CPS ENERGY - UTSA ENERGY RESEARCH ALLIANCE

TexasSustainableEnergy
RESEARCH INSTITUTE

2010 - 2011 REPORT

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This project and the preparation of this report were funded in part by monies provided by CPS Energy through an Agreement with The University of Texas at San Antonio.

A MESSAGE FROM THE DIRECTOR

It was slightly more than a year ago that the Texas Sustainable Energy Research Institute (i.e., Institute) was created by the University of Texas at San Antonio (UTSA) to partner with others from across the Alamo region to position San Antonio as a technology and innovation leader in the 21st century global energy economy. It was a year where I was routinely inspired by the "spirit of San Antonio" – a spirit that is pervasive throughout our region to make a profound difference in our future! The Institute is committed to nurturing this spirit and to serving the needs of our community as we establish San Antonio's leadership position in the new energy economy.

The CPS Energy – UTSA Energy Research Alliance (i.e., Alliance) was founded on the principle that innovation sits at the heart of long-term economic prosperity, serves as a magnet to attract the "best and brightest" from across the globe to the San Antonio area, and enables a diverse, cost competitive, reliable energy portfolio to fuel our economy for decades to come. Our user-inspired research spans a continuum from discovery-based science and engineering to economic and system analyses and strives to have pragmatic outcomes that serve our community best. To be successful we must connect with the local, regional, national and global innovation community to expand our research capabilities and to accelerate technology innovations through multidisciplinary research in science, engineering, policy and architecture coupled with systems and economic analyses.

We are working together with the business, investment, and technology incubation community to create a clean energy incubator that is expected to contribute to the clean energy global marketplace. The long term strategic partnership between CPS Energy and UTSA, when coupled with other partners in our energy innovation ecosystem, will further elevate the stature of San Antonio as a recognized thought-leader in the next global energy transition and will allow us to become a magnet for national and global talent that will further contribute to our potential for innovation and economic stimulus.

Over the course of the last year I have had the privilege to interact with many of our UTSA students who are a wonderful, diverse, enthusiastic group that represent tomorrow's America. Our students fully understand the nature of the challenges before us, but more importantly, they understand the ramifications if we fail to act. Our future is bright and the leadership of tomorrow is fully capable of rising to the challenges they will face. I feel deeply privileged to be involved with the students of UTSA and to be a very small part of their future.

> I was routinely inspired by the "SPIRIT OF SAN ANTONIO" – a spirit that is pervasive throughout our region to make a profound difference in our future!

Let me close by extending my personal thanks to the San Antonio community for their tremendous outpouring of support. We look forward to your ideas and input to help shape the Institute in the coming years to have a lasting impact on San Antonio, Texas and the nation!

Sincerely,

Les

Les E. Shephard
Director
Texas Sustainable Energy Research Institute

THE TEXAS SUSTAINABLE ENERGY RESEARCH INSTITUTE

The Texas Sustainable Energy Research Institute (the Institute) was created to contribute to the energy future of San Antonio, Texas and the nation.

UTSA created the Institute in 2010 in response to a growing need for UTSA to play a leadership role in contributing to the energy future of San Antonio and south Texas. The mission of the Institute is to develop citizen leaders; leaders committed to transform the energy future of San Antonio, Texas and the nation.

The Institute integrates scientific discovery, engineering innovation and policy deliberations with pragmatic implementation and a commitment to our multicultural traditions to realize the promise of tomorrow's America as a global energy leader. The Institute also serves as a center of intellectual creativity that promotes socioeconomic development regionally, nationally and globally.

We provide systems solutions that pursue novel opportunities for technology insertion to reduce costs, improve reliability and assure responsible environmental stewardship that contributes to our energy future. Our impact will drive San Antonio's economic future, coalesce our intellectual capital, serve as a magnet for thought leaders from around the nation and the globe and secure a foundation for enhanced prosperity for south Texas and the country.

THE CPS ENERGY - UTSA ENERGY RESEARCH ALLIANCE

The Energy Research Alliance was created to support the CPS Energy 2020 goals and objectives related to developing a cost competitive, diverse and reliable generation portfolio that is fully coupled with initiatives to increase energy conservation and enhance energy efficiency. The Alliance will mitigate risks associated with advances in new technology deployed to improve grid reliability, enhance grid security and sustained performance, and will promote integration of innovation into the generation, transmission and distribution sectors in a mindful manner. Many of these advances can have significant meaningful impact on long-term grid performance, energy delivery and reliability. The Alliance will also actively engage across San Antonio and the Alamo Region to promote energy and sustainability education and awareness.

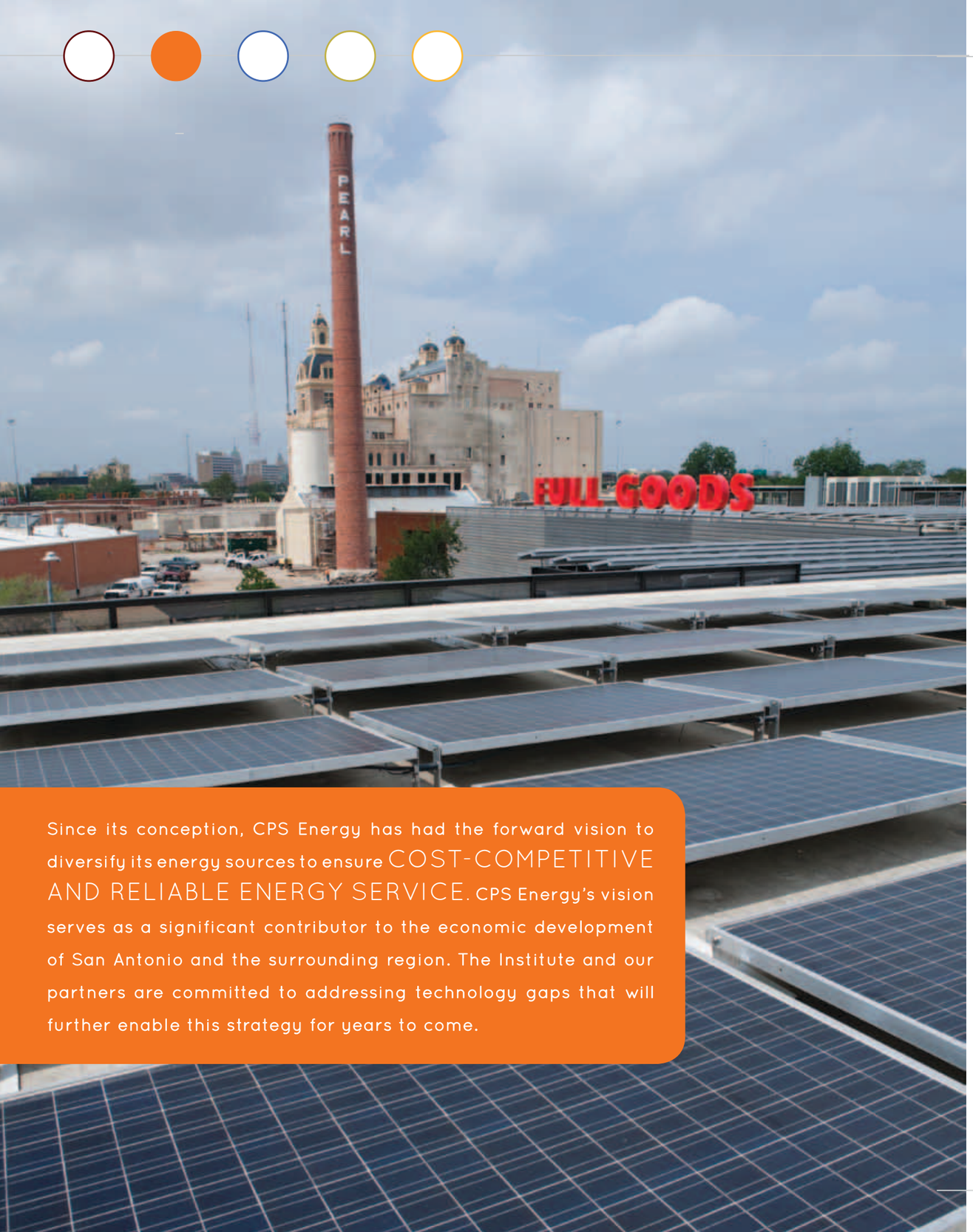
In support of these objectives, we are actively focused on education and working on developing a Teachers program to work with other kindergarten through 12th grade teachers to find more effective ways to bring sustainability into the classroom at the earliest possible stage.

We are building a SMART, integrated renewable generation test bed, intended to integrate solar PV systems from across the city, to test and evaluate the concept of a virtual photovoltaic power plant to assess system performance and to evaluate new protocols for cyber security.

THE INSTITUTE STRIVES TO BE A "PARTNER OF CHOICE" IN SERVING THE CIVIC AND BUSINESS COMMUNITY OF SAN ANTONIO AND THE ALAMO REGION.

We are evaluating alternative approaches for the capture, storage, and reutilization of carbon dioxide; approaches that may uniquely benefit San Antonio and south Texas.

Finally, to accelerate the transition to demand side energy management, we are actively involved in assessing how we can more effectively couple technology and people's behaviors to accelerate this transition. These and other contributions are described in the following sections.



Since its conception, CPS Energy has had the forward vision to diversify its energy sources to ensure COST-COMPETITIVE AND RELIABLE ENERGY SERVICE. CPS Energy's vision serves as a significant contributor to the economic development of San Antonio and the surrounding region. The Institute and our partners are committed to addressing technology gaps that will further enable this strategy for years to come.

THE INSTITUTE IS EXPANDING LOCAL CAPABILITIES TO BETTER SERVE SAN ANTONIO'S VISION

In addition to the contributions by the Institute as part of the formal Energy Research Alliance summarized above, this strategic partnership has provided numerous opportunities to expand local capabilities to better serve San Antonio's vision to connect with the global energy economy.

CONTRIBUTIONS INCLUDE:

- The San Antonio Clean Energy Incubator (i.e., Incubator) was formed as part of the Institute. The Incubator's primary mission is to assist promising local clean technology entrepreneurs to commercialize technology that contributes to local and regional economic growth and job creation.
- Development of a distributed photovoltaic test bed that includes solar photovoltaic systems ranging in capacity from a few tens of kW to more than 140 kW on both the 1604 and Downtown UTSA campuses
- Electric vehicle charging stations are installed on both UTSA campuses to incentivize electric vehicle use and to better understand consumer needs and behaviors
- UTSA established "Nexus," a laboratory created to evaluate the interrelationships between energy and water and to assess the complex interdependencies of energy systems including energy supply, responsible environmental stewardship, and economic prosperity.
- The development of a strategic partnership with the National Renewable Energy Laboratory (NREL) that includes a memorandum of understanding between UTSA and NREL
- Partnerships with several private sector energy technology companies with an emphasis on technology development, commercialization, and education.
- Mentoring community high school students and engaging them in the UTSA Science, Technology, Engineering and Math Programs to develop citizen leaders

Each of these contributions is possible because of the strategic Energy Research Alliance and the sustained leadership support from San Antonio and Alamo Region. These contributions have included alternative sources of state and federal funding that exceeds $ 2.1 M over the last year.

THE ENERGY RESEARCH ALLIANCE: ONGOING PROJECTS

The initial agreement between CPS Energy and UTSA identified

FIVE STRATEGIC FOCUS AREAS

that provide a framework for project definition.

1. CARBON MANAGEMENT, CAPTURE AND REUTILIZATION
2. DISTRIBUTED, SECURE, SMART GRID NETWORK
3. RENEWABLE ENERGY AND ENERGY STORAGE
4. ENERGY EFFICIENCY AND CONSERVATION
5. ELECTRIC TRANSPORATION

As the result of advances in technology, evolving policy deliberations, and insights gained from ongoing research elsewhere, the focus areas evolved into multiple active projects:

- Energy Efficiency and Conservation
- Smart, Secure, and Distributed Grid Network
- Carbon Capture, Storage, Sequestration and Reutilization
- Sustainability Education and Outreach Program
- Electrification of Transportation
- Large Scale Photovoltaic Penetration into the Electric Grid (A collaborative effort with NREL)
- Energy Efficiency (A collaborative effort with NREL)

ENERGY EFFICIENCY AND CONSERVATION

Energy efficiency and conservation are concepts central to meeting our global future energy demands. This project postulates that tailoring educational outreach programs to address explicit customer needs and behaviors can enhance overall energy efficiency and accelerate the marriage of technology and people to reduce energy consumption.

Understanding energy demographics will allow researchers to develop and evaluate analyses and modeling tools that enable utilities and policymakers to quantify the impacts of energy-efficient technologies on reducing CO2 emissions and to explore analytical frameworks, tools, and methodologies to assign value to the impact of energy efficient measures and demand response behaviors.

MODELING HOUSEHOLD ENERGY CONSUMPTION IN BEXAR COUNTY, 2010 – 2011 PROJECT

The purpose of this project is to develop an understanding of how relevant demographic, socioeconomic, housing unit, and geospatial characteristics are associated with variations in energy consumption within much of the CPS Energy service area. Knowledge developed from this modeling process will be utilized for characterizing energy consumption patterns across the CPS Energy service area and for targeting specific groups of CPS Energy consumers with energy conservation strategies. Preliminary results published in a report entitled, "Modeling Household Energy Consumption In Bexar County, 2010" suggests that understanding various covariates of energy consumption can contribute to better energy utilization due to the impacts of:

- Natural Variables
- Social Variables
- Human Variables

The first phase of the project involved research into previous analyses and methods used to examine consumer/household characteristics associated with variation in levels of energy consumption. One of the most important elements of this involved examination of indicators of energy consumption that have been previously utilized. We have identified several different methods of constructing energy consumption measures that will include a strategy to combine natural gas consumption with electricity consumption.

Review of the literature on research that attempts to examine consumer and household characteristics associated with energy consumption suggests there is a dearth of scientific research in this area. Many of the studies are based in Europe and few had been able to utilize household level energy consumption and characteristics in their analyses. In addition there is a lack of literature in the area of research that utilized spatial analysis techniques. Based on the literature review, the research being conducted under this project will both produce information about characteristics of consumers associated with variations in energy consumption, and will also contribute to the science of understanding variation in energy consumption in a way that will assist energy conservation efforts more broadly.

One of the most significant challenges identified early in this effort was the lack of data at the household level that would be expected to have an association with variation in household levels of energy consumption. To address the shortcoming, a methodology has been developed utilizing higher levels of aggregation (i.e. census tract or census block group) and using principles in statistics to select and impute values for variables of interest to household units.

The objective of this research is to UNDERSTAND ENERGY CONSUMPTION DATA, DEMOGRAPHIC DATA AND CONSUMER BEHAVIOR to develop energy consumption models that will accurately represent different groups of customers within the CPS Energy service areas. Such models will allow researchers to develop targeted campaigns to promote energy efficiency and conservation in the San Antonio Area.

Several simulation runs of the methods have been conducted using data from the American Community Survey.

At the larger geographic level of analysis, energy consumption and characteristics of the housing stock and households will be estimated for each area (block group or census tract) within Bexar County. Spatial analytic approaches using geographic information systems (GIS) software and hierarchical modeling methods are also being utilized.

The deliverable for the first year of this project will be a report that presents results from the various analytic approaches employed, maps of the CPS service area in Bexar County that visually represent geographic areas by indicators of levels of energy consumption in relation to other characteristics and a narrative description of methods, findings, and recommendations. The results are expected to allow segmentation of CPS Energy customers in a way that will provide insight into the who, where, and how CPS Energy might target customers with energy conservation programs and incentives in a way that will likely facilitate more efficient energy usage.

This project will EVALUATE various technologies, capabilities and environments to include incorporation of the UTSA campus micro-grid to FACILITATE CPS Energy's goals of large scale renewable penetration.

SMART, SECURE, AND DISTRIBUTED GRID NETWORK

The objective of this project is to assess the potential benefits and challenges associated with the deployment of a smart and secure distributed electric grid.

The team's goal is to develop a distributed generation test bed that will provide a basis for testing, evaluating and modeling distributed energy system components including hardware and software. The laboratory scale microgrid test-bed will be equipped with:

- Photovoltaic Sources
- Emulators along with Power Conversion and Storage Equipment
- Advanced Metering Infrastructure (AMI)
- Real-Time Control
- Cyber Security

The test-bed will allow for the assessment of distributed energy system hardware and software components, the photovoltaic inverters, energy storage, advanced metering, inverter smart grid functionalities, control algorithms, modeling of PV systems, optimization of energy storage integrated with PV, and secure two-way communications.

The test bed is currently under construction with an expected completion in Spring 2012. The test bed will be housed at the redesigned 1,200 square foot "CPS Energy-UTSA Energy Research Alliance Laboratory" located at the west side of the UTSA 1604 Campus.

Researchers will have access to a variety of residential and commercial scale PV installations ranging in size from 12 kW to 14.5 MW. These installations are dispersed throughout the region including the UTSA 1604 and Downtown Campuses, and the Blue Wing facility. These systems will provide actual data to be emulated in the test-bed physically located at the UTSA 1604 Campus.

In the area of inverter technology, the following progress has been noted:

- Preliminary analysis of different inverter technologies available in the market is completed.
- Completed literature review with a specific emphasis on smart grid functionalities. This detailed literature survey resulted in the identification of the different real power and reactive power control strategies used on the PV inverter.
- Simulation studies of PV inverters with reactive power control were performed.
- The PV inverter to demonstrate dynamic reactive power control is being designed and in building process.
- Equipment such as a solar array simulator, three-phase programmable AC load and real-time hardware were procured and are being installed at the CPS Energy Laboratory.

In the area of cyber security, the team is coordinating with CPS Energy staff to procure and replicate existing CPS Energy infrastructure at the UTSA 1604 Campus. CPS Energy has donated two smart meters with the same specifications of those being installed as part of the smart meter pilot program throughout San Antonio.

The next steps in this project include completing the build-out of the CPS Energy Laboratory including inverter and emulator installations. Future tasks to be completed included replicating data for cyber security research and exploring the virtual power plant concept.

PUBLICATIONS AND PRESENTATIONS:

- Bonab and E. Morales, and H. Krishnaswami "Bi-Directional Multi-Mode Grid Tied Converter for Solar Energy Conversion Systems," under preparation for submission to IEEE Conference.
- Chia, C J Qian, H. Du and M. Jamshidi, "Semi-Global Finite-Time Stabilization via Output Feedback of Planar Nonlinear Systems with Application to MPPT in Photovoltaic Systems," Submitted to 2012 ACC.
- Crosier, S. Wang, and M. Jamshidi, "Investigation of the Topology and Control for A 4800-V Grid-Connected Electrical Vehicle Charging Station with STACOM-APF Functions Using A Bi-directional, Multi-level, Cascaded Converter." Paper accepted for poster at APEC 2012 Conference, Orlando FL, February 2012.
- Daali, E. Bonab and M. Jamshidi, "Modeling and Simulation of a Hybrid PV-Wind Energy Systems," to be submitted.
- Ferrer, V., Perdomo, A., Rashed Ali, H., Fies, C., Quarles, J. "AR-SEE: Mobile Phone Augmented Reality for Passive Solar Energy Education " submitted to the 3D User Interfaces Symposium 2012.
- Ferrer, V., Perdomo, A., Rashed Ali, H., Fies, C., Quarles, J. "Virtual Humans for Temperature Visualization in a Tangible Augmented Reality Educational Game" submitted to the 3D User Interfaces Symposium 2012.
- Krishnaswami, "Photovoltaic Microinverter Using Single-Stage Isolated High Frequency Link Series Resonant Topology," Accepted for publication in IEEE Energy Conversion Congress and Exposition (ECCE), Sept 2011.
- Manjili, A. Rajaee, B. Kelley and M. Jamshidi, "Fuzzy-Logic Based Control for Battery Management in Microgrids," Paper submitted to UTSA COS Conference.
- Manjili, A. Rajaee, M. Jamshidi, and B. Kelley, "Fuzzy Control of Electricity Storage Unit for Energy Management of Micro-Grids." Paper submitted to WAC Conference 2012.
- Manjili, A. Rajaee, B. Kelley and M. Jamshidi, "Optimization Using Fuzzy-Logic and Markov Chain Model for Micro-Grid Systems," paper to be submitted to WAC 2012.
- Manoj, A. Rajaee, B. Kelley, and M. Jamshidi, "Smart Grid AMI Communication Networks and Capacity Analysis Using 4G Cognitive Radio." Paper submitted to IEEE Journal on Selected Areas in Communications.
- Mohyedinbonab, E. Morales, H. Krishnaswami, and M. Jamshidi, "Bi-Directional Multi-Mode Grid tied Converter for Solar Energy Conversion Systems." Paper submitted to World Automation Congress, Puerto Vallarta, Mexico, June 2012.
- Nagothu, B. Kelley, M. Jamshidi, and A. Rajaee, "Persistent Net-AMI for Microgrid Infrastructure Using Cognitive Radio on Cloud Data Centers." Paper accepted to IEEE Systems Journal.
- Narra and R, Krishnan, "Key Management for Secure and Fault-Tolerant Communication in Advance Metering Infrastructure," to be submitted to IEEE Conf on Cyber-security.
- Rajaee, K. Nagothu, B. Kelley, "Cognitive Radio Capacity Analysis for Smart Grid Networks."
- Rajaee, K. Nagothu, B. Kelley, and M. Jamshidi, "Throughput Analysis for AMI Meters in Smart Grid on Cognitive Radio Networks." Paper accepted to ICNC.
- Shahgoshtasbi, and M. Jamshidi, "Energy Efficiency in a Smart House with an Intelligent Neuro-Fuzzy Lookup Table." Paper accepted and presented at IEEE SOSE2011 Conference, Albuquerque, NM. June 2011.
- Shahgoshtasbi, and M. Jamshidi, "Modified Intelligent Energy Management System in a Smart House." Paper submitted for presentatin at WAC2012 Conference, June 2012.
- Shahgoshtasbi and M. Jamshidi, "Energy efficiency in a smart house with an intelligent Neuro-Fuzzy lookup table," Proc. IEEE SoSE 2011, paper #1569453099, Albuquerque, NM, June 27-31, 2011.
- Vaishnav and H. Krishnaswami, "Single-Stage Bi-Directional Converter Topology Using High Frequency AC Link for Charging and V2G Applications of PHEV," Accepted for publication in IEEE Vehicle Power and Propulsion Conference (VPPC), Sept 2011.

CARBON CAPTURE, STORAGE, SEQUESTRATION AND REUTILIZATION

The Institute is commissioned with evaluating diverse approaches and technologies for carbon capture, storage, sequestration, reutilization and management to economically reduce and manage carbon dioxide emissions from existing coal and natural gas power plants.

This project will consider the unique characteristics of the CPS Energy service area to develop cost-effective, environmentally sensitive, energy and water efficient alternatives for reducing CPS Energy's carbon footprint.

The initial effort was to conduct an extensive literature review to collect relevant information related to each of the five main carbon categories (capture, storage, reutilization, sequestration and management). The UTSA Carbon team analyzed the information collected during the literature review and is finalizing an Integrated Carbon Solutions Index Library (Index Library).

The Index Library organizes available literature in the field and focuses on applied research that could translate to demonstration projects at various scales. The Index Library will facilitate evaluation and comparison of existing and innovative technologies and assess their real life application potential. The Index Library will allow researchers to screen out technologies and/or concepts with limited application in the San Antonio area.

Collaborations between the Institute, regional and national private companies, and organizations will provide San Antonio and CPS Energy with access to state of the art technologies and carbon management strategies to successfully implement CPS Energy's vision by 2020 and beyond.

The objective of this project is to DEVELOP A MODEL FOR OPTIMIZATION that contributes to the long-term carbon strategy for CPS Energy generation assests, identifying explicit technologies and capabilities that are uniquely relevant for demonstration at CPS Energy facilities.

The next step for the Carbon team in year two is developing Technology Fact Sheets that provide detailed information on these up and coming technologies including a

- Process description,
- Energy and water footprint,
- Advantages and disadvantages, and
- Cost (capital, annual operations and maintenance and life cycle).

THROUGH THE TECHNOLOGY FACT SHEETS, THE TEAM WILL EVALUATE THESE UP TO DATE TECHNOLOGIES BASED ON THEIR POTENTIAL FIT WITH THE UNIQUE GEOGRAPHIC, CLIMATIC, ECONOMIC, AND SOCIO-CULTURAL CONDITIONS OF THE CPS ENERGY SERVICE AREA.

Screened technologies will pave the way to a strategic roadmap for technology validation, testing and implementation as they relate to carbon management, reduction and reutilization in the CPS Energy Service Area.

The future goal of the Carbon team is to understand CPS Energy's system-wide carbon budget, so that a greenhouse gas emissions reduction and management optimization model can be established.

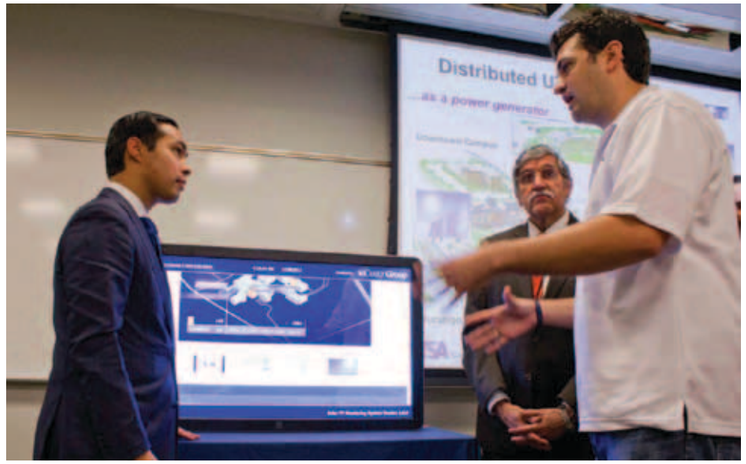
SUSTAINABILITY EDUCATION AND OUTREACH PROJECT

The UTSA Department of Interdisciplinary Learning and Teaching, in partnership with the Texas Sustainable Energy Research Institute is a growing collaborative of educators, scientists and local stakeholders dedicated to the sustainability of San Antonio and the South-Central Texas Region.

By promoting research and outreach, our goal is to merge the interests of the community with the K-12 school system through sustainability education.

Understanding our community's needs and meeting them in ways that are sustainable for future generations requires a fundamental shift in the way we live and interact with our environment and each other. Meeting the growing demands for alternative and renewable sources of energy, informing wise public policy, and developing responsible behaviors that will sustain us well into the future begins with education.

Coordination between the various organizations interested in sustainable development and K-12 educators is often missing. Recognizing this disconnect,



the Institute is currently in the process of creating a much-needed online clearinghouse of local resources to connect K-12 educators with the available educational tools at their disposal. All these initiatives and more are known as the Texas Sustainability Education Project.

By identifying curriculum matches, the clearinghouse will not only help teachers locate education resources, but will help them incorporate sustainability education into their regular classroom. The clearinghouse website will provide access for informal education organizations to upload and update curricula using an internal alignment tool that will help educators identify best practices in sustainable education. The website will ensure a useable connection to the Texas Essential Knowledge and Skills (TEKS) and the new State of Texas Assessments of Academic Readiness (STAAR) test.In addition an Education Advisory Committee has been created and is bringing together a consortium of formal and informal educators, business leaders, and academics to collaborate and present ideas for future programs to benefit the local community. The Advisory Committee will not only impact future planned events, but also help shape the trajectory of the Institute's educational research and outreach program.

The objective of this research is to IDENTIFY KEY ELEMENTS OF SUSTAINABILITY education program targeting "K through 12" levels that can be broadly deplyed to enhance understanding of sustainability as well as energy generation consumption, efficiency and conservation across the CPS Energy service area.

AUGMENTED REALITY – SUSTAINABILITY EDUCATION:

In an era of information technology, Augmented Reality (AR) superimposes computer graphics seamlessly into the real world and provides users with opportunities to access information that is not readily obtainable through tangible observations.

This project is in the process of developing a smart phone type technology application to demonstrate the concept of "Passive Solar Energy."

Currently a prototype is being tested in three pilot studies with nine teachers and thirteen high school students to evaluate the usability and acceptability of AR-Solar Energy Education. Another pilot is being conducted with UTSA undergraduates and graduates in three different disciplines.

Future work will explore the use of additional sensors (besides vision) to enable tangible interfaces for reconfiguring the real-time simulation. In addition, formal studies with both teachers and children in authentic classroom settings to investigate Augmented Reality impacts on collaborative learning will be completed.

ELECTRIFICATION OF TRANSPORTATION

New technologies and infrastructure requirements will be critical to the success of electric transportation. Electric vehicles have the potential to revolutionize fuel efficiency and improve air quality at the city level.

The project will investigate

1) early adopter segmentation,

2) technology standards for vehicle charging,

3) utility tariff design for electric vehicles,

4) public charging infrastructure location selection criteria and guidelines,

5) municipal rules, regulations and policies for electric vehicles, and

6) incentive design and value proposition assessment for promoting and enabling electric vehicle adoption. This will include developing a strategic road map for electric vehicles and conducting large-scale pilots.

The objective of this project is to examine various approaches to enable WIDE SPREAD ADOPTION of electric and hybrid vehicles in the San Antonio community.

A workshop was held August 2011 with contributions from across San Antonio and Texas to understand key challenges and ongoing work associated with electrification of the transportation sector. Based on the feedback from the workshop, UTSA is proceeding with the installation of 11 electric vehicle-charging stations at both UTSA Downtown (3) and UTSA 1604 (8) Campuses. In addition, the team is developing a research roadmap for technology deployment, and developing an action plan and implementation schedule for conducting pilot and demonstration projects utilizing electric vehicles.

LARGE SCALE PHOTOVOLTAIC PENETRATION INTO THE ELECTRIC GRID (in collaboration with NREL**)

CPS Energy has an ambitious goal to achieve 1,500 MW of renewable energy capacity in its resource portfolio by 2020. As part of its renewable portfolio, CPS Energy is evaluating the use of PV technology to convert sunlight directly into electricity.

The goal of this project is to help CPS with the INTEGRATION OF HIGH-PENETRATION LEVELS OF PV into the electric distribution system.

Performance Evaulations of Current Solar Depoloyment within the CPS Energy Service Area

Smart Grid Demand Response Design to Address Intermittency

Circuit Reliability Analysis for the Blue Wing Solar Farm

Energy Storage Evaluation (Technology & Economics)

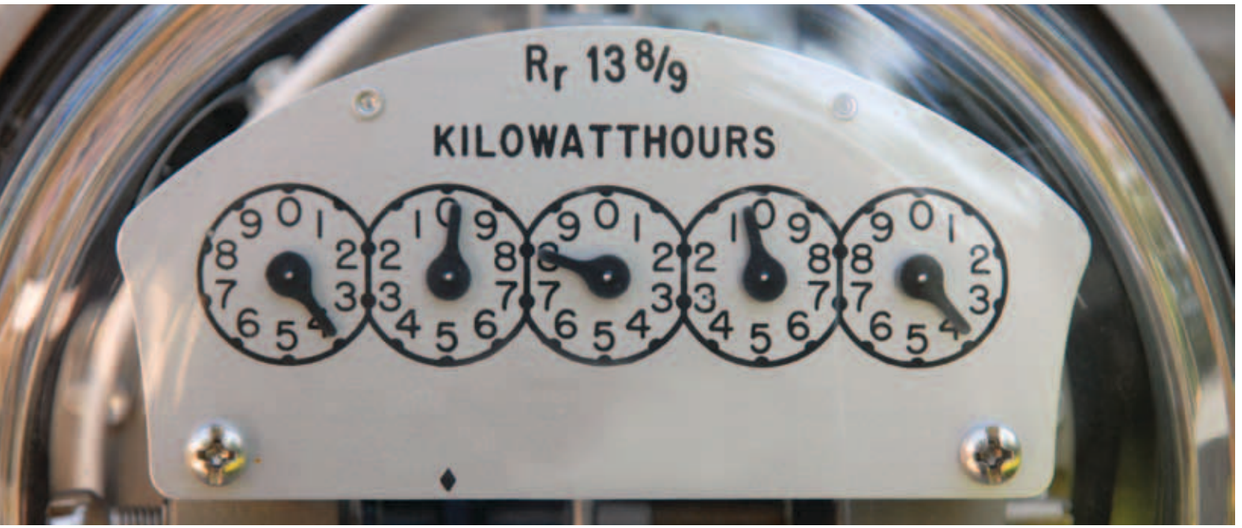
Innovative Forecasting Methodologies

Currently CPS Energy has installed a large Photovoltaic (PV) plant known as the Blue Wing Solar Farm. This PV facility is located southeast of San Antonio, TX on 140 acres and is rated at 16.6 MWdc or 14.4 MWac power. The Blue Wing system is connected to two 13kV distribution circuits in the CPS Energy service territory. On an installed capacity penetration basis, this installation represents one of the highest levels of distributed PV on any circuit in the United States.

The project team, consisting of CPS Energy, NREL, and UTSA, will conduct data collection, analysis, modeling and simulation of the Blue Wing Solar Farm to understand the effect of high penetrations of PV on electrical distribution systems.

The project will consist of several key deliverables including an assessment of the distribution system, system modeling and simulation, field-testing and analysis, and results publication and information dissemination. The results will be summarized and presented to CPS Energy in a Distribution System Planning Handout.

** The National Renewable Energy Laboratory (NREL) is a federal laboratory dedicated to the research, development, commercialization and deployment of renewable energy and energy efficiency technologies (Source: NREL).



ENERGY EFFICIENCY (in collaboration with NREL)

Over the last decade, the National Renewable Energy Laboratory has developed advanced building energy analysis tools such as the Building Energy Optimization software known as BEopt. NREL's tools and processes comprise a proven toolkit for identifying optimal combinations of energy efficiency technologies and operating strategies, in both design of new construction homes and retrofit packages for existing homes.

The objective of this project is to go beyond the conventional residential building energy efficiency programs by using differentiated housing characteristics and advanced building energy modeling to IDENTIFY TARGETED, BUILDING-SPECIFIC APPROACHES to promote energy efficiency in residential building in San Antonio.

In a collaborative approach with NREL and CPS Energy, the Institute will build on energy efficiency work being conducted by UTSA in support of CPS Energy's efficiency programs. Work will utilize BEopt modeling capability to assess optimal investments for retrofits of existing residential and potentially commercial buildings.

Developed by the National renewable Energy Laboratory in Golden, CO, BEopt is a computer program designed to find optimal building designs along the path to highly efficient buildings.

Some of the highlighted tasks in this project include:

- Housing stock characterization
- Model development
- Scoping simulations
- Field testing
- Model calibration
- Simulation and optimization
- Retrofit strategy development

In addition, this collaborative project will provide workforce training and development on issues related to residential building energy efficiency. NREL will work with UTSA to develop course work and professional development programs that will help train architects and engineers within the community on how to use computer tools to design maximum cost-optimal energy efficiency into residential buildings.

PERFORMANCE SUMMARY TABLE

	GOALS	DELIVERABLES	ACHIEVEMENTS TO DATE	FUTURE PLANS
ENERGY EFFICIENCY AND CONSERVATION	Develop tools that summarize energy consumption data and data trends for the CPS Energy service area Support a basis for technology deployment to enhance the effectiveness of CPS Energy efficiency and conservation campaigns	Develop a model for assessing energy consumption patterns that support public outreach, education and communication efforts	• Completed literature review. Published a report entitled "Modeling Household Energy Consumption in Bexar County, 2010" • Examined indicators of energy consumption previously utilized • Developed a methodology that uses higher levels of data aggregation to supplant the lack of data available at the household level • Created project model based on established methodology and modeling software	• Once CPS Energy data set has been delivered to UTSA, CPS Energy will be incorporated into the project model • Using CPS Energy data, create model, maps, and tables to assist in development of energy efficiency and conservation strategies
SMART, SECURE, AND DISTRIBUTED GRID NETWORK	Development of a distributed generation test bed that incorporates capacities of UTSA campus green grid Define a strategy for evaluating various technologies, capabilities and environments for plausible future CPS Energy distribution systems	Develop distributed generation test bed for assessing technologies and optimizing PV system performance in a virtual, distributed power plant	• Constructing the UTSA-CPS Energy Laboratory to research test and evaluate software and hardware components for the smart grid • Performed simulation studies of the photovoltaic inverter with reactive power control to evaluate technology • Explored high frequency AC link for single phase and two-port applications, related to inverter technology • Began design of an inverter to demonstrate dynamic reactive power control applications • Contributing to technical literature and conferences • Gained access to PV installations including both UTSA 1604 and Downtown Campuses solar panels and electric vehicle charging stations. These systems will provide actual data to be emulated in the test-bed	• Install and operate emulator, assess inverter technology for systems studies, and complete build-out for the CPS Energy-UTSA Energy Research Alliance Laboratory • Assess the intermittency of power generation through modeling and dynamic operations • Evaluate approaches to assess physical and cyber security challenges • Explore the virtual power plant concept
CARBON CAPTURE, STORAGE, SEQUESTRATION AND REUTILIZATION	Develop a long-term carbon strategy for CPS Energy generation assets Identify explicit technologies and capabilities that are uniquely relevant for demonstration at CPS Energy facilities	Develop an integrated strategy and technology model for optimization specific to the characteristics and attributes of San Antonio and the Alamo Region for carbon management, storage and reutilization	• Completed extensive literature review in the process of being integrated into the Carbon Solutions Index Library • Identified 5 explicit technology areas relevant to CPS service area • Established process criteria for Technology Fact Sheets to identify technologies that have potential for demonstration	• Gain understanding of CPS Energy's system-wide carbon budget • Use Technology Fact Sheets to develop a roadmap for technology implementation

PERFORMANCE SUMMARY TABLE

	GOALS	DELIVERABLES	ACHIEVEMENTS TO DATE	FUTURE PLANS
SUSTAINABILITY EDUCATION AND OUTREACH PROGRAM	Identify key elements of a sustainability education program Provide education resources targeted at the "K through 12" level Enhance understanding of energy conservation and efficiency across the CPS Energy service area	Develop baseline assessment of sustainability curriculum statewide including the application of augmented reality to enhance student learning	• Created Education Advisory Board • Created a much-needed online clearinghouse of local resources to connect K-12 educators with the available educational tools at their disposal	• Create and post clearinghouse website for sustainability curriculum • Deploy smart phone application prototype • Sponsor several educational events and workshops
ELECTRIFICATION OF TRANSPORTATION	Examine various approaches for widespread adoption of electric and hybrid vehicles in the San Antonio community Contribute to development of a strategic roadmap for electric vehicles and conduct large-scale pilots	Develop an action plan identifying stakeholders and outreach strategy for conducting large-scale pilot programs	• Identified key university, CPS Energy and city personnel • Conducted a facilitated workshop to achieve collaboration among project members • Establish initial research agenda • Installed electric vehicle charging stations at both UTSA Campuses	• Install electric vehicle charging stations at both UTSA Campuses • Develop a research roadmap and action plan • Conduct large scale pilots
LARGE SCALE PHOTOVOLTAIC PENETRATION INTO THE ELECTRIC GRID*	Aid CPS in the integration of high-penetration levels of photovoltaic into the electric distribution system Conduct data collection, analysis, modeling and simulation of the Blue Wing PV Plant Understand the effect of high penetration of photovoltaic on the electrical distribution system	Develop a "Best Practices" report to instruct utilities on how to integrate high levels of distributed PV systems into the electrical distribution system The report will be based on CPS distribution system assessment to include modeling, simulation and field test analysis	• Established strategic relationship with the National Renewable Energy Laboratory to assist with data collection, analysis, modeling and simulation efforts of the Blue Wing facility	• Conduct preliminary visit by the NREL team to the Blue Wing facility and corresponding distribution circuits • Assess the data acquisition systems currently in place and obtain details of the circuits • Develop a High-penetration PV Handbook to present to CPS Energy in the form of a Distribution System Planning Handbook
ENERGY EFFICIENCY*	Collaborate with NREL to utilize the BEopt modeling program to assess optimal investments for retrofits of existing residential buildings	Develop a "Best Value" package using BEopt simulation models and retrofit strategies to help the CPS Energy service area implement cost-optimal savings in residential buildings	• Established strategic relationship with the National Renewable Energy Laboratory to introduce the BEopt program tools for future implementation	• Produce a map of the CPS Energy neighborhoods based on various housing type and age characteristics and their effect on energy consumption • Utilize BEopt and other tools to identify "Best Value" packages to increase level of energy savings • Develop coursework and professional development programs to train architects and engineers

*(A COLLABORATIVE EFFORT WITH NREL)

THE INSTITUTE: A PARTNER OF CHOICE

The initial success of the Institute rests largely with our ability to become a "partner of choice," for centers of discovery and innovation across Texas, the nation, and the world.

Our goal is to coalesce the best talent and ideas to address our future energy challenges. San Antonio is becoming recognized as a thought-leader regionally and nationally and is poised to impact the new energy economy in a substantial manner. This recognition is attributed in part to an existing "innovation ecosystem" that includes the Southwest Research Institute, the Texas A&M University System, UTSA, the Alamo Colleges and others here in San Antonio and with universities, national laboratories and other industry partners across America.

THE INSTITUTE IS DEVELOPING PARTNERSHIPS WITH CENTERS OF INNOVATION AND DISCOVERY ACROSS THE NATION AND AROUND THE WORLD.

At no time in the past has it been more critical for leadership from industry and the universities to work collaboratively, and to facilitate joint venture projects. In San Antonio these collaborations are routinely facilitated by the San Antonio Clean Technology Forum and the Mission Verde Alliance.

The Institute continues to leverage the Energy Research Alliance to partner with world-class expertise and pursue additional funding opportunities. The Alliance benefits greatly from these collaborations and will continue to pursue formal partnerships that extend our impact and contribution.

In the past year over $2.1 million in grants were awarded through various external proposal efforts at the Institute. Proposals were submitted to a variety of potential sponsors including the following:

- Department of Energy
- National Science Foundation
- State Energy Conservation Office
- Department of Commerce
- Water Research Foundation
- State of Texas

PARTNERING FOR OUR COMMUNITY

Madison High School MadSci Solar Powered Vehicle

In an effort to engage high school students about Science, Technology, Engineering and Math Programs (STEM) and to provide UTSA students opportunities to mentor high school students. The Institute partnered with the Madison High School MadSci Team to fabricate a solar powered vehicle.

The Institute is promoting initiatives to develop citizen leaders by engaging UTSA students with community high schools, and showing them how "COOL" SCIENCE AND ENGINEERING IS.

Through this project, UTSA science and engineering students routinely interacted with students affiliated with the MadSci Team to provide a foundation for future interactions with other schools across San Antonio.

The Institute will continue to leverage the Energy Research Alliance and the multidisciplinary teams found within areas the breadth of the UTSA Colleges to pursue energy and sustainability projects, improve our local community, and educate our youth to prepare them for a better tomorrow.

SAN ANTONIO CLEAN ENERGY INCUBATOR (SACEI)

From a State Energy Conservation Office seed grant, the San Antonio Clean Energy Incubator (SACEI), known as the Incubator, was formed within the Institute. Its primary mission is to assist promising local clean technology startups on their path, by working with them intensively to help them:

- Form their business models, teams and staff
- Prepare their sales pitches to investors and customers
- Get access to present to investors and customers
- Strike partnerships to progress R&D for their products

The Incubator's mission and roles, align very well with some of the key missions of the city (for example, SA2020), CPS Energy, UTSA, the Institute, San Antonio Clean Tech Forum, and the Mission Verde Alliance, to name a few.

The Incubator was created through a grant from the State Energy Conservation Office (SECO). The objective of the incubator is to PROMOTE CLEAN TECHNOLOGY and aid aspiring entrepreneurs to move their ideas from the prototype and concept development stages to commercialization.

INSTALLATION OF DISTRIBUTED SOLAR ENERGY RESOURCES AT UTSA 1604 CAMPUS WITH SENSOR NETWORK MONITORING AND CONTROL

This project will produce small- and medium-scale solar energy in prototype buildings on the UTSA Campus. These installations can be replicated on college campuses and in residential neighborhoods throughout Texas. Solar installations are already on their way at the UTSA 1604 Campus. The installations will include sensors for real time fault monitoring to provide energy usage feedback along with a centralized energy information kiosk.

DISTRIBUTED SOLAR ENERGY DEPLOYMENT AT UTSA DOWNTOWN CAMPUS: BUILDING DISTRIBUTION, VEHICLE ELECTRIFICATION, AND REMOTE MONITORING

This project will deploy small-scale, grid-tied PV systems on the Durango site of the UTSA Downtown Campus. This project will also provide electric vehicle charging stations on the UTSA Downtown Campus at the visitors' parking garage. The goal is to provide 190 mega-watt-hours of energy annually and provide CPS Energy research information on EV charging needs and patterns.

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