Education • Research • Industry
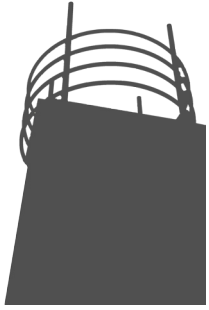

CURENT

CENTER FOR ULTRA-WIDE-AREA RESILIENT
ELECTRIC ENERGY TRANSMISSION NETWORKS

Welcome to CURENT

Spring 2017

Dr. Tomsovic

Dear CURENT colleagues and supporters,

Thank you for your interest in CURENT. It is our pleasure to update you about recent Center activities.

Our Annual Industry Day and NSF / DOE Site Visit was held Nov. 15th-17th, 2016. We hosted approximately 250 members of industry; invited speakers; the NSF / DOE Site Visit Team; faculty and students from the four CURENT partner schools; and other guests. On Industry Day, invited industry leaders spoke about their work and our students gave presentations on their research. During the Site Visit the next day, faculty provided research updates and we toured the CURENT headquarters and laboratories. The Center received an outstanding review overall and we enjoyed the chance to show off our Center and laboratories and to introduce people to the work being done here.

We have added eight new Industry Members since August 2016, bringing our total number of Industry members to 36. Our member web portal was launched last year, and each month we've seen an increase in industry traffic to view presentations and seminars. Please take some time to view the intriguing research results posted on the portal. Our monthly industry seminars continue to provide our students with invaluable information about the power industry and the webcasts of these seminars have proven very attractive to industry. Interest in our students remains high and several of our students are currently doing internships.

As always, our newsletter contains research overviews and/or updates. In this issue, we'll discuss *Denoising and Data Compression* by Dr. Jesmin Khan, Dr. Gregory Murphy, Dr. Sherif Bhuiyan and Jonathan Williams and *Social-Psychological Approaches of Demand Response* by Dr. Chien-fei Chen and Dr. Xiaojing Xu, among others. This type of progressive research keeps us excited about the future here at CURENT.

We are now halfway through the Center's sixth year. Day to day operations are well-established and our program has steadily evolved into a highly-structured Center with both mature and newly developing research areas. Our industry membership has provided and provides an important base of support and our industry partnerships continue to increase. As far as we've come, we feel like there is still much more to be done. And with your help, we are looking forward to a bright and progressive future.

Please let us know how we are doing and how we can support you needs and provide value to your organization. Your feedback and comments are crucial to us.

Sincerely,

Kevin Tomsovic

a National Science Foundation & Department of Energy
Engineering Research Center

Table of Contents

CURENT LEADERSHIP

Director
Dr. Kevin Tomsovic

Deputy Director
Dr. Yilu Liu

Technical Director
Dr. Fred Wang

NEU Campus Director
Dr. Ali Abur

RPI Campus Director
Dr. Joe Chow

TU Campus Director
Dr. Greg Murphy

UTK Campus Director & Large-scale Testbed Thrust Leader
Dr. Fran Li

Director of Education and Diversity
Dr. Chien-fei Chen

Co-Director of Education and Diversity
Dr. Daniel Costinett

Director of Innovation and Industry
Mr. Tom King

Industry Outreach Director
Ms. Lisa Beard

Industry Technovator
Mr. Bill Giewont

Hardware Testbed Thrust Leader
Dr. Leon Tolbert

Administrative Director
Pam Arrowood

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Research Highlights

Data Denoising and Compression for Smart Grid Communication

by Dr. Jesmin Khan, Dr. Gregory Murphy, Dr. Sherif Bhuiyan and Jonathan Williams

The basic concept behind Smart Grid (SG) can be defined as the transformation of the traditional power grid using communications, artificial intelligence, advanced automatic control, information technology and signal processing techniques. This concept allows effective generation, distribution, communication and consumption of energy. In the Smart Grid, the monitoring and measurement units (e.g. smart meters, frequency disturbance recorders (FDRs), phasor measurement units (PMUs), Wide Area Monitoring Systems (WAMSs), Supervisory Control and Data Acquisition Systems (SCADAs)) record statuses across all levels of the grid. Accordingly, there is an overwhelming flow of data to be circulated and stored among utilities, control centers, and customers in SG in real time.

Therefore, the communication and storage of the data is an important issue in SG that needs effective data compression. On the other hand, denoising of the power system signal is necessary for power system disturbance analysis, as the effectiveness of the disturbance detection techniques is greatly deteriorated by the noises riding on the signals. We propose a complete framework based on wavelet packet decomposition (WPD) for power system data denoising and compression in smart grid communication. We verify our proposed method on real data from FDR, PMU and power system load; which are recorded during the occurrence of different types of faults. We have compared our method with wavelet decomposition (WD) and the Matlab built-in function 'wpdencmp'. The simulation results show that the proposed method has better performance than the WD and the built-in Matlab function 'wpdencmp' and the proposed approach is capable of denoising and compressing any type of SG data.
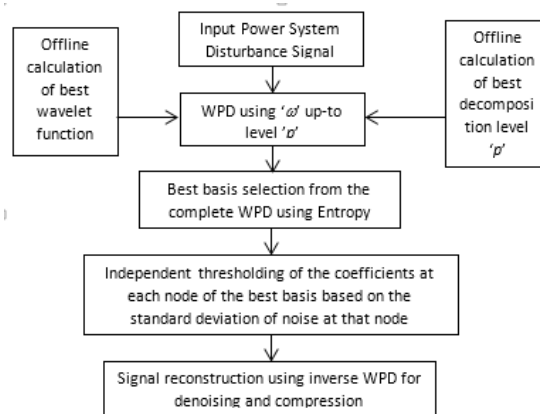

Figure 1: Block diagram of the proposed method

Simulation results show the comparisons with other methods in denoising and compressing the signal.
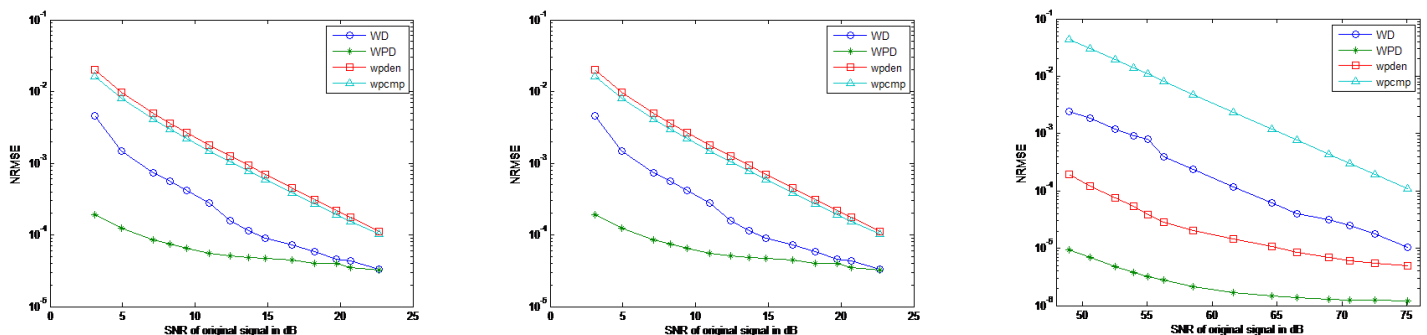

Figure 2: Denoising performance for a PMU, FDR and power system load voltage signal showing NRMSE vs signal to noise ratio (SNR)
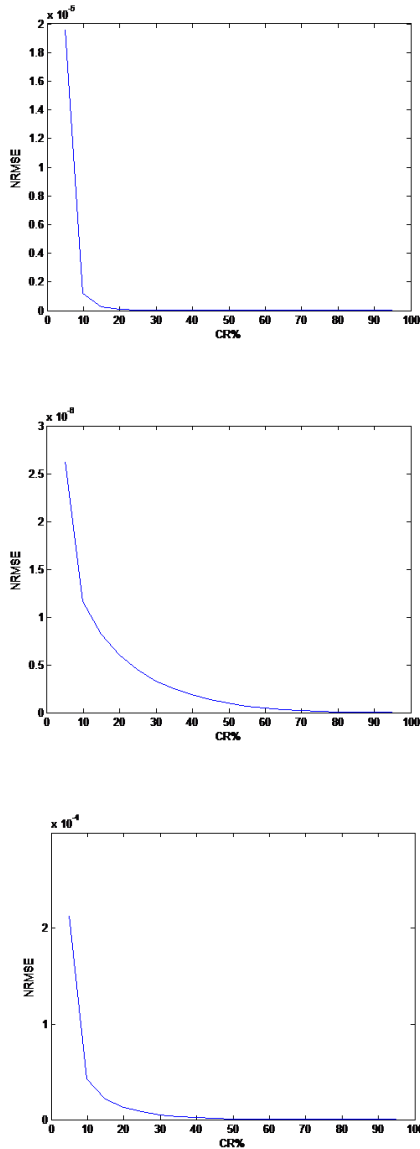
Data Denoising (continued)

Figure 3: Compression performance for a PMU, FDR and power system load voltage signal showing NRMSE vs compression ratio (CR)

Experimental results show that the proposed WPD method is better than or comparable with the WD and 'wpdencmp'. The proposed WPD based power system data denoising and compression algorithm is a general framework that can compress upto 2% of the original data size; and can remove noise with an improvement of upto 30dB in the signal to noise ratio (SNR). The results of experiments show that a better SNR and NRMSE can be achieved for a very good compression ratios compared to WD and 'wpdencmp' method. Future work will involve the extensive application of the WPD algorithm not only to the denoising and compression but also for detection, analysis and classification of disturbance/fault/transient events in power system.

~end~

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Academic Excellence

Above: Dr. Michael Wozney, Dayna Herling and Dr. Joe Choe

CURENT Students Awarded PES Scholarships for 2016-2017

Several CURENT students have been awarded 2016-17 IEEE PES Scholarships. Since the program launched in 2011, 1,172 scholarships have been awarded to 723 students at more than 160 universities across the USA, Canada & Puerto Rico. This year, for the first time ever, 25% of the recipients were female. Eight CURENT students from the University of Tennessee, Northeastern University and Rensselaer Polytechnic Institute were awarded scholarships. Additionally, Northeastern University placed in the top ten of schools with the highest number of PES scholars. Below are our scholarship recipents:

Jessica Bardio

Jared Baxter

Summer Fabus (Church)

Drew HasBrouk

Dayna Hering

Gianna Scioletti

Gregory Tolj

Andrew Whitaker

Additionally, we'd like to give an extra shout-out to Drew HasBrouk who, as a 3rd year student, has won a PES scholarship for a third time.

Research Highlights

PMU Data Analytics by Exploiting Low-dimensional Structures

By Dr. Meng Wang and Dr. Joe H. Chow

Two thousand multi-channel phasor measurement units (PMU) have now been installed North America. PMUs can directly measure bus voltage phasors and line current phasors at synchronized time instants. With data rates of 30 or 60 samples per second, these PMUs produce terabytes of data daily, offering dynamic visibility into the power system.

As the coverage of PMUs in power systems becomes denser, it is natural to collect data from PMUs in electrically close areas over a certain period of time and process this spatial-temporal blocks of PMU simultaneously. Interestingly, the PMU data block exhibits low-dimensional structures despite its high ambient dimension. The low-dimensional structure can be exploited to enable and simplify a variety of PMU data management tasks such as data compression, error correction, and feature extraction. We have obtained promising results on missing data recovery, detection of cyber data attacks, enhance PMU data privacy, and identify system events.
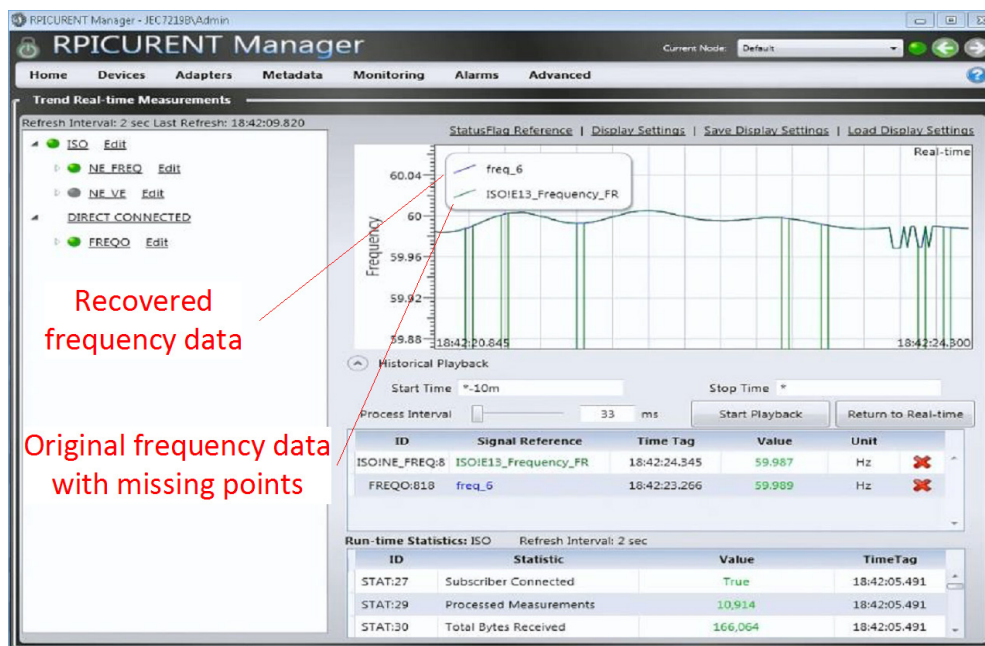

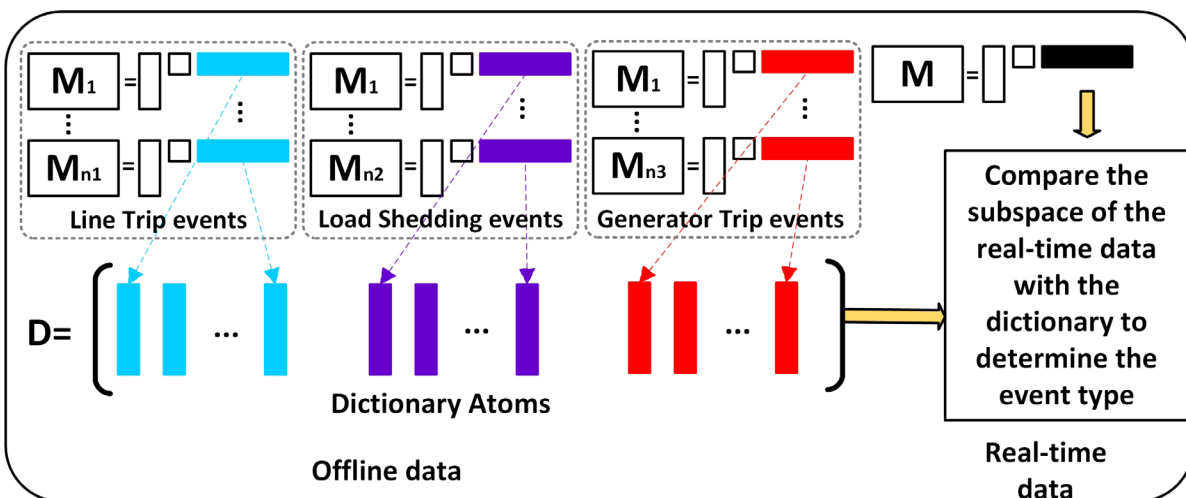*Figure 1: Block diagram of the proposed method*

Figure 2: Dictionary construction from recorded PMU datasets. Events are characterized by presentative subspaces
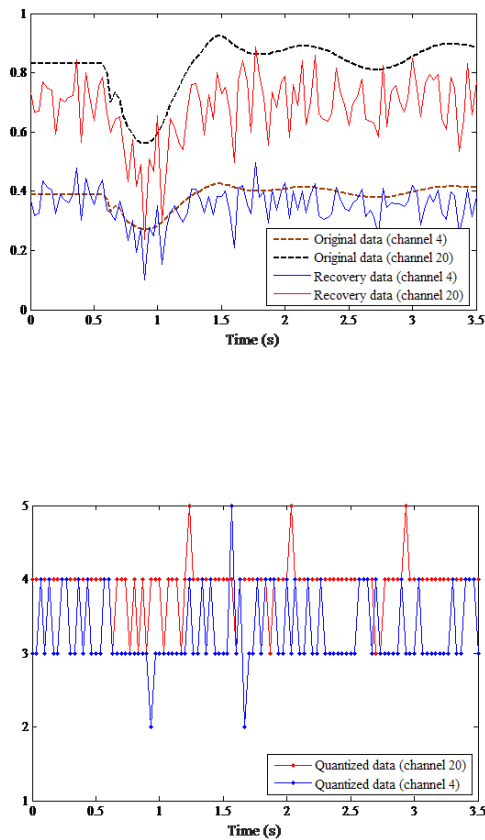
PMU Data Analytics (continued)

Figure 3: Original, quantized, and recovered data of two voltage magnitudes in a recorded PMU dataset

For instance, we developed OLAP, an online missing data recovery algorithm that can fill in the missing values in the streaming PMU data. Fig. 1 shows the interface of our OLAP method implemented on openPDC. We further exploited the low-rank property of the Hankel matrix of the data matrix such that consecutive and simultaneous data losses can be correctly recovery without modeling the power system.

We developed a novel data-driven method to identify and locate events without modeling the power system. The critical innovation is to characterize an event by a low-dimensional row subspace spanned by the dominant singular vectors of the data matrix that contains spatial temporal blocks of measurements from multiple PMUs. This subspace characterization is a compact representation of system dynamics. Then an event is identified by comparing the obtained data with a pre-computed event dictionary with each dictionary atom corresponding to a row subspace of an event. Figure 2 illustrates the dictionary construction. The subspace representation significantly reduces the dictionary size, leading to a fast and efficient event identification method.

We also proposed a simple signal processing approach to achieve data compression and data privatization simultaneously for PMU data. Random noises are added to the measurements to protect data privacy, and the quantization is applied afterwards to reduce the amount of information to transmit. The privacy of each PMU is enhanced because an intruder can only observe highly quantized values even if it eavesdrops the data communication from some PMUs to the operator. Our major contribution is a data recovery method for the operator to recover actual values from quantized measurements of multiple PMUs. Therefore, the reduced data transmission, privacy enhancement of individual utilities, and the information accuracy for the central operator are achieved simultaneously. Figure 3 shows the original data, highly noisy and quantized values, and the recovered data from the quantized values of two bus voltages in recorded PMU datasets.

~end~

Faculty News

Dr. Joe Chow, RPI Campus Director, was elected to the National Academy of Engineering on February 8, 2017. Election to the National Academy of Engineering is among the highest professional distinctions accorded to an engineer. Dr. Chow and the newly elected class will be formally inducted during a ceremony at the NAE's annual meeting in Washington, D.C., on Oct. 8, 2017.

Above: Dr. Joe Chow

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Research Highlights

Network Model Parameter Error Detection and Correction

By Dr. Ali Abur and Yuzhang Lin (PhD student)

Most applications in power system operation today rely on accurate network models. The network parameter database, however, can be corrupted due to a number of reasons: inaccurate manufacturing data, human data entry error, unreported device replacement and upgrade, operating status update failure, and ambient condition variations. Based on state estimation, we develop a very effective methodology for the detection and correction of parameter errors, which will facilitate the maintenance of a clean network parameter database, and benefit a number of model-based applications in power system operation.

This method exploits the Lagrange multipliers associated with parameter errors when solving the state estimation problem by the constrained weighted least squares method. It is applied jointly with the well-known normalized residual test for measurement error identification, and is referred to as the Normalized Lagrange Multiplier/Normalized Residual (NLMNR) test. Key features of this approach include: (1) Capability of differentiating between parameter errors and measurement errors; (2) No need to make an a priori selection of suspicious parameters; (3) No need to modify core state estimation software code.
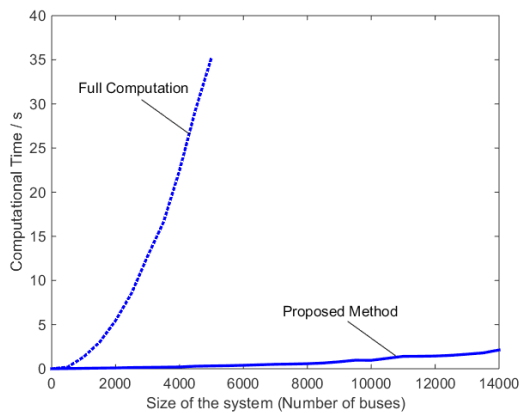

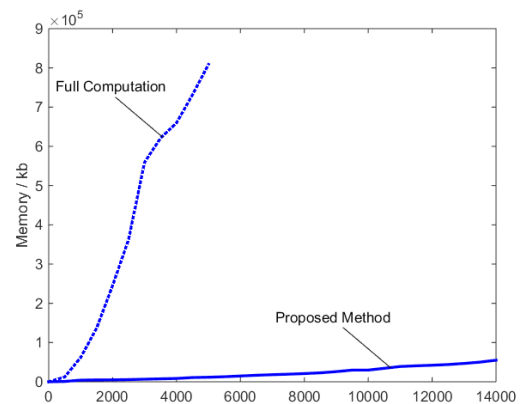Figure 1: CPU time of full
computation vs. proposed algorithm

Figure 2: Memory requirement of full
computation vs. proposed algorithm

By exploiting the sparse nature of power networks, a highly efficient implementation of the NLM test has been developed. It avoids the full computation of a series of large dense matrices, and significantly reduces the computational burden of this approach. Simulation results show that the required CPU time (Fig. 1) and memory requirements (Fig. 2) will be very modest, even when this algorithm is executed on a very large real-world power system (>14,000 buses).
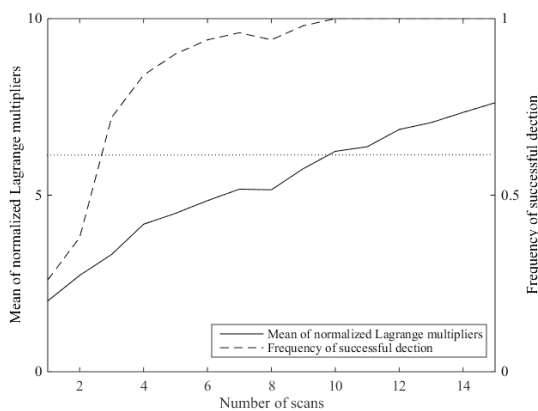

Figure 3: Performance of the NLMNR test
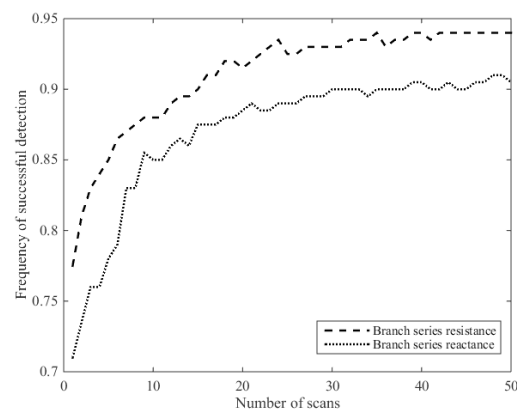for a parameter whose error is difficult to detect

Figure 4: Performance of the NLMNR test
on an entire large utility system

Network Model Pparameter Error (continued)

Besides the improvement of computational efficiency, an enhanced version of the NLMNR test, which exploits multiple measurement scans, is also developed. This test first identifies those parameters whose errors are difficult to detect, and then determines the minimum number of scans needed to ensure their detection thus avoiding unnecessary computational effort. Simulation results validate the improvement in NLMNR test's performance as the number of measurement scans is increased, both for an individual parameter (Fig. 3) as well as for the entire system (Fig. 4).

Finally, an efficient scheme to correct the identified parameter errors is also developed. Traditionally, suspicious parameters are estimated using by including the parameters in the state vector, and performing the augmented nonlinear state estimation. The novel correction scheme has several notable advantages over the traditional solution: negligible computational burden, free from numerical stability issues, and very modest coding effort. The accuracy of the results is also guaranteed.

We are currently undertaking a project with ISO New England, one of CURENT's industry members, to address the issue of parameter errors in their transmission system. Results of the developed method applied to ISO-New England's network data will be reported in the near future.

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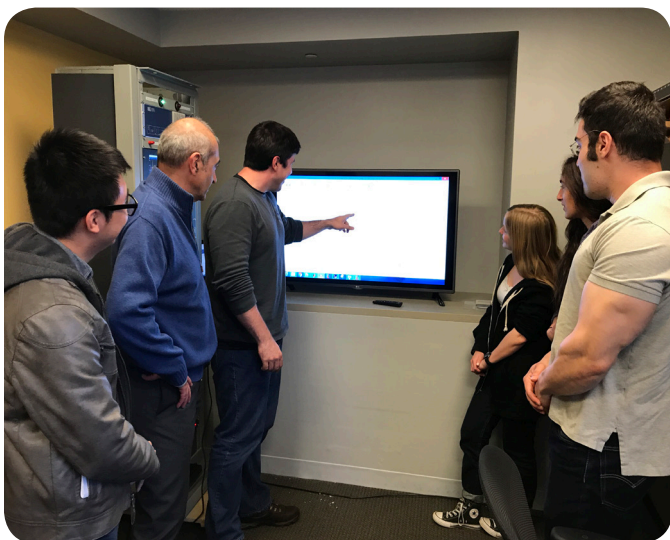
Above: in the NEU Lab - Yuzhang Lin (PhD student), Dr. Ali Abur, Arthur Mouco (PhD Student), Alina Rossi-Conaway (undergraduate reseacher), Gianna Scioletti (undergraduate researcher) and Alireza Rouhani (PhD student)

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Faculty News

Dr. Yilu Liu, Deputy Director for CURENT, has been inducted into the National Academy of Inventors (NAI). The academy recognized Liu for her "spirit of innovation" and for the impact of her work on everyday life. She and the other NAI inductees were recognized at the academy's annual conference on April 6, 2017, in Boston, MA.

Above: Dr. Yilu Liu

Dr. Fran Li, UTK Campus Director for CURENT, was recently named an IEEE Fellow, effective January 1, 2017. He was recognized for his work in power system markets, specifically for "for contributions to locational marginal price calculation." Within IEEE, Dr. Li is also serving or has served as Vice Chair of IEEE PES PSPI Committee, Co-Vice Chair of PES PSOPE Committee, an Editor of IEEE Transactions on Sustainable Energy and of IEEE PES Letters and a Guest Editor of IEEE Transactions on Smart Grid and of IEEE Transactions on Industrial Informatics.

Above: Dr. Fran Li

Research Highlights

A Smart and Flexible Microgrid with a Low-cost Scalable Open-source Controller

By Dr. Fred Wang, Dr. Yilu Liu, Dr. Leon Tolbert, Dr. Lin Zhu and Yiwei Ma (PhD student)

Microgrids (MGs), with their distributed energy resources (DER) and ability to operate both in grid-connected and islanded modes, can significantly improve reliability and resilience of the power grid. For example, when a natural disaster, such as Hurricane Sandy, caused millions of customers to be without electricity for weeks and billions of dollars of economic losses, MGs could have made an appreciable difference. A MG controller is essential to achieving smooth transition between the grid-connected and islanded operation modes, and also for optimal operation during both modes.

While there have been dozens of MG systems developed around the nation since the concept was proposed a decade ago, almost all of them were deployed for serving special sites such as military bases, or university/business campuses. MGs have not yet been commercially utilized for communities in the U.S due partly to the high cost of added energy resources such as battery energy storage systems, and also due to the high deployment cost of sensors, communication infrastructure, and proprietary controllers.

ARPA-E is funding CURENT UTK team to develop and demonstrate a community-based smart and flexible MG with an open source scalable MG controller for enhanced functionality and low cost. One end project objective is to have the controller developed, tested and ready for commercialization. Based on the smart distribution system of the CURENT member Electric Power Board of Chattanooga (EPB), the MG and its controller will make use of the existing intelligent switches and fiber optics links for control and communications. Minimum number of new switches, sensors or communication links will be needed. In addition, flexible grid interface points will be featured in this project for better asset use, reliability, and economics, as shown in Figure 1. In addition to EPB, other industry partners on the project include CURENT industry members National Instruments (NI), Electric Power Research Institute (EPRI), and TVA. The Green Energy Corp (GEC) will work as the commercialization partner.
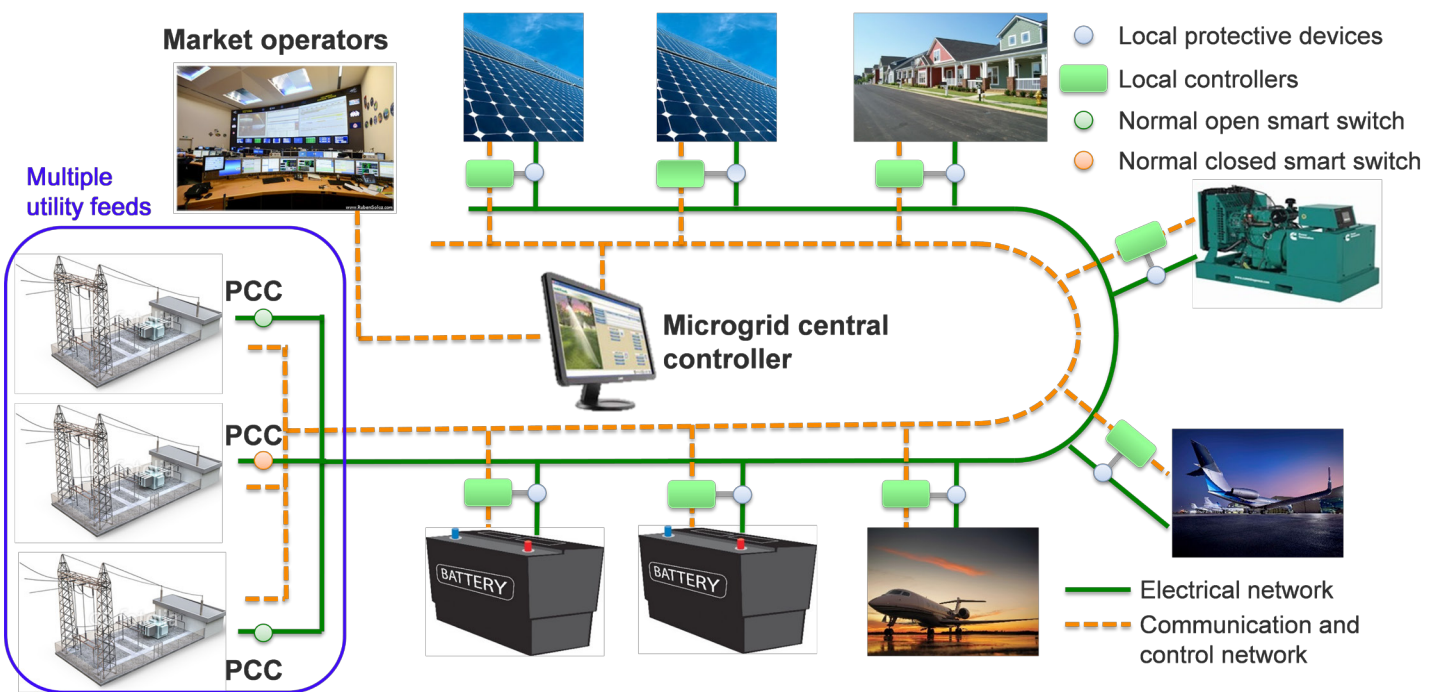

Figure 1: Conceptual MG diagram with multiple utility feeds (PCC: Point of Common Coupling)

As shown in Figure 2, three main technical tasks are being performed: MG design, MG controller development, and system testing. The MG control algorithms will be implemented on NI general-purpose controllers to further reduce the deployment cost, and the system will be developed and tested in multi-platform environment including CURENT's unique grid emulation platform Hardware Testbed (HTB).
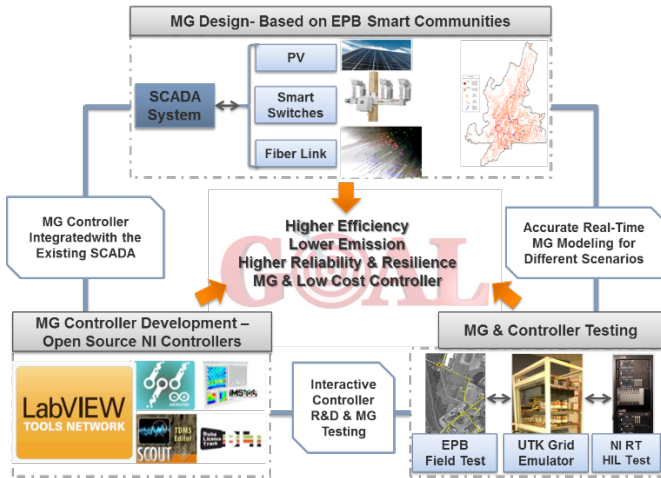
A smart, flexible microgrid (continued)

Figure 2: Overall technical approaches for the project

The proposed microgrid is expected to reduce the annual critical loads interruption time by 98%, reduce emission by >20%, and improve the energy use efficiency by 20%.

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Both above: The CURENT booth at the APRA-E Summit in Feb.

New Industry Members

We'd like to welcome CURENT's newest Industry Members. They are Arizona Public Service Company (APS), EDD, EnerNex. Geiri North America, Genscape, Keysight Technologies, Raytheon and OSIsoft. We are proud to announce that our industry Membership now stands at 36.

Rensselaer • Northeastern

Research Highlights

Social-psychological Approaches of Analyzing Demand Response

By Dr. Chien-Fei Chen and Dr. Xiaojing Xu

Social psychology is the pursuit of understanding how we view ourselves in relation to the rest of the world. Social psychologists are interested in the diverse aspects in which interpersonal relationships and environmental factors can work together – with the hope of improving these interactions. CURENT has assembled a social science team that works with engineers and computer scientists in order to better understand the social behavioral aspects behind energy efficiency issues and the rapid growth of renewable energy technology use. Specifically, CURENT focuses on the research areas of demand response, smart meter technology adoption, energy saving behaviors in both residential and commercial buildings and low-income household
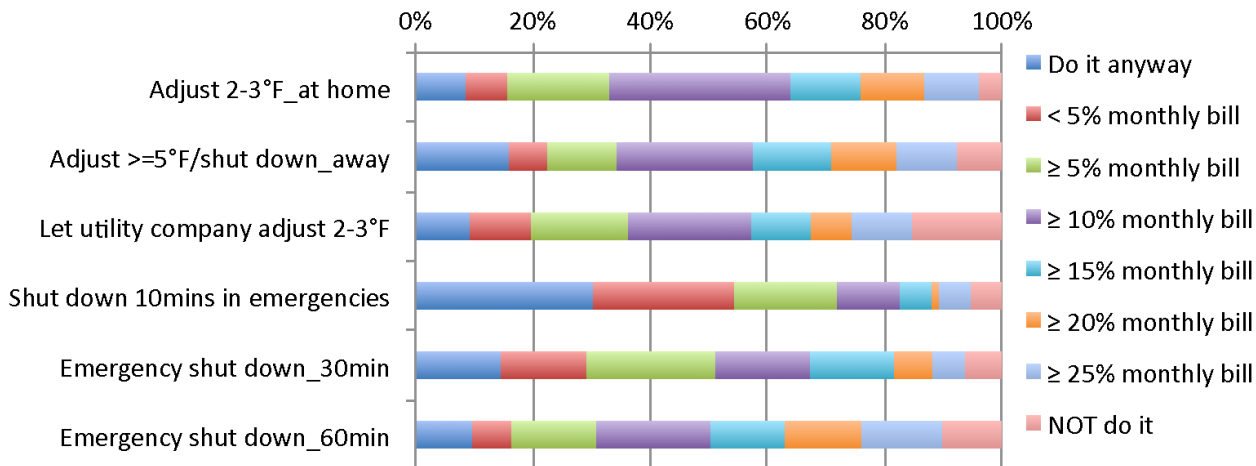

Figure 1: The minimum amount of financial rewards requested for major household DR behaviors
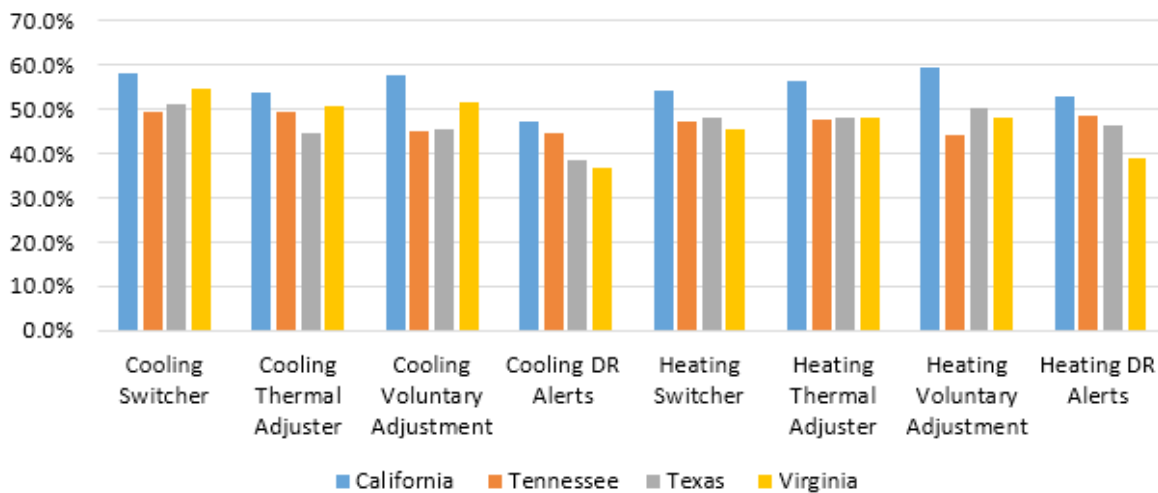

Figure 2: Anticipated participation rate (yes%) for each DR program across 4 states
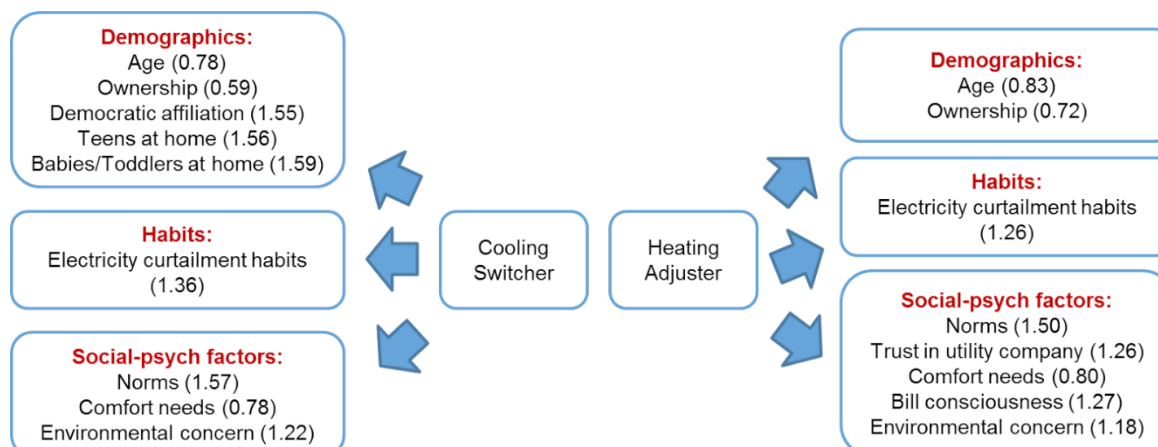

Figure 3: Factors predicting participation of DR programs (odds ratios in parentheses)

Social-psychological Approaches(continued)

CURENT's research on demand response (DR) has yielded interesting results by considering social-psychological factors. CURENT has designed and conducted several national surveys from 2014 to 2016, aiming to investigate: 1) the minimum amount of financial rewards that consumers requested to adopt various DR related behaviors, that is, voluntarily adjusting A/C settings for 2-3 degrees when at home, allowing utility companies to adjust A/C settings, and shutting down the A/C for 10-60 minutes in response to emergency messages; and 2) how demographics (e.g., income, household size, race, political orientation, etc.) and social-psychological factors (e.g., norms, comfort needs, energy concern, attention to bills, and trust in utility companies) affect the amount of financial rewards requested.

In the first 2 surveys, 1511 residents were sampled across 48 states in the U.S. Fig. 1 shows the minimum amount of financial rewards requested (i.e., a reduction of a portion of monthly electricity bill) for adopting each major DR behavior. Specifically, our analysis indicated that about 10% of the participants said that they would do it even without incentive to adopt the behavior of adjusting thermostat settings for 2-3 degrees in the summer, while about 5% of the participants said that they would not do it no matter how much incentives were provided. Among all the DR behaviors, people were more willing to accept the 10-minute emergency shut-down than other DR behaviors. Multinomial logistic regression model was further used to identify the significant predictors (α = 0.05) of each DR behavior. Results indicate that dwelling size, attention to utility bills, and comfort needs (both in summer and winter) significantly predicted the incentive amount requested to adjust A/C settings for 2-3 degree when someone at home.

A recent study with a representative sample of 1631 residents across 4 states -California, Texas, Virginia, and Tennessee- was designed and conducted by CURENT in 2016 to investigate 1) whether consumers are willing to participate in several important DR programs in order to reduce electricity consumption during peak hours (e.g., 2-5 pm in the summer) including: installing an automatic switcher to re-schedule A/C cycling, installing an automatic thermostat controller to tweak A/C settings, voluntarily reducing A/C use during peak hours, and responding to emergency alerts by adjusting A/C thermostat settings; 2) how additional incentives, such as a $30 reward, affect consumers' willingness to participate in those programs; and 3) how demographic and social-psychological factors (e.g., environmental concern, bill consciousness, social norms, and trust in the utility company) affecting residents' decisions to participate in popular DR programs in the market.

This data showed that residents differed in their preferences in each of DR program across 4 states. For example, residents in California and Virginia felt more favorable about voluntary thermal adjustment in summer during peak hours than those in Tennessee and Texas did, χ^2 (3) = 16.69, p < .001 (Fig. 2). In addition, Virginia residents had significantly less interest in DR alert programs in winter, χ^2 (3) = 16.12, p < .001. Fig. 3 presents the significant factors predicting willingness to participate in two popular DR programs in the market- installing an A/C outdoor switcher in the summer and installing of a thermostat adjuster in the winter. Results of the regression model suggested that democrats were 55% more likely to install the A/C outdoor switcher than non-democrats, and that people with a positive level of social norms (i.e., perceiving significant others as being supportive to install the switcher) were 57% more likely to install the switcher themselves than their counterparts.

Further, we have analyzed the social-psychological and demographics factor affecting low-income households' willingness to adopt the DR behaviors. Data collected from the 354 LIHs suggested that attitudes toward energy savings, social norms, and perceived behavior control were all positively predictive of willingness to accept voluntary demand reduction, while comfort need was a negative predictor. Regarding the acceptance of automaton, only attitudes, social norms and environmental concern were positive predictors. Additionally, perceived risks to privacy was negatively associated with the automation acceptance. Age, the only significant demographic predictor, was negatively related to the acceptance of automation.

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Industry Highlights

Annual Industry Day and NSF / DOE Site Visit

The 5th Annual Industry Day and NSF / DOE Site Visit was held on Nov. 15th-17th, 2016 at the Crowne Plaza in downtown Knoxville, TN. This is the first time the Crowne Plaza has been the venue for this event and it seemed like a good fit. The weather held for the event as well and attendees were treated to mostly clear skies and warmer than usual November temperatures.

Industry Day and the Site Visit saw CURENT host approximately 250 members of industry, faculty and students from the four CURENT partner schools, invited speakers, other guests and the NSF / DOE Site Visit Team. On Industry Day, invited industry leaders spoke about their work and CURENT students gave presentations on their research. Invited speakers were Zhiwei Wang, President of GEIRI North America; Jose Conto, Principal, Dynamic Studies System Planning for ERCOT; David Schoenwald, Principal Member of Technical Staff at Sandia National Laboratories; Clifton Black, Senior Research Engineer at Southern Company; and Jeff Hildreth, Principal Engineer at Bonneville Power Administration. "It's an honor to have speakers of this caliber at our event," said Tom King, Director of Innovation and Industry, "We respect the knowledge and expertise they bring to our conference and our students gain a lot from the interactions."

During the Site Visit the next day, faculty gave research updates and then the site visit team and interested industry members toured the CURENT headquarters and laboratories. The lab tour consisted of the hardware testbed, the largescale testbed, the FNet lab, the power electronics lab, the high power electronics lab and the visualization room. After the lab tour, the group attended a student poster session, which consisted of over 100 research posters.

Despite conflicting industry conferences, we had one of the largest groups of industry attendees so far. The event was quite successful and we received a great deal of positive feedback about the Center and iour laboratories and research projects.

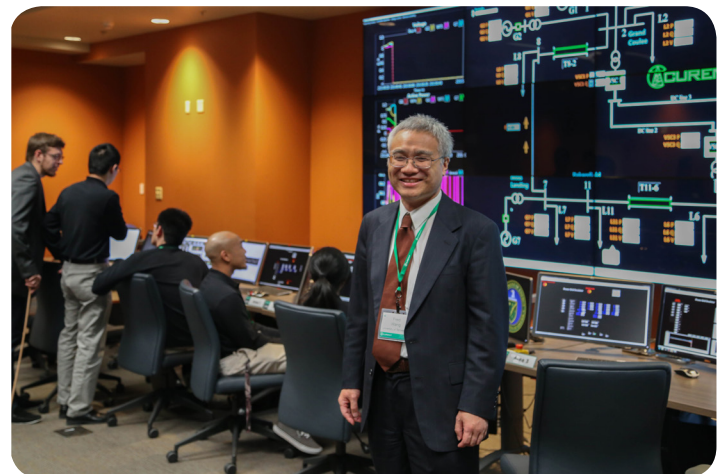Above: Approximately 250 people attended our 5th year site visit

The dates for this year's site visit have been finalized and they are Nov. 14-16. Tues., Nov. 14 will be Industry Day and Wed., Nov. 15 and Thur., Nov. 16 will be the NSF / DOE Site Visit. We have sent a "Save the Date" and will be sending further details soon. Please plan to join us.
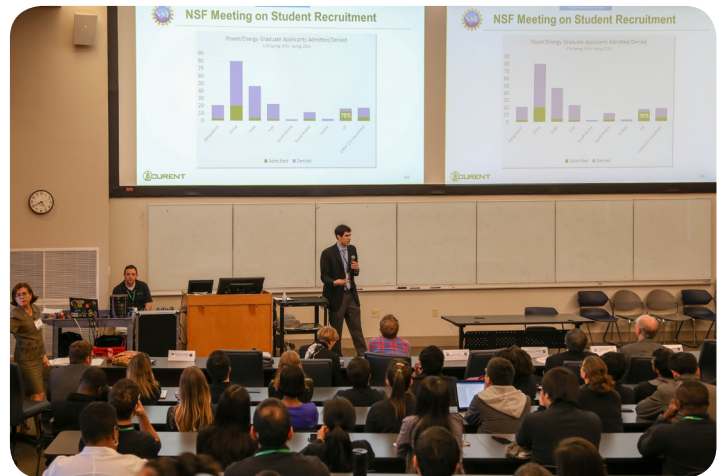
Above: Dr. Costinett addresses the audience during education presentation

Above: Dr. Fred Wang in the Visualization Room during the lab tour

Above: Dr. Joe Chow and Dr. Peter Sauer (CURENT Scientific Advisory Board) discuss during a break

Memberships

"Industry members have found a lot of value in CURENT membership and our growth speaks to CURENT's commitment to research and industry application," says Tom King, Director of Innovation and Industry, "Additionally, access to knowledgeable interns is an added value of membership and these internships are a plus for our students as well."

CURENT has added eight new Industry Members since September 2016, bringing the total number of members to 36. That's approximately a 22% increase in a little over six months. The newest members are Arizona Public Service Company (APS), EDD, EnerNex. Geiri North America, Genscape, Keysight Technologies, Raytheon and OSIsoft.

Above: Brad Trento accepts a service award from Dr. Tomsovic

Above: Dr. Tomsovic addresses the attendees at the Strategic Planning meeting in San Juan, PR in April.

Ch-ch-ch-changes

We have a couple of announcements. First, we want to let everyone know that Brad Trento accepted a position with EPRI. He will be sorely missed. Second, we want to announce that Lisa Beard is replacing him as CURENT's Industry Liaison Officer. Please contact Lisa for any questions regarding contracts, invoicing, technology transfer, licensing agreements or any other information regarding CURENT's Industry Membership Program.

Member's Web Portal

CURENT's member's web portal was launched in January, 2016, and each month has seen an increase in industry traffic to view presentations and seminars. "It's a goal of mine to have our member's portal be a central hub for our members, says Lisa Beard, Industry Outreach Director. "Our monthly industry seminars continue to provide our students with invaluable information about the power industry and these same webcasts have also proven to be very attractive and informative to industry." CURENT industry seminars are usually scheduled on the last Friday of the month. See curent.utk.edu for details.

Upcoming Events

May 16-18, NERC SMS, Audubon, PA
July 16-20, IEEE PES General Meeting, Chicago, IL
July 20-21, CURENT Strategic Planning Meeting,
     Chicago, IL
Nov. 14-16, Industry Day and NSF / DOE Site,
     Knoxville, TN

Recent internships for CURENT students:

Xiaohu Zhang - GEIRNA
Ben Dean - Southern Company
Yongli Zhu - GE-Alstom
Drew HasBrouck - Black & Veatch Management
Wei Feng - GEIRNA
Mark Nakmali - Zhejiang University
Josh Ray - Zhejiang University

Wiehong Huang - ISO New England
Hesen Liu - Dominion
Abigail Till - Southern Company
Chongwen Zhao - Texas Instruments
Yajun Wang - VA Electric and Power Company
Ben Dean - Zhejiang University

"Student internship experiences are both a benefit to students' professional development and a valuable recruiting tool to increase company name recognition among students. CURENT Industry Members have access to top notch power systems and power electronics students."

- Lisa Beard, CURENT Industry Outreach Director

If you are interested in sponsoring an undergraduate or graduate student intern, contact Lisa at lbeard10@utk.edu or 865-974-8655 to begin the internship process.

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