

OPPORTUNITIES FOR SYNERGISTIC COLLABORATION AMONG THE PUBLIC, ACADEMIC AND PRIVATE SECTORS IN THE APPLICATION OF WIND PREDICTION TECHNOLOGY TO LOWER GRID INTEGRATION COSTS

JOHN ZACK, MICHAEL BROWER AND BRUCE BAILEY
AWS TRUEPOWER, LLC

Overview

- **Problem Overview**
- **Wind Forecast Improvement Project Highlights**
- **Roles of Team Members from Each Sector**
- **Highlights of Project Results**
- **Project Benefits**

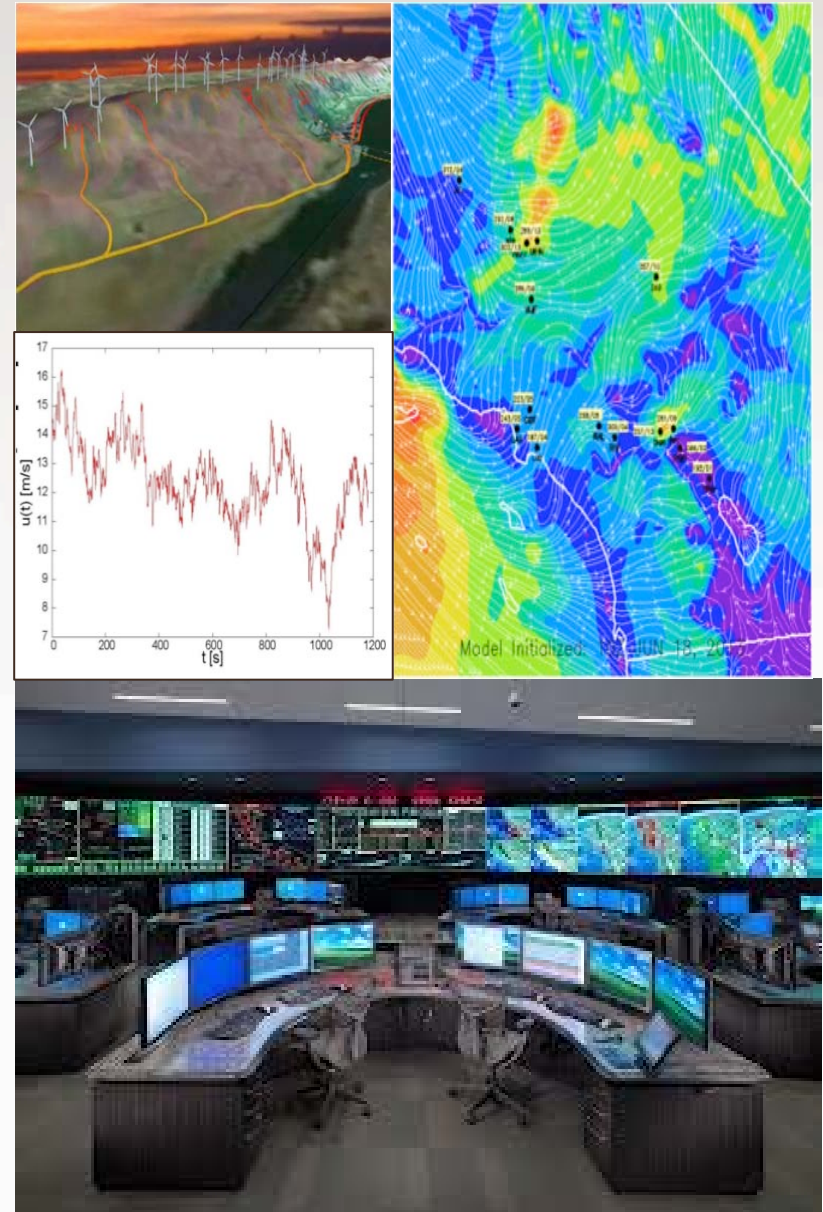
The Goal: Minimization of Renewable Energy Grid Integration Costs

- **Problem:** Managing non-dispatchable variability of wind and solar generation results in an increased grid integration cost to maintain reliability
- **Potential Solutions**
 - Flexible/ lower cost backup gen
 - Storage
 - Reduce variability through diversity
 - Demand response programs
 - **Forecasting production**



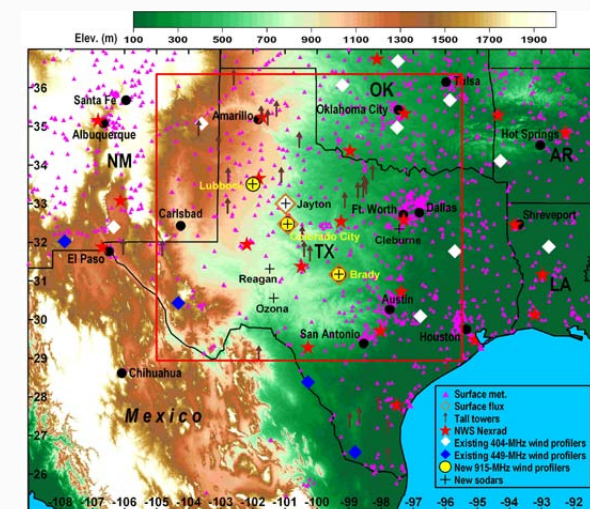
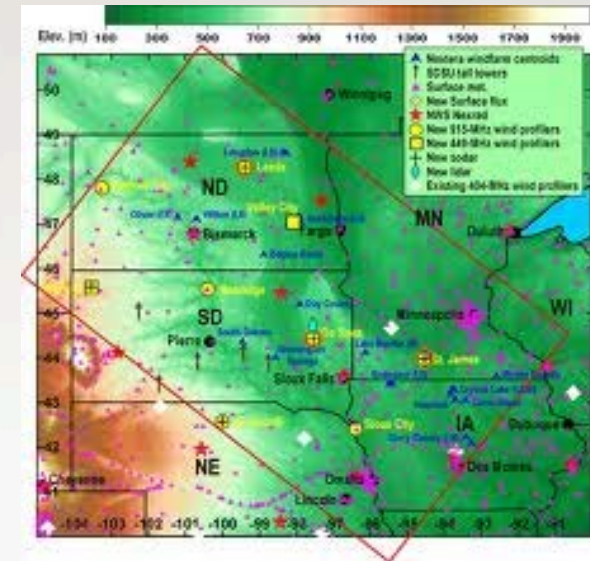
Opportunity: Improve the Value of Forecasting for Reduction of Grid Integration Costs

- **Improve Forecast Performance**
 - Gather additional (targeted) data
 - More effective data assimilation
 - Improve physics-based models
 - Apply advanced statistical tools
 - Refined facility generation models
- **More Effective Forecast Utilization**
 - Customize content/format
 - Increase user confidence in forecasts
 - Use probabilistic information



Multi-Sector Collaborative Effort: Wind Forecast Improvement Project (WFIP)

- Objective:
 - Demonstrate impact of additional sensors and “next generation” wind prediction techniques on performance and value of 0-6 hr wind power forecasts
- Concept:
 - DOE sponsored project
 - Participation by NOAA
 - Project teams led by private sector entity
- Structure:
 - Two study regions
 - North (led by WindLogics)
 - South (led by AWS Truepower)
 - Different technical approaches and team composition in each region



WFIP-South Project

Key Underlying Questions

- Amount of dependence of forecast performance on data assimilation and NWP model formulation?
- Value of multi-member rapid update ensemble?
- Variation of forecast performance by weather scenario?
- Impact of supplemental targeted observations?
- Economic value to ERCOT stakeholders of forecast improvement?
- How is the economic benefit distributed among stakeholders?

**To get meaningful answers:
Need a diverse team with a broad range of expertise.....**

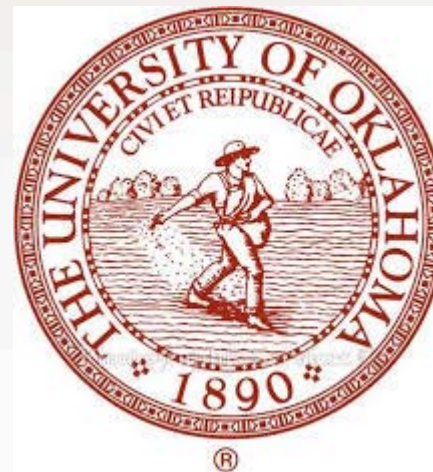
WFIP-South Project Team: Private Sector Members and Roles

- **AWS Truepower**
 - technical and management leader
 - sensor deployment
 - analyzed forecast performance
 - integrated project results
- **MESO, Inc**
 - conducted observation targeting study
 - Implemented and operated real-time experimental forecast system
- **ICF International**
 - evaluation of economic value of forecasts
- **Participating Wind Farms**
 - provided real-time wind farm data



WFIP-South Project Team: Academic Sector Members and Roles

- **Texas Tech**
 - provided data from sensors at its facility in Lubbock, TX
 - conducted forecast sensitivity experiments to assess impact of data assimilation scheme
- **University of Oklahoma**
 - periodically provided forecasts from advanced higher res modeling and data assimilation system
 - conducted forecast sensitivity experiments
- **North Carolina State University**
 - provided and operated SODAR



WFIP-South Project Team: Public Sector Members and Roles

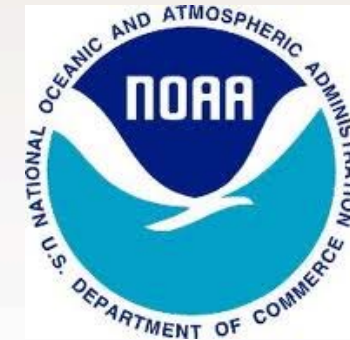
- **Department of Energy (DOE)**

- project sponsor
- assisted in project coordination



- **NOAA/ESRL**

- customized real-time HRRR modeling system for wind energy forecasting
- analyzed HRRR forecast performance
- deployed sensors in targeted locations



- **National Renewable Energy Lab (NREL)**

- assisted ICF in economic impact analysis

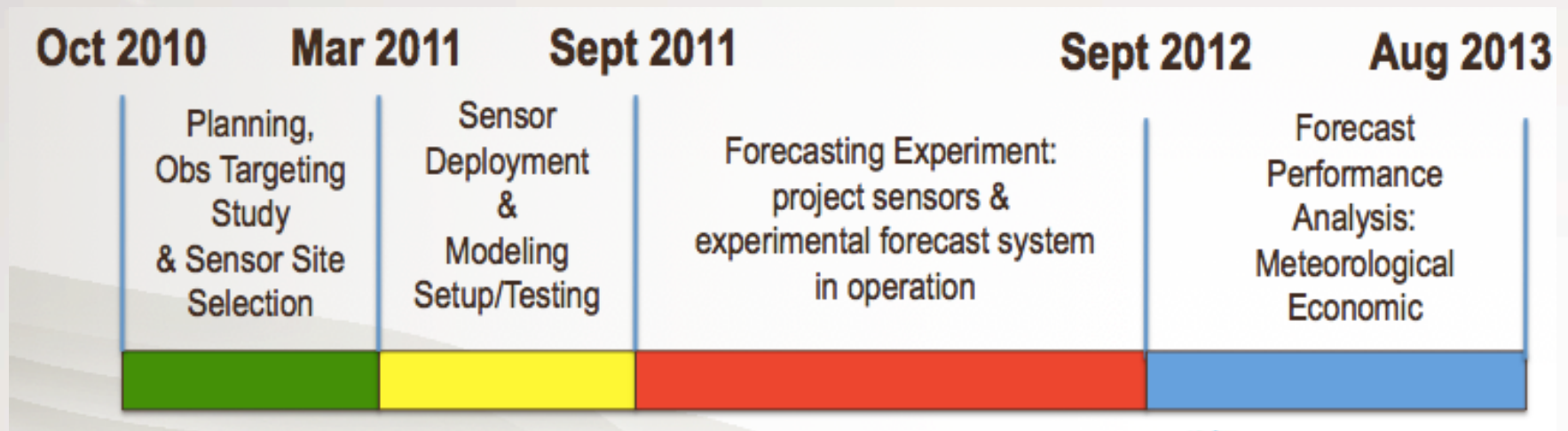


- **ERCOT**

- provided guidance on forecast value
- facilitated dissemination of real-time data

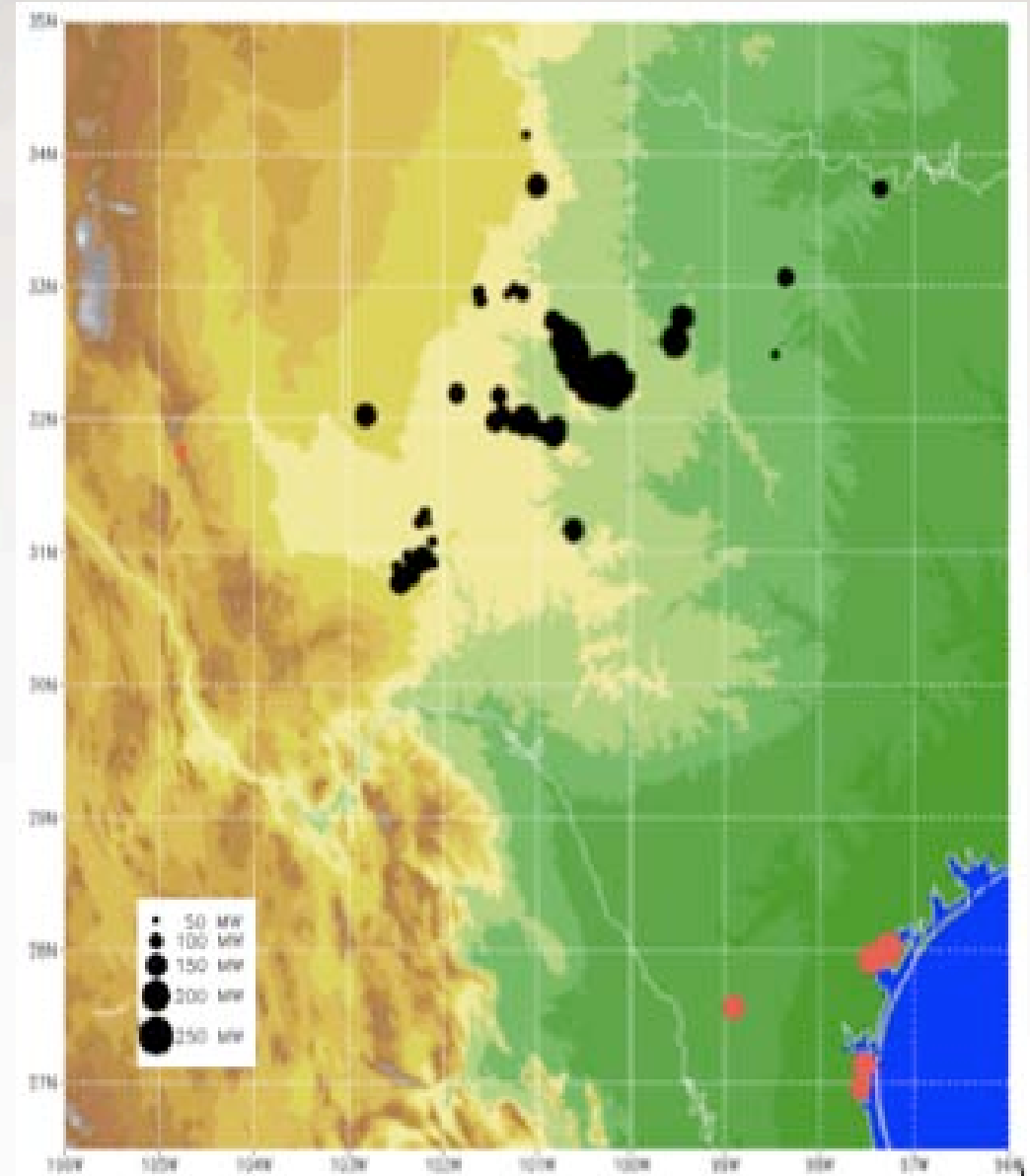


WFIP-South Project Timeline



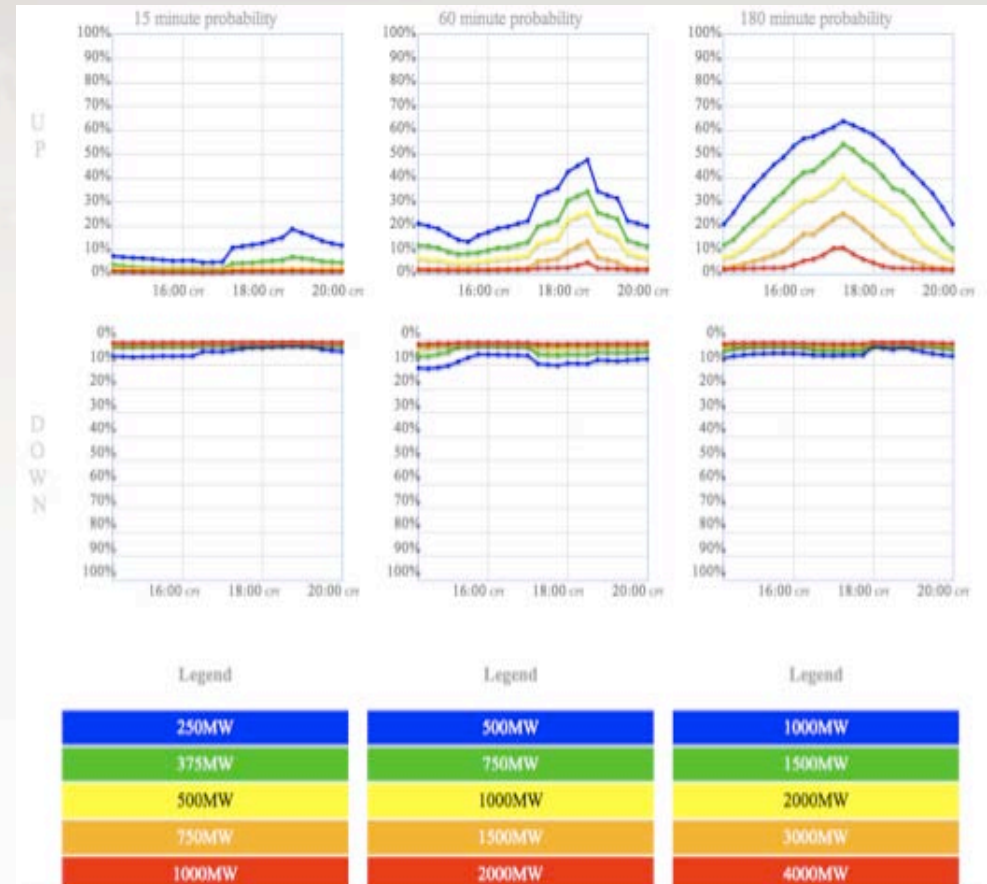
Venue: ERCOT System

- **System Load (2011)**
 - Average hourly: 38,255 MW
 - Range: 22,386 to 68,392 MW
- **Wind Power**
 - Total: 9801 MW (Jan 2012)
 - In WFIP area: 8296 MW (85%)
 - Referred to as "WFIP project aggregate"
 - Much of capacity concentrated in a small area of NW Texas (near Sweetwater, TX)
 - Frequent occurrence of large system-wide ramps



Baseline: Pre-WFIP Forecast Products for ERCOT

- Short Term Wind Power Forecast (STWPF)
 - **Operational - Deterministic**
 - Delivery: 15 mins after the hour
 - 0-48 hour forecast
 - Average hourly MW
 - 80% POE MW (labeled as WGRPP)
- ERCOT Large Ramp Alert System (ELRAS)
 - **Experimental - Probabilistic**
 - Delivery: every 15 minutes
 - 0-6 hr forecast
 - POE for ramp rate thresholds for 3 time periods beginning at interval
 - List of ramp events with attributes
 - Situational awareness information

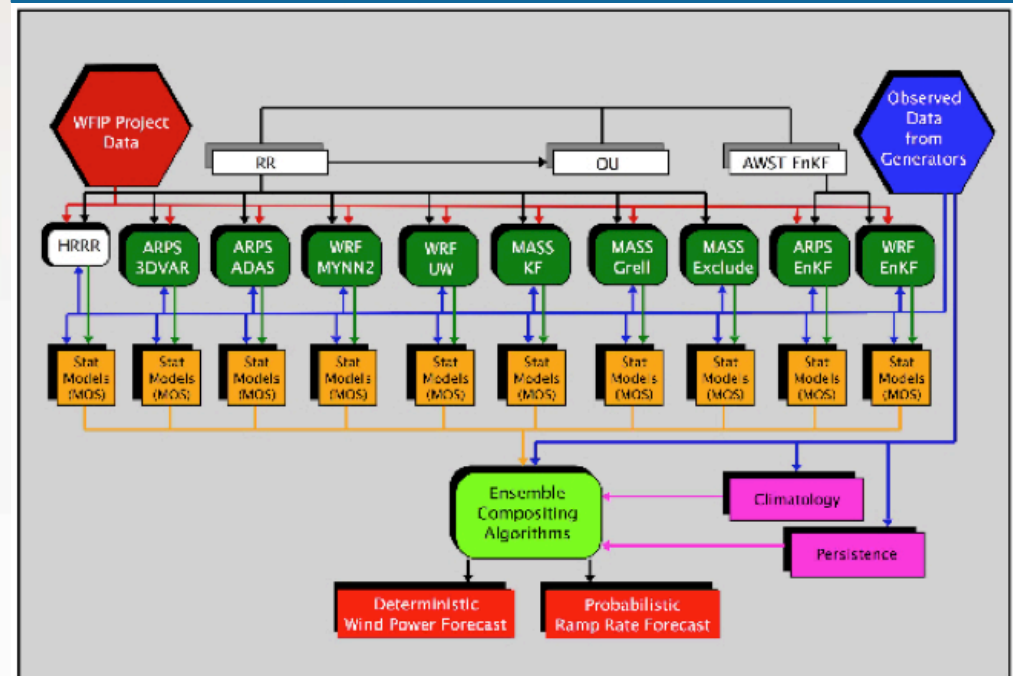


ELRAS 6-hr Probabilistic Ramp Rate Forecast from 1/21/12 1400 CST

WFIP-South Technical Approach

- **Sensors at targeted locations**
 - 7 SODARs
 - 3 wind profilers
 - other sensors (flux stations etc.)
- **10-member NWP Ensemble**
 - HRRR from NOAA/ESRL
 - CONUS - 1 hr update cycle
 - 9-member AWST/MESO ensemble
 - Project area - 2-hr update cycle
 - Assimilation of project (and other publicly available) data
- **Model Output Statistics**
 - Applied to each model
 - Screening multiple linear regression
- **Optimized Ensemble Algorithm**
 - Constructs composite forecast by statistically combining the ensemble of MOS adjusted forecasts
 - Deterministic and probabilistic forecasts analogous to ERCOT baseline forecasts

Schematic of the Components and Data Flow of the WFIP Rapid Update Ensemble Forecast System

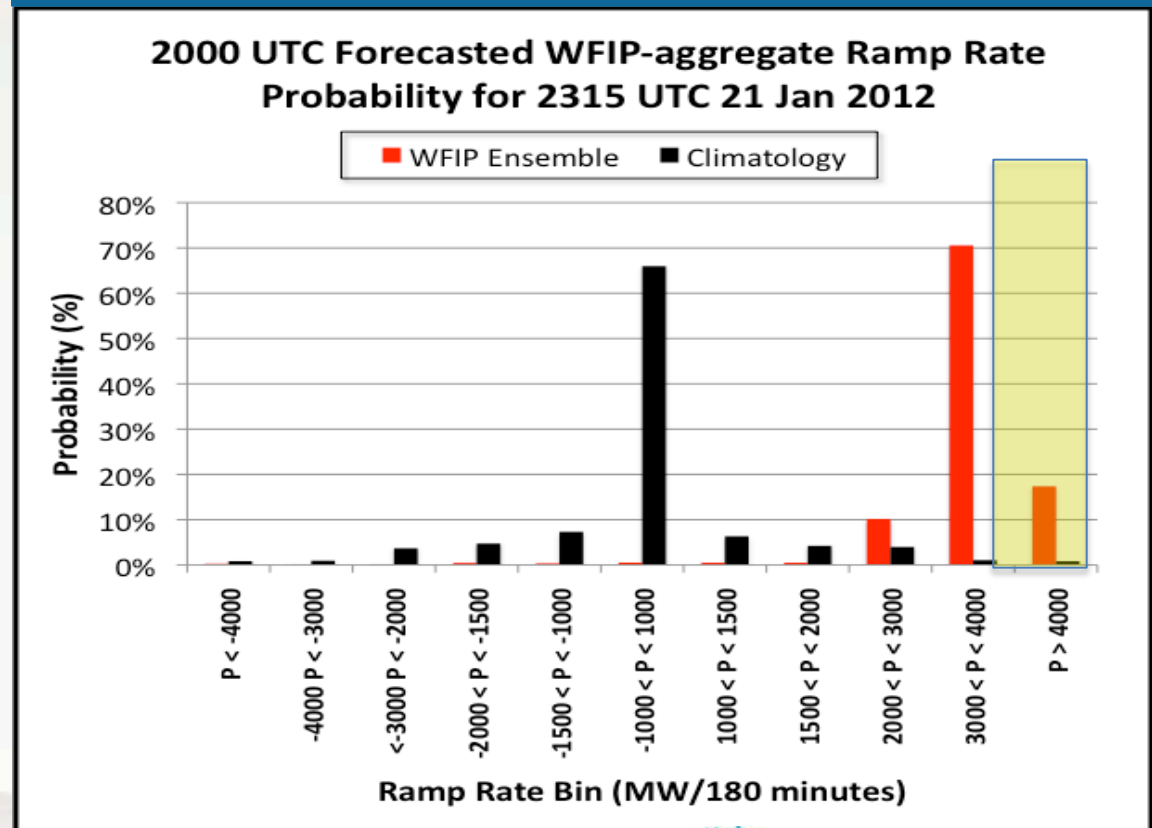


Most Significant Project Impact: Probabilistic Ramp Rate Forecasts

- Metric: RPSS (Ranked Probability Skill Score)
- Measures performance relative to climatology
- Considers key attributes of a probability forecast
 - Reliability
 - Resolution
 - Sharpness
- RPSS Characteristics
 - **Higher scores indicate better performance**
 - RPSS = 0 when skill is the same as climatology
 - RPSS > 0 when performance is better than climatology

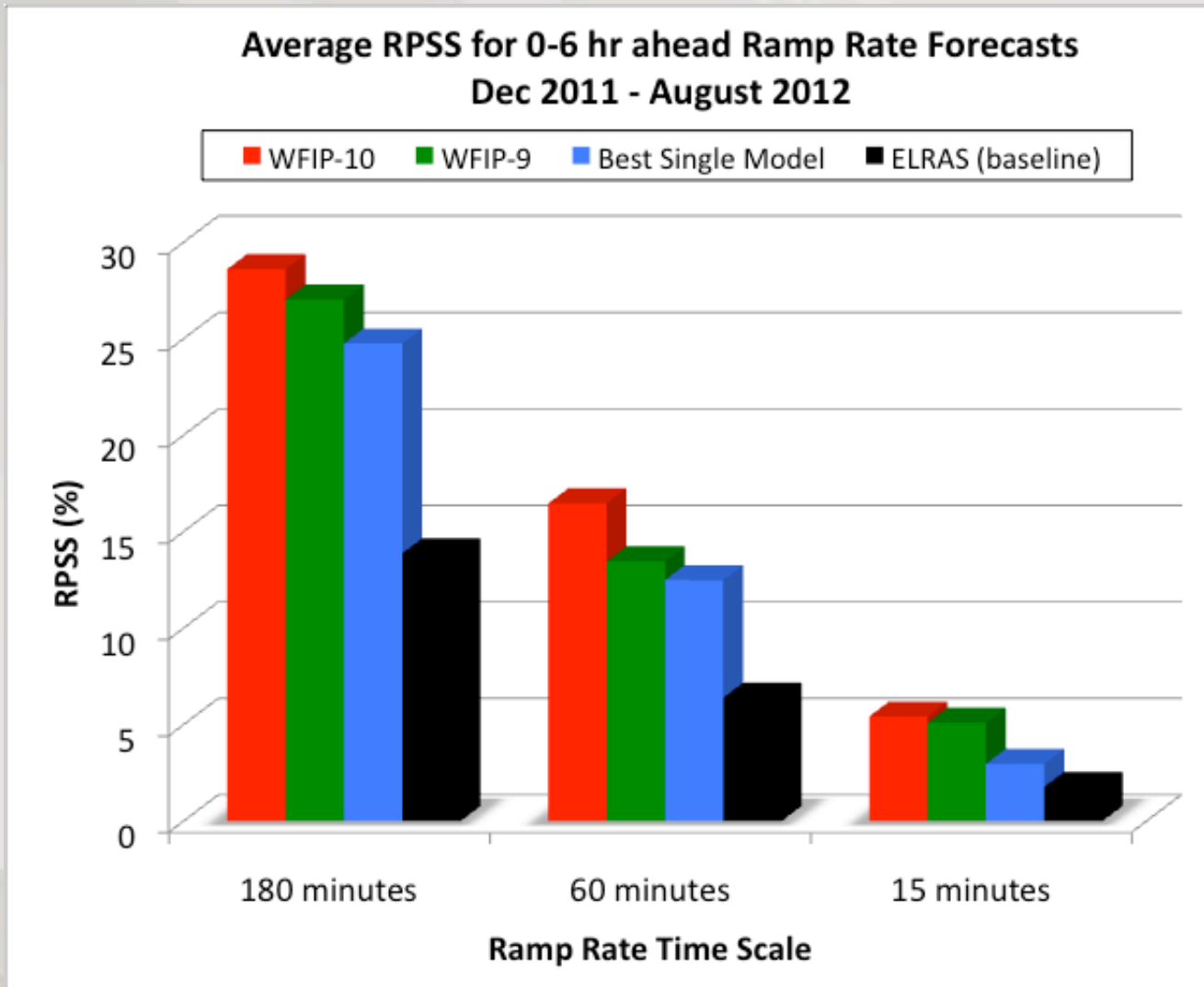
Example of RPSS Metric

- Horizontal Axis: 11 ramp rate bins (MW/180-min)
- Vertical Axis: probability of occurrence
- Black: climatology
- Red: WFIP ensemble forecast
- Yellow box: observed outcome
- RPSS for this case: 83.6%



Probabilistic Ramp Rate Forecast Performance

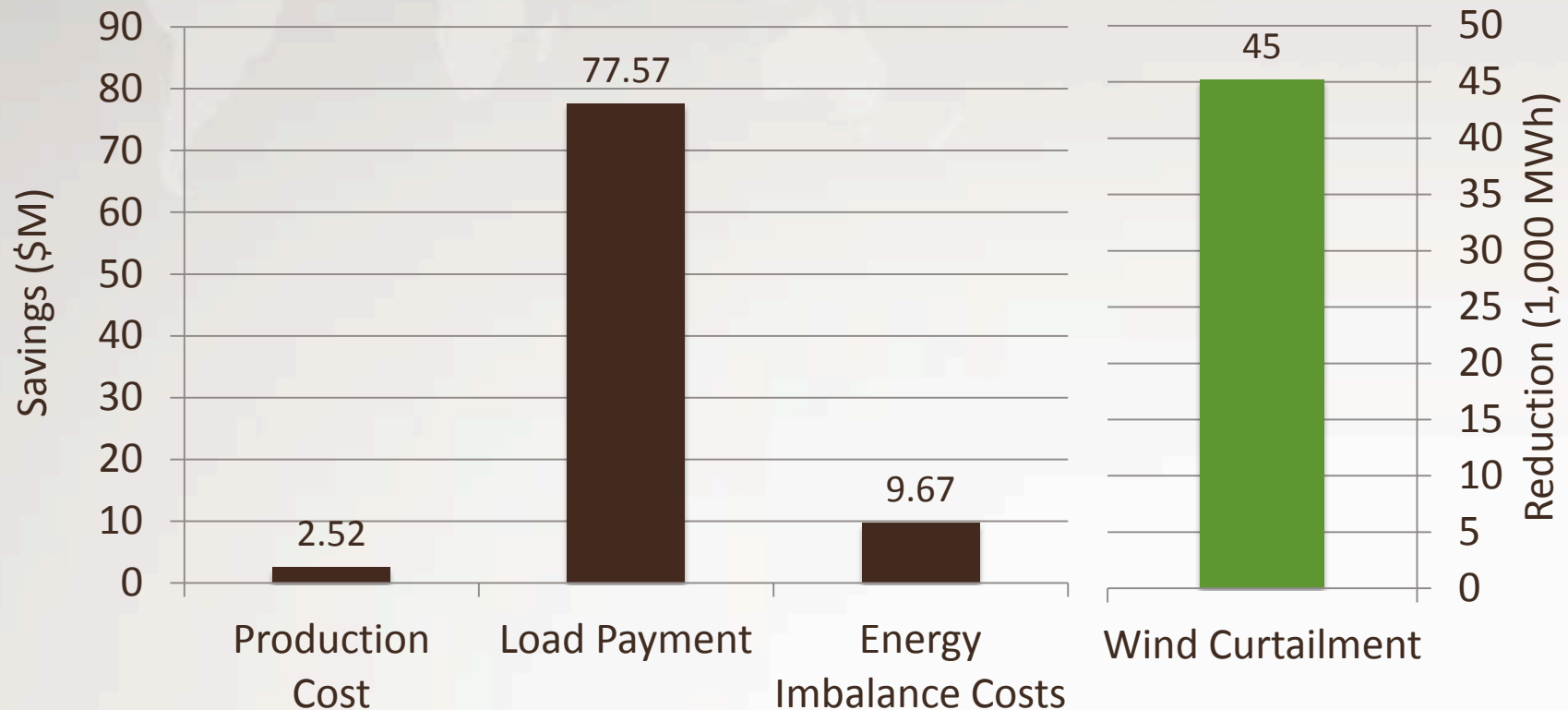
December 2011 – August 2012



- 10-member ensemble is the best performing forecast for all three time scales
- Improves by a factor of >2 over baseline forecast (ELRAS)
- Best single model (HRRR) does not perform as well as an ensemble (WFIP-9) without that model
- Skill much greater for 180-minute events than for 15-minute events

Impact of 1-Year of Improved 6-hr Deterministic Forecasts: STWPF - WFIP

Preliminary Results:



- Improved WFIP deterministic forecasts yield several significant value streams that accrue to different stakeholders

Economic analysis by ICF International using the GE-MAPS power system operations simulation model

Project Benefits

- **Improved Forecasting Services for Grid Operators**
 - Key components of WFIP system are being implemented into the system that generates operational forecast products for ERCOT
 - Analogous upgrades for other grid operators served by AWST
- **Broad Range Expanded Knowledge**
 - Value of rapid update NWP ensemble
 - Sensitivity to targeted data and data assimilation method
 - Variations in forecast performance by caused-based type of ramp
- **Ongoing Collaborative Relationships**
 - Further exploration of forecast performance issues
- **Enhanced Career Opportunities**
 - Student from Texas Tech now part of the AWST/MESO renewable energy forecast team



AWS Truepower[®]
Where science delivers performance.

Thank You



AWS Truepower[™]
Where science delivers performance.