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Western Interconnection Energy Imbalance Market Status and Prospects

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UWIG Market Operations and Transmission Policy Users Group

Michael Milligan (NREL)
Brendan Kirby and
Jack King (NREL consultants),
Steve Beuning (Xcel)

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Contents

- Introduction to the Western Energy Imbalance Market (EIM);
- Evaluation status;
- Method;
- Analysis overview of results;
- Appendix:
  - Study Data;
  - Sub-regional results,
- (Brendan Kirby will discuss allocation on Thursday).

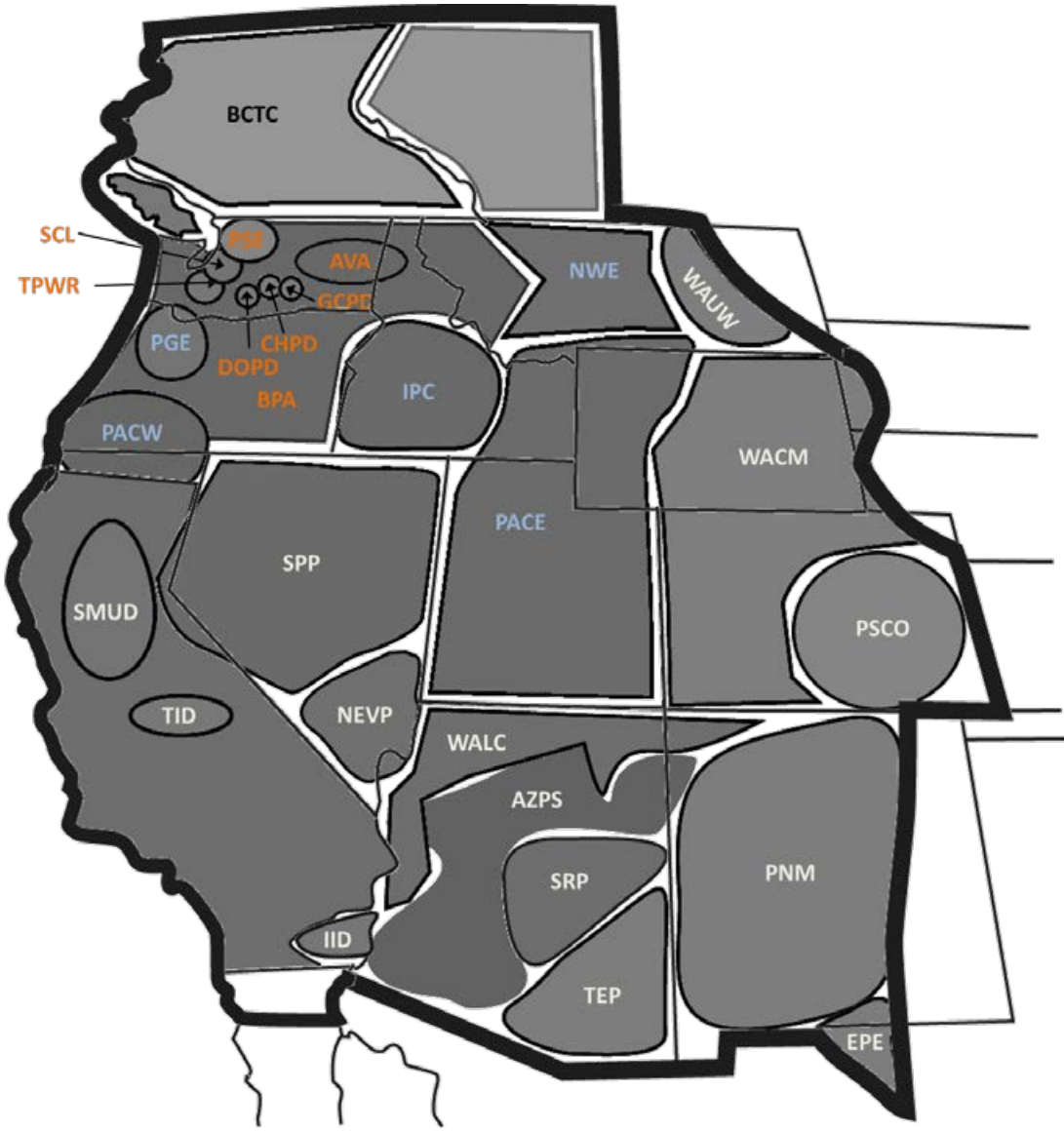
This presentation is based on

NREL Variability Analysis for the Western Interconnect, Webinar by NREL for WECC, July 29, 2011. Available at www.nrel.gov/publications

King, Kirby, Milligan, Beuning, "Operating Reserve Implication of Alternative Implementations of an Energy Imbalance Service on Wind Integration in the Western Interconnection, NREL Technical Report NREL/TP-5500-52330, in press. Available at www.nrel.gov/publications

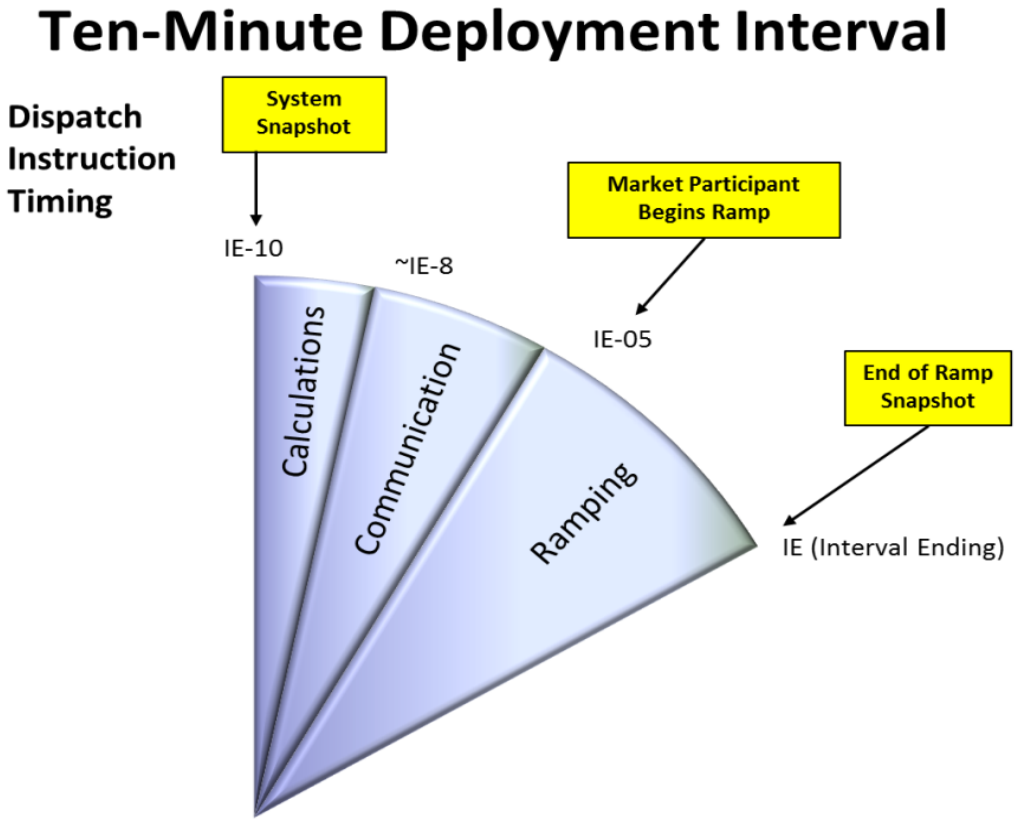
What Footprint Would the EIM Cover?

- Potentially, the entire Western Interconnect, absent CAISO and AESO;
- Individual balancing area (BA) decision to join;
- Full footprint or sub-regional implementations possible (or others).



What is the Energy Imbalance Market (EIM)?

- 5-minute energy imbalances settled across participants in Western Interconnection;
- Dispatch only (no coordination on commitment);
- Modeled after SPP's energy market.



Operational Overview

time →

Schedule Day-Ahead & Up-to 30 minutes prior to Operating Hour

Market Participant:

- ✓Forecast and unit Commit
- ✓Generators self-schedule
- ✓Generators voluntary submit offers
- ✓DSM resources voluntary submit offers
- ✓Prepare and finalize pre-dispatch schedules

Real-time Dispatch

WECC EIS Market Operator:

- ✓Perform security-constrained economic dispatch to keep balance
- ✓Provide re-dispatch if any congestion occurs
- ✓Send dispatch setpoints to generators
- ✓Coordinate any contingency reserve deployments with EIS dispatch

Post-Operating

WECC EIS Market Operator:

- ✓Gather meter data to support settlements
- ✓Provide settlement statement and invoices

Transmission Provider:

- ✓Provide meter data to support settlements

Who Would Operate the Market?

- Unclear;
- Possibly WECC[1];
- Many discussions are ongoing;
- Functional specifications for the market are now under development;
- Unclear whether software would be developed from scratch or adapted from other similar markets (SPP, CAISO with modifications, MISO, PJM, ???).

[1] We differentiate WECC – Western Electricity Coordinating Council, (WECC) an institution, from the Western Interconnection, which is a physical electrical footprint.

Cost-benefit Study

- Key costs are:
  - Implementation;
  - Ongoing market operations;
  - Difficult to define without knowing whether develop from scratch or purchase/modify existing system.
- Benefits:
  - Reduction in operating cost:
    - More economic dispatch;
    - Reduced reserve deployment for:
      - Regulation;
      - Short-term load following (spin);
      - Load following (non-spin and supplemental).

Benefit Study

- Carried out by WECC's consultant E3;
- Gridview production simulations with/without the EIM;
- NREL-provided reserve deployment:
  - With EIM;
  - Without EIM,
- Modeling challenges:
  - Production simulation of business-as-usual is difficult, if not impossible (given data availability) in the WI.

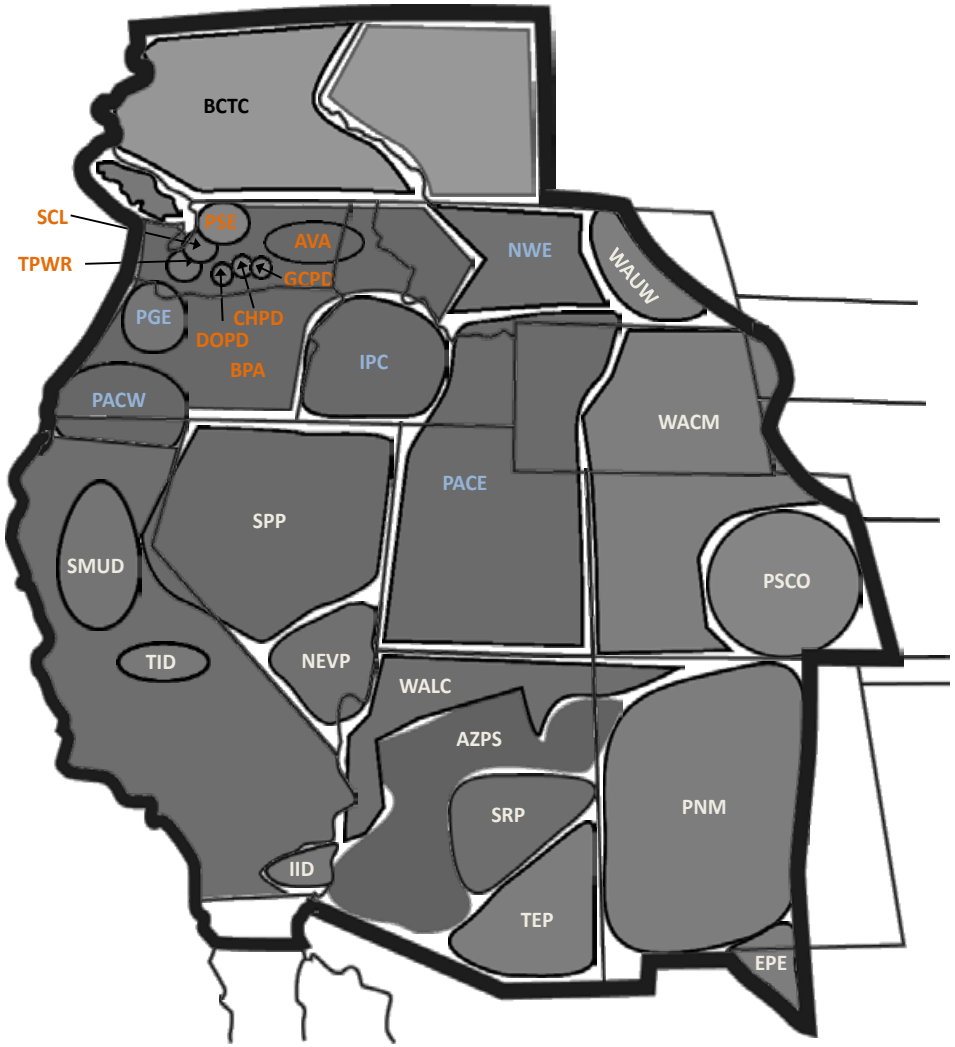
Prospects

- Unclear;
- E3 study evaluated only system-wide benefits;
- Individual BA's decide whether to participate (and generators can decline within the BA);
- Individual BA analysis is underway;
- Timeline for final decision is unclear.

Reserve deployment implications

Model Area

- Based on TEPPC PC 0;
- Areas of the WI not already in a market structure (CAISO, Alberta);
- LADWP not included;
- Analysis at BAA granularity;
- Generation only BAAs not considered;
- 28 load and generation BAAs retained – The study 'Footprint';
- Regions are:
  - Columbia Grid – Orange;
  - NTTG – Blue;
  - West Connect – White.



Reserve Calculations

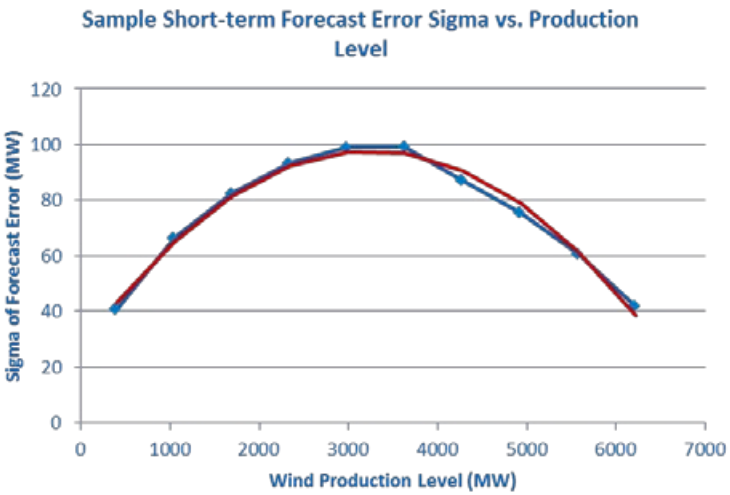
Reserve Calculations

- Method developed for the EWITS study*;
- Statistical approach based on 10-minute time series wind, solar and load;
- Method that can estimate adequate reserves to cover the short term and hour-ahead forecast error based on historical data;
- Predicts requirements based on current hour load and wind, solar production;
- Statistically combine with load regulation requirements;
- Provide 8760 vector of requirements for the production simulations.

*For in-depth discussion, see section 5 of the EWITS final report: http://www.nrel.gov/wind/systemsintegration/pdfs/2010/ewits_final_report.pdf

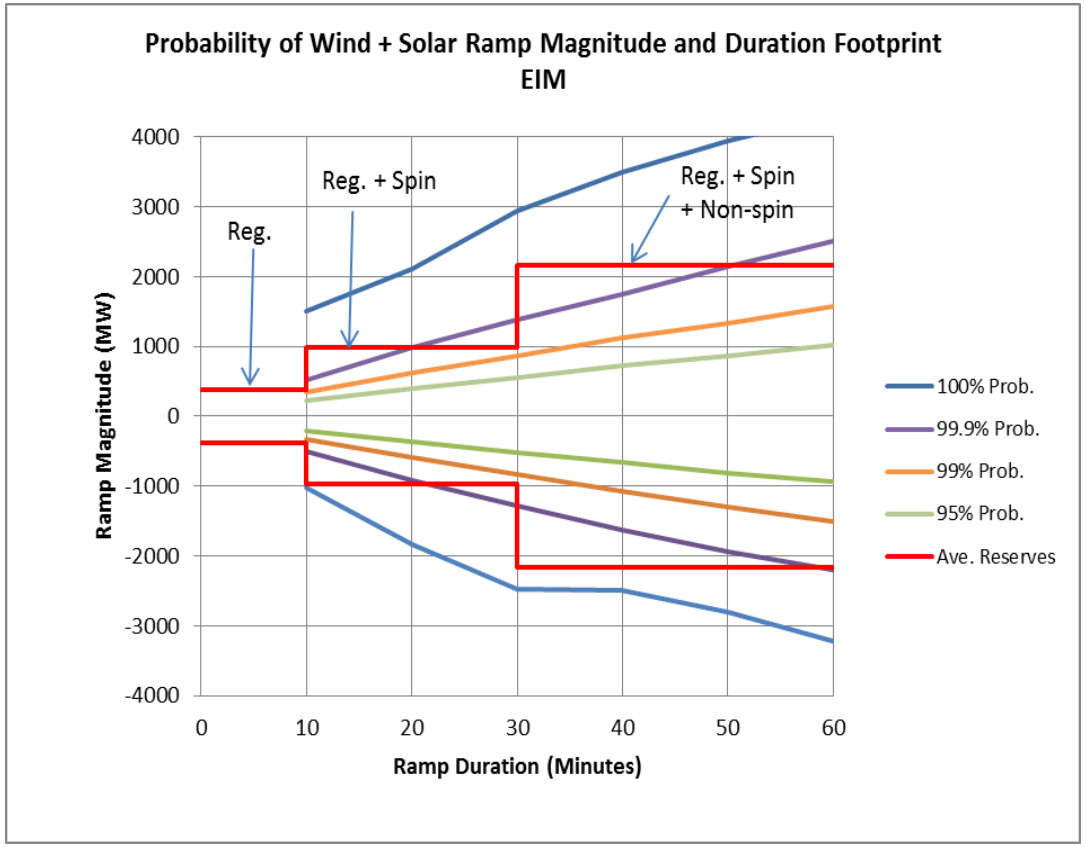
Reserve Definitions

- Regulation – Fast changes:
  - Due to variability and short term forecast errors;
  - Faster than re-dispatch period;
  - AGC resources required.
- Spinning – larger, less frequent variations:
  - Due to longer term forecast errors;
  - AGC not required;
  - 10-minute response.
- Non-spinning/supplemental:
  - Large, infrequent, slow moving events such as unforecasted ramps.
  - 30-minute response.



Verification of Reserve Coverage

- Shows coverage of VG intra-hour movements;
- Actual ramp data from footprint EIM;
- Red line – Actual average reserve calcs from footprint EIM;
- Probability lines are z% of all ramps at x minutes are less than y MW.



Reserves Provided to E3 for Phase 2 Study

- NREL provided reserve calculations to E3 for phase 2 study;
- Slight variation in calculation of regulation component – load not included in E3 Flex;
- Does not include contingency reserves;
- Areas are slightly different from each other.

NREL	E3	Response	Notes
Regulation	Flex	AGC	E3 flex reserve does not contain load
Spin	Spin	<10 minutes	
Non-spin	Supplemental	<30 minutes	Terminology change

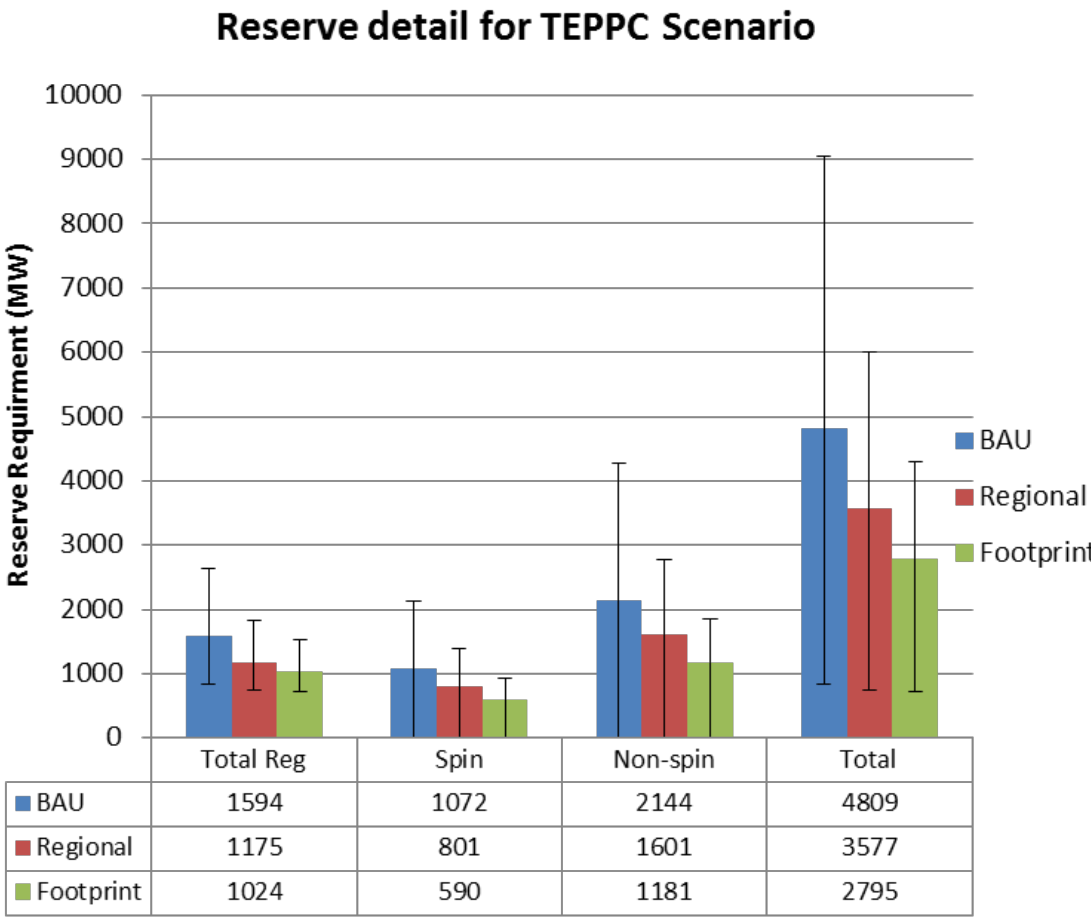
Analysis

Cases

- Complete analysis includes:
  - Footprint EIM
    - All 28 BAAs participating.
  - ‘Regional’ EIM implementations
    - Columbia Grid;
    - Northern Tier Transmission Group;
    - WestConnect.
  - EIM implementations without BPA and/or WAPA participation.
  - Comparison to the Business As Usual (BAU) case – No EIM in place.
  - Selected results.

Reserve Details for Footprint and Regional EIM

- **Up to 42% (2000 MW) reduction in total reserve requirement for footprint EIM;**
- **26% for regional EIMs.**

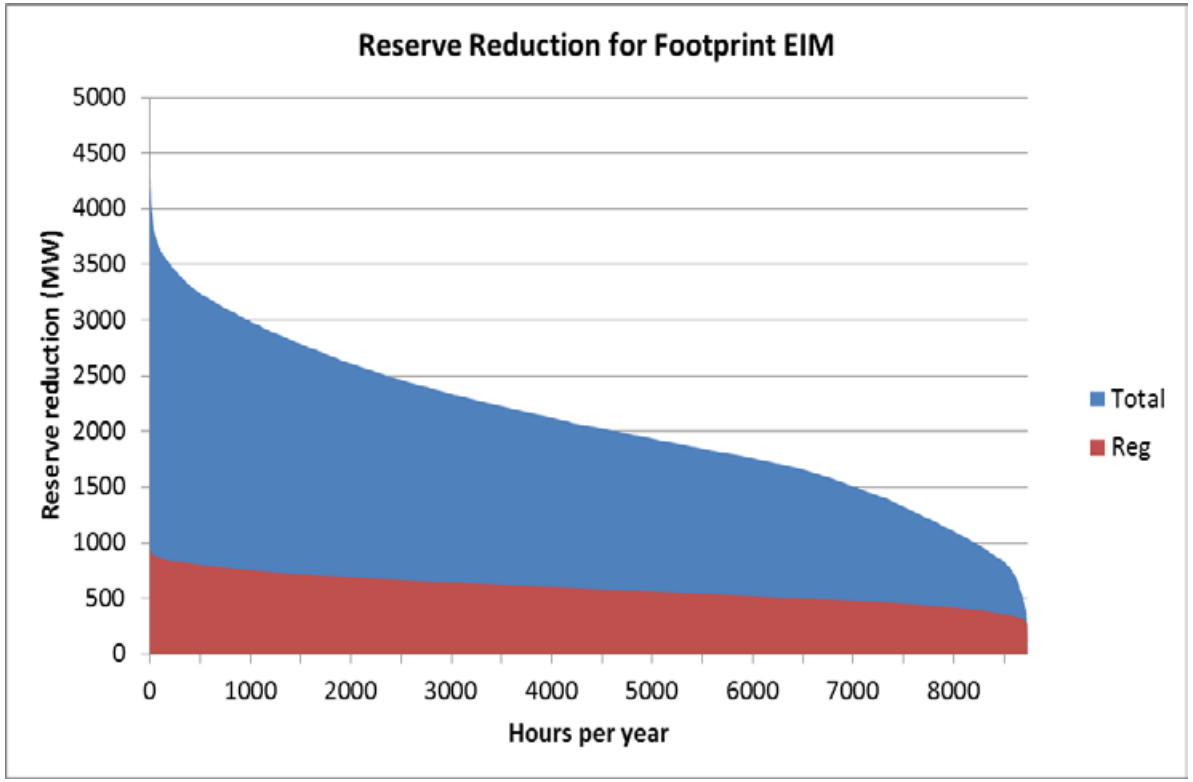


Reduction over BAU

	Footprint		Regional	
	MW	% Reduct.	MW	% Reduct.
Total Reg	570	36%	419	26%
Spin	481	45%	271	25%
Non-spin	963	45%	542	25%
Total	2014	42%	1233	26%

Reserve Reduction Duration – Footprint EIM

- Average reductions:
  - 590-MW Regulation
  - 2092-MW Total Reserves

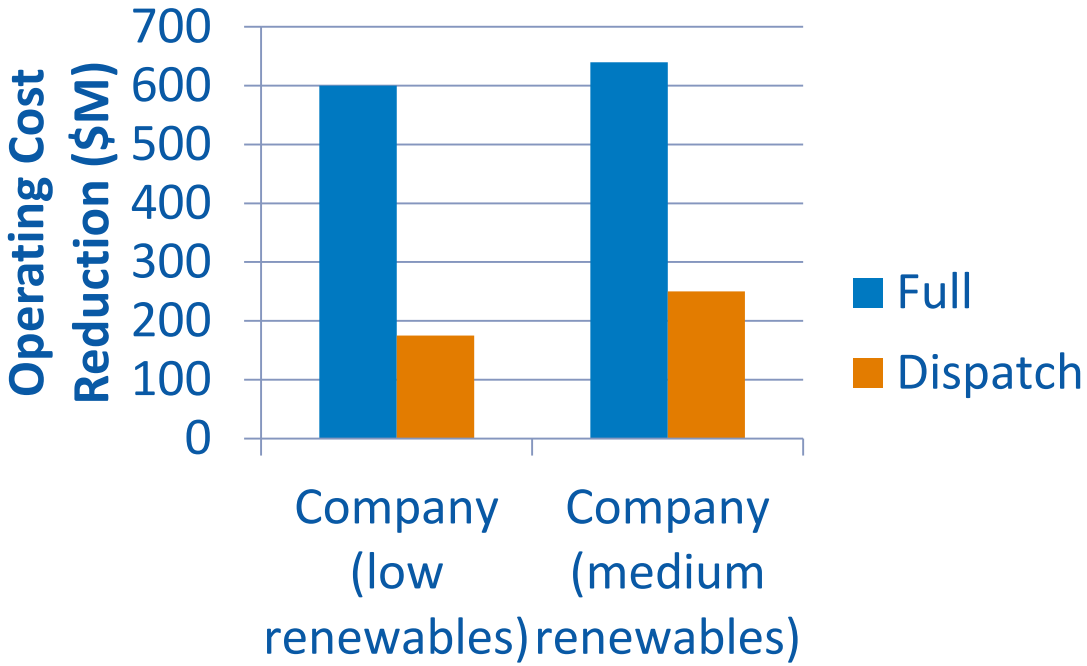


E3 Gridview Analysis

- http://www.wecc.biz/committees/BOD/EDTSC/EDTTRS/EDTTRS%20Meeting06142011/default.aspx?InstanceID=1;
- Found $175M annual operational savings;
- Approximately $101M from reduced reserve deployment;
- Individual utilities/BAs are undertaking their own analyses to localize benefits;
- NREL assistance for some areas with funding from OE.

EIM Benefit Depends On…

- Penetration of wind/solar;
- Level of participation, including market scope;
- Method, including the difficulties in accurately modeling today's case;
- WECC/E3 is a "point" analysis with no apparent recognition of this;
- Example: Lew, Milligan, Jordan, Piwko, Kirby, King, Beuning: "An Analysis of the Impact of Balancing Area Cooperation on the Operation of the Western Interconnection with Wind and Solar Generation."



www.nrel.gov/docs/fy11osti/51546.pdf

Conclusions

- Method for calculating additional reserve requirements due to wind and solar production;
- EIM results in substantial reduction in reserves requirements and ramping demand;
- Reduced participation reduces benefits for all but reduces the benefits to non-participants the most;
- Full participation leads to maximum benefit across the Western Interconnection, up to 42% of total reserve requirement;
- Regional EIM implementations have smaller but substantial benefits.

More Information

- http://www.wecc.biz/committees/BOD/EDTSC/EDTTRS/EDTTRS%20Meeting06142011/Lists/Presentations/1/E3_Phase2_Methodology_and_Benchmark_EDTTRS_Update_2011-06-14am_update.pdf (hint: open the WECC calendar, move to June 14, 2011, and find the EDTTRS meetings.
- www.nrel.gov/publications - several reports by Milligan, King, Kirby, Beuning

Appendix

Load Data

- 2020 loads provided by WECC;
- Load shape is based on 2006 load;
- 193,700 MW in full Western Interconnect (non-coincident;)
- 116,700 MW in analysis footprint (non-coincident);
- One hour load provided, 10-minute synthesized.

Wind Data

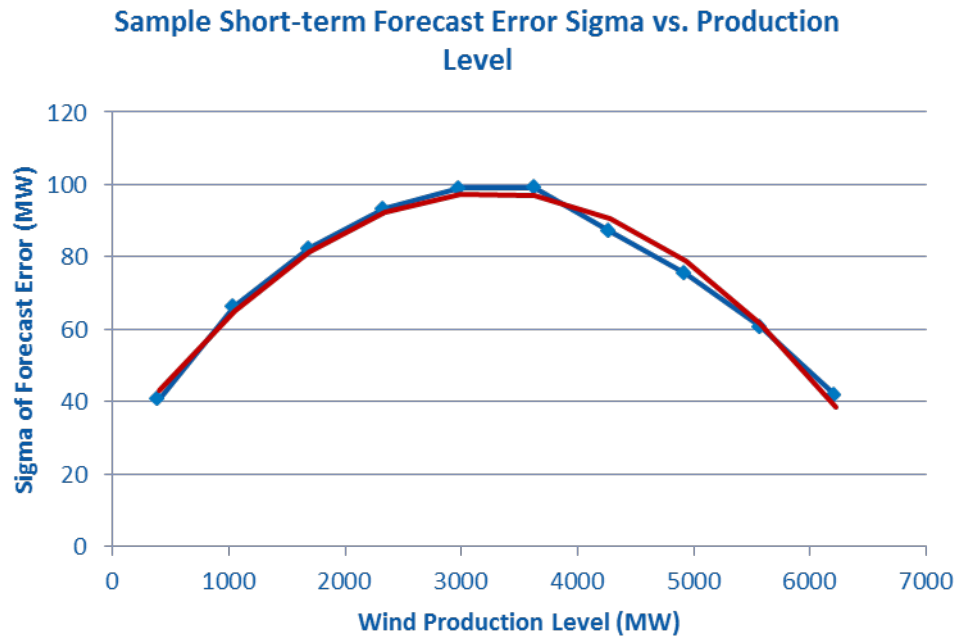
- NREL WWSIS wind dataset for 2006
- 10 Minute resolution
- Sites identified by TEPPC 2020 PC 0
- 29,085 MW in Western Interconnect
- Approximately 8% of WI 2020 load
- 18,272 MW nameplate modeled in analysis footprint

Solar Data

- NREL WECC Solar dataset for 2006
- 10-minute resolution;
- Sites identified by TEPPC 2020 PC 0;
- 14,300 MW in WI;
- Approximately 3% of WI 2020 load;
- 4,568-MW nameplate capacity in analysis footprint.

Calculation of Short-term Forecast Error

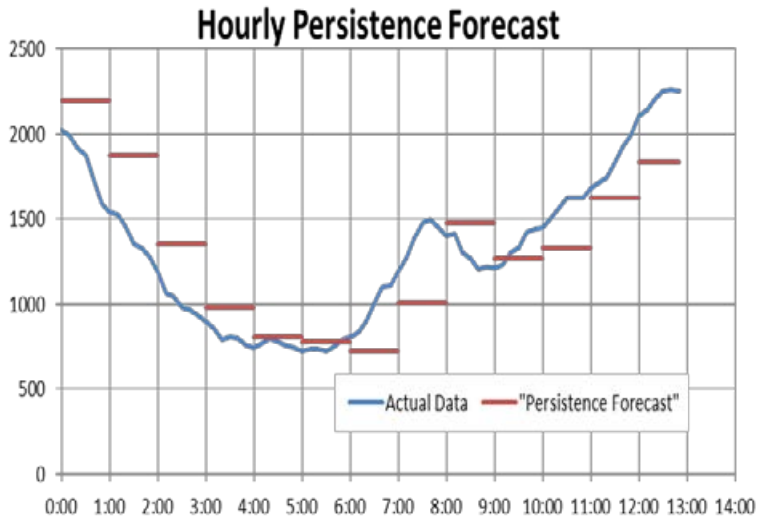
- Calculate and sort error by production level;
- Divide production into deciles;
- Calculate error sigma in each decile;
- Blue line is calculated from data;
- Red line is curve-fit;
- Equation of the curve shown below.

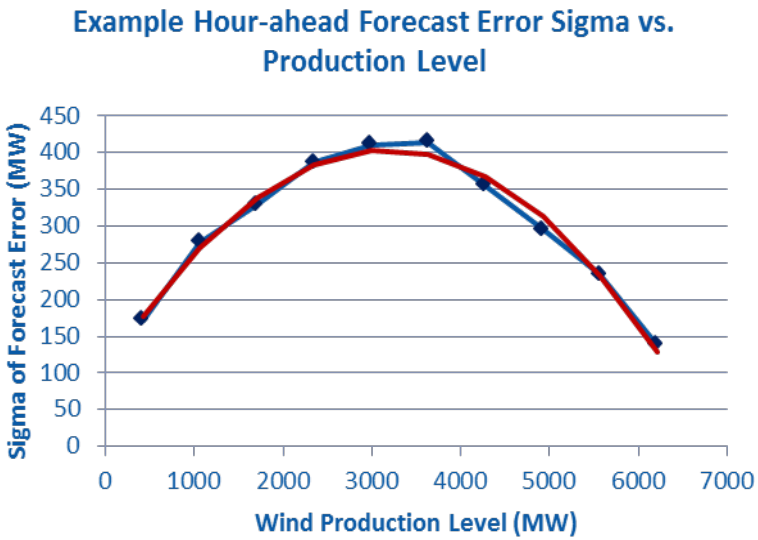


$$\sigma_{ST}\,(Hourly\ Wind) = -6.72E-06 \cdot (Hourly\ Wind)^2 + 0.0437 \cdot (Hourly\ Wind) + 26.74$$

Hour-ahead Forecast Errors

- Repeat the short-term forecast procedure with hour-ahead forecasting;
- Again, same procedure for wind and solar;
- Load following not included.





$$\sigma_{Hour-ahead}(Hourly\ Wind) = -2.985E-05 \cdot (Hourly\ Wind)^2 + 0.1895 \cdot (Hourly\ Wind) + 103.2$$

Spin and Non-spin Calculation

- One sigma allocated to **Spinning** category

  $Spinning\ Requirement\ (Hour - ahead\ wind\ forecast\ error)$

  $1 \cdot \sigma_{hour-ahead}(Previous\ Hour\ Wind)$

  – Covers 68%* of all movements less than 1 hour

  – With regulation, covers approximately 98% of 30 minute movements

- Two sigma allocated to **Non-spin** category

  $$Non - spin\ Requirement\ (Hour - ahead\ wind\ forecast\ error) = 2 \cdot \sigma_{hour-ahead}(Previous\ Hour\ Wind)$$

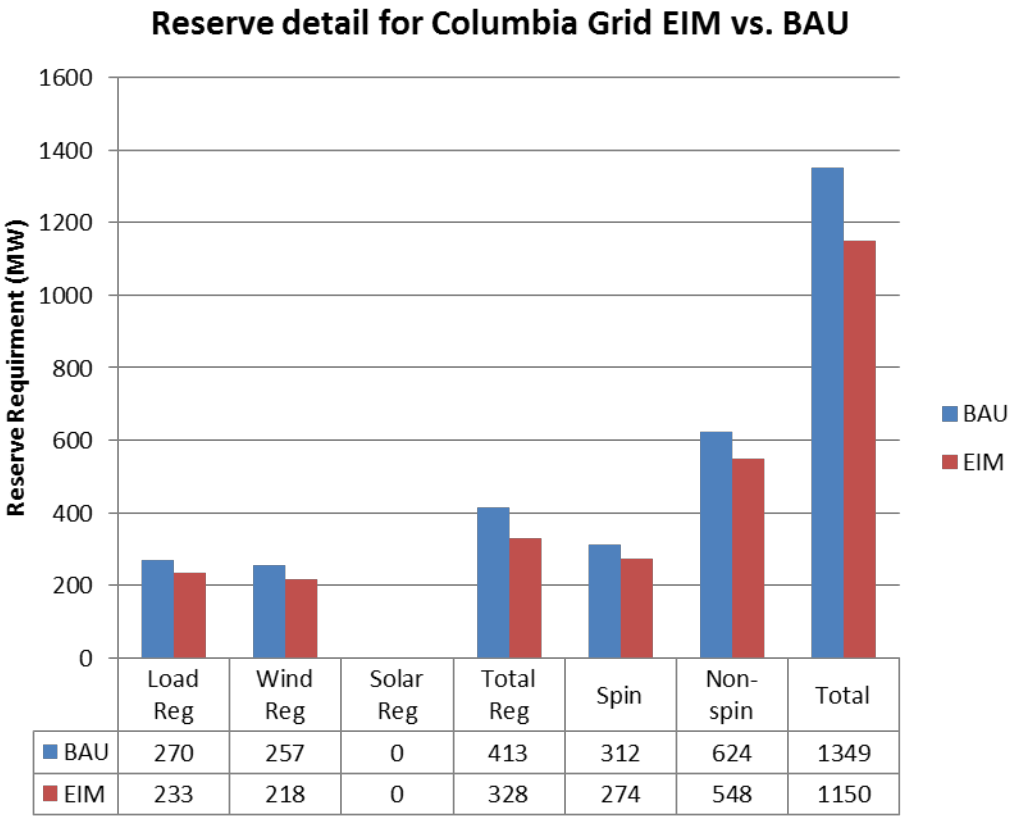
  – With spin, covers 99.7%* of all movements less than 1 hour

*assuming movements are normally distributed which is slightly optimistic

Regional EIM – Columbia Grid (CG)

- Average reserves for a CG EIM;
- BPA dominates the wind so saving less than other regions;
- 8070 MW wind.

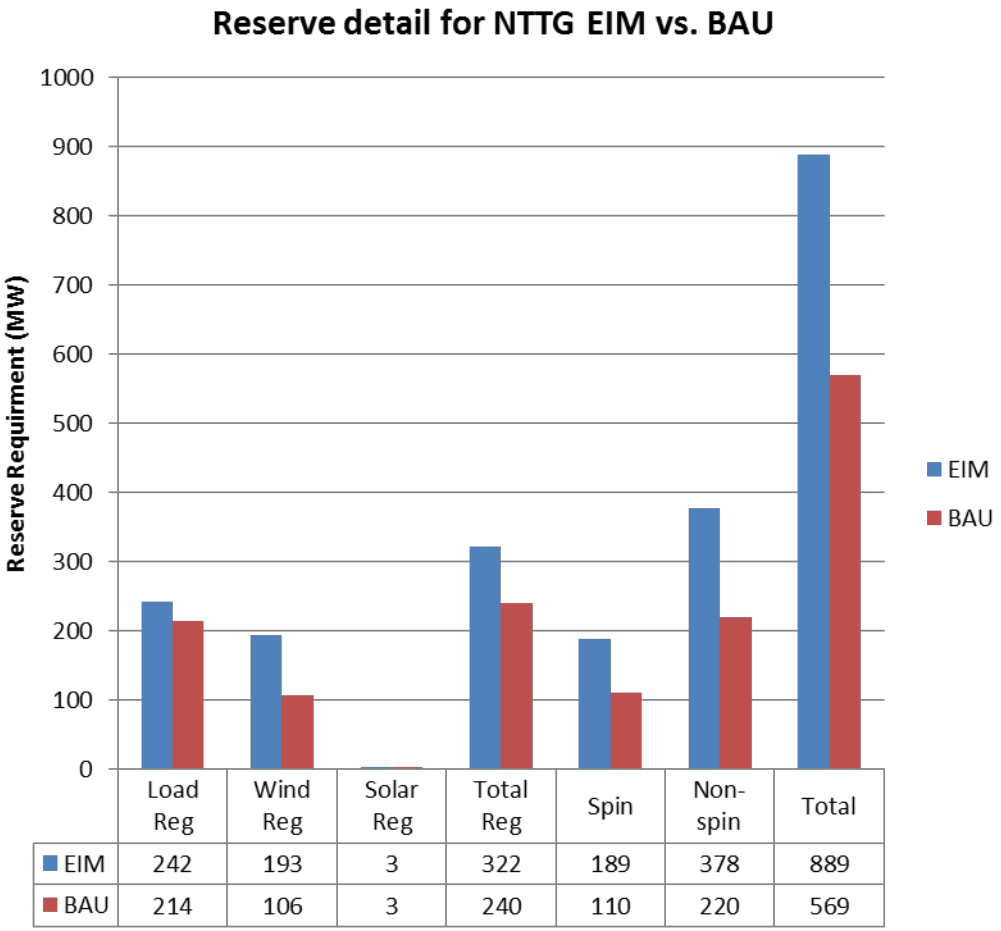
	Reserve Reduction	
	MW	% Reduc.
Load Reg	37	14%
Wind Reg	39	15%
Solar Reg	0	0%
Total Reg	85	21%
Spin	38	12%
Non-spin	76	12%
Total	199	15%



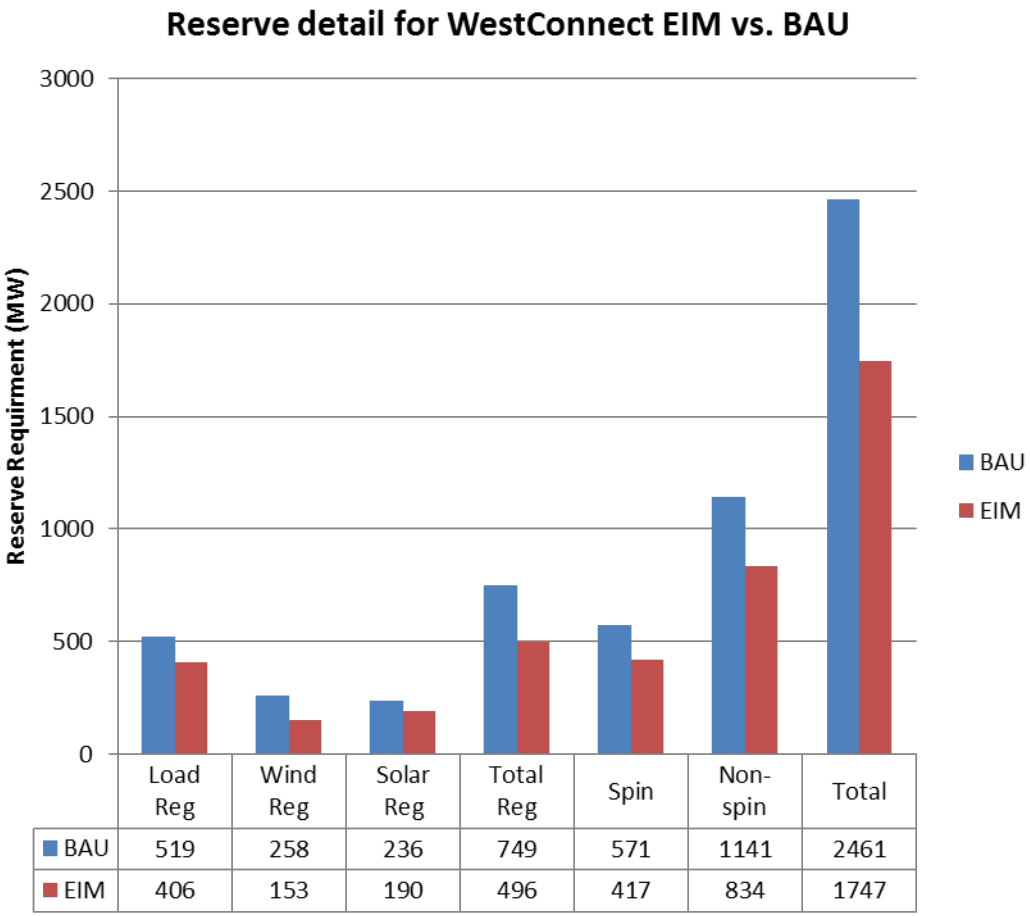
Regional EIM – NTTG

- Average reserves;
- Very small solar;
- Wind dominates savings;
- ~4200 MW wind and 20 MW solar.

	Reserve Reduction	
	MW	% Reduc.
Load Reg	28	12%
Wind Reg	87	45%
Solar Reg	0	0%
Total Reg	82	25%
Spin	79	42%
Non-spin	158	42%
Total	319	36%



Regional EIM – WestConnect (WC)

- Average reserves;
- Substantial saving from wind and solar;
- ~5700 MW wind and 4550 MW solar.

	Reserve Reduction	
	MW	% Reduc.
Load Reg	113	22%
Wind Reg	105	41%
Solar Reg	46	20%
Total Reg	253	34%
Spin	154	27%
Non-spin	307	27%
Total	714	29%