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Laboratory for Energy Smart Systems (LESS)

FINAL REPORT
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16. Abstract

The US power grid ageing fast and the societal and environmental pressures for clean energy are increasing more than ever. The ageing power infrastructure poses major limitations on energy reliability and resiliency, especially in lieu of recent extreme weather conditions and the emergence of new load and electrification patterns in transportation, manufacturing, built environment and all other sectors of economy. At the same time, the costs of maintaining the power grid in a good state of repair and in its current vertical form will soon be beyond what public and private industry combined can afford. To meet these challenges and to ensure energy security and resiliency, the power industry, supported by extensive funds from the Federal government, has already started embracing major technological changes brought by smart grid and enabled by advanced IT and communication technologies. Microgrids, Distributed Energy Resources (DER) and advanced technological solutions to Demand Side Management (DSM) are being promoted by many communities, cities/townships and industry. DSM technology allows for end-users to take advantage of dynamic pricing and energy efficiency measures, and thus reduce the overall load, especially at peak times. DER technology brings renewables, natural gas-fired generation, combined heat and power (CHP) and energy storage to communities, thus avoiding expensive investments in new transmission and distribution capacities. DSM and DER combined provide the means of deferring infrastructure investment while delivering reliable and quality energy to communities and industry. The combined technology also allows for additional capacity localized to where it is needed the most with capital and maintenance costs that are significantly lower. California, New York and New Jersey are among the first states that are embracing these changes. In these and some other states, utilities have started running programs to communicate many benefits of DSM to their customers, and to find and demonstrate effective ways of adopting DER solutions. At the same time, many large and small communities are trying to figure out optimal ways of investing in DSM and DER.

This project will provide seed funding for the newly established Laboratory for Smart Energy Systems (LESS) at CAIT. LESS brings together many years of R&D expertise on energy systems and plans to establish strong ties to industry and public agencies. Its mission is to work with communities and industry on how to effectively and economically implement DER and DSM solutions, so that their current and the future projected demands are met using clean and sustainable means.

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Microgrids, distributed energy resources, energy efficiency, energy systems asset management.	

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DESCRIPTION OF THE PROBLEM

This project was intended to provide seed funding for the newly established Laboratory for Smart Energy Systems (LESS) at CAIT to partially support its ongoing research activities and to develop a roadmap that will help to achieve the following long-term goals and objectives:

1. Partnership with energy related industry for the purpose of identifying technology barriers and challenges of DER and DSM.
2. Collaboration with public agencies to develop tools and analytics to identify policy and regulation barriers of DER and DSM.
3. Collaborate with other units at CAIT to develop tools that can be used for DER analysis and asset management.
4. Organize a forum to raise public awareness on energy efficiency and the need for public and private investment in DER and DSM solutions.

Strong corporate partnership and community outreach programs are primary outcomes of this project. The public and private partnership will guide LESS R&D activities and will provide its team to develop concepts and tools that are of primary use for industry and public. Engaging policy makers and regulatory bodies in the long-term operational vision of LESS will help to position it right at the forefront of developing tools that support public policies and quantify their outcomes.

Approach

LESS implemented an extensive outreach program to engage industry and government agencies. We also reached out to New Jersey municipalities and local townships extending our R&D services to these agencies.

This project also provided partial funding to our team of students to continue their research work on a number of energy related topics, including energy storage networks, distributed controls of heating and cooling in buildings, and also a cyber-physical platform for energy smart communities. The platform can be used to optimize design and operation of clean energy communities. Two Ph.D. theses have been partially involved with this project. In addition, two undergraduate students were partially funded to work with the Ph.D. team on the development of the cyber-physical platform.

Project Outcomes

Three industry partnerships were established:

(i) The funding from this project led to the expansion of an existing relationship between LESS and DNV GL Energy - an industry leader on energy efficiency and distributed energy resources. Around the same time that this project was funded, LESS also received a project from DNV GL Energy on the development of advanced analytic for building energy asset management and operations (BOMA). The UTC project partially supported BOMA's testing and validation. BOMA allows building owners and operators to optimize asset management of energy resources in buildings and communities. For energy modeling of buildings, BOMA has access to EnergyPlus simulations and a statistical model that forecasts building energy load. As a result of the expanded relationship, one of the Ph.D. students from LESS interned at DNV GL for a period of approximately 6 months.

(ii) The funding from this project led to a new relationship between LESS and Quanta Technology – an industry leader in power and energy systems with focus on

microgrids, distributed energy resources, and asset management. One of the Ph.D. graduates from LESS was hired as energy consultant by Quanta since the establishment of this relationship. Quanta also helped LESS to organize an industry workshop (which will be discussed later). With a technical support from Quanta a concept paper was developed and submitted to the US Department of Energy on innovation in building energy control and management. Quanta and LESS have had several meetings on the use of new technology on asset management of power plants, utility pipelines, and other power systems assets. Quanta is also working with Rutgers LESS to prepare a proposal to the New Jersey Board of Public Utility on the state's initiative on DER. Finally, the two teams are discussing ways of addressing natural gas and power nexus – a critical issues for Northeast and Midwest regions, especially in winter seasons.

(iii) A new relationship was developed with a New Jersey based contracting company (M&E Engineers), which specializes on advanced building controls (energy and Co2). M&E worked with our team to prepare a concept paper to the US Department of Energy on building energy efficiency. We expect this relation to grow and benefit our students and research team.

The funding from this project was very instrumental in helping us to develop the necessary preliminary ideas and tools that led to two funded projects from The New Jersey Board of Public Utility. The first funded project started on July 1, 2015 and ended on June 30, 2016 with the objective of helping the state to develop an incentive and evaluation program for energy storage installations across the state and over different applications (e.g., hospitals, schools, hotels). This project led to the development of a scenario based engineering model of energy storage installations. The second project, which started on July 1, 2016 with expected completion data of June 30, 2017, focuses on CHP and fuel cells installations. Currently we are working with the State of New Jersey to develop plans for distributed energy resources. This project is planned to start in spring 2017.

The UTC funding also led to extension of LESS activities in the area of industrial energy assessments. Now, LESS is managing the activities of the DOE funded Industry Assessment Center (IAC) at Rutgers, focusing on field management of DOE IAC centers in US.

With the help of CAIT and partial funding from this project, LESS organized a workshop on the utility of the future. Over 50 experts attended this workshop from industry, government and academia. The workshop focused on issues and challenges that technology transformation will pose on utilities and public agencies in the next decade. The workshop slide proceedings were published with access given only to the workshop participants. This workshop will continue on an annual basis.

A cyber-physical platform was developed to simulate energy consumption of a community of buildings, distributed generation resources, electric vehicles, and shared assets between buildings. The platform is programmed on top of TRNSYS (commercial software) and EnergyPlus from the USE Department of Energy (DOE), and uses BCVTB (from the Berkeley National Lab) for communication between buildings, generation assets and other loads. The platform includes Electrical Vehicle (EV) simulators and can connect to physical buildings using wireless communication. It includes connections to our in-house BOMA[1] platform that allows for optimal maintenance and operation of energy assets. This is a friendly environment to program

[1] BOMA – Building O&M Analyzer built by Rutgers team in collaboration with industry

new building and community level controls, and optimize sizing of energy consuming assets in the community. It also allows for electric vehicle charging planning and optimization.

Findings

The deliverables for this project were geared toward the long-term plans of LESS. It is the mission of LESS to provide energy related R&D services to New Jersey government and localities. To that end, the funding from this project helped us to secure two projects from the New Jersey Board of Public Utility in the following areas:

1. Engineering models for policy evaluation of energy storage installations, funded by New Jersey Board of Public Utility, July 1, 2015 – June 30, 2016 ($150,000).
2. Engineering models for policy evaluation of CHP and Fuel Cell installations, funded by New Jersey Board of Public Utility, July 1, 2016 – June 30, 2017 ($150,000).

The funding from this project also helped us to develop a concept paper in collaboration with several units at Rutgers and two industry partners. The concept paper addresses the integrated control of building smart materials and heating and cooling systems. If approved, the team will work on the preparation of a full proposal with a budget of $500,000.

The workshop on the utility of the future was very successful. The workshop included four sessions with speakers from utilities, government agencies, industry and academic centers. The main topic of interest was the role of utility and government agencies on adopting new distributed energy technologies at state and local levels. Examples from New York and California were discussed. The workshop will continue in an annual basis and industry sponsorship will be sought. Another workshop of clean energy is being planned for New Jersey municipalities and counties with expected date in spring 2017.

The following publications were partially supported by the funds from this project:

“Distributed Air Conditioning Control in a Commercial Building based on a Physical-Statistical Approach,” Ali Ghofrani and Mohsen Jafari, under review in Journal of Energy and buildings, 2016.

“Cyber-Physical Simulation of Energy Smart Communities,” Ali Ghofrani and Mohsen A Jafari, Proceedings of the International Conference on Smart Infrastructure and Construction, Cambridge University, UK, June 2016.

“Sizing Methodologies for Combined Renewable Energy Systems,” Jaimie Schwartz, Ali Ghofrani and Mohsen A Jafari, submitted to 2017 IEEE PES Innovative Smart Grid Technologies Conferences (ISGT).

"Disaggregating and Forecasting the Total Energy Consumption of a Building: A Case Study of a High Cooling Demand Facility", Juliana Barcelos Cordeiro, Khashayar Mahani, Farbod Farzan, and Mohsen A. Jafari, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering (Energy economics) Vol. 10, No:6, 2016.

CONCLUSIONS

Energy value chain and the use of clean energy in our built environment are fundamental to the health of our society and economy. Clean energy research and education and promotion of

energy efficient communities and industries are essential to our national growth. The funding from this project helped us to significantly expand R&D activities of LESS laboratory at CAIT. We developed new industry relationships and were able to reach out to New Jersey communities to promote new technologies in distributed energy resources. We organized a workshop where experts brainstormed the technology of the future and its impacts on how energy industry will operate. Using a state of art simulation platform, we were able to build tools for optimal sizing and operation of communities with clean energy. Several technical papers were published.