Testbed Overview

Overview and Problem Statement

To provide a cutting-edge facility that enables foundational research in the smart grid domain.

Research Objectives

- Span transmission, distribution & metering, distributed generation, and home automation & control, providing true end-to-end capabilities.
- Provide foundational support for TCIPG projects.
- Analyze research across varying fidelities and scales.
- Serve as a national resource for experimental work in research and analysis of trustworthy power grid systems.

Technical Description and Solution Approach

- Problem Space:
  - How does one provide a scalable and flexible framework that can operate at varying fidelities to facilitate emerging research?
  - What is the right mix of simulation, emulation, and real equipment to accomplish the research goals?
  - How does one programmatically set up, integrate, control, and interact with this equipment?
- Approach:
  - Develop new modeling and evaluation technologies to enhance evaluation capabilities of the testbed.
  - Continue to expand testbed capabilities, features, and functionality through strategic integration of equipment.
  - Provide integration glue that provides unique capabilities in the testbed environment.
  - Leverage existing & emerging research from other areas when it can advance the testbed effort's goals.
- **Smart Grid Application Area:** End-to-end system and individual components.

Results and Benefits

- Virtual Power System Testbed (VPST and RINSE/S3F): large-scale cyber-physical simulation.
- Network Access Policy Tool (NetAPT/NP-View): policy tool to evaluate network access paths and verify compliance with a global policy.
- Tools and analysis of smart grid protocols (Amilyzer, protocol parsers and test harnesses, and scalable environment).
- Quantum Key Distribution: validation of external quantum computing research through application to smart grid systems.
- Enabling advanced research for smart grid efforts throughout the world via federation and collaboration.
- Flexible framework leverages tailored operating constraints to use resources efficiently.
- Open for collaborative research, facility-driven use, sponsored research, and technical testing.
- **Partnerships and External Interactions**:
  - Enabling smart grid research and transition of technology.
  - Leveraged for other industry interactions and projects.
- **Technology Readiness Level:** Always adding capabilities, but fully functional and in active use.

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Capabilities

- Full end-to-end smart grid capabilities.
- On-grid testing capabilities via Ameren TAC facility (with fiber-optic interconnects to our primary testbed).
- Deployed advanced metering infrastructure (AMI).
- Solar research platforms.
- Real, emulated, and simulated hardware/software for scalability.
- Real data from the grid, industry partners, etc.
- Power simulation, modeling, and optimization of various forms.
- Network simulation, modeling, and visualization of various forms.
- Advanced hardware-in-the-loop cyber-physical simulation.
- WAN/LAN/HAN integration and probes.
- Security and protocol assessment tools (static/dynamic analysis, test harnesses, fuzzing).
- …and more

Assets

- RTDS, PowerWorld, PSSE, PSCAD, PSLF, DSAtools, DynRed.
- RINSE, tstBench, LabView, OSI PI, OSIi Monarch, SEL suites, PGDA.
- Full range of open-source power grid tools (openDNP3, openPDC, openPG, openXDA/openFLE, openHistorian, SIEGate).
- GPSes, substation computers, relays, PMUs, testing equipment, PLCs, security gateways, NI platforms.
- Power analysis tools, PDCs, data analytics.
- Full AMI deployment, TCIPG Smart Meter Research Platform.
- RTUs, F-Nets, inverters, oscilloscopes, firewalls, embedded devices, sensors, spectrum analyzers, SIEMs, IDSes.
- Home EMS, energy and environmental monitoring devices, ZigBee, automation.
- Display wall, visualization platforms (STI, RTDMS), training platforms.
- Mu Dynamics, Fortify, security research tools, IBM Tivoli suite.
- DETER integration and cyber-physical extension via federation.
- … and more.

Use Cases

- Provide a multifaceted approach to security through testbeds, education and training, field testing, and tool creation.
- Facilitate collaboration among researchers and industry to work towards creation of more resilient critical infrastructure.
- Facilitate rapid transition and adoption of research in industry.
- Provide positive real-world impact through engagement.
- Allow for cutting-edge smart grid security research.

Industry Donations

Bayshore Networks, Byres Security, Electric Power Group, Endace, GE, InStep Software, IBM, Invensys, Itron, Mu Dynamics, National Instruments, Novatech, Nuclear Regulatory Commission, Open Systems International (OSI), OSIsoft, PowerWorld, Schweitzer Engineering Labs, Siemens AG, SISCO, Space Time Insight, Trilliant.

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