GOALS
• Span transmission, distribution & metering, distributed generation, and home automation and 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.

FUNDAMENTAL QUESTIONS/CHALLENGES
• 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?

RESEARCH PLAN
• Develop new modeling and evaluation technologies to enhance evaluation capabilities of the testbed.
• Continue to expand the testbed capabilities, features, and functionality through strategic integration of equipment.
• Provide integration glue that provides unique capabilities in the testbed environment.
• Leverage existing and emerging research from other areas when it can advance the goals of the testbed effort.

HIGHLIGHTED RESEARCH RESULTS
• 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.

BROADER IMPACT
• 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.

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, 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)
• GPSs, 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, IDSs
• 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.