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Data Analytics R&D within the DOE OE

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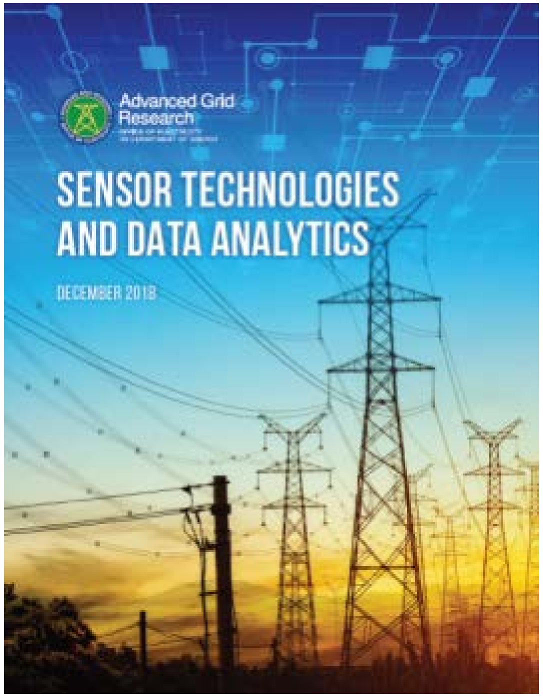
Program Manager: Eric Lightner

March 2019

Sensor Technologies and Data Analytics Program



New Program for 2020

Core Technical Areas

- Enhanced Power System Resilience
- Incipient Failure/Fault Detection
- Detecting and Forecasting Behind-the-Meter DER Impacts
- Monitoring for Critical Infrastructure Interdependencies

Crosscut Technical Areas

- Collaborative, Cyberaware Sensors
- Sensor Valuation

Program launch anticipated in FY20 - contingent on appropriations

OE Priority Area and a Key Technical Area for GMI/GMLC Roadmap Implementation

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Grid Modernization Laboratory Consortium (GMLC)


Project 1.2.5: Sensing & Measurement

Technology Review and Assessment Document

August 2018

DRAFT

Project 1.2.5: Sensing & Measurement

Technology Roadmap Document

August 2018

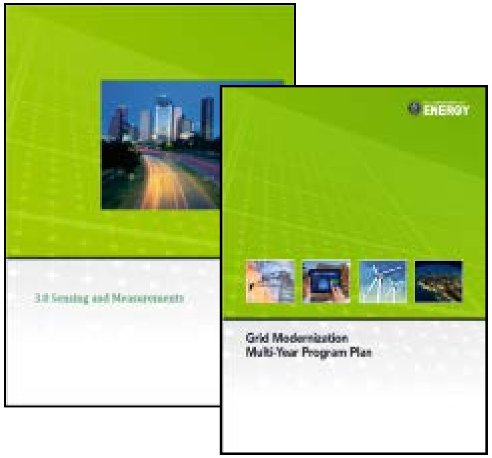
DRAFT

- A strategic partnership between DOE and the National Labs
- Brings together leading experts, technologies and resources
- Lab call funded 88 projects

GMLC Projects laid the groundwork for new Sensor and Data Analytics Program

OE & GLMC Funded Projects Relevant to Analytics

- Discovery Through Situational Awareness (PNNL)
- Advanced Machine Learning for Synchrophasor Technology (LANL)
- Integrated Multi Scale Data Analytics and Machine Learning for the Grid (LLNL)
- Sensing Electrical Networks Securely and Economically (GA Tech)
- ADMS Test Bed - VVO Use Case (NREL)

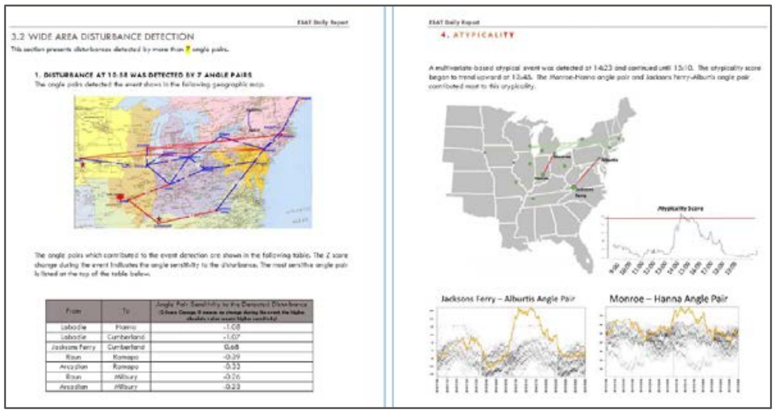


Discovery Through Situational Awareness

Project Goal: Creating situational awareness methods and tools that rely on machine-learning, statistical data mining, and data visualizations to provide insight into power grid behavior

ESAMS

Eastern Interconnection Situational Awareness Monitoring System



- Incorporates multivariate, ML algorithms for detecting phase angle anomalies and oscillations.
- Developing event detection and classification algorithms for load switching, faults, generator drops, & reactive load changes

MARTINI

Testing environment using real-time PMU data

- Evaluates anomaly detection algorithms for accuracy and functionality prior to being incorporated into ESAMS

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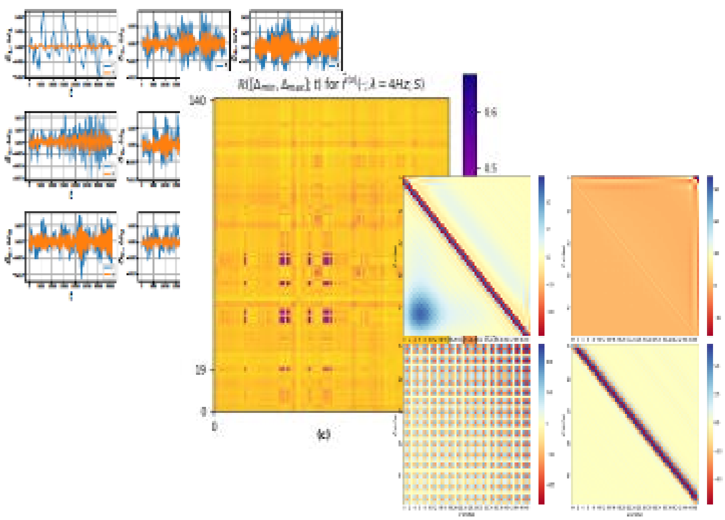
Advanced Machine Learning for Synchrophasor Technology

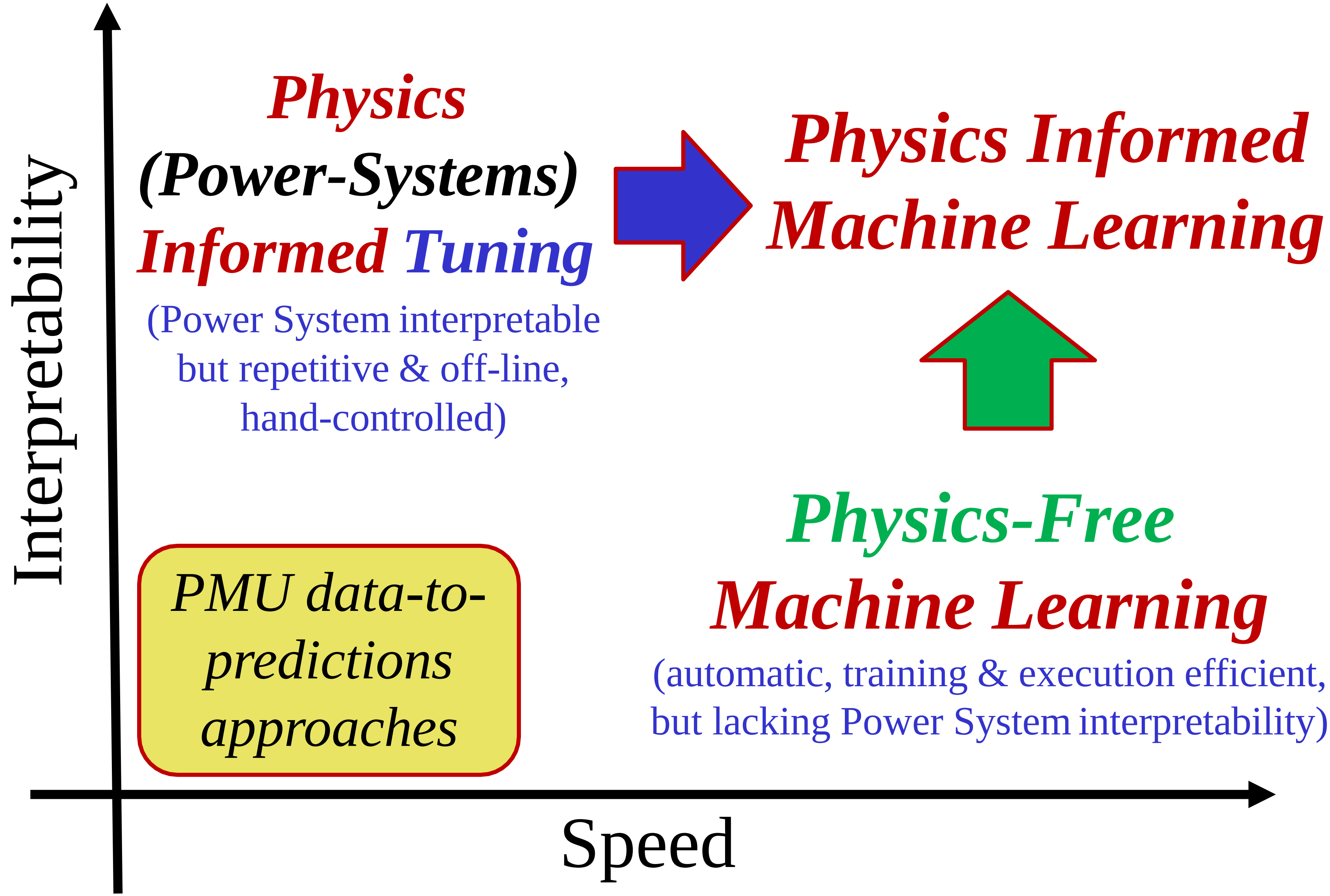
Project Goal: Use PMU data to develop Dynamic Machine Learning Technology for

- Parameter identification & topology change detection (under limited observability)
- Hidden anomaly detection such as asset malfunction (generators, transformers)
- Event/anomaly classification (load drop, forced oscillations, etc.)



Modern Data Science Tools:

- Graphical Model Learning
- Constrained Optimization
- Applied Statistics
- PCA, filtering
- auto- & cross- correlations
- Neural Networks (e.g. deep)



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Pacific Northwest NATIONAL LABORATORY

BERKELEY LAB

Lawrence Livermore National Laboratory

COLUMBIA UNIVERSITY

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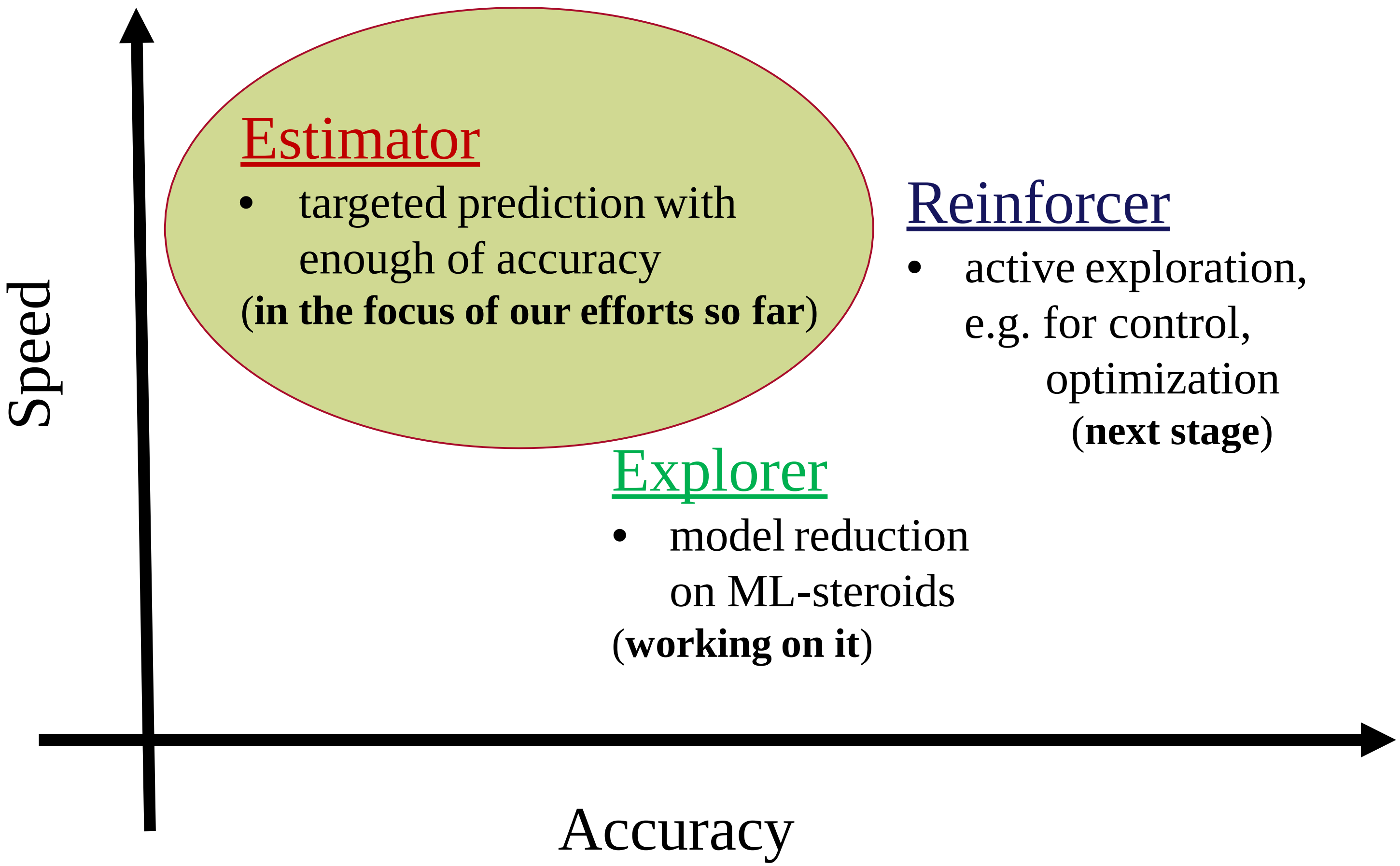
Physics (of Power Grid) Informed Machine Learning



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Integrated Multi-scale Data Analytics and Machine Learning for the Grid

Project Objectives: Develop advanced, distributed data analytics solutions; Provide visibility, and controllability to distribution grid and building operators, leveraging multi-scale data sets, from both sides of the meter; Evaluate and demonstrate machine learning techniques to create actionable information for grid and building operators.

Approach

- ✓ Investigate how machine learning techniques can be applied to streaming distributed datasets, & evaluate impacts of data quality on those methods
- ✓ Investigate how ML and data analytics techniques from other industries could be applied to the grid space
- ✓ Create an event signature database (Event Detect) to evaluate new/existing anomaly detection/classification algorithms and develop new anomaly algorithms for specific use cases

Applications investigated

- ✓ Topology and parameter estimation
- ✓ DR and DER availability and verification
- ✓ Event detection, classification and localization using streaming µPMU data

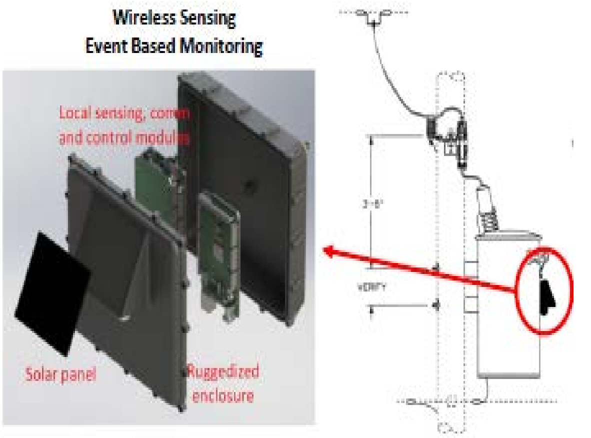
Georgia Tech Research Corporation

SENSE (Sensing Electrical Networks Securely and Economically)

Project Goal: Develop and demonstrate a secure, ubiquitous, low-cost sensor network for monitoring distribution assets which provides a sustainable ROI for utility deployments.

Project Features

- Incorporate modular sensors based on 3D printing for voltage, current and temperature, configurable for transformers, capacitor banks, reclosers and fuses.
- Integrate flexible energy management, communications, adv. functionality, data storage, cloud connectivity, cybersecurity, analytics, machine learning and user interface.
- Develop ML algorithms that identify symptoms of degradation based on measured current, ambient temperature and case temperature, for better prediction of transformer life
- Leverage historical Pecan Street AMI data to "learn" loading vs temperature relationship

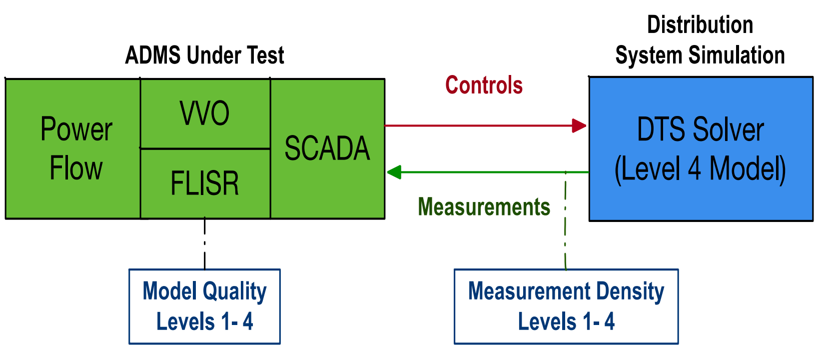


ADMS Testbed: Model Improvement Use Case

Project Objective: Evaluate the performance of an ADMS VVO application for different levels of data remediation and measurement density

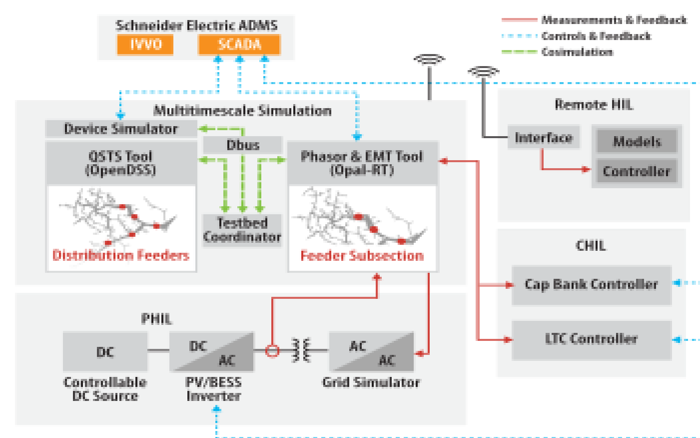
First phase:

- Software simulation only
- 4 levels of model quality
- 4 levels of measurement density



Second phase:

- Simulation on ADMS testbed
- Subset of scenarios



ADMS Testbed: Scenarios

Model Quality (MQ) Levels

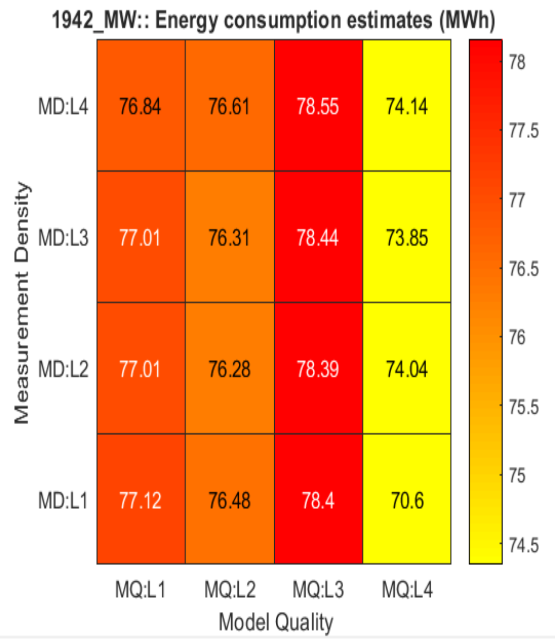
1. Base level GIS data
2. Field verification at select locations; confirm step transformer attributes, and collect capacitor, regulator and recloser attributes
3. Tap phase verifications
4. Field confirming each primary pole line by circuit to obtain distribution transformer attributes, phasing, and using Xcel Energy GIS data

Measurement Density (MD) Levels

1. Feeder head measurements.
2. D1 + voltage regulators, capacitor banks, reclosers, and 1 tail-end voltage sensor (AMI sensor) per feeder
3. D2 + a total of 10 AMI sensors per feeder
4. D2 + a total of 20 AMI sensors per feeder.

ADMS Testbed: Results

Results for a semi-rural feeder



Summary of Findings

- Results vary across feeders
- Long feeders show difference in performance for varying measurement densities
- Rural feeders show greater improvement with increasing levels of model quality
- Higher measurement density results in fewer violations

New Funding Opportunities

FY19 FOA:
Big Data Analysis of Synchrophasor Data

- Explore the use of big data, AI, and ML technology and tools on PMU data for better grid operation and management to enhance the reliability and resiliency of the nation's power grid
- Pending selection notifications and award

FY19 GMI Lab Call:
Advanced Sensors & Data Analytics

- One of five major areas
- Reflective of the foundational R&D topics identified in the *Sensor Technologies and Data Analytics MYPP*
- Addresses key OE priority
- Opportunity to jump start program prior to FY2020

Voices of Experience Series

Voices Series

Focus on areas that pose operational challenges or are critical to industry transformation.

Share knowledge to further enhance grid modernization efforts.

Capturing the Collective Voice and Experience of Utilities at the Forefront on Modernization Efforts

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AMI and Analytics

- Analytics is the foundation for making broader data-driven decisions
- Finding hidden failures or patterns requires advanced analytics and pairing AMI with new data sources (e.g., data about weather, lightning strikes, etc.)
- Involves the analysis of large imblanced and multi-structured data sets
- Requires considerable computing power that can be costly to maintain
- Cloud computing raises privacy and security concerns and questions around cost recovery

Using AMI for Analytics

- Theft detection/revenue protection
- Asset health and maintenance
- Predicting equipment failures
- Assessing impact of TOU rates
- Addressing power quality issues
- Understanding impacts of DER
- Increasing safety (detecting downed conductors & identifying unregistered DER)
- Improving customer service (new program recommendations or anticipating customer calls)

Voices of Experience What Utilities are Doing

- **Florida Power & Light Company:** iOMS, tool-based artificial intelligence ticket processing robot that eliminates non-value added truck rolls. 96% accurate, runs 24/7, resolves tickets 8X faster.
- **KCPL/Westar Energy:** Piloted a predictive failure effort for transformers. Allows them to reduce unanticipated transformer failures, better plan replacements, reduce outage times, and decrease overtime costs.
- **Oncor:** Outage notification platform sends proactive messages to customers when an outage is detected, includes an estimated time of restoration and notifies customers when power is restored.
- **PG&E:** Used customer analytics to target communications to customers that would be the most receptive to a product or service; increased enrollment in their Solar Choice program from 1 to 3%.

Insights

- Data is a valuable asset
- It's not necessary to start with a big program – start small and expand
- Pair someone who understands the data with someone who knows the business
- Requires different staffing resources
- Data scientists can use analytics to find information hidden in the data
- Look outside the utility industry at nontraditional disciplines

- **SMUD:** Will use segmentation and customer analytics to better understand forecasted load reductions based on demographics and house size for improved distribution planning forecasts

Overview

DataGuard
Energy Data Privacy Program

DOE facilitated an industry-developed framework for the protection, access, use, and sharing of customers' electricity usage data.

- A voluntary code of conduct for energy usage data
- An industry developed framework
- Outlines high level concepts and principles to be addressed; companies provide specificity
- Respects existing laws, regulations, governance policies, and business environments

Five Core Concepts

1. Notice & Awareness
2. Choice & Consent
3. Data Access
4. Integrity & Security
5. Self Enforcement & Management & Redress

DataGuard = Consumer Assurance + Responsible Sharing

DOE Program Activities

DataGuard
Energy Data Privacy Program

Recruit Industry Adopters

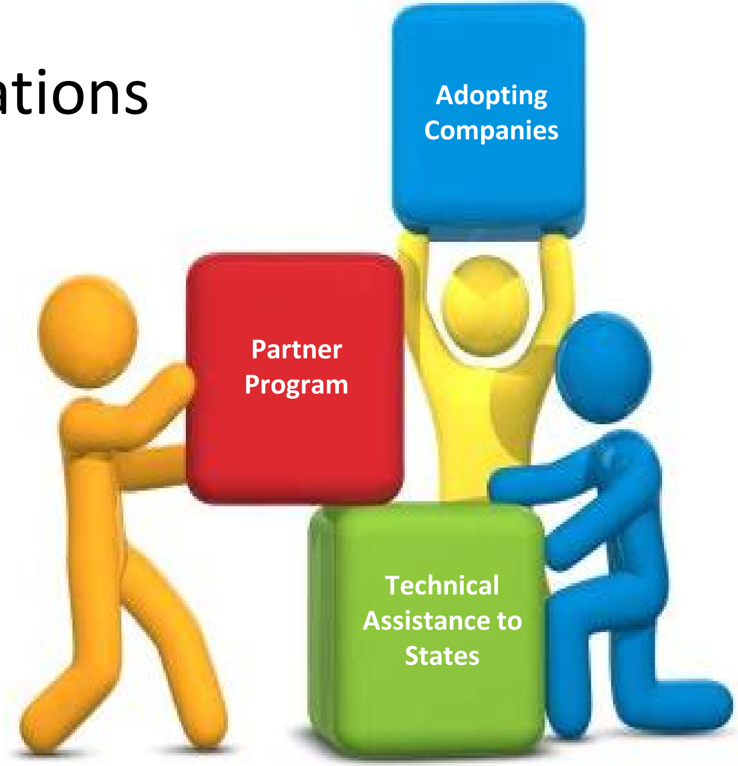
- Awareness campaign focused on third party vendors

Partner Program for Member Organizations

- Mechanism for member-based organizations to indicate their support

Technical Assistance to States

- Assist commissions considering new/updated data access, sharing and privacy regulations
- VCC as a framework



Backup Slides

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