



# SMART GRID CENTER

TEXAS A&M ENGINEERING EXPERIMENT STATION



## Annual Report

### September 2015 - August 2016

The implementation of the large-scale smart grid testbeds and related strategic projects were the focus of the annual activities of the Smart Grid Center (SGC) endorsed by the Advisory Board.

#### Comprehensive Large-Scale Testbeds

For integrated large-scale testbeds, the novel concept of complex cyber-physical systems integrated at virtual and physical levels has been developed by the Center to mimic new grid control solutions at various spatial and temporal scales. Collaborations were initiated with several vendors, national labs, non-profit organizations, and universities domestically and abroad resulting in interdisciplinary collaborative projects. Donations of hardware, software, and services have been received in total over \$5 million from AE Techron, Colfax International, Electric Power Group, GE Grid Solutions/Alstom, Mitsubishi, NI, OPAL-RT, OSIsoft, and Powertech.

Testbeds are currently being implemented for synchrophasors, smart grids big data, cybersecurity, and microgrids.

#### Strategic Project Focus Areas

- Synchrophasors and synchronized sampling technology for T&D applications;
- Cyber-physical security with emphasis on interactions between different critical infrastructures;
- Big data including weather analyses integrated into GIS framework;
- Flexible loads, including on-site energy storage and distributed generation at different scales;
- Renewables forecasting with focus on solar and wind generation at different voltage levels;
- Future whole sale ancillary service products and retail market participation strategies.



Director: Dr. Mladen Kezunovic

Multidisciplinary proposals were in the process of being submitted. More information about the current and completed projects can be viewed at [http://smartgridcenter.tamu.edu/sgc/web/?page\\_id=115](http://smartgridcenter.tamu.edu/sgc/web/?page_id=115).

Smart Grid Center founded in August 2012

**The Center focuses on strategic projects, comprehensive large-scale testbeds, and smart grid training.**

#### New Large Research Projects

- “Timing Intrusion Management Ensuring Resiliency (TIMER)”, \$4.4 million over 3 years, Department of Energy-DOE National Energy Technology Laboratory-NETL. PI: M. Kezunovic (ECE TAMU), Co-PIs: A. Sprintson (ECE TAMU), J.-C. S. Liu (CSE TAMU), Partners: Idaho Power Company-IPC, GE Grid Solutions, Pacific Northwest National Laboratory-PNNL.
- “Large-Scale Testbed Implementation”, \$1.5 million over 5 years by the Texas Engineering Experiment Station-TEES. PI: M. Kezunovic (ECE TAMU).
- “Smart Grids Big Data”, \$1 million over 3 years, NSF- Big Data Spoke program. PI: M. Kezunovic (ECE TAMU), Co-PIs: D. Da Silva (CSE TAMU), P.R. Kumar (ECE TAMU), L. Xie (ECE TAMU), Z. Obradovic (Temple University), and S. Grijalva (Georgia Institute of Technology-GaTech).
- “Integration of Solar Generation and Electrical Vehicles into the Smart Grid”, \$788,997 over 3 years, the Qatar National Research Foundation-QNRF. PIs: M. Kezunovic (ECE TAMU), H. Abu-Rub (ECE TAMU-Qatar).
- “Microgrids Advanced Dynamic Control Architecture and Distributed Energy Optimization”, \$788,997 over 3 years, QNRF. PI: H. Abu-Rub (ECE TAMU-Qatar).
- “Air Pollution Cleanup Based Water Energy Food Nexus Technology”, \$693,707 over 4 years, QNRF. PI: G. McKay (HBKU, Qatar), Co-PI: A. Han (ECE TAMU), H. Park (KNU, Korea), H. Shon (UTS, Australia).
- “Microgrid Interconnections Control via Voltage Angle Drop Methods”, \$400,000 over 3 years, NSF. PI: Le Xie (ECE TAMU), Co-PI: Prasad Enjeti (ECE TAMU) associated with the Center.
- “Vegetation Management Risk Model”, \$102,000 over 1 year, CenterPoint Energy, PI: M. Kezunovic (ECE TAMU).

#### Technology Transfer

An extensive Technology-to-Market transfer effort is underway as a part of the “Robust Adaptive Topology Control” project funded by DOE ARPA-E.

#### Advisory Board Meetings

The meetings of the Board were held on November 23<sup>rd</sup>, 2015, and April 27<sup>th</sup>, 2016. Members of the Board and the Center Director discussed current status of the strategic efforts and future plans of the Center. The Board includes the chair, J. Bermúdez (President and CEO of Byebrook Group), the vice chair, J. McDonald, P.E. (Director of Technical Strategy & Policy Development of GE Grid Solutions), and members: G. Arnold, Ph.D. (CEO, Tercio Solutions), M. Begovic, Ph.D. (Department Head, ECE Texas A&M), T. Doggett, P.E. (President, Benchmark Power Consulting), C. Eugster, Ph.D. (Chief Operating Officer, CPS Energy), K. Mercado, P.E. (Senior Vice President, CenterPoint Energy), M. O’Quinn (Vice President for Government Relations, Texas A&M), M. Scholtz, Ph.D. (Vice President for Research, Texas A&M), L. Tang, Ph.D. (Vice President and Head, ABB Corporate Research Center, USA), and P. Wood (Principal, Wood3 Resources).



From top left to right: M. O’Quinn, K. Mercado, T. Doggett, H. Abu-Rub (guest, Ph.D., SGC-Q), G. Arnold, M. Kezunovic, J. McDonald, J. Bermúdez, M. Begovic, T. Overbye (guest, Ph.D., UIUC), R. da Piedade Francisco, and M. R. Bialecki Leandro (guests, Ph.D., UFSC, Brazil).

#### Publications

Research results were published in 41 peer-reviewed papers, 2 books and a book chapter, and 64 conference publications.

Reference information may be viewed and some publications can be downloaded at the Center’s website.

#### SGC Websites

Expertise of collaborating faculty members, information of industry partners, faculty activities, related publications, news and more can be viewed at <http://smartgridcenter.tamu.edu>.

For the SGC-Q, news and information on people, projects and publications are posted at <http://www.sgc-q.com>.

#### Fourth Smart Grid Workshop

“Smart Grids Big Data” was the theme of this event held on April 28, 2016. The invited talk was given by A. Ghasseman from the Office of Electricity Delivery and Energy Reliability, DOE. Two panels and four focus groups facilitated discussions. Graduate students gave poster presentations.



The more than 100 attendees included faculty members from the Texas A&M University System, representatives from DOE, CenterPoint Energy, GE Grid Solutions, Esri, Knowledge Based Systems, National Instruments, OSIsoft, the National Renewable Energy Laboratory, Los Alamos National Laboratory, PNNL, and the Electric Power Research Institute, as well as 58 students, and faculty members from universities in Brazil and Qatar.

#### Expanding the SGC Portfolio

New collaborating faculty members:

- Dilma Da Silva (Computer Science & Engineering);
- Bonnie Dunbar Aerospace Engineering; TEES Institute for Engineering Education & Innovation);
- Jorge Leon (Engineering Technology & Industrial Distribution);
- Jyn-Charn (Steve) Liu (Computer Science & Engineering);
- Walt Magnussen (The Academy for Advanced Telecommunications & Learning Technologies);
- Daniel (Rags) Ragsdale (Computer Science & Engineering);
- Srinivas Shakkottai (Electrical & Computer Engineering).

#### Future Plans

- Implementing the EMS/DMS control center testbeds;
- Exploring new funding opportunities;
- Engaging existing and new partners;
- Developing a comprehensive plan for using testbeds for industry training;
- Expanding the SGC Advisory Board;
- Organizing the 5th SG Workshop and professional training events.