



# TCIPG Testbed Overview

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# Testbed Overview

- Testbed equipment and simulators span the grid system
  - Generation
    - Power system modeling, RTDS
  - Transmission & Distribution
    - Relays, Substation computers, PMUs, PDCs
    - EMS, Planning, Protocol test-harnesses
  - Advanced metering
    - Meter platforms, emulation testbed
  - Consumers
    - Energy monitoring, Home automation

# Testbed Tour



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# Testbed Problem Statement

Testbed aims to support academic and industrial evaluation of TCIPG and other Smart Grid technologies

Experimental evaluation is critical for emerging technologies

- Challenge is to create virtual environment faithful to reality ...
- That is measurable, repeatable, flexible, and adaptable to emerging technology while maintaining integration with legacy gear

Leverages multiple funding sources to provide efficiency

# Testbed Objectives

- Diverse inventory of domain-specific hardware, software and simulators
- Integration of live hardware/software, hardware and software simulators/emulators into a unified virtual environment
- Intuitive description of experiment followed by automated configuration and data harvesting
- Repeatability
- Federation

# Testbed Impact

- The testbed has
  - Enabled researchers to test out algorithms using real data and real hardware
  - Spurred new activities and research revelations through use of the facilities
  - Generated project specific tools that are being evaluated for generic inclusion



# Testbed Key Accomplishments

- Horizontally and vertically scalable virtualization platforms in use and to be expanded with use of DETER
- Creation and polishing of research tools for integration into the testbed
- Leveraging industry provided data (e.g., PMUs) and provide a repository for secure data redistribution amongst approved researchers

# Testbed Tasks Completed

- Integration of new hardware and software to augment research capabilities (RTDS, power modeling, protocol harnesses, data concentration, security monitoring and assessment)
- Integration of DETER experimentation framework to provide dynamic computer resource allocation and hierarchical topologies
- Domain-specific traffic generation, interception, and coupling with simulation systems
- Evaluation of emerging technologies for their use in the testbed and pursuit of applicable technology through both donation and purchasing

# Example use of Testbed by TCIPG Activities

- **Topology Perturbation for Bad Data Detection**
  - Leverages RTDS, DETER, and other testbed resources extensively to provide modeling and validation of research ideas
- **Specification-based IDS for AMI**
  - Leverages smart-meter testbed emulation to prototype and refine research
- **S3F Network Simulation Engine**
  - Leverages testbed hardware and domain-specific software to advance scaled cyber-physical simulation

# Testbed Directions for Coming Year

- Ongoing expansion of DETER to support vertically scaled resources and customized integration of domain-specific hardware
- Expansion of automated reconfiguration of domain-specific hardware and software
- Increased interaction with industry and other testbeds to evaluate technology use, match direction, provide insight, and increase engagement

# Questions and Discussion