northwest have set a precedent for explicit wind integration cost assessment by specifying dedicated VER integration services in their tariffs:
  - BPA[1]
  - PSE[2]
- Another balancing area, Westar (in Southwest Power Pool), obtained FERC approval to charge for wind integration services *temporarily*, until the full SPP market is implemented (target March 2014)[3]

1 BPA, *BP-14 Initial Rate Proposal, Transmission, Ancillary and Control Area Service Rate Schedules and General Rate Schedule Provisions,* BP-14-E-BPA-10, Nov 2012.
2 *Puget Sound Energy, Inc.*, FERC Docket Nos. ER11-3735-000 and -001
3 *Westar Energy, Inc.*, Letter Order issued Mar 18, 2010, FERC Docket No. ER09-1273-000.

Rationale for Wind Integration Cost Assessment in some Jurisdictions without Organized Markets

- The areas charging explicitly for wind integration have overlapping concerns that are not shared by the organized markets or other entities:
  - High Penetration Levels of Wind[1] :
    - BPA: 19% wind energy penetration[2]
      - "The increase in variable generation interconnecting to BPA's transmission system is imposing costs and operating constraints associated with within-hour balancing services that necessitate setting a Wind Balancing Service rate in this proceeding to recover these costs. The existence of these costs is supported by substantial evidence in the record."[3]
    - PSE: 10% wind energy penetration[4]
    - Idaho Power: 2.26% wind energy penetration[5]
  - Limited ability in the rest of the generation fleet in the area to provide cost-effective integration service.
  - Reallocation of wind integration costs from power customers to wind generators:
    - Assess integration costs to exports (*e.g.,* BPA, Idaho Power).
    - Enable competition in the supply of integration services (*e.g.,* NWE).

1 Penetration factor calculated using energy produced
2 EV Data
3 BPA, 2010 Whole Power and Transmission Rate Adjustment Proceeding (BPA-10) Administrator's Final Record of Decision, July 2009. p.247
4 PSE, http://pse.com/aboutpse/EnergySupply/Pages/Wind-Power.aspx, Accessed March 25, 2012
5 Idaho Power, http://www.idahopower.com/aboutus/companyinformation/facts/, Accessed March 25, 2012

Challenges to BPA in VER Integration

- BPA has challenges with VER integration similar to other areas with high wind penetration.[1]
- BPA faces unique challenges due to:[1]
  - Majority of wind produced in BPA is exported to serve load in other Balancing Areas
  - BPA's load of between 5,000 and 7,000 MW is served mostly by the hydro and nuclear facilities in the area
  - In the first half of 2012 the average load was 6,394 MW, the average hydro output was 10,888 MW and the wind average output was 1,322 MW
  - Wind installed capacity in area was 4,711 MW as of May 2012
  - BPA hydro facilities are under additional restrictions due to flood control, fish protection, and other non-power requirements

1 *BPA, Summary of the Upcoming BPA Wind Integration Team Work Plan 2.0, November 2010*

Case Study: VER Integration in BPA

BPA's Integration Rates and Services

"As increasing amounts of wind generation have integrated into BPA's transmission system, the variability and uncertainty of wind generation have led to increased costs through the need for additional reserve capacity, the shift of energy generation from heavy load hours to light load hours, and reduced system efficiency. The proposed Wind Integration − Within-Hour Balancing Service rate will ensure that these costs are borne by the parties that cause the costs"[1]

- BPA offers three unbundled, separately priced intra-hour *Basic VER integration services*: Regulation, (*Load*) Following, and Imbalance.[2]
  - The proposed rates for the 2014-2015 Rate Case are:
    - Regulation costs $0.08/kW-month per kW of installed wind capacity.
    - Following costs $0.36/kW-month per kW of installed wind capacity.
    - Imbalance integration services costs $0.70/kW-month.
      - A 44% discount is provided to VER that update their schedule every 30 minutes ($0.39/kw-month).
      - If a VER cannot commit to schedule either 30 or 60 minute ahead, the rate is increased to $0.95/kW-month.

1 *BPA, Testimony of Elliot E. Manzier et al. on Overview of Wind Integration – Within-Hour Balancing Service Rate Proposal,* WI-09-BPA-01, p. 2.
2 *BPA, BP-14 Initial Rate Proposal, Transmission, Ancillary and Control Area Service Rate Schedules and General Rate Schedule Provisions,* BP-14-E-BPA-10, Nov 2012.

BPA's Integration Rates and Services

- In addition, VER can contract for *Full* service, to significantly lower the possibility of being curtailed by purchasing additional reserves.[1]
  - *Full* service subscribers have higher dispatch priority that *Basic* service subscribers in situations when *dec* reserves are near depletion and require curtailments.
- BPA does not provide longer-term energy storage (one hour or more) to firm VER output as part of the VER integration services[2]

1 BPA, *BP-14 Initial Rate Proposal, Transmission, Ancillary and Control Area Service Rate Schedules and General Rate Schedule Provisions,* BP-14-E-BPA-10, Nov 2012.
2 BPA, *Testimony of M. A. Jackson et al. on ANCILLARY AND CONTROL AREA SERVICE RATE DESIGN,* BP-14-E-BPA-28, p. 11.

BPA's Methodology for Integration Rates

- BPA first calculates the total costs of providing integration services in the rate period.[1]
  - Embedded Costs: Revenue requirements of the generators providing balancing services.
  - Direct Assignment Costs: Costs incurred by BPA for specific wind projects. In the 2012 rate case the projects were the Wind Integration Team and the *Dec* Acquisition Pilot program.
  - Variable Costs: Costs associated with holding sufficient capacity ready to meet balancing requirements. These costs include the Stand Ready and Deployment Costs.
- Total costs are then divided by the average installed capacity of wind for the rate period. For the imbalance component the divisor is set to the average installed capacity of wind minus the expected installed capacity to self-supply this service.[1]
- Wind integration service rates are assessed on all wind generators in the BPA service area that choose not to self-supply these services.[2]

1 *BPA, 2012 Final Rate Proposal, Generation Inputs Study, July 2011*
2 *BPA, Testimony of Elliot E. Manzier et al. on Overview of Wind Integration – Within-Hour Balancing Service Rate Proposal,* WI-09-BPA-01

BPA's Historical Integration Rates

Year	Schedule Updating Commitment	Rate ($/kW-month)
2009	-	$0.68
2010-2011	-	$1.29
2012-2013	-	$1.23
2014-2015 (Proposed)	Not Committed	$1.39
	60 min	$1.14
	30 min	$0.83

Sources: 1,2,3,4

- There was a substantial increase in the wind integration rate between the 2009 settlement rate and the 2010 rate case due to increased understanding of wind integration costs and additional time to develop appropriate charges.[2]
- The proposal for the 2014 rate case will increase integration charges for wind generators that do not commit to updating their generation schedules every 60 minutes or less, but lowers the cost for generators with this scheduling commitment.

1 *BPA, 2009 Wind Integration Rate Case Final Proposal, Final Record of Decision, June 2008*
2 *BPA, 2010 Wholesale Power and Transmission Rate Adjustment Proceeding (BPA-10) Administrator's Final Record of Decision, Appendix C, July 2009*
3 *BPA, 2012 Final Rate Proposal, Generation Inputs Study, July 2011*
4 BPA, *BP-14 Initial Rate Proposal, Transmission, Ancillary and Control Area Service Rate Schedules and General Rate Schedule Provisions,* BP-14-E-BPA-10, Nov 2012

BPA's Integration Initiatives

- As part of the settlement for VER Integration rates, BPA has implemented six programs to help wind integration in its footprint.[1]
  - Intra-Hour Scheduling – as required for compliance with FERC 764
  - Dynamic Transfer Limits – working to identify available dynamic transfer capability (DTC), determine what hardware and software capabilities need to be added to increase DTC, and working with wind generators to allocate available quantities.
  - Wind Power Forecasting – BPA purchased services from 2 wind forecast vendors to help wind generators provide more accurate forecasting.
  - Customer Supplied Generation Imbalance – Iberdrola Pilot
  - Third-Party Supply – this initiative was created for BPA to seek information on possible sources for *decremental* imbalance reserves. The project was put on hold in 2011.
- As of Nov 2012, BPA provides all the VER integration services using its own generation resources[3]
  - The responses to a BPA RFP in 2008 for the purchase of reserves from non-BPA resources, as well as a 2010 3-month third-party supply concept with Calpine[2] indicated costs five to six higher than the cost of the reserve capacity supplied by the BPA system.[3]

1 *BPA Wind Integration Initiatives, http://www.bpa.gov/Projects/Initiatives/Wind/Pages/Wind-Integration-Initiatives.aspx , accessed March 2013.*
2 *BPA, Summary of the Upcoming BPA Wind Integration Team Work Plan 2.0, November 2010*
3 *BPA, Testimony of D. H. Fischer et al. on GENERATION INPUTS POLICY,* BP-14-E-BPA-21, p. 42.

Case Study: VER Integration in BPA

BPA's Self-Supply Pilot

- BPA and Iberdrola have created a pilot program for self-supplying the Generation Imbalance as an Ancillary Services
- This program was created to both:
  - Increase the current cost-effectiveness of ancillary services
  - Plan for future increased wind penetration levels such that the Federal Columbia River Power System does not have sufficient capacity for firming.
- Iberdrola procures balancing capacity from:
  - Their own natural gas plants, Klamath Cogeneration and Klamath Natural Gas peaking units
  - Contract with TransAlta
  - Contract with Grant County Public Utility District (separate Balancing Authority)

Sources: 1 Iberdrola Renewables Press Release, Pilot Project seeks to put more clean energy on the grid: Thanks to Iberdrola Renewables, BPA, and Constellation Energy collaboration, September 22, 2010. 2 BPA, Generation Imbalance Self Supply Pilot, July 29, 2009.

PSE VER Integration Rates

- PSE offers a single VER integration service (Schedule 13: Regulation and Frequency Response Service for Generators Selling Outside of Control Area)[1]
  - This service effectively aggregates regulation, load following and balancing functions, but is titled as "Regulation and Frequency Response")
- The charge for the Schedule 13 service for VER agreed by all stakeholders in a Settlement filed with FERC is $1.55/kW-month (where kW refers to installed VER capacity used for export)[1]
  - A 30% discount is provided to VER that update their schedule every 30 minutes
  - A 50% discount is provided to VER that update their schedule every 15 minutes
- Self-supplying of integration services is explicitly allowed

1 *Puget Sound Energy, Inc.*, FERC Docket Nos. ER11-3735-000 and -001.

Service Costs Methodology and Rationale

- A previous rate proposal to set a capacity charge of $12.39/kW-month of regulation capacity used by exporting wind generators and require exporting wind generators to purchase 16.77% of the generator's transmission reservation was dropped with the Settlement (Note that the kW here refers to regulation capacity, rather than VER capacity)[1]
- The methodology for the initial proposed regulation requirement was calculated based on portfolio-wide analysis assuming hourly scheduling, and the initial proposed cost was obtained using an average of the $/kW-year cost of the pool of resources providing regulation, but the final negotiated rate was a settlement.[1]
  - The pool of regulation resources includes eight generating units that are employed on a regular basis to provide regulation capacity.
  - The annual weighted average cost of each unit is calculated by dividing the capacity of that resource by the total capacity of the pool and multiplying by the cost ($/kW-year) for that unit. PSE then adds all the units costs together and divides by 12 which yields a monthly charge.

1 *Puget Sound Energy, Inc.*, Order issued Oct 20, 2011, FERC Docket No. ER11-3735-000.

Service Costs Methodology and Rationale

- PSE Rationale for introducing VER-specific charges via Schedule 13[1]
  - Significant development of wind resources in its balancing area.
  - Need to maintain additional regulation reserves, more than the 2% of capacity previously required under Schedule 13 for controllable generation
  - Significant costs of regulation reserves in the area (changes in hydro operations and introduction of thermal units in the regulation resource pool).

1 *Puget Sound Energy, Inc.*, Order issued Oct 20, 2011, FERC Docket No. ER11-3735-000.

VER Integration Service Costs in Westar

- Westar Energy, Inc. is a utility located in Kansas, and a member of the Southwest Power Pool (SPP).
- SPP currently operates a real-time Imbalance Market, but some ancillary services, such as regulation service, are provided by each of the balancing authorities that constitute SPP
- A full SPP market implementation has a target date of March 2014. It will include day-ahead commitment and ancillary services markets. All balancing authorities in SPP will be consolidated in a single SPP BA.
- Westar obtained FERC approval to charge for wind integration services *temporarily*, until the full SPP market is implemented.[1]

1 *Westar Energy, Inc.*, Letter Order issued Mar 18, 2010, FERC Docket No. ER09-1273-000.

Case Study: VER Integration in Westar
Service Costs Methodology

- Westar provides Balancing Area Services under Schedule 3A of its tariff (Generator Regulation and Frequency Response Service), and charges $4.44/kW-month per kW of regulation capacity. Wind exports out of the Westar BA or sales to the SPP Imbalance Market are required to buy or self-supply 3.32% of the installed wind capacity in regulation.[1,2]
- The Methodology used by Westar calculates the total regulation requirement for the BA, allocates the requirement to different sources of regulation service need, and estimates the total costs of providing regulation service.
- The total regulation service requirement calculation aggregates the 10-minute schedule deviations in the BA for all sources of such deviations, and obtains the regulation capacity needed to cover those deviations 95% of the time[2] assuming that the deviations follow a Gaussian pdf.

1 *Westar Energy, Inc.*, OATT FERC Electric Tariff, Third Revised Vol. No. 5.
2 *Westar Energy, Inc.*, Informational Filing, OATT, Schedule 3A, Mar 14, 2013, FERC Docket No. ER09-1273-000

Case Study: VER Integration in Westar
Service Costs Methodology

- To allocate regulation needs, the regulation capacity needed to meet the regulation standards 95% of the time is calculated for each source of deviations, separately. The requirement for each individual source is scaled to reflect its share of the total requirement.[1]
- The regulation percentage purchase obligation for wind is its allocation of regulation requirement divided by the wind nameplate capacity.[1]
- The regulation cost represents the fixed costs associated with the generation units Westar is likely to use to provide Regulation Service.[2]

1 *Westar Energy, Inc.*, Informational Filing, OATT, Schedule 3A, Mar 14, 2013, FERC Docket No. ER09-1273-000.
2 *Westar Energy, Inc.*, Direct Testimony of D. L. Reed, June 3, 2009, page 16, FERC Docket No. ER09-1273-000.

Case Study: VER Integration in NorthWestern Energy

- As of January 2013, NorthWestern Energy (NWE) has a wind-specific integration service. The fee depends on the wind facilities' distance to the 135 MW Judith Gap Wind Farm and the term length of the contract. Wind generators can choose to self-supply these services to avoid the NWE fee.[1]
  - The Montana Public Service Commission approved the Schedule WI-1

	Distance from Judith Gap	Short Term ($/kW/Month)	Long Term ($/kW/Month)
Zone 1	**< 25 Miles**	1.09	1.58
Zone 2	**> 25, < 60 Miles**	0.40	0.58
Zone 3	**> 60 Miles**	0.15	0.21

  - The fees based on a wind plants distance from Judith Gap are due to the geographic diversity of wind. A plant closer to Judith Gap is more likely to need integration services at exactly the same time as Judith Gap, making the services more costly.

1 *NorthWestern Energy Electric Tariff., Schedule No. WI-1, Docket No.: D2012.1.3, Order No. 7199d, Tariff Letter No. 235-E*

Case Study: VER Integration in NorthWestern Energy

- Zonal fees were established by Montana Public Service Commission Order No. 7199d.[1]
- Prior to 2011, balancing was partly supplied by contracts with Powerex, Avista and Grant County Public Utility District.[2]
- NWE developed DGGS to secure cost-effective long-term balancing services, which were not otherwise available.[3]

1 *NorthWestern Energy Docket No. D2012.1.3, Order No. 7199d*
2 *NorthWestern Energy, Inc.*, Rebuttal Testimony of R. D. Tabors, June 12, 2012, FERC Docket No. ER10-1273-000.
3 *NorthWestern Energy, Inc.*, Revisions to Schedule 3, Regulation and Frequency Response, of NEW's OATT, April 29, 2010, FERC Docket No. ER10-1273-000.

Case Study: VER Integration in Idaho Power

- Idaho Power completed a wind integration study in 2007 that found the costs of integrating ~500 MW of wind were $7.92/MWh.[1]
  - Currently, Idaho Power has 638 MW of wind capacity online its territory, with another 40 MW under contract.[2]
- Small wind generation projects (<100 kW) that sell power to Idaho Power are paid the published Avoided Cost Rates, which are determined by the Idaho Public Utilities Commission (IPUC). A settlement of rates by the IPUC set wind integration charges to be a percentage (7%-9%) of the avoided cost rates, capped at $6.50/MWh.[2]
- Large wind generation projects negotiate their own PPA with Idaho Power.[2] Presumably, they are also assessed similar wind integration charges.[3]

1 *Idaho Power, Report Addendum: operational Impacts of Integrating Wind Generation into Idaho Power's Existing Resource Portfolio. October 2007*
2 *Public Utilities Commission of Idaho, Order Number 30488, February 20, 2008. p.8.*
3 *Idaho Power, Wind Integration and Forecasting, October 4, 2012*

Case Study: VER Integration in Idaho Power

- Since Idaho does not have an RPS, wind developed in Idaho can be interpreted as an export of RECs to jurisdictions that do have an RPS. As such, wind integration fees are effectively assessed on "wind power exports"
- In 2012, Idaho Power completed a second wind integration study that showed:[1]
  - Integration costs and wind curtailment increase rapid after ~800 MW of installed capacity.
  - If rates cannot be increased for wind farms currently paying $6.50, the incremental cost to new wind farms becomes much higher.

Installed Capacity (MW)	Average ($/MWh)	Incremental ($/MWh)
800	8.06	10.65
1,000	13.06	33.42
1,200	19.01	49.46

1 *Idaho Power, Wind Integration and Forecasting, October 4, 2012*

NaturEner's Own Integration Methodology

- NaturEner Power Watch, LLC is the first Wind-only Balancing Area in North America, scheduling 210 MW of wind capacity.[1]
  - Constellation Energy Control and Dispatch runs the balancing operation.[2]
  - San Diego Gas & Electric has a PPA with NaturEner for Glacier Wind 1 and 2.[3,4]
- Grant County Public Utility District (GCPUD) provides regulation services to the Balancing Area.[2]
  - When only Glacier Wind I was online (106 MW), the contract provided the ability for use of up to 24 MW from GCPUD to provide regulation services at any time.

1 *PowerWatch, Operating A Wind Farm as a Balancing Authority, OSIsoft Users Conference 2012*
2 *NERC, NERC Balancing Authority (BA) Certification of Naturener Glacier Wind Energy 1 (GWA) Operated by Constellation Energy Control and Dispatch (CECD), September 3-5 2008*
3 *California Public Utilities Commission, Master Power Purchase And Sale Agreement, May 2008*
4 *Sand Diego Gas and Electric, Request For Approval of First Amendment to the Power Purchase and Sale Agreement With NaturEner Glacier Wind Energy 2, LLC, June 2009*

Summary of Intra-hour Wind Integration Rates

	MW Installed Capacity	Published Capacity Factor	Published Rate ($/kW-month)	Rate in $/MWh (for published capacity factor)	Rate in $/MWh (reference capacity factor of 35%)
BPA	4711	32%	$1.23	$5.27	$4.81
PSE	430	30%	$1.55	$7.08	$6.07
Westar*	614	40%	$4.44	$0.50	$0.58
NorthWestern**	141	40%	$0.67	$2.29	$2.62
Idaho Power	678	27%	*Rate in $/MWh*	$6.50	$5.01

* Rates for Westar are for regulation only, while for the four other utilities the rate includes following and imbalance services.

** Rates for NorthWestern Energy represent an average the rates for all zones and contract durations.

1 Installed Capacity:

BPA, Wind Generation Capacity in the BPA Balancing Authority Area, May 2012.
PSE, IRP 2011 Appendix G, 2011.
Westar, http://www.westarenergy.com/renewables, Accessed March 28th, 2013.
NorthWestern,
Idaho Power, 2012 Wind Integration Study, February 2013.

2 Capacity Factors:

BPA, BPA Overgeneration Analysis, 2012.
PSE, IRP 2011 Appendix G, 2011.
Westar, http://www.kansasenergy.org/documents/Kansas_wind_capacity_Factors_122012.pdf, Accessed March 28th, 2013.
NorthWestern, 2009 Electric Supply Resource Planning and Procurement Plan Document, Volume 3, Chapter 3.
Idaho Power, 2012 Wind Integration Study, February 2013.