



# *“Discovery Across Texas”*

*New Technology Solutions for Wind Integration in  
ERCOT*

## ***Synchrophasor Project Status Update***

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# DOE Smart Grid Demonstration Project

- Title: *Discovery Across Texas*: Technology Solutions for Wind Integration in ERCOT
- Prime contractor: Center for the Commercialization of Electric Technologies (CCET)
- Original Award Date:
  - 4 January 2010
- Award Number:
  - DE-OE-0000194



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## A Smart Grid Demonstration That is 3-5 Years Ahead of the Market in ERCOT & Addresses a National Challenge

- **Demo Focus #1:** Grid management challenges with 18 GW of wind
- **Demo Focus #2:** The promise of demand response in the residential and small commercial sector that is more compatible with the wind
- **Demo Focus #3:** Utility scale battery storage matched with wind power profiles
- **Demo Focus #4:** Plug-in Electric Vehicles influence on redistributing load to complement the wind



# Demo Focus #1: Improve Grid Management

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- Grid monitoring through Wide-Area Visualization
- Improved operator tools
- Application of Phasor Measurement
  - Post-event analysis
  - Model validation



# Demo Focus #2: The Promise of Demand Response

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- Direct load control with combined capabilities of radio/Internet-based and smart meter/AMI/SMT based systems
- Consumer response to pricing programs (critical peak, TOU for PEV, wind incentive, timing of PEV charging)



# Demo Focus #2: Featured Technologies and Services Through Pecan Street Inc.



High efficiency HVAC systems



Electronic Vehicle (EV) charging



Rooftop solar for serving as Distributed Generation (DG) for each home



Home energy management services including an in-home display & software applications to help homeowners manage their electricity more efficiently



2-way metering capabilities to support DG and new-generation demand response programs



Wind Power Purchases Available from AE



Extraordinary high building envelope efficiencies



Smart appliances



# Demo Focus #3: Wind Farm and Battery Storage

Reese Technology Center will have six wind turbines operating in 2013.

CCET will provide a utility scale battery system at Reese Technology Center.



Source: Reese Technology Center Web Site



Example Battery System at Xtreme Power.  
Source: Xtreme Power Web Site



# Demo Focus #3: Wind Farm and Battery Storage

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- Reese Technology Center will have six wind turbines operating in 2013
- CCET will provide a utility scale battery system at Reese Technology Center
- South Plains Electric Co-op will own and operate the battery system to complement wind generation
- Texas Tech will evaluate performance





# Demo Focus #4: Plug-in Electric Vehicles

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- Demonstration at the Mueller Community
- Incentives for changing charging times
- Current Federal CAFE policy provides incentives for PEV
- U.S. and foreign OEMs are rolling out PEV
- Charging infrastructure is being planned and deployed
- Note: a typical 3 kW vehicle charging load could raise the average household load by 50-100%



# Synchrophasor Project Participants

- Center for the Commercialization of Electric Technologies
  - Dr. Milton Holloway
- Project TO/asset owner partners
  - American Electric Power Texas – 14 locations\*, 1 PDC
  - Oncor Electric Delivery - 16 locations\*, 3 PDCs
  - Sharyland Utilities - 3 locations\*
  - Electric Reliability Council Of Texas (ERCOT) - 1 PDC, RTDMS visualization platform, ePDC data archiving, PGDA event analysis
- Electric Power Group – synchrophasor tools & services
- Southwest Research Institute – cyber security services

*	Total Planned Locations		Committed for Cost Share	
	AEP	14	4	
	Oncor	16	12	
	Sharyland	3	3	



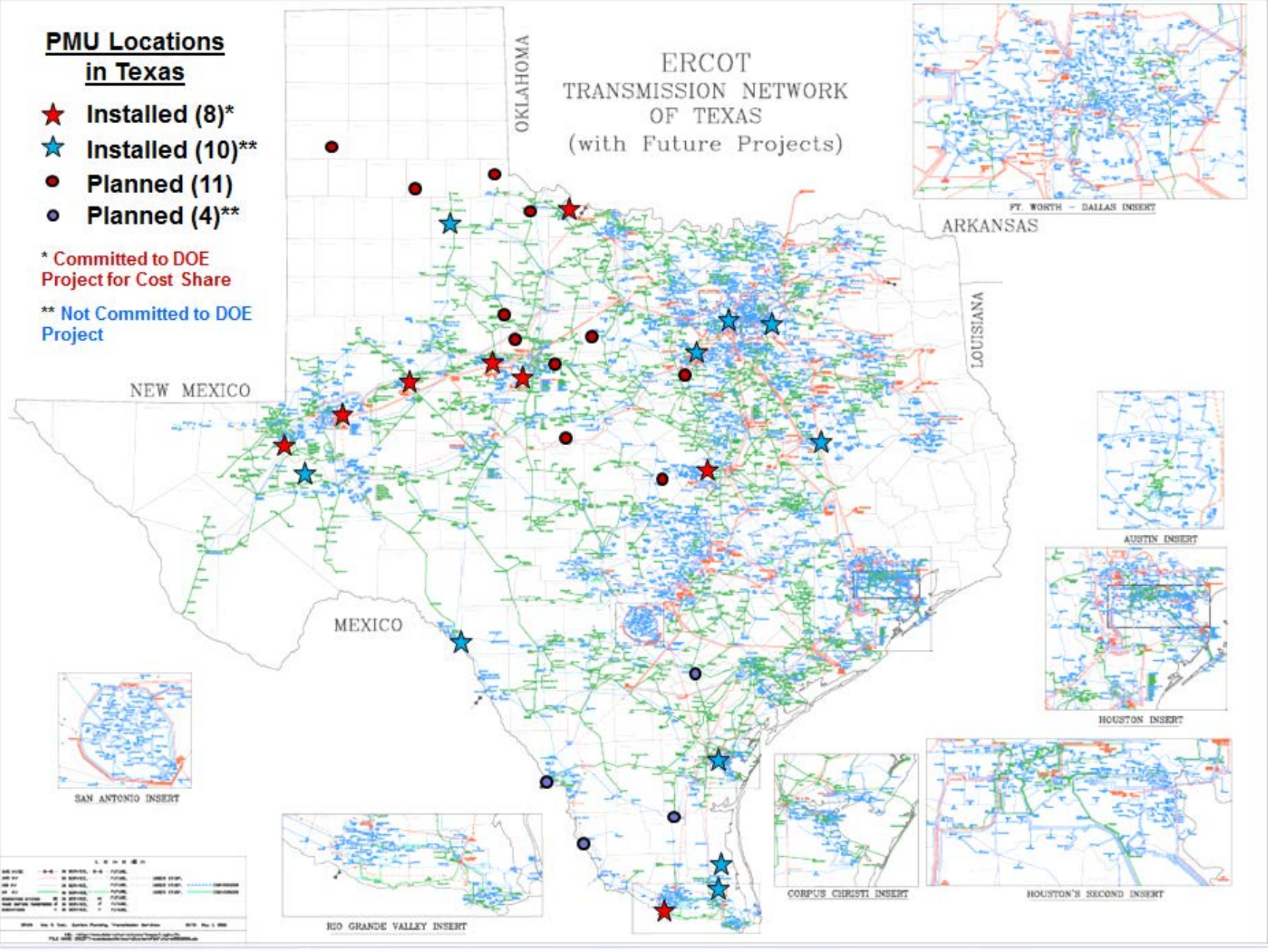
## PMU Locations in Texas

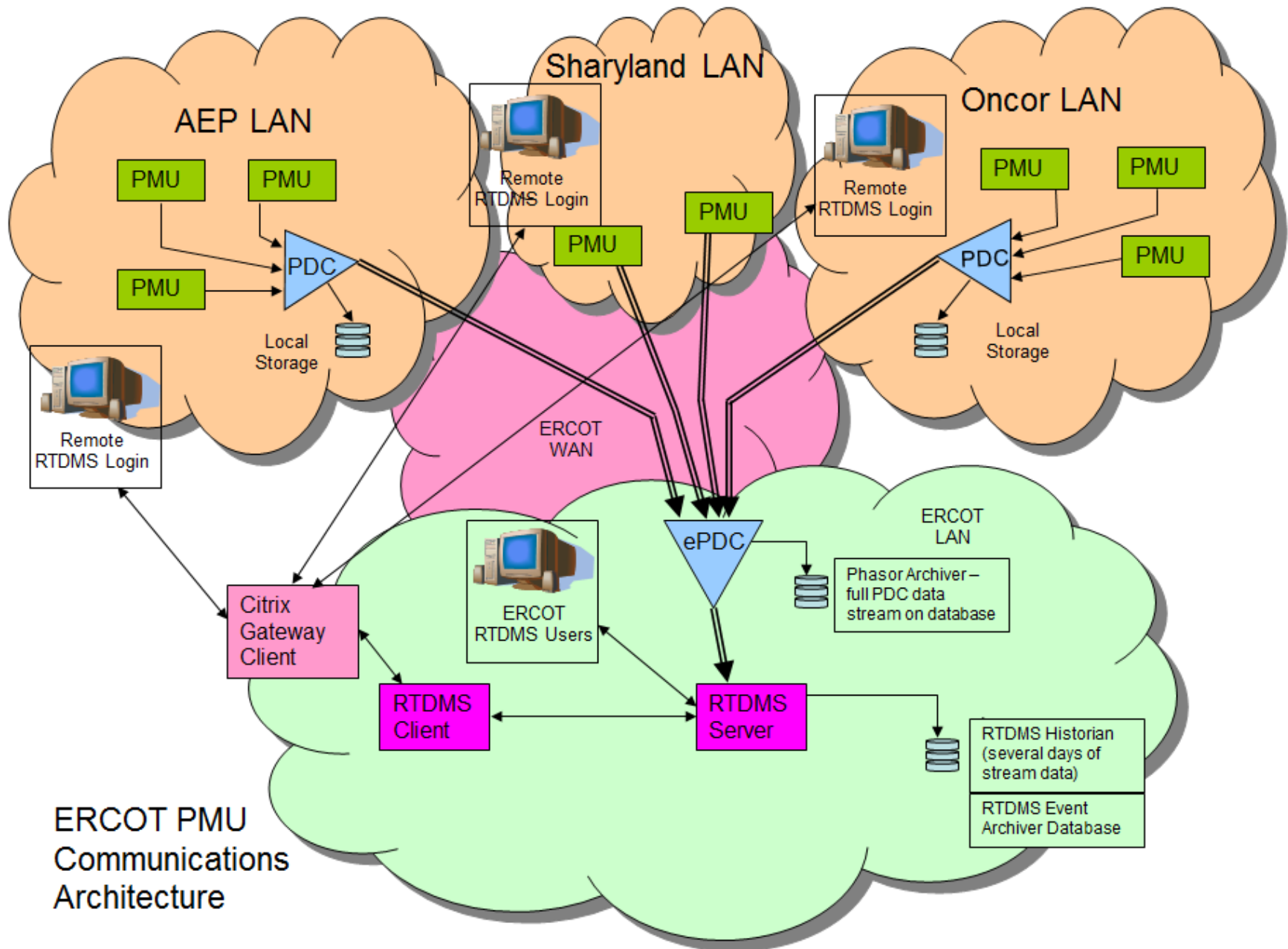
- ★ Installed (8)\*
- ★ Installed (10)\*\*
- Planned (11)
- Planned (4)\*\*

\* Committed to DOE  
Project for Cost Share

\*\* Not Committed to DOE  
Project

## ERCOT TRANSMISSION NETWORK OF TEXAS (with Future Projects)





ERCOT PMU  
Communications  
Architecture

# Project Timeline

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- PMU Installations
  - 18 locations installed and operational (26 PMUs)
  - 15 additional locations planned (26 PMUs)
- PDCs
  - 3 PDCs installed and operational (two TOs and ERCOT)
- Communications
  - TOs using internal utility networks between PMUs and TO.PDCs
  - ERCOT Private WAN being used for all TO.PDC—to—ERCOT.PDC communications – fully operational
- Real Time Dynamics Monitoring System (RTDMS) deployed at ERCOT
  - RTDMS presently used for monitoring
  - TOs have client access to ERCOT displays





# PMU Coverage

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(At Project Completion)

- Sparse network of PMUs touching ~70% of regional grid footprint for wide-area applications
- Three transmission owners in project and total of 52 PMUs at 33 locations (planned)
  - Each TO is selecting its own PMU specs and vendor
- Transmission elements to be monitored by PMUs
  - 18 substations at 345 kV
  - 13 substations at 138 kV
  - 2 substations at 69 kV
- Minimum PMU sampling rate – 30 samples/second
- PMU types
  - Using SEL 421 and GE D60 relays as PMUs



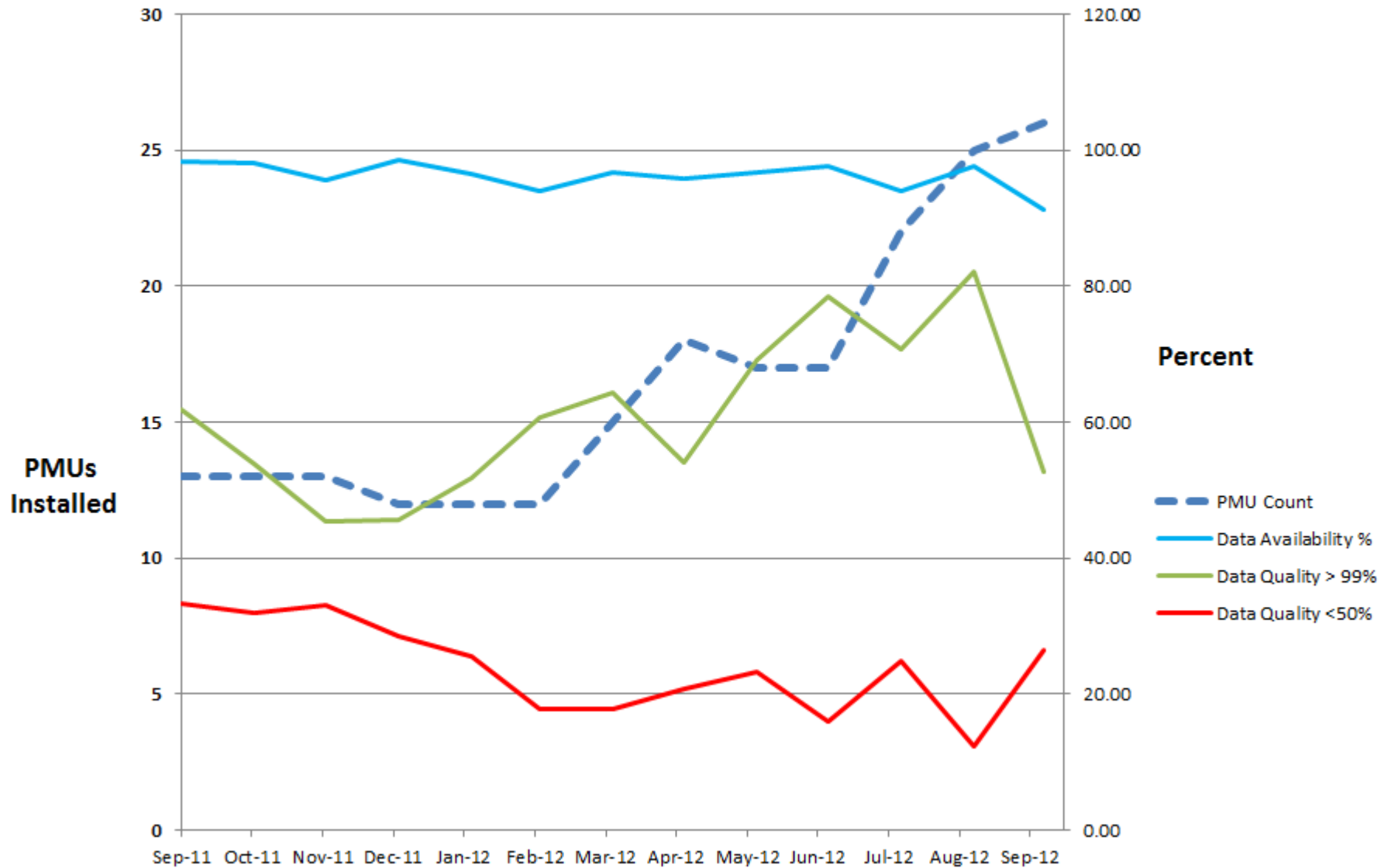
# PDCs and Communications

(At project completion)

- PDCs
  - One ePDC at ERCOT Control Center
  - Three TOs will have central PDCs
  - One TO will have a two substation PDCs
  - Archive/database configuration
    - RTDMS Data Base sized for 30 days of stream storage (50 GB)
    - ePDC Data Archiver sized at 1 TB, sufficient for 400 days
    - Data is being replicated from Data Archiver onto off-line storage
      - Current plan is to retain full resolution stream data for at least three years
- Communications system
  - PMU communications circuits include both utility-owned and leased circuits, such as copper and microwave radio
  - PMU data streams are aggregated via PDC at each utility, and delivered over ERCOT Private WAN to ePDC at ERCOT



# ERCOT PMU Data Quality and Availability



# PMU Data Quality - Observations

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- The number of connected PMUs has doubled over the past 13 months
- Overall data availability has remained consistently high (>90%)
- The percentage of high quality timely data has risen from 60% to 80%
- The percentage of poor quality data has fallen from 33% to 20%
- Data quality for new PMUs is initially low, but improves rapidly





# Phasor data-sharing

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- Three TOs are participating in this Demonstration Project
- All participating TOs will have access to view ERCOT's wide-area situational awareness displays
- Phasor data is delivered from the TOs to ERCOT
- Phasor data is archived and used for post-event analysis by ERCOT
- Phasor data is available for research purposes (with appropriate NDA)





# Major Operational Applications Using Phasor Data

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- Wide-area situational awareness
  - RTDMS system (Electric Power Group) installed at ERCOT
  - Currently planned to be used as monitoring system
    - Integration into other control room applications to be determined
  - RTDMS will be implemented in Control Room for monitoring in early 2013
  - All three TOs will have access to all ERCOT RTDMS displays via remote client
- Event Analysis
  - Phasor Grid Dynamics Analyzer being used to analyze ERCOT grid events after the fact, focusing on the interactions between wind generation levels and ...
    - Inertial frequency response and governor response
    - Oscillation modes and damping
    - Angle-pair swings across network
- Model Validation
  - Phasor data has been used to identify an incorrect generator model
  - Phasor data has been used to validate State Estimator results for a major generation trip event



# Challenges and Lessons Learned

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- Biggest technical challenges:
  - Getting adequate communications services in place
  - Getting PMUs properly configured and calibrated
- Biggest execution challenges:
  - Coordinating troubleshooting of the network that connects the TO PDCs to the ERCOT PDC
    - Changes that were supposed to be transparent resulted in complete loss of data for extended periods
    - Getting the right personnel at each end of the connection engaged in resolving the connection problems in a timely manner
  - Coordinating changes in the PMU data stream
    - naming/ID changes
    - time synchronization (between upstream and downstream PDCs)
    - router and firewall configurations
    - data base management



# Other Observations

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- When the communications are functioning properly, the PMU data quality is very good
- Loss of a TO.PDC data stream cripples the ability to analyze the grid, given sparse nature of PMU locations
- Daily monitoring of PMU performance is expected to improve the overall quality of the phasor data
  - What gets measured gets done (or at least maintained)!
- Close coordination is required between TOs and ERCOT when new PMUs are added to the data stream
  - Configuration in WAMS/RTDMS system, Daily Report, etc
  - Entry of appropriate meta data



# Technology Transfer

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- Two additional TOs in the ERCOT grid have joined the project team meetings and calls to “listen and learn”
- ERCOT is hosting a broader stakeholder workshop in November focused on synchrophasor technologies



# Cyber Security Approach –

## EPG – Intel/McAfee Collaboration on Security Fabric

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- EPG and Intel/McAfee are collaborating on Security Fabric to address the electric industry cyber security challenge
- Security Fabric architected to address cyber security NIST-IR tenets for synchrophasor networks
- EPG and Intel/McAfee teams have been working on design and architecture – goal is to enable technology to work in any network using SF Gateway
- Plan is to test and validate prototype in EPG and Intel/McAfee labs prior to field demonstration and validation
- EPG will incorporate the Security Fabric elements into RTDMS and ePDC as well as provide a stand-alone Security Fabric Gateway to provide end-to-end security for synchrophasor networks
- Deployment of Security Fabric planned via software upgrade or/and Security Fabric Gateway – goal is no change to existing hardware that use TPM silicon chips in existing servers for security
- DOE was briefed on the Security Fabric





# Security Fabric Demonstration at ERCOT

## (final negotiations in progress)

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- EPG/McAfee will design, architect, and develop Security Fabric for synchrophasor networks
- EPG will implement Security Fabric components in its ePDC and RTDMS products and SF Gateway
- EPG/McAfee will test and demonstrate Security Fabric in EPG test environment
- EPG will install SF-enabled components on ERCOT synchrophasor network
  - SF-enabled ePDC and RTDMS products on ERCOT system
  - SF-enabled ePDC at AEP and SF Gateways at Oncor and Sharyland
  - SF-enabled RTDMS clients at TOs
- Perform secure data demonstration and secure visualization demonstration
  - Demonstrate resiliency in the face of cyber attack
  - Demonstrate performance
  - Demonstrations will inform industry about best practices and lessons learned



# Contacts

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