Transmission and Integration into PJM

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Presenter

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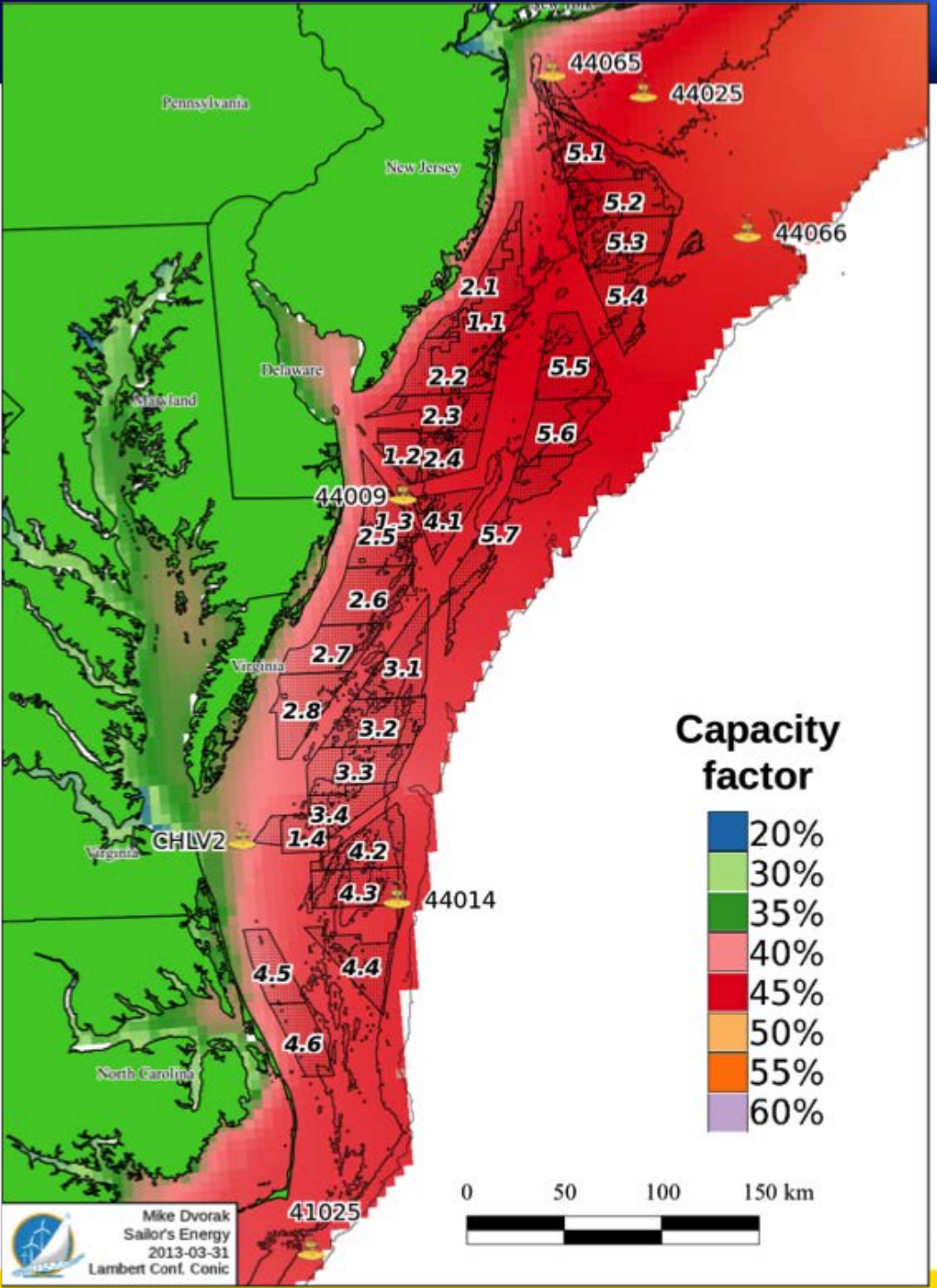


The offshore wind resource

Buildout level	Installed capacity (GW)	Percent of PJM load
1 (WEA)	7.3	4.4%
2	25.3	15.0%
3	35.8	21.4%
4	48.9	29.1%
5	69.7	42.0%

- WRF-ARW model
- 5-km resolution
- REpower 5-MW wind turbine
- 10Dx10D, 10% array and transmission losses

Objectives

1. Examination of offshore wind penetrations consistent with DOE targets and with their assumed resource size

2. Comparison of piecemeal radial connections to the Independent System Operator with connections via an high-voltage direct current (HVDC) offshore network similar to a team partner.

3. High-resolution examination of power fluctuations at each node due to wind energy variability

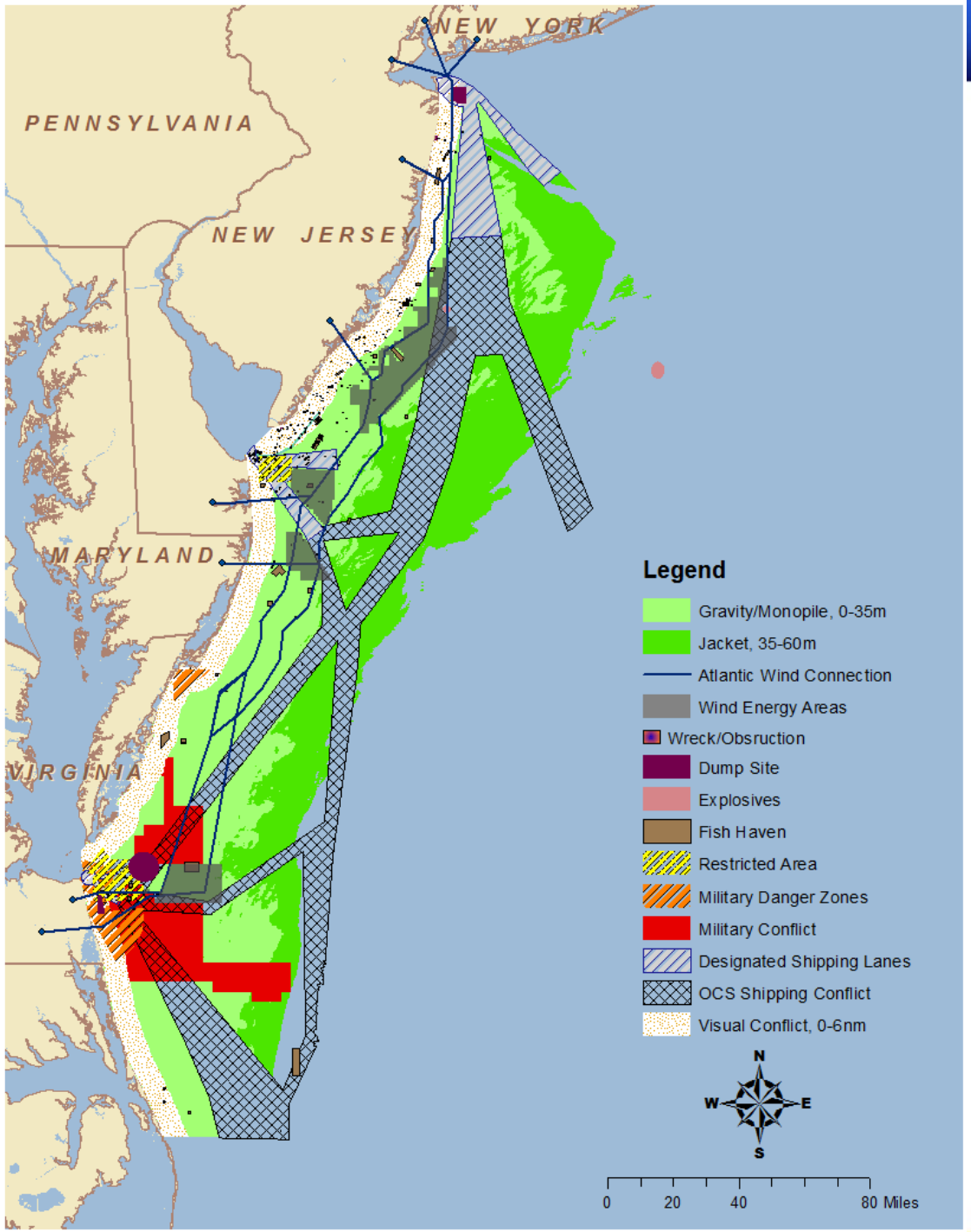
4. Analysis of wind power production profiles over the Eastern offshore region of the regional ISO to assess the effectiveness of long-distance, North-South transmission for leveling offshore wind energy output

5. Analysis of how the third and fourth items affect the need for ISO grid upgrades, congestion management, and demand for Ancillary Services (A/S)

6. Analysis of actual historical PJM forecasts to help develop a stochastic error model for offshore forecasts to help solve the unit commitment problem and determine the optimal mix of generators given the need to respond to both wind variability and wind forecasting uncertainties.

Introduction

- Long-term thinking about offshore wind power along U.S. East Coast
- Research questions:
  - How much offshore wind is available in PJM's ocean? 77 GW
  - How much offshore wind can be integrated with today's power management system? >36 GW
  - Role of forecasting: how much wind can be integrated with today's power management system <u>and</u> perfect forecasts? >70 GW



Copywright 2012: Blaise Sheridan & Scott Baker, University of Delaware

The MAOWIT domain

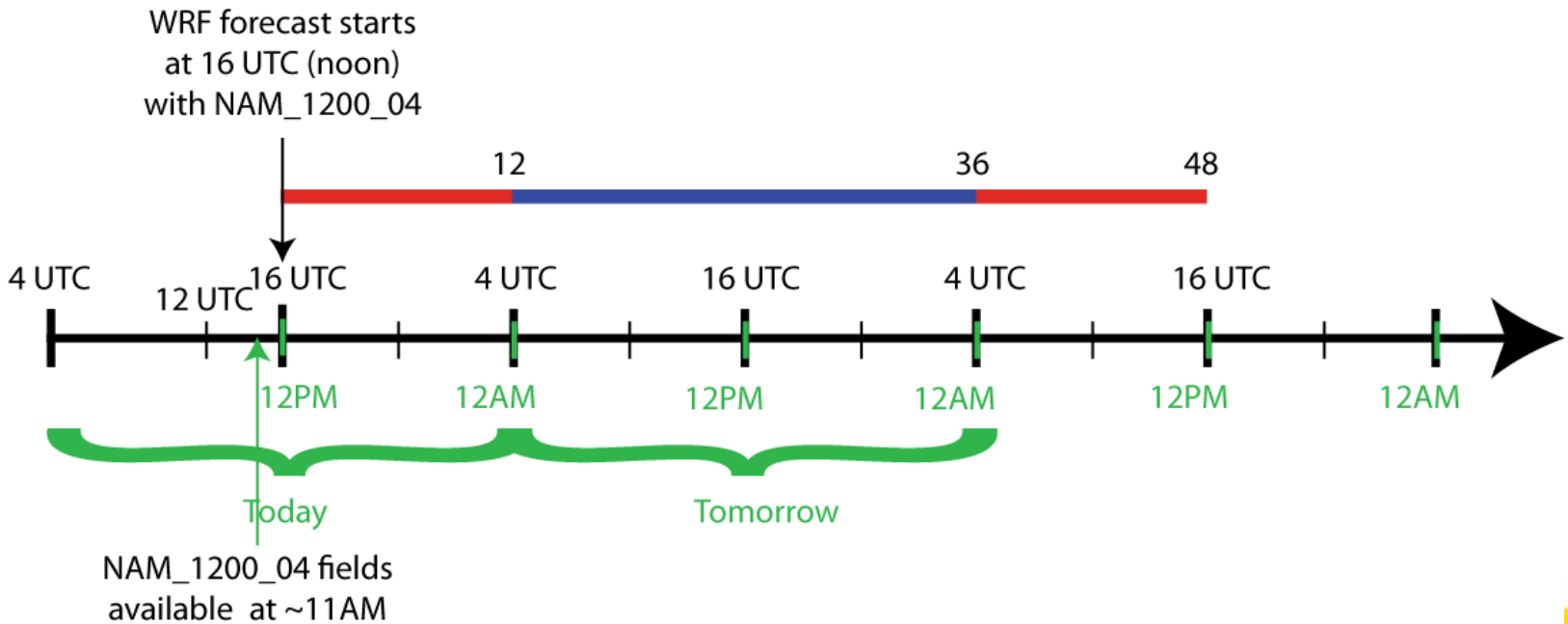
- Conflict areas:
  - *Environmental*
  - *Shipping*
  - *Military*
  - *Visual*
- Ocean bathymetry
- Atlantic Wind Connection (AWC)
- BOEM designated Wind Energy Areas (WEA)

Challenges for MAOWIT

- Forecasts, not simulations:
  - Initialization must mimic real-time, operational forecasts;
  - High-frequency output (10-min);
  - Geo-physical database for precise spatial data access (PostGRES).
- No observations of 90-m winds exist along the East Coast:
  - Need to generate “synthetic” actuals;
  - Need multiple, equally-plausible forecast error time series for Smart-ISO.

WRF forecasts, not simulations

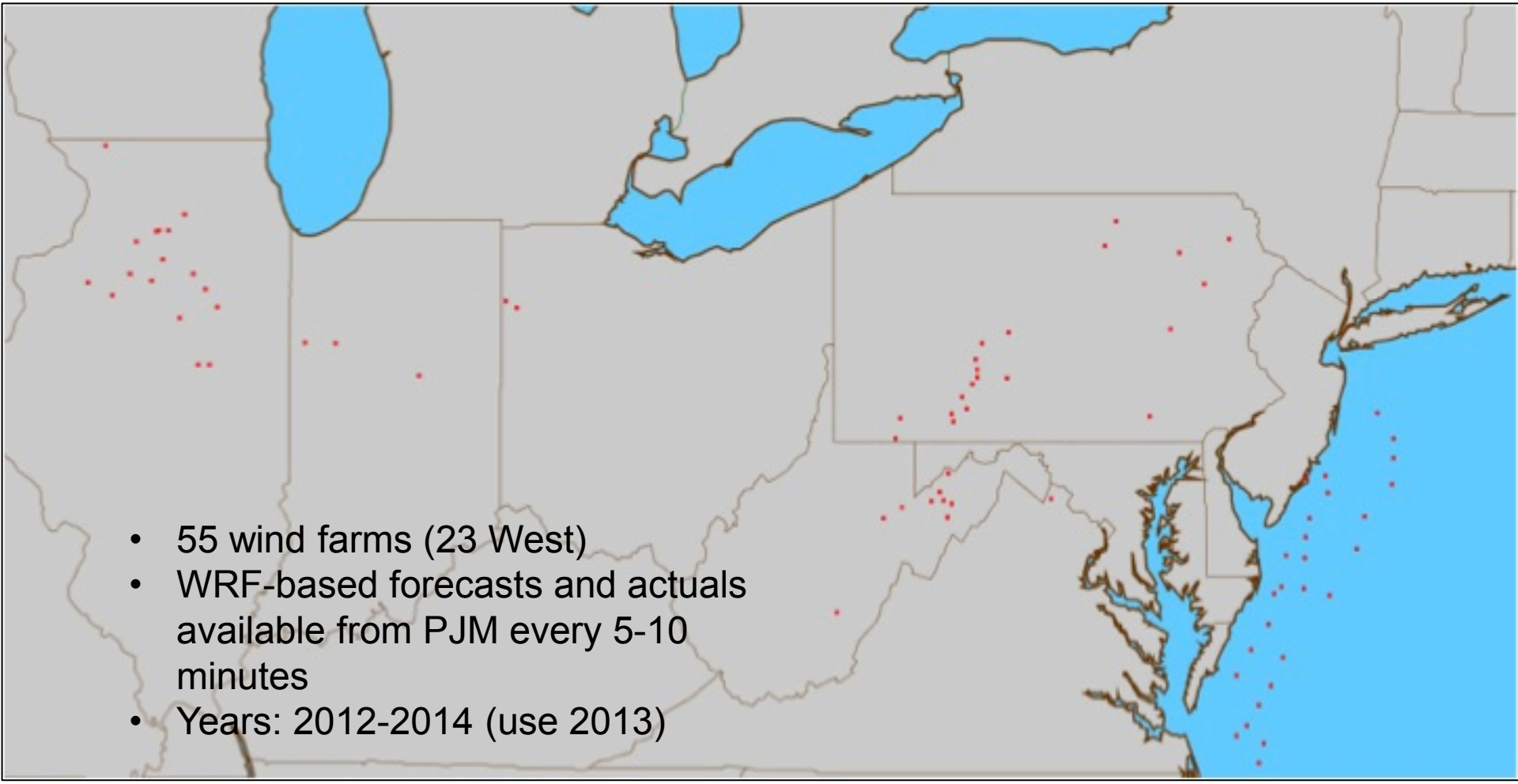
- Pretend to be “real-time”
- Initial conditions from NAM forecasts
- 12-36 hr forecasts needed for UC model
- 4 months in 2010 (Jan, Apr, Jul, Oct)



How to obtain actuals offshore?

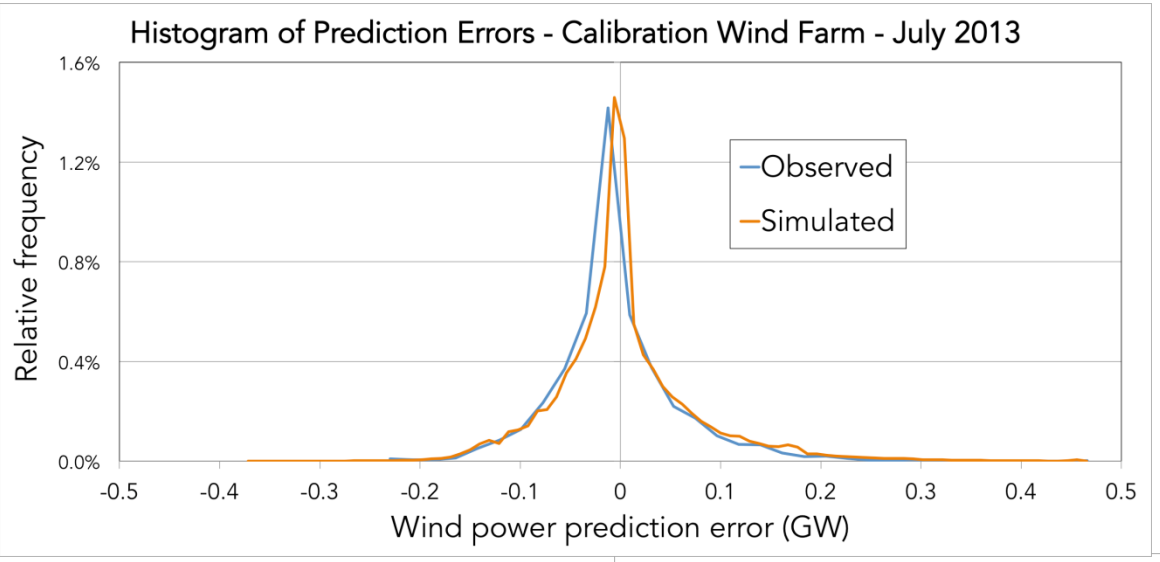
- Only 7 buoys/towers available offshore, none with data at 90 m;
- Profile of wind speed with height unknown (except at Cape Wind);
- Idea: use the forecast errors at PJM's current, inland wind farms to generate synthetic, offshore actuals.

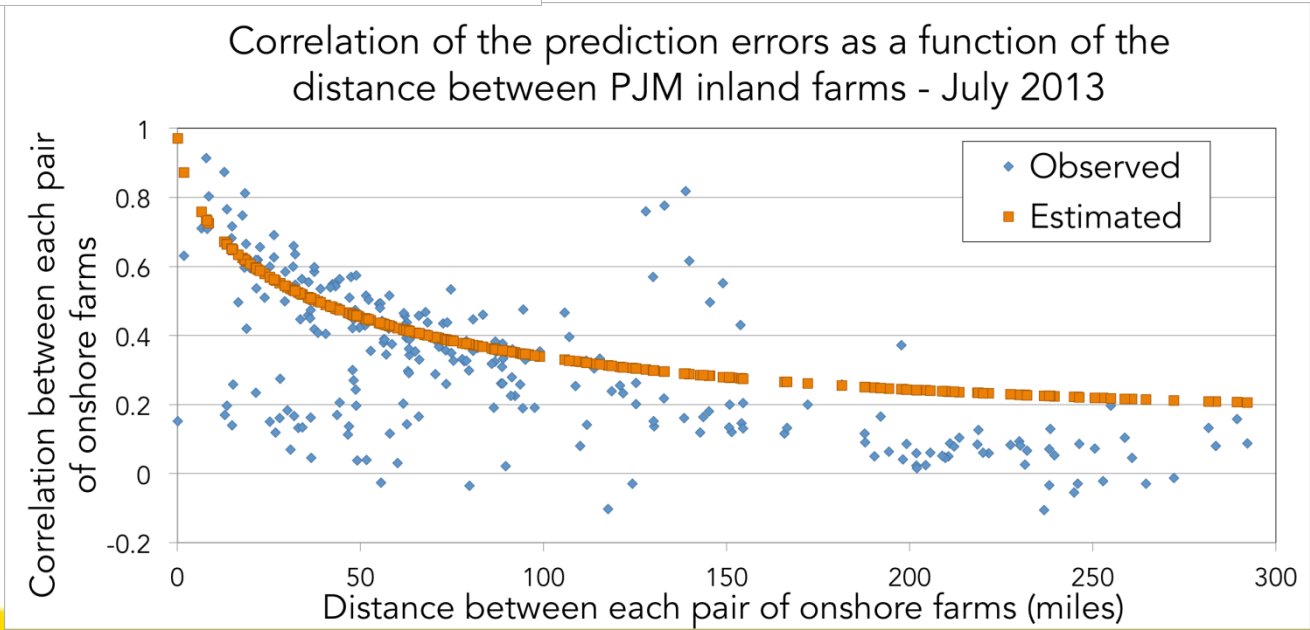
The current PJM inland wind farms



- 55 wind farms (23 West)
- WRF-based forecasts and actuals available from PJM every 5-10 minutes
- Years: 2012-2014 (use 2013)

Error model validation





Importance of forecasting

July 2010	**Current forecasts**		**Perfect forecasts**	
	Buildout 4	Buildout 5	Buildout 4	Buildout 5
Wind capacity (GW)	48.9	69.7	48.9	69.7
Available wind (% of demand)	18.2	25.6	17.8	25
Used wind (% of demand)	15	17.8	14.3	16.7
Ramping reserves (GW)	13	15	2	3
Peak demand shortage (GW)	1.6	0.9	0	0
Probability of demand shortage (%)	23.8	19.1	0	0

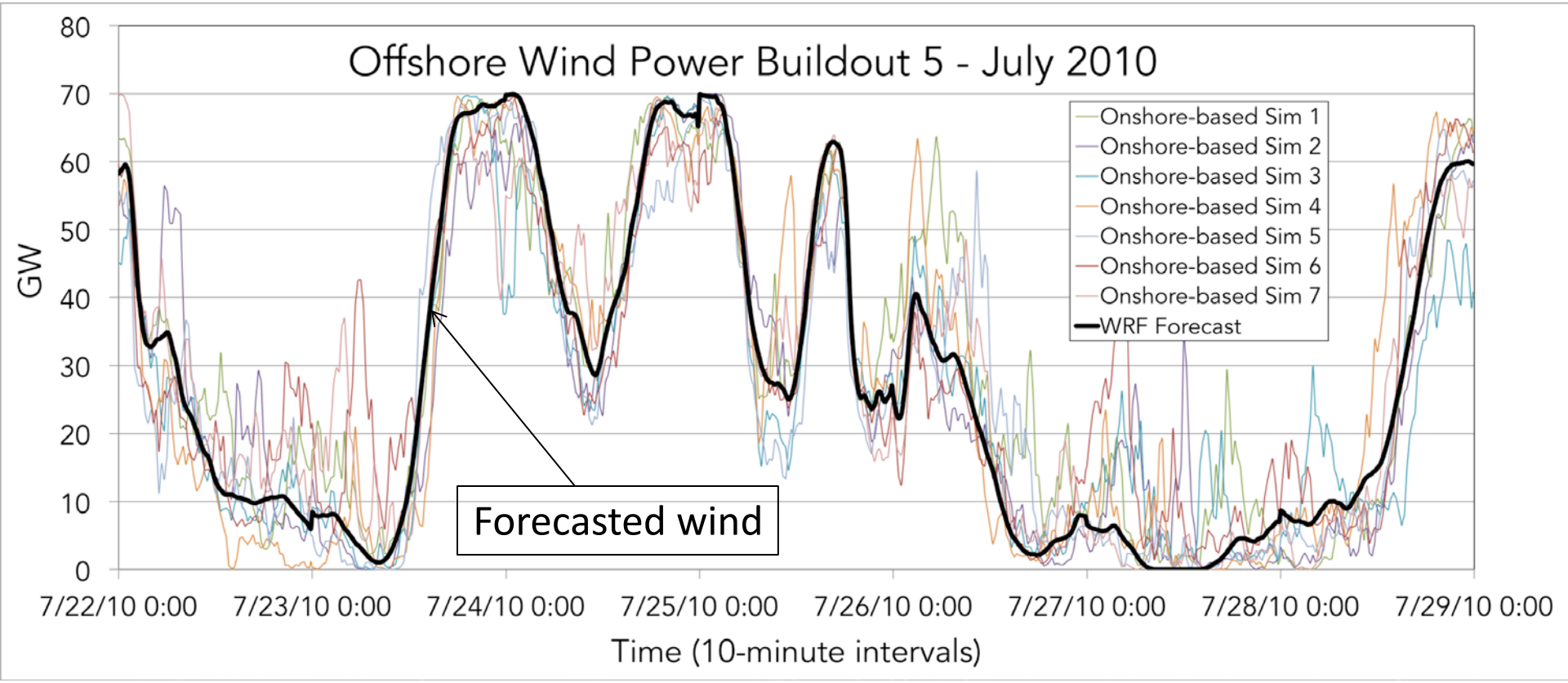
Modeling the power grid

- Modeling the power grid
  - A DC model is used to approximate the grid when we are looking into the future.
    - Standard practice when solving unit commitment problems
    - Models real power, but not reactive power.
  - … but we use a full AC model to check feasibility in real-time.
    - Full model of real and reactive power.
    - More realistic model of how the grid responds to voltage variations.

Modeling the power grid

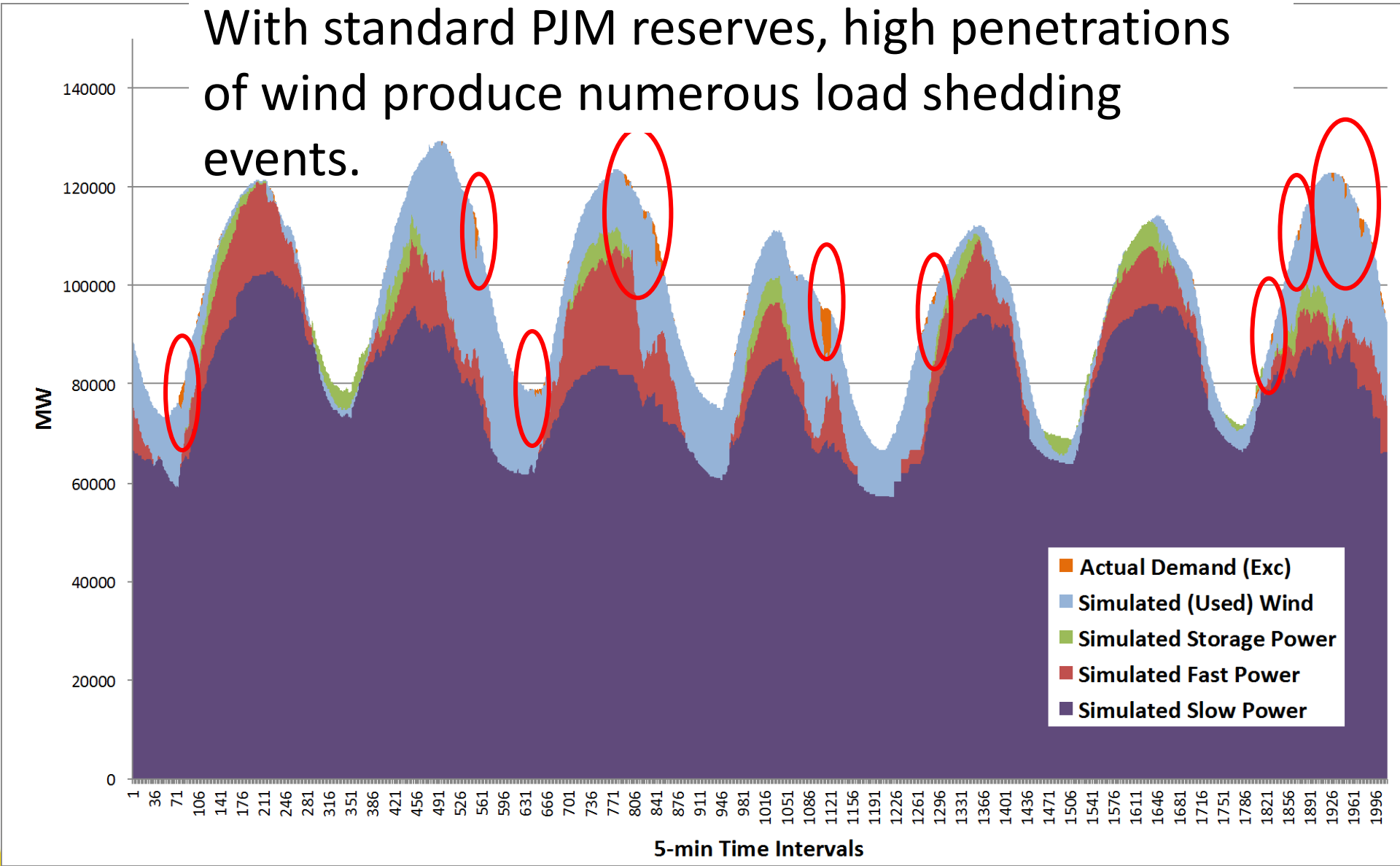
Simulating offshore wind

- Offshore wind – Buildout level 5

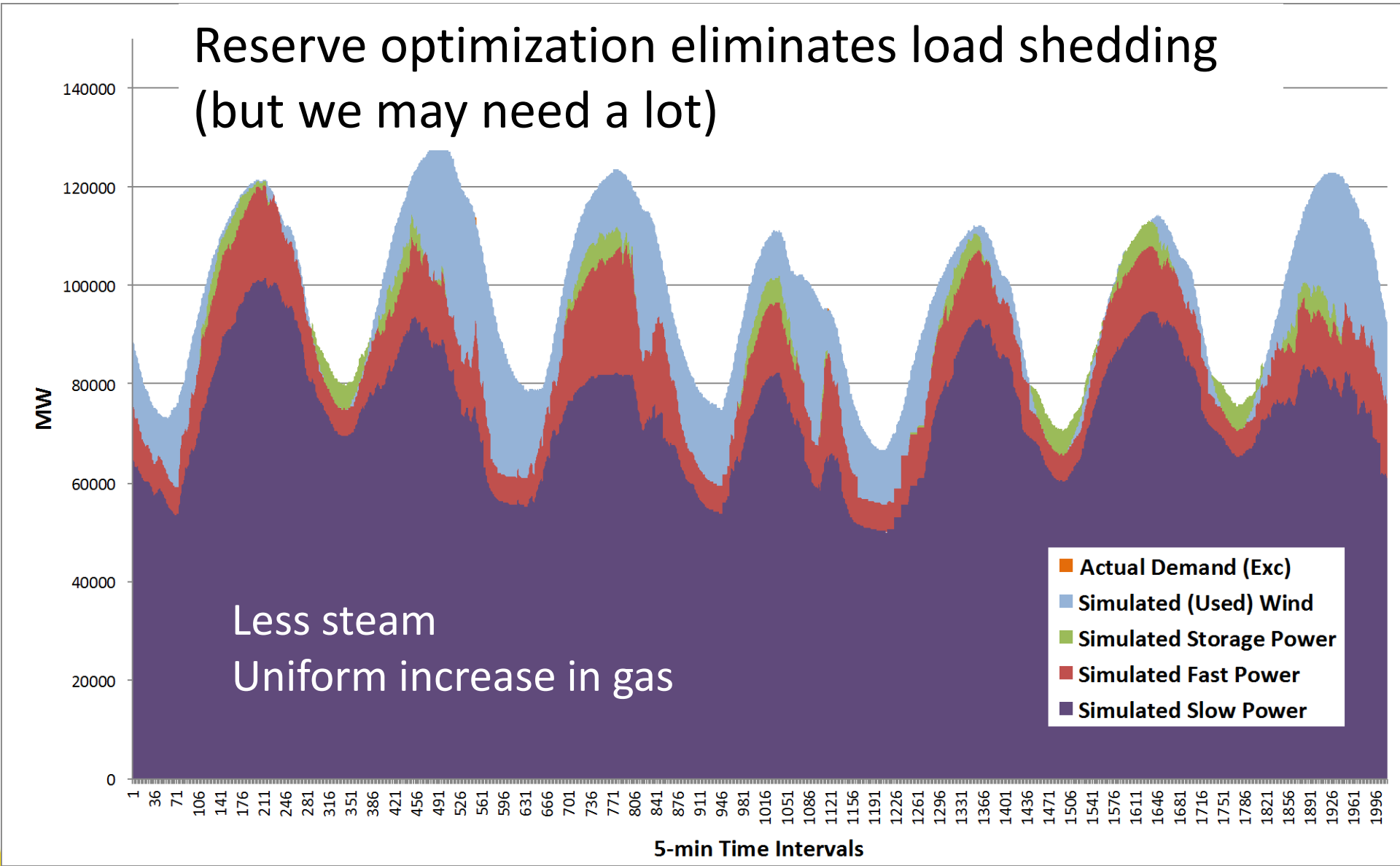


Unit commitment under uncertainty

With standard PJM reserves, high penetrations of wind produce numerous load shedding events.

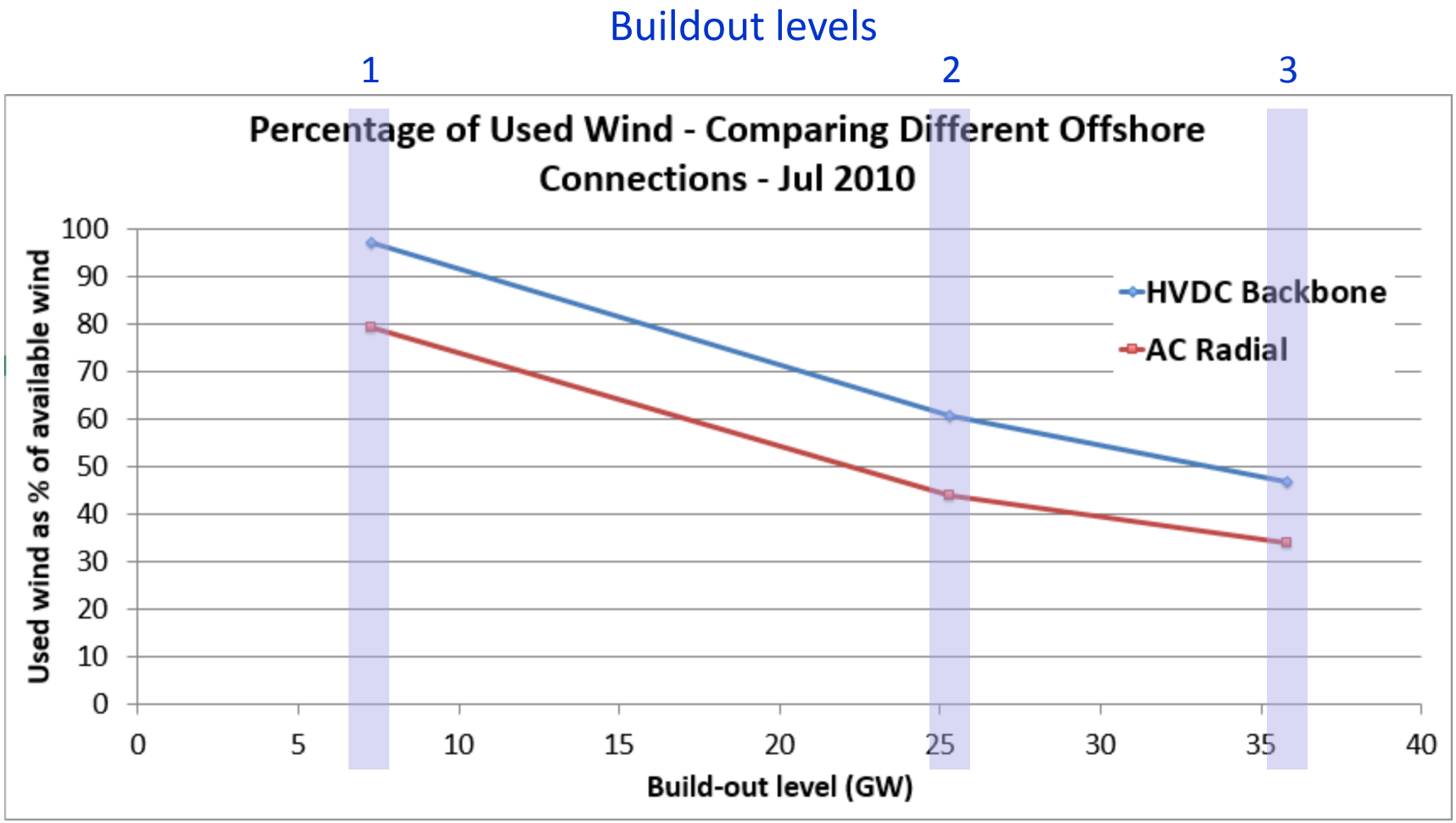


Unit commitment under uncertainty



Constrained grid

- Percentage of used wind
  - HVDC backbone vs. AC radial



Unconstrained grid

- Reserves required to eliminate load shedding
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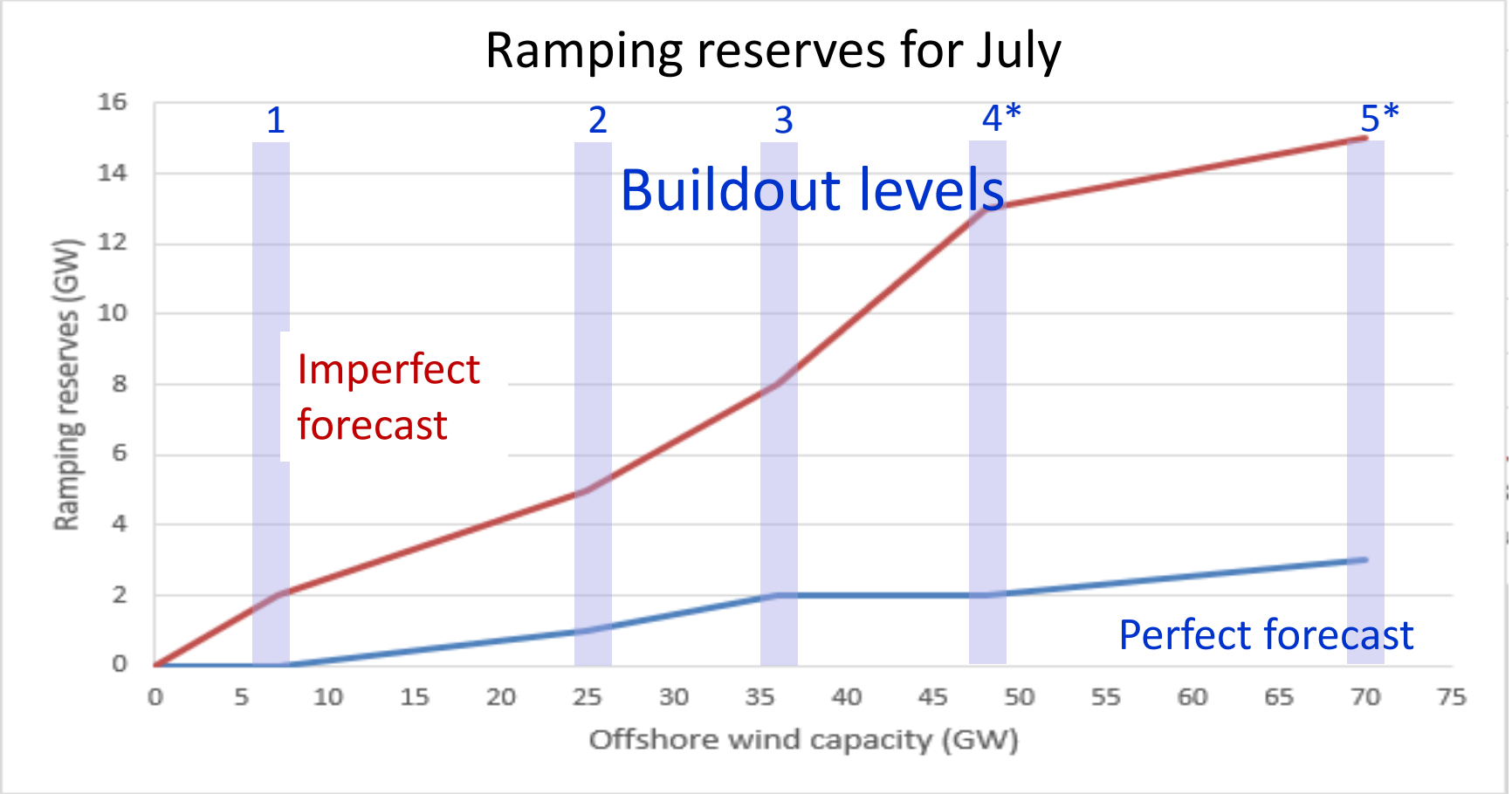

Conclusions

- Developed offshore areas for wind development
- Created a stochastic model of the offshore wind forecasting error using existing inland PJM wind farms
- Developed the SMART-ISO model to simulate PJM's grid
- Analyses were completed using the SMART-ISO model
  - Constrained vs. Unconstrained Grid
  - Perfect information vs. reserves
  - Injecting with DC/AC