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SMART GRID NEWS FROM UCF

FEEDER Grows Education and Research



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Inside FEEDER

FEEDER News	2
FEEDER Summer Institute	3
Student Innovation Board	3
FEEDER Shared Course	4
Capstone Design Project	4
Research & Development	5

UCF leads the 12-university **FEEDER** team for the Department of Energy, and news of the overall FEEDER Program is summarized in the pages that follow. But we want to be "upfront" here on Page 1 about the many ways that FEEDER is bringing together our faculty and students with utilities and supporting industries, aggressively growing innovative research, education and professional development towards a smarter and more reliable, resilient, economic and sustainable grid. Recent examples include:

The Resilient, Intelligent and Sustainable Energy Systems (**RISES**) cluster is a university-wide, multi-disciplinary team of faculty and students committed to transformative and collaborative research in resilient, intelligent and sustainable energy systems. Through partnerships among university, utility and government stakeholders, we aim to facilitate deployment and integration of renewable energy resources, as well as provide innovative solutions that make electricity grids self-organizing, efficient and resilient. The cluster focuses upon holistic analysis, design, development and deployment of distributed renewable energy resources (PV systems in particular), advanced information, communication, control and optimization technologies, along with supporting economic and management policies. Through meeting these technical goals, we can reliably integrate renewable resources, achieve better power quality and best use markets to enable customers to make intelligent and environmentally conscientious decisions.

UCF leads a team working on the DOE project ENabling Extreme Real-time Grid Integration of Solar Energy (**ENERGISE)**. The team includes FEEDER partners Duke Energy, Siemens and the University of Hawaii. This three-year project will design and develop a scalable architecture and set of algorithms for distributed control and optimization. The platform encompasses automatic fault location, isolation and service restoration and Volt-VAR optimization; distribution system state estimation algorithms; a three-phase unbalanced power flow model that captures the non-linear behavior of system components and enables rapid computation of the sub-transmission and unbalanced distribution networks; a two-stage stochastic security-constrained algorithm for real-time operational planning; and a distribution energy market framework to provide market-based signals for real and reactive power control of PV systems.



Longtime partners UCF and Siemens recently launched the **Siemens Digital Grid Lab**, which features the cutting-edge technology used by progressive electric utilities to manage the nation's power systems. At UCF, the lab will help the next generation of engineers modernize America's energy grid. Students now have hands-on training with real-world software and hardware to design and manage self-healing power-distribution grids to quickly recover from natural disasters, cyberattacks and other outages. They also train on the industry's latest microgrid software to manage and operate dynamic generation assets such as solar, wind power, storage and electric vehicles. The lab also features software platforms to map out grid transmission needs and simulate models of of the UCF campus power system where students will learn how to design and actually test a self-healing distribution grid. The lab can also be used to conduct simulations for commercial customers, helping energy users better analyze distributed-generation assets.

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From the IAB Chair:

FEEDER is an innovative network among utilities, their supporting industries, university faculty and the students who will be their future leaders in the rapidly changing energy business. This collaboration provides a platform for seizing the business opportunities of the smart and distributed grid. Our unique programs focus on the practical challenges of today which are stimulating research into new devices and enhanced methods for control, communication, cyber-physical security and economic optimization, while re-defining standards for reliability and resiliency.

For a utility veteran, it is truly exciting to see the investment and corporate interest moving out onto the circuit feeder and beyond to the end customer. The energy of our FEEDER students confirms this is "where the action is."

-- Tom Lawery



Tom Lawery

Wholesale Renewables Manager, Duke Energy

Chair, FEEDER Industry Advisory Board

GEARED-FEEDER NEWS

The FEEDER (Foundations for Engineering Education for Distributed Energy Resources) Consortium, funded by the GEARED (Grid Engineering for Accelerated Renewable Energy Deployment) program under the Energy Efficiency and Renewable Energy (EERE) of the Department of Energy, is one of three national-network centers that support power systems curriculum development and professional training based on R&D, data generation, collection, analysis, and simulation. The overall goal is to advance adoption of distributed energy resources and deployment of smart grid technologies through partnering with highly-qualified advisory and steering committees from utilities, universities, national laboratories and product suppliers. The FEEDER Consortium attracts and educates students to become future power engineers, and to meet the challenges of re-engineering the electric grid to incorporate distributed generation. FEEDER enhances the legacy curriculum for power systems to include distributed generation, electric vehicle charging and other smart grid issues. Program features include the FEEDER Summer Institute, Student Innovation Board, regular seminars and related activities. Its cross-institutional research collaborations are achieved through active involvement of partner utilities, consultants, manufacturer and suppliers , effectively transferring relevant knowledge and expertise from existing power engineering experts to a new generation of engineers. Concurrently, faculty from the consortium are able to deliver the latest advances to mid-career engineers through professional development programs using a variety of options, including on-site short courses, video conferencing, distance learning, online face-to-face and other media.



FEEDER Summer Institute

In order to train graduate and advanced undergraduate students who are interested in distributed energy resources, FEEDER offers the Summer Institute each year. This is a unique opportunity to combine theory and practice with the development of leadership skills among the students who will be the next generation of leaders in the electric utility industry. In 2016, the FEEDER Summer Institute was held in at NREL in Golden, Colorado, when thirty students and more than ten faculty members participated in the program. As part of the technical program, students had the opportunity to tour the NREL labs and attend lectures delivered by NREL and FEEDER researchers on distributed energy resources, distribution planning and analysis, and distribution system operation and control, while acquiring hands-on experience in group projects. There were also social activities for the participants in the mountains of Colorado, visiting the Red Rocks Park and Dinosaur Ridge.

During FEEDER Summer Institute 2015 at University of Kentucky, and 2014 at University of Central Florida, FEEDER students had tours at the Bluegrass Energy Distribution Site, Ohio Falls Hydroelectric Station of LG&E, Chalmers Wind Farm, the Duke Envision Center and TVA's Bellefonte Nuclear Plant. Included were workshops and short courses on Introduction to Smart Grid, Complex Networks and Fundamentals of Electricity Grids. The FEEDER Summer Institute thus helps the students develop professional contacts, technical skills and practical knowledge related to utility distributed and smart grid technologies.



Industrial tour at Duke Envision Center (Smart Grid Education Center) as part of 2015 FEEDER Summer Institute

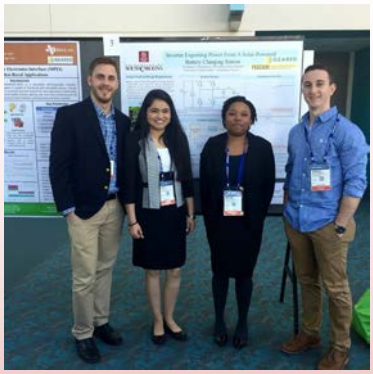
"The SIB members work closely with fellow students, faculty, utility and industry professionals to develop innovative solutions to key challenges facing the electric power industry."

Student Innovation Board

To address both technological and workforce challenges associated with the exponential growth in distributed energy resources, and to better engage students in the GEARED – FEEDER program, FEEDER Consortium university partners have created Student Innovation Boards (SIB). The SIB members work closely with fellow students, faculty, utility and industry professionals to develop innovative solutions to key challenges facing the electric power industry. Some key roles of SIB members are

- Provide leadership and encouragement for student participation in GEARED projects and activities such as industry and utility-sponsored design competitions, market analysis and business model development based on products, process and services related distributed technologies and smart grid
- Participate in an advisory role with utility and industry
- Attend and participate in the GEARED annual student conferences

In an example from the perspective of the University of South Carolina, GEARED-FEEDER SIB members Andrew Wunderlich (team leader), Vanu Kapoor, Jerrod Wigmore, and Briana Luckey, from USC attended the 2017 DistribuTECH Conference and presented two posters on PV-powered charging stations and inverters for bidirectional power flow of grid-tied PV system. Subsequently, a panel session was held in the EE Dept. at USC where the students shared their experience in how the conference helped them to develop professional contacts, leadership skills, learn more about smart grid technologies and motivated them to develop their future career path in the area of power systems. This session in turn generated interest among other EE students at USC to become part of the FEEDER program.

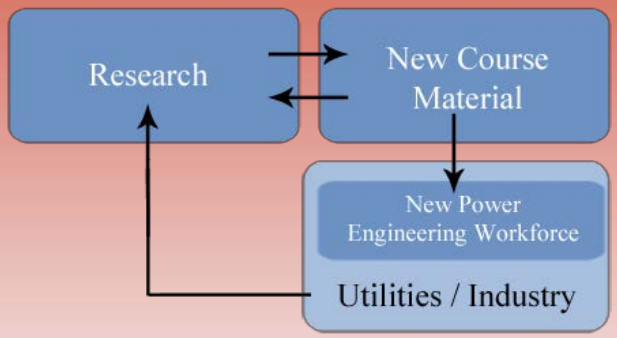


USC FEEDER students at the 2017 DistribuTECH conference

FEEDER Shared Courses

There is a heavy projected demand for power engineers to replace retiring engineers, and that demand exceeds the abil- ity of any few institutions to address. Further, education of the modern power engineering workforce needs to include recently developed topics such as integrated and distributed generation technologies, advanced grid control, protection, communications and security, as well as related content on power system economics, policy, environmental and social impacts. However, few institutions have the teaching resources in faculty specialties and faculty capacity available to teach the whole range of these topics on a regular basis.

In response, the FEEDER Consortium shares delivery of courses on distributed energy resources and emerging smart grid technologies among multiple universities. For the development of FEEDER shared courses, a survey of FEEDER industry partners is conducted in order to seek input on potential course topics. The industry partners are to consider each potential course topics and rate both its importance to the power student in general and also to be the students to be employed directly in their company.



Development of FEEDER shared course flow chart

Based on the industry partners rating and the topics that are important to them in the area of distributed energy resources, FEEDER developed and began offering these shared courses. The present and future schedule includes Spring 2017 (5 courses), Fall 2017 (8 courses), and Spring 2018 (6 courses). Some examples of these courses are Distributed Optimization and Control, Integration of Distributed Generation, Integration of Photovoltaic Generation, Design of Advanced Power Distribution Systems, Introduction to Smart Grid and Advanced Power Systems Analysis. All shared courses are listed at http://feeder-center.org/education.php#fall2017

Capstone Design Projects

FEEDER also enhances Capstone Design Projects (called Senior Design Projects at some universities) on distributed energy resources and smart grid technologies. From its utility members FEEDER solicits project titles and descriptions which are important to them for development in the area of distributed generation and smart power systems. For example, the Capstone Design Projects for the EE program at the University of South Carolina (USC) continued eight utility power projects this year. Some of these projects include:

- Ride-through DC power source for distribution-level power quality (PQ) monitoring equipment
- Photovoltaic-powered recharging station for electric scooter company
- Supercapacitor-based uninterrupted ac power supply
- Inverter for exporting to grid excess PV energy from battery recharging station
- Residential load monitor/identifier
- Battery conditioning battery change controller for PV energy



Testing of Capstone Design product PV-powered re-charging station at USC lab

For successful completion of these projects, senior design students team up with the local industry advisory members, receive continuous technical guid- ance and feedback, and get access to utility technologies over the course of the product development cycle. For example, the USC DC ride- through design team attended design review meetings with SCE&G utility advisors Will Bledsoe, Jeff Inadinat and Joey Jeffcoat for their technical guidance when needed, and used a PQ monitor provided by SCE&G for the ride-through module testing program. This interactive collaboration in turn led to successful completion of the PQ monitor module for SCE&G Thus, FEEDER Capstone Design Projects not only help the student to develop professional contacts and utilize utility technologies for technical skills development, but also assists its utility partners for their product development and provides an opportunity for them to consider the students for future hire.

Research & Development

The FEEDER Consortium also establishes the capacity and mechanisms to pursue collaborative research across multiple universities and with their partner utilities, industries and national labs. As described in the GEARED FOA, analysis, research and development focus upon the following topics:

- Power systems engineering
- Distributed power management
- System planning and operation
- Interconnection and communication hardware and soft- ware development
- Demand response, and use of storage technologies for integrating PV
- Network science, communication theory, controls and automation
- Implementation of cyber-physical systems as applied to the electric grid

In addition to input from industry, utility and national lab partners regarding the development of shared courses and Senior Capstone Design Projects, FEEDER also provides input to the universities on the distributed energy resources and smart grid topics that are important to their partners from a research and development perspective. FEEDER encourages corporate participation to express those interests in FEEDER Industry Advisory Board (IAB) meetings, FEEDER annual meetings and online interactions, with intention for this all to result in support for the utility's local university.

FEEDER also organizes bi-weekly online research seminars on distributed energy resources, distribution system planning and operation, smart grid control, management and security, and other related topics where highly skilled faculty members, utility and industry engineers, and national lab professionals provide an insight to the innovative smart grid techniques being explored in their research. These research seminars keep FEEDER members and students current with the existing and upcoming technologies in the area of distributed energy resources and smart grid technologies.

Upcoming in the Fall Issue:

New FEEDER facilities

Siemens Digital Grid Lab Revealed

Student Activities

2017 FEEDER Summer Institute

New Research Collaboration

SOLAREXPERT, ENERGISE Program **DOE**

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FEEDER Foundations for Engineering Education for Distributed Energy Resources