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## ABSTRACT – RESEARCH CAPABILITIES AND INTERESTS FOR ELECTRICITY INFRASTRUCTURE HARDENING

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INFRASTRUCTURE HARDENING

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### Current Capabilities:

The current capabilities affiliated with the Power Center for Utility Explorations at the University of South Florida include unique facilities, faculty expertise, extensive collaborations on infrastructure development, and an electric utility specific power engineering program with numerous outreach efforts.

**Facilities** - The main facility related to infrastructure issues is the Power and Energy Applied Research Laboratory (PEARL). This facility is an outgrowth of the previous Power Quality Lab which has been in existence for 20 years in Florida. The lab has the following capabilities:

1. First facility in the world with the capability to generate three-phase arbitrary field captured electrical measurements of voltages and currents to apply to devices under test. Devices and systems under test may include substations, underground lines, overhead lines, transformers, meters, breakers, motors, motor drives, and many other utility and customer systems. This capability is useful for monitoring, modeling and evaluating the status of power system elements during both normal and contingency conditions due to severe weather. Further, this capability permits controlled lab studies of utility systems prior to severe conditions occurring in the utility grid for both **Preparedness** and **Hardening** evaluations.
2. The facility has been used to monitor power systems in Florida and nationally in real-time over a sustained 2-decade period.
3. Some of the main equipment in the facility includes advanced power line conditioners, waveform generators, three-phase power amplifiers, precision power measurement standards, transconductance three-phase amplifiers, dynamometer, remote monitoring and data acquisition systems, advanced relay testing systems.
4. Numerous advanced power system analysis packages for simulation studies.

**Expertise** – The faculty at USF and collaborating faculty worldwide include experts in specific areas related to electricity infrastructure, and include the following key people with the PCUE: Dr. Alex Domijan (flexible-reliability-intelligent-energy-delivery-systems, weather and reliability, power quality), Dr. Suresh Khator (performance of underground vs. overhead systems, computer data-base management), Dr. Ralph Fehr (system planning, distribution systems), Dr. Rimas Slavickas (Infrastructure management and cost/benefit analysis, load factor improvement analysis), Dr. Carlos Alvarez, affiliated faculty (distributed systems, micro-grids, non-intrusive measurements). Additional collaborators include Dr. Lee Stefanakos and Dr. Yogi Goswami in alternate energy systems. Furthermore, approximately 30 faculty from around the world (Spain, Japan, Taiwan, South Korea, Europe) are affiliated via the FRIENDS effort in electrical infrastructure development.

Also, Dr. Domijan and his staff at PCUE have many years of experience in monitoring the weather and reliability in a large part of Florida (FPL system) with 100+ people involved. Correlations of reliability with weather factors such as wind, pressure, rain, etc...are being conducted along with statistical, neural network and extensive database management techniques.

***Collaborations on Electricity Infrastructure Development*** – The Flexible-Reliable-Intelligent-Electrical-eNergy-Delivery-Systems (FRIENDS) is a decade long international collaborative effort to form a road-map from the grid of today to the future. The future electrical grid may be one that is hardened for various contingencies, including severe weather, but fits within the financial realities of present utility systems. FRIENDS efforts include hardened substation architectures, reliable grid topologies, and quality control centers, among many others. Collaborations with experts involved with systems that are similarly affected by severe weather are desirable and may be shared with Florida utilities to assist in hardening issues.

***Electric Utility Power Engineering Program and Outreach*** – The Power Center for Utility Explorations operates an electric power engineering program geared for electric utilities and power equipment manufacturers, so as to both develop future engineers and assist in training current engineers. The power program is an outgrowth of the previous Florida Power Affiliates program which has existed for 20 years. Several hundred power engineers are employed by the utilities in Florida having been trained in this power program. The courses offered by the PCUE include: Electromechanical Systems 1 • Electromechanical Systems 2 • Energy Conversion Laboratory • Electric Utility and Energy Systems Seminar Series • Power System Analysis 1 • Power System Analysis 2 • Industrial Power Distribution 1 • Industrial Power Distribution • Power Quality • Power Electronics • Electronic Converter Systems and Drives • Utility Distribution Systems • Power System Protection • Power Markets • Energy Management Systems • Power Plant Engineering • Power System Reliability.

**Special Feature:** Joint International Degree Power & Energy Program with FRIENDS partner Spain (50+ credits)

**Numerous Outreach Activities:** Power Cons on Blackouts, New Technologies, PQ, Weather and Reliability

The next generation of power engineers, as well as current utility engineers, must be trained to meet the challenges of preparing and hardening the electrical grid due to hurricanes. The PCUE power program may be used to meet this challenge in collaboration with the utility industry, state universities, and many other international partners.

**USF Overview and Additional Capabilities:** USF has 43K students (9<sup>th</sup> largest in the U.S.), \$1.4B budget, \$3.2B annual economic impact, ranked 18<sup>th</sup> nationally for student diversity and 66<sup>th</sup> in research (tied for 1<sup>st</sup> in R&D growth nationally), and is classified nationally the same as UF and FSU with “Very High Research Activity.” Major thrusts in the College of Engineering partially related to infrastructure preparedness are in Critical Infrastructures (National Institute for Systems Test and Productivity), Transportation and Logistics (Center for Urban Transportation), Energy and the Environment (Clean Energy Research Center, Center for Monitoring Hydrologic and Aquatic Systems), Nanotechnology (Nanomanufacturing Research Center), and Robotics (Center for Robot-Assisted Search and Rescue).

## **Interests:**

Projects performed related to the electrical infrastructure have included: weather and reliability, grid optimization, demand response, premium power park, FRIENDS, and biomass systems, among many others. Interests for potential studies to assist the electric utility industry in Florida include a broad spectrum of efforts related to preparedness and hardening. This assistance may include topics such as:

- Weather and Reliability studies and monitoring;
- Grid Hot Spots determination and solutions;
- Technology evaluations and forensic Analysis;
- Performance aspects of underground and overhead systems;
- Additional Interests: Power Quality, Micro-grids, distributed systems, system planning, demand response, vegetation management needs determination, crew allocation and manpower needs for fast restoration of service, real time monitoring and non-intrusive measurements.

**Working With State University Partners:** The Florida Coastal Monitoring Program at UF (Dr. Kurt Gurley) working in collaboration with PCUE at USF would enhance hurricane information during the event in a weather and reliability database. The Center for Advanced Power Systems at FSU is a collaborator on electricity infrastructure and their lab facility has substantial capabilities for real-time analysis.