MODELING OF PV PLUS STORAGE FOR PUBLIC SERVICE COMPANY OF NEW MEXICO'S PROSPERITY ENERGY STORAGE PROJECT

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INTRODUCTION

At the Public Service Company of New Mexico (PNM), in collaboration with other partners (Electric Power Research Institute [EPRI], University of New Mexico [UNM], East Penn Manufacturing Inc. [EPM], Sandia National Laboratories, and Northern New Mexico College), a demonstration project is under way that will couple an advanced lead acid battery with the output of a 500-kW photovoltaic (PV) installation. The main objectives of this demonstration project are two-fold: (1) demonstration of power peak shifting from the typical mid-day peak by planned ("slow") action from the battery, and (2) simultaneous smoothing of the PV plant output by fast-response counteraction from the battery. The system has been rigorously modeled (using GridLAB-D™ software) in order to derive the optimal load shifting and smoothing algorithms that lead to the optimal Levelized Energy Cost (LCOE) as well as optimal lifetime of the battery. Once installed, the system will be tested in various configurations to validate or correct predicted models starting from 2011 Q4.

System Description

The system is located at New Mexico's Mesa del Sol, a sustainable master-planned community that will contain different types of distributed energy resources such as PV, fuel-cell, co-generation, and the EPM shifting/smoothing storage system, which is the subject of this paper. The residential part of Mesa del Sol is also a state-of-the-art smart grid community. Houses will be equipped with smart meters and a significant percentage of them will have PV generation. Additional provisions will be taken with the expectation of significant percentage of electric vehicle ownership.

The EPM system combines two technologies to provide 0.5-megawatt (MW) smoothing capacity and 1-megawatt hour (MWh) storage capacity. The first technology is the UltraBattery, which is a valve-regulated lead-acid (VRLA) battery exhibiting ultra-capacitor features for rapid discharge applications. The second is the Advanced Carbon Battery, which is a VRLA battery exhibiting significantly longer cycle life than standard VRLA technology. The combination of these two battery technologies enables long-life VRLA batteries to be deployed with solar PV power plants to both smooth power generation that is interrupted by variable clouds, and shift power generation to times of high power demand. A power system one-line of the bulk electric system (BES) in combination with the 500-kW solar PV power plant is shown in Figure 1.

MODELING AND RESULTS

GridLAB-D™, developed by Pacific Northwest National Laboratory (PNNL) for the Department of Energy (DOE), was identified as a software platform used for modeling of our system. GridLAB-D is an open-source agent-based power distribution system simulation and analysis tool designed specifically for analyzing smart grids with decentralized control. GridLAB-D™ can also be integrated with a variety of third-party data management and analysis tools. Additional conversion software for exporting utility's infrastructure (from databases such as ARC-GIS) had to be developed by UNM. Additionally, special care was taken to develop the battery model because any large-scale battery is not a standard battery module included in the software.

Two distinct cases for optimization were evaluated: when charging at night is allowed ("any" electrons) or when charging is restricted to charging from the local PV source only ("green" or "renewable" electrons only). Although charging from the "renewable" electrons is one of the goals, it is intuitive that charging at night from "any" electron mix is a cheaper solution at the current state of utilities. Figure 2 shows an example of load shifting for these two cases. Since charging only from a PV source is allowed for the "green" electrons, no additional load is experienced for charging the battery during the off-peak hours.

Several scenarios with different parameters to be optimized have been considered. Of primary importance are reduction of the peak load on the feeder during Albuquerque peak load time, and evaluation of cost-efficiency of the battery for load shifting application. A number of criteria were used to estimate cost-efficiency. One of the ways to quantify cost-efficiency is to normalize the cost savings to the capacity of a feeder [1]. Figure 3 shows two plots representing results of such comparison for summer and winter seasons for the "green" electrons case. Peak shifting proved to be approximately twice more cost-effective in summer months than in winter.

CONCLUSIONS

We present results of modeling of various scenarios of advanced lead-acid battery with the output of a 500-kW PV installation. For each scenario, a number of benefits is evaluated and compared, taking into account battery cost and finite lifetime. We present a detailed description of modeling and results of the LCOE analysis.

ACKNOWLEDGMENTS

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REFERENCES

[1] "Statewide Joint IOU Study of Permanent Load Shifting," a report Prepared for Southern California Edison, Pacific Gas and Electric, San Diego Gas and Electric, December 1, 2010, CALMAC Study ID SCE0292.01.

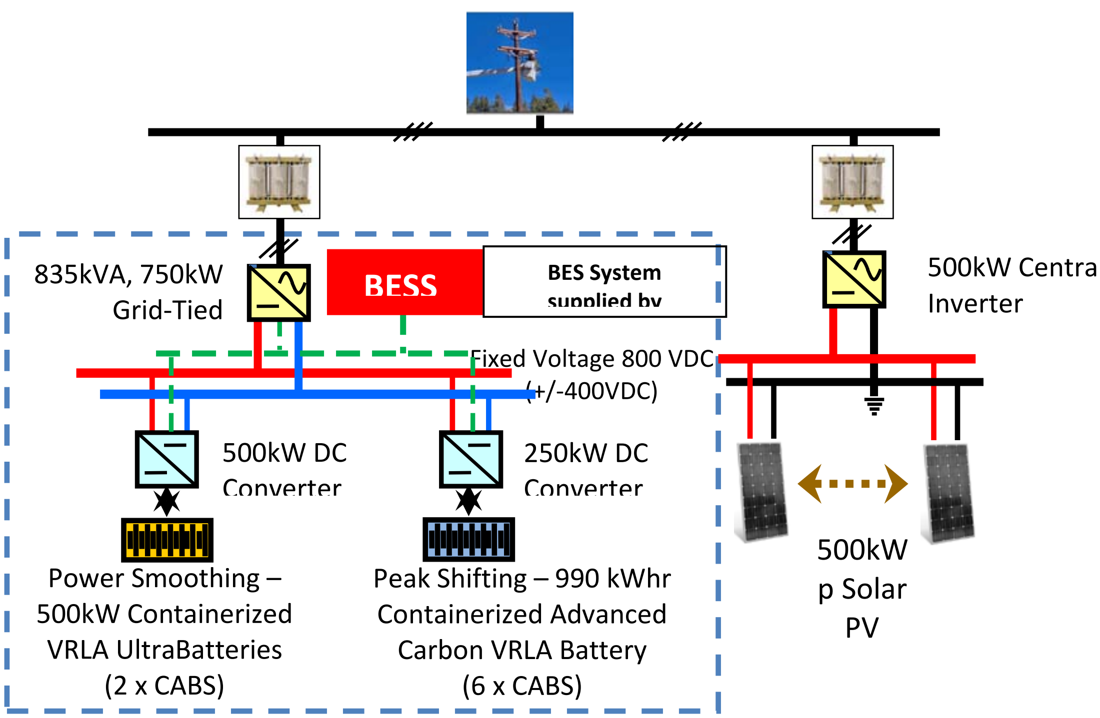


Fig. 1. One-line diagram of the solar PV power plant integrated with the BES.

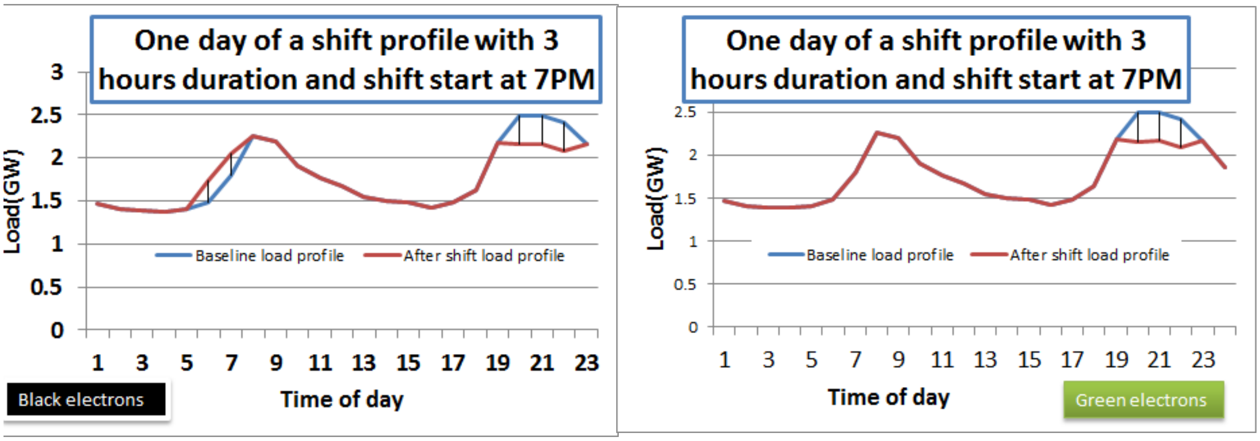
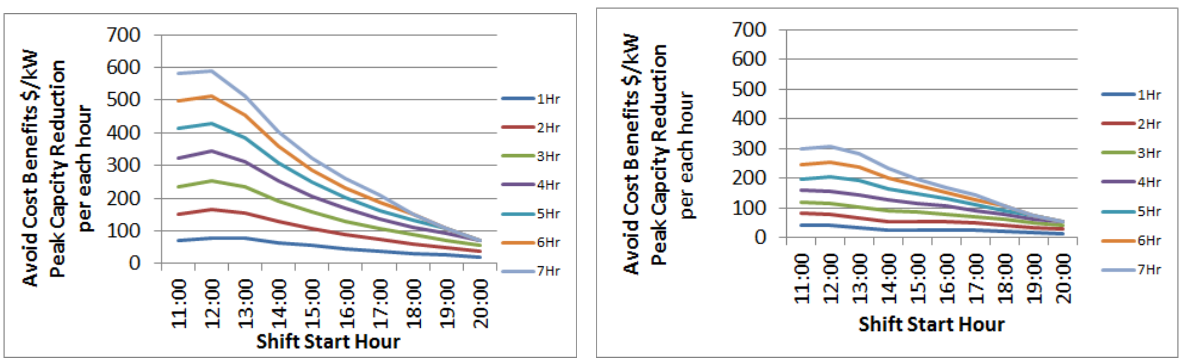


Fig. 2. Two cases of load shifting, when charging from the grid (or "any" electrons) is allowed (a), or when charging from only PV ("green" electrons) is allowed (b).



(a) (b)

Fig. 3. Comparison of avoided cost normalized by the peak capacity reduction per hour for the case of "green" electrons for summer (a) and winter (b) for different shift durations and start times.

BIOGRAPHICAL NOTES

Conference presenter: Olga Lavrova (SM 2000, M 2011) was born in St. Petersburg, Russia. She received her B.Sc. degree in Physics and M.Sc. degree in Electrical Engineering from the St. Petersburg State Electrical Engineering University, and her Ph.D. degree from the University of California at Santa Barbara (UCSB) in 2001. Her employment experience includes postdoctorate research at UCSB, as well as working in the areas of optoelectronic devices at two startup companies and a major corporation (Emcore Corporation). She joined the University of New Mexico in 2007 as a Research Professor, and is now Assistant Professor at the Electrical and Computer Engineering Department. Her current work and areas of interest include photovoltaics and nano-scale semiconductor structures for photovoltaic applications, smart grids, and emerging energy generation, distribution, and storage technologies.

Feng Cheng was born in Shanxi, China. She graduated from Beijing Jiaotong University in 2007 with the major of power system and automation. Now she is pursuing her Ph.D. in electrical and computer engineering at the University of New Mexico. Her research interests are in the area of smart grids and renewable energy.

Shahin Abdollahy (SM 2011) received the B.Sc. degree in electrical engineering from IUT, Isfahan, Iran, in 1998 and the M.Sc. degree in electrical engineering from Tehran Polytechnic, Tehran, Iran, in 2000. He worked in industry from 2000 to 2009 in drives and power converters design as senior design engineer and R&D manager. He is currently pursuing a Ph.D. in electrical engineering at the University of New Mexico, Albuquerque, NM, USA.

Andrea Mammoli was born in Ancona, Italy. He graduated with a Bachelor of Engineering in 1991 and a Ph.D. in 1995 from the Department of Mechanical & Materials Engineering at the University of Western Australia.

He was a Director Funded Postdoctoral Fellow at Los Alamos National Laboratory from 1995 to 1997. He subsequently joined the University of New Mexico as a research faculty member, and is now Associate Professor in Mechanical Engineering and co-Director of the Center for Emerging Energy Technologies. His current research deals with the integration of building-scale energy systems with the electricity grid, particularly as applied to energy storage and distributed systems management. Mammoli is Regents' Lecturer and Halliburton Professor at the University of New Mexico. His projects received several awards, including the Association of Energy Engineers Region 4 Renewable Energy Project of the Year in 2009 and the GridWise Architecture Council's GridWise Applied Award in 2008.

Steve Willard, Professional Engineer, currently serves as the Principal Investigator for PNM's Smart Grid Demonstration Project with the Department of Energy. He has more than 25 years' experience in the energy industry in regulated and unregulated markets, including product development and support, energy system engineering and analysis, as well as energy industry market research. Previous positions include Manager of the Center for Innovation and Technology at PNM, Product Support Manager for Honeywell Power Systems, Lecturer in the U.S. Peace Corps, and Computer Applications Engineer at Bridgers and Paxton Consulting Engineers Inc. Mr. Willard holds two U.S. Patents, BSME and MBA degrees (both from the University of New Mexico), and is a licensed engineer in the State of New Mexico.

Brian Arellano was born in Farmington, New Mexico. He graduated from the University of New Mexico in 2006 with a Bachelors of Science in Electrical Engineering.

His employment experience includes Geographic Information Systems Technical Supervisor with Public Service Company of New Mexico (PNM), Distribution Engineer with PNM, Santa Fe Division in Northern New Mexico, and continuing as an Advanced Technology Project Manager with PNM Resources. His special fields of interest include smart grid technology in the utility industry along with process improvements using Lean and Six Sigma Methodology. He is currently working on an Energy Storage Research and Development Project supported by the DOE. Project partners of this project include the University of New Mexico, as well as Sandia National Laboratories providing support for data modeling and analysis.

Mr. Arellano received nominations and has been accepted for the advisory boards of two organizations as the PNM representative: STEM, which promotes Science, Technology, Engineering and Math Education in New Mexico; and the New Mexico Engineering Foundation (NMEF), which promotes the advancement of engineering education and conducts and support educational programs in engineering.

Clemens van Zeyl**,** MBA, Professional Engineer, has a diverse range of experience as a senior executive in multiple engineering and technology firms. In the span of 30 years, through various roles in the industry, Mr. van Zeyl has been a visionary in the implementation and commercialization of advanced technological products. His multifaceted expertise is demonstrated by his success in the starting, growing, and repositioning of companies. Product introduction, marketing, operations efficiency, and financing are more than familiar to Mr. van Zeyl. Before forming vZenergy, he successfully led research and development projects for such Fortune 500 companies as GE and Shell, and was crucial in bringing multiple innovative products into the market. Mr. van Zeyl's ability to pair technical know-how with sharp business acumen allowed him to facilitate multimillion dollar agreements with leading technological manufacturers and government agencies.