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

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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

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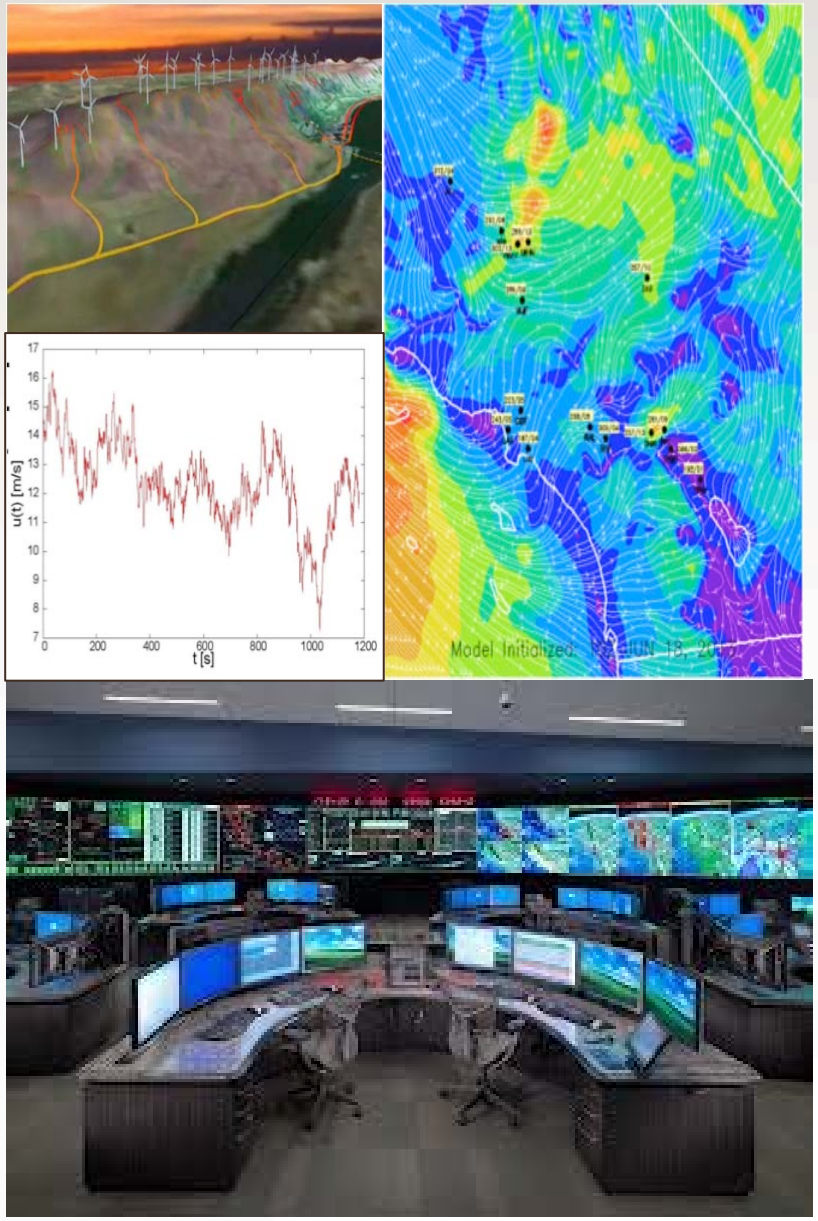
Opportunity: Improve the Value of Forecasting for Reduction of Grid Integration Costs

- **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



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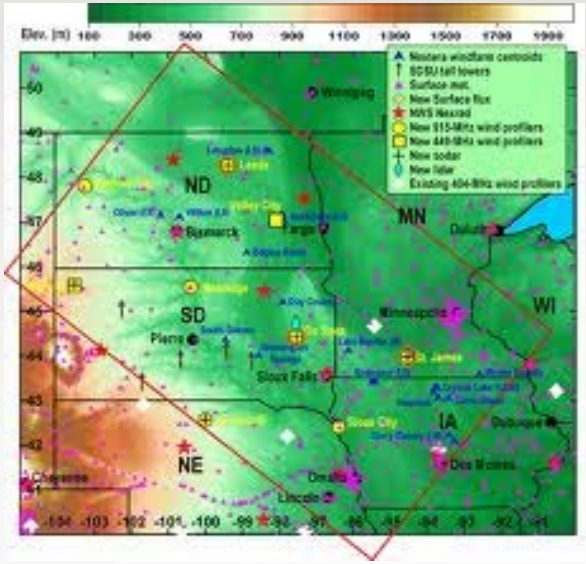
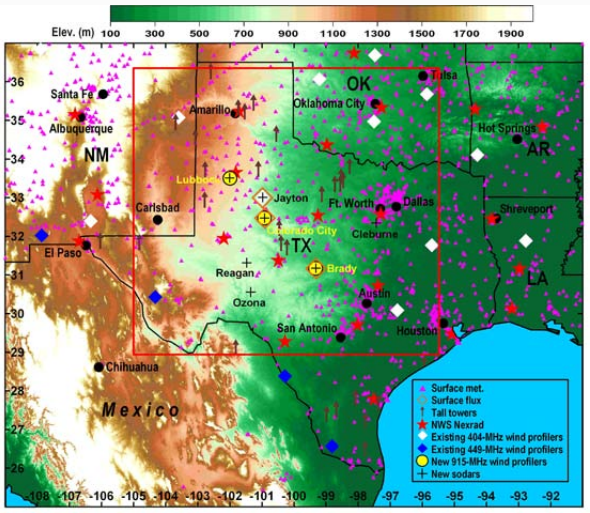
Multi-Sector Collaborative Effort: Wind Forecast Improvement Project (WFIP)

- 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





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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.....

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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

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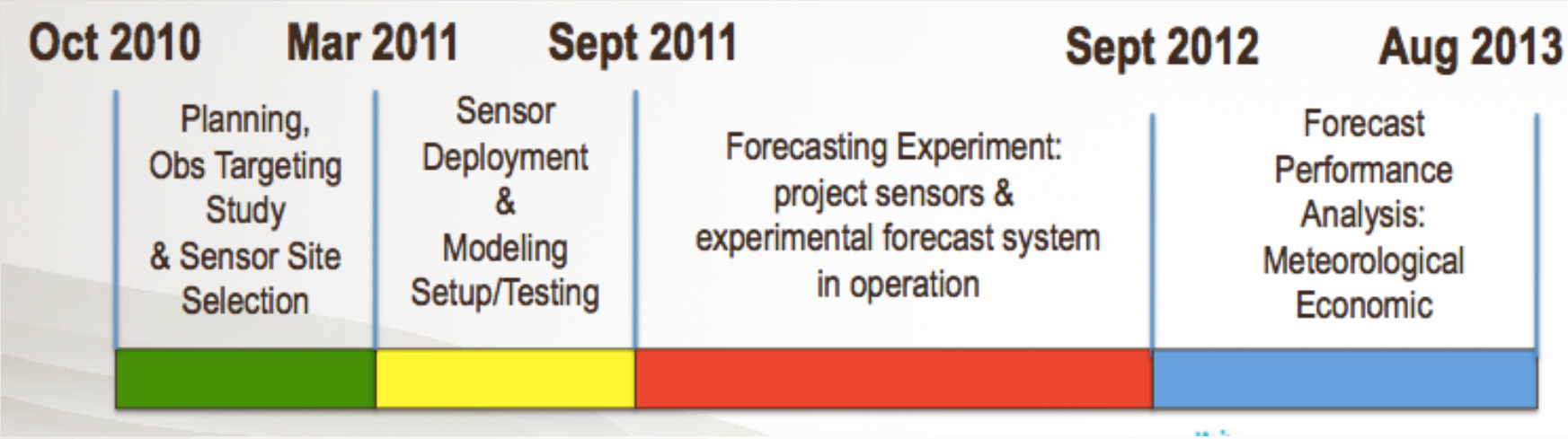
WFIP-South Project Team: Public Sector Members and Roles

- **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



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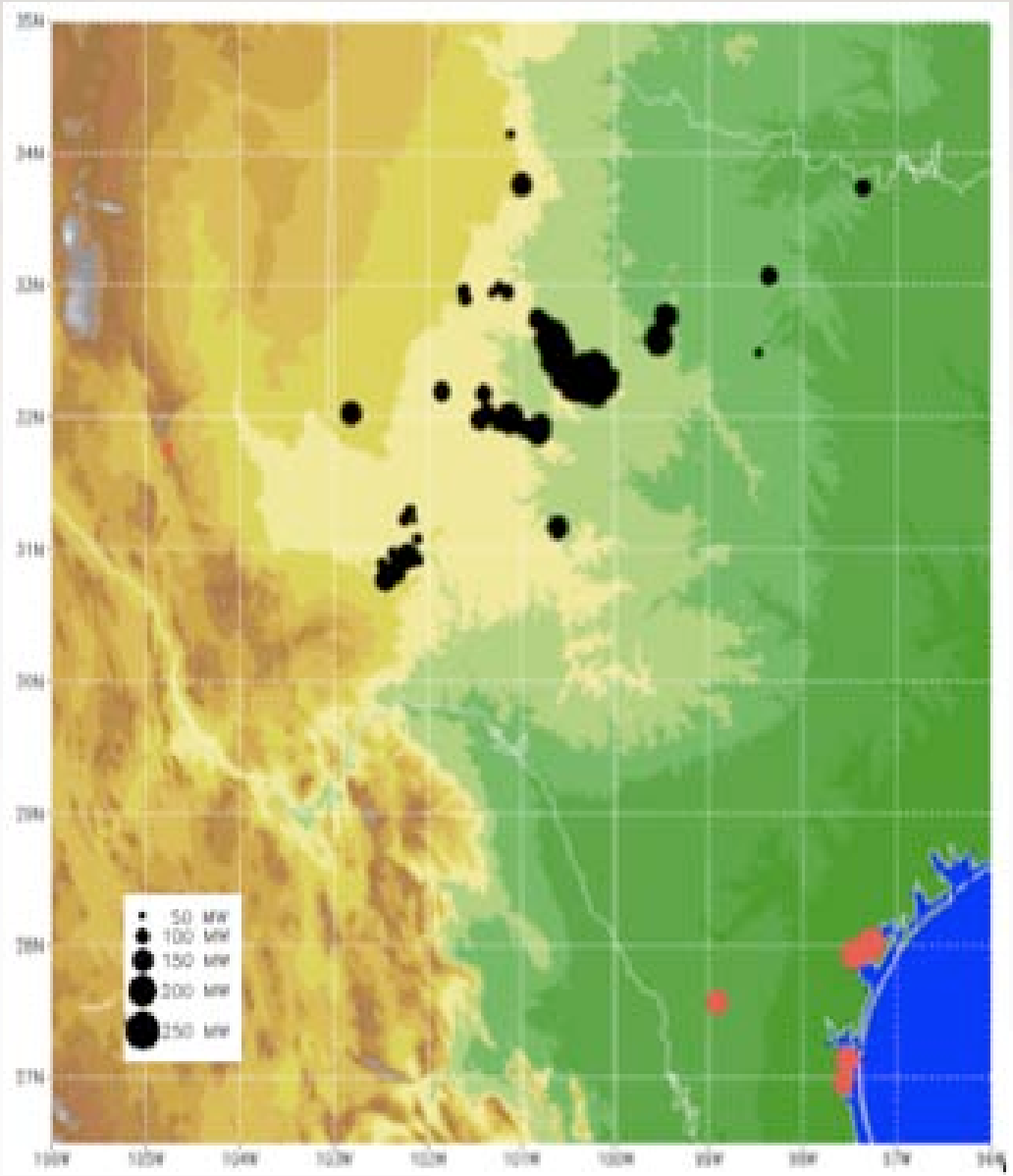
Venue: ERCOT System

- **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



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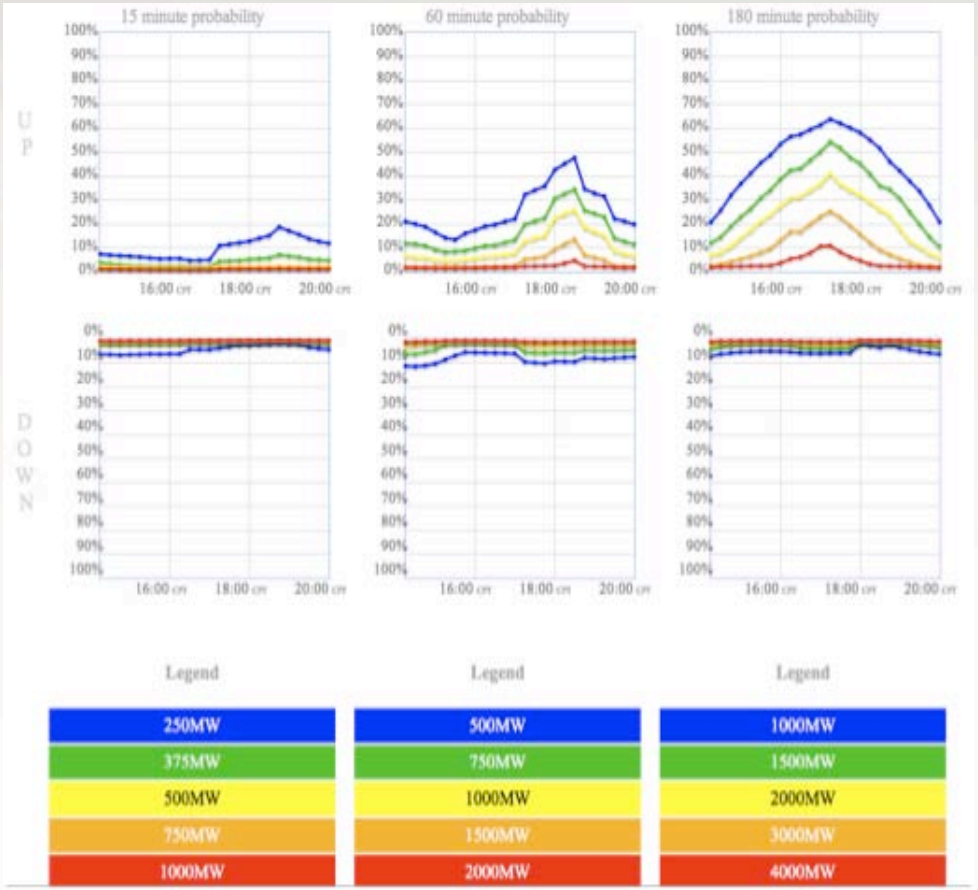
Baseline: Pre-WFIP Forecast Products for ERCOT

- 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

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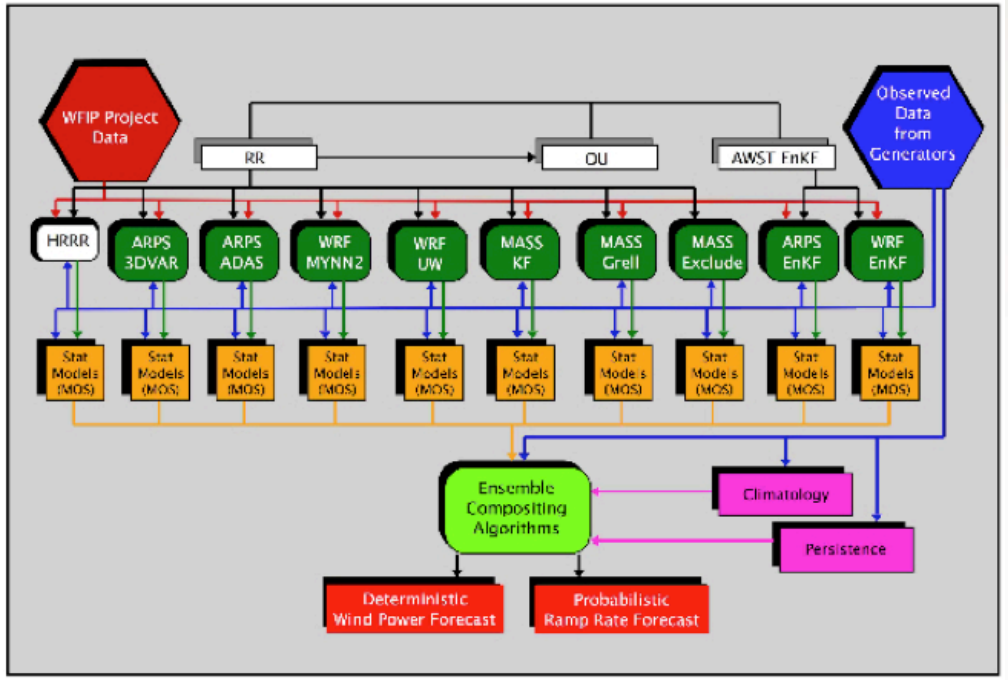
WFIP-South Technical Approach

- **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



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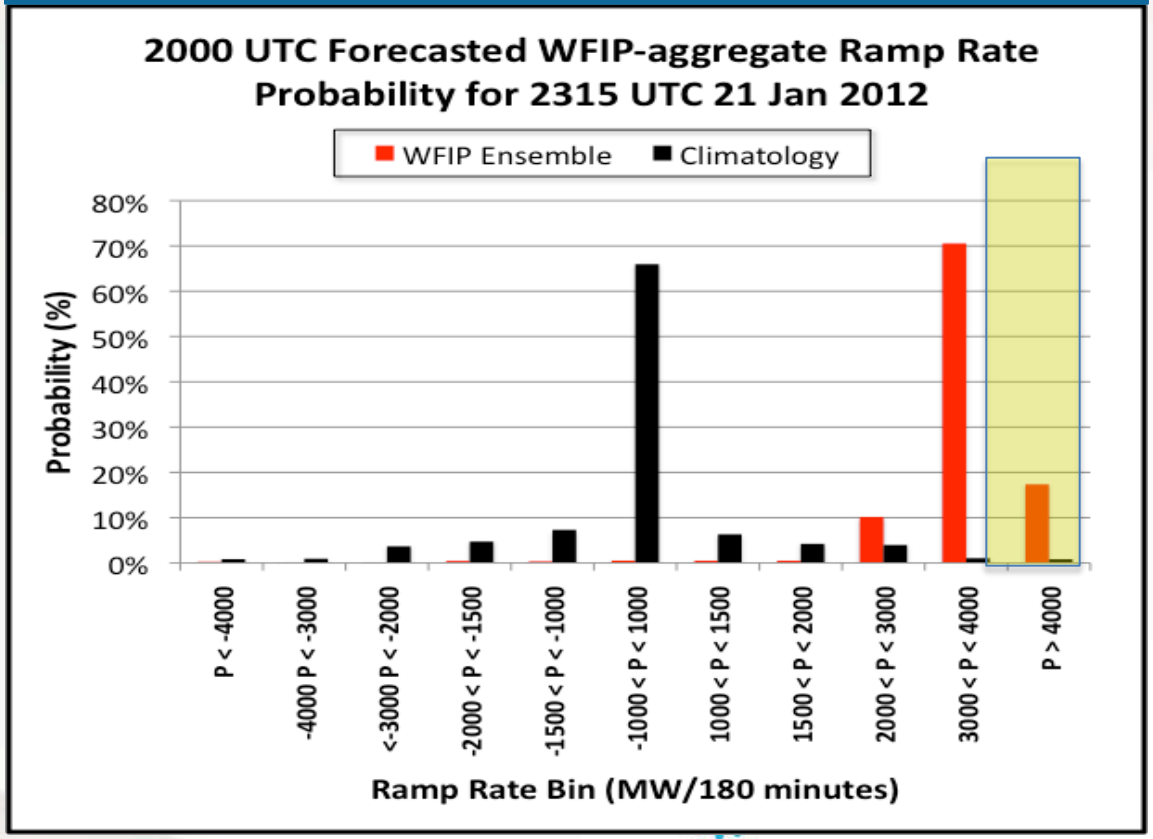
Most Significant Project Impact: Probabilistic Ramp Rate Forecasts

- 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%



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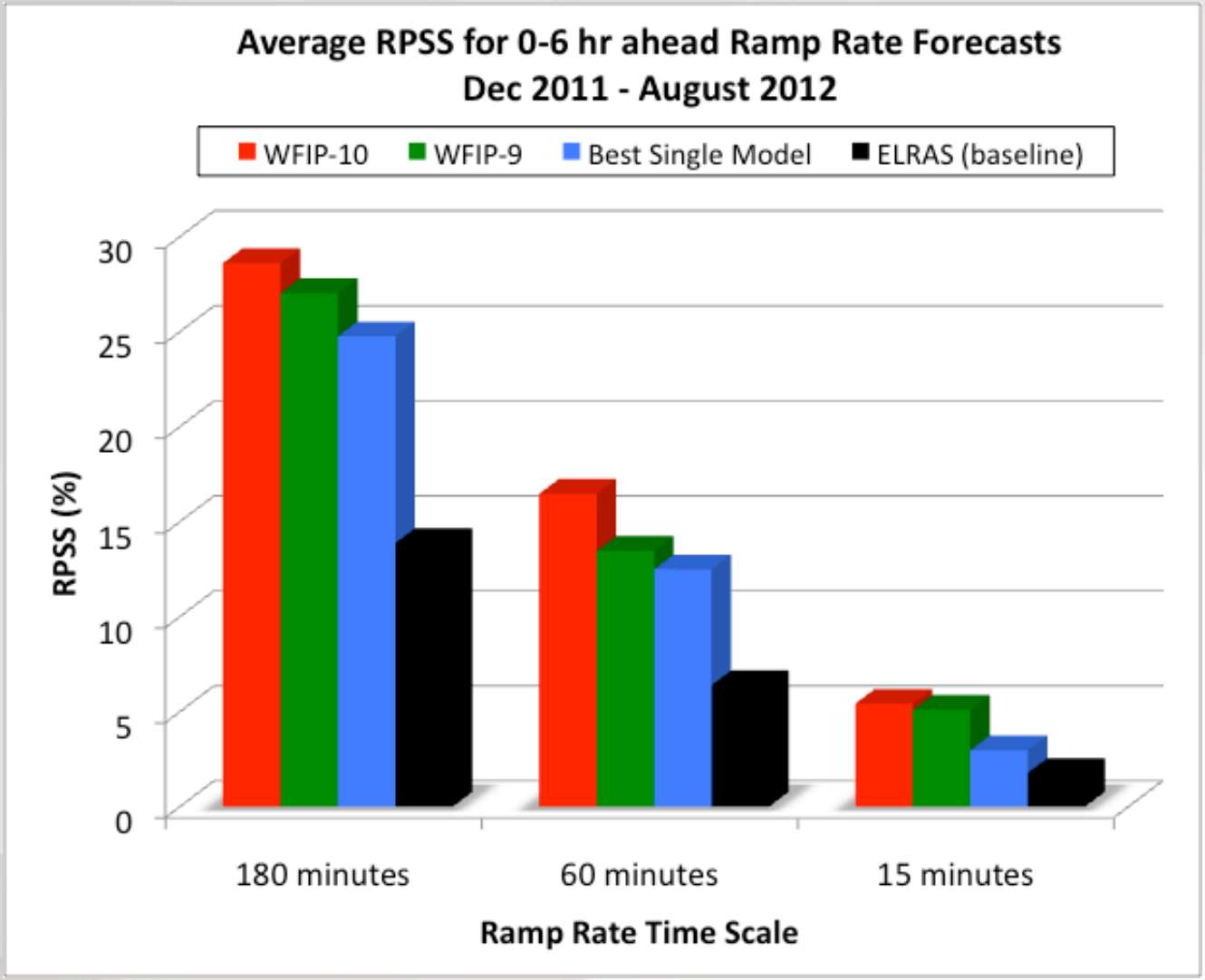
Probabilistic Ramp Rate Forecast Performance December 2011 – August 2012



- 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

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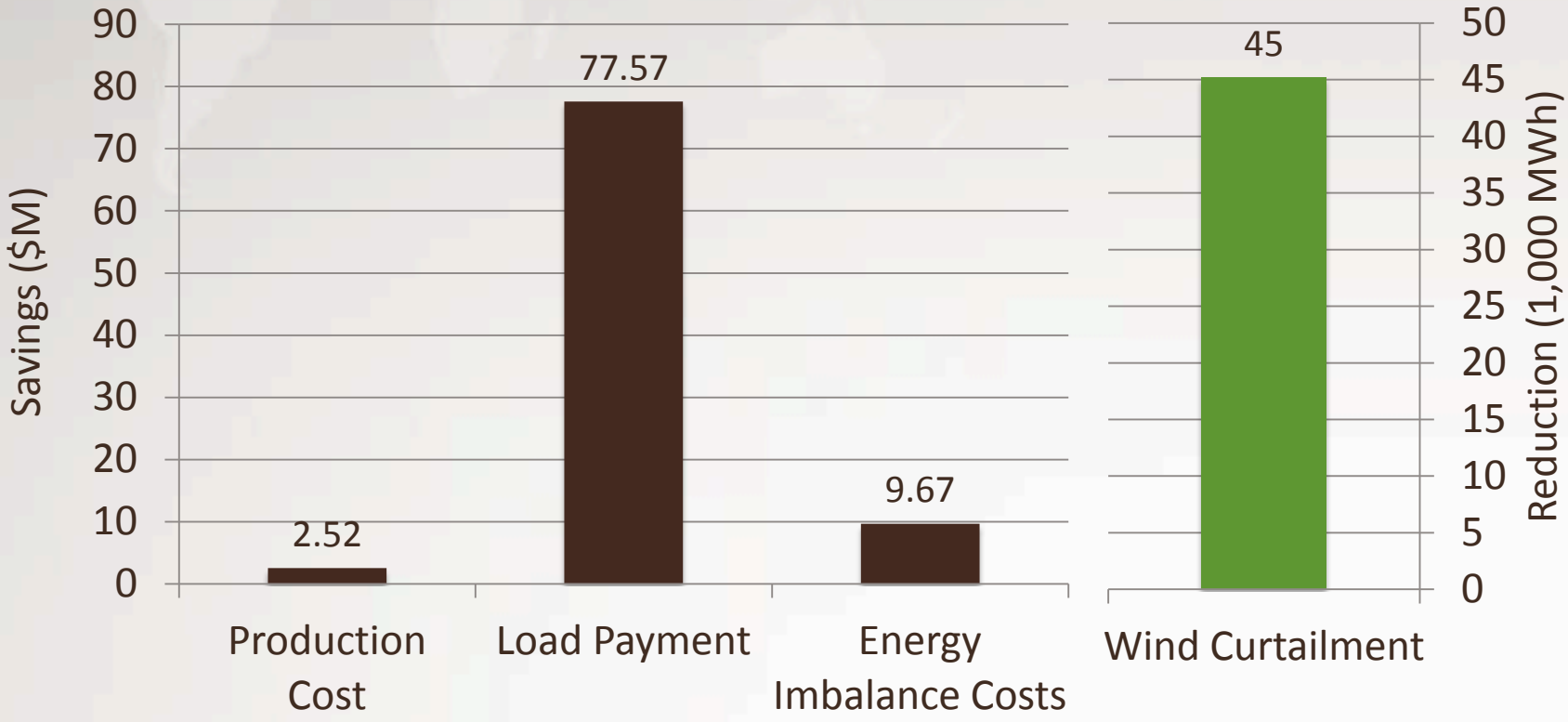
Impact of 1-Year of Improved 6-hr Deterministic Forecasts: STWPF - WFIP

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

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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

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Thank You

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