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Sandia National Laboratories

Project Accomplishment Summary

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Sandia National Laboratories

Operated for the U.S. Department of Energy by
Sandia Corporation
Albuquerque, New Mexico

PROJECT ACCOMPLISHMENTS SUMMARY

Cooperative Research and Development Agreement (#1752.02)

between **Sandia National Labs** and Forest City Residential Group, Inc

Note: This Project Accomplishments Summary will serve to meet the requirements for a final abstract and final report as specified in Article XI of the CRADA.

Title: Military Housing Foam Application and Analysis

Final Abstract:

Sandia and Forest City have established a Cooperative Research and Development Agreement (CRADA), the partnership provides a unique opportunity to take technology research and development from demonstration to application in sustainable communities. This project consists of two activities conducted in Hawaii that focus on performance, integration and application of energy saving technologies. Hawaii has many energy challenges, making this location an excellent testbed for these activities. Under this project, spray foam technology was applied at military housing on Oahu and the consumption data collected. A cost benefit and operational analysis of the foam was completed. The second phase of this project included design, integration, and analysis of photovoltaic systems at a military community on Oahu. This phase of the project was conducted as part of Forest City's second Solar America Showcase Award.

Background:

In the spring of 2009, Sandia National Laboratories (Sandia) and Forest City Residential Group, Inc. (FCRG) entered into an Umbrella Cooperative Research and Development Agreement (CRADA) that facilitates joint efforts between the two organizations. This CRADA has focused on clean and sustainable energy technologies that reduce demand and efficiency in diverse energy environments. Sandia and Forest City share a common vision and commitment to having a positive, significant impact on our environment and on our nation's energy and water resources.

Both organizations share similar objectives for the integration and use of renewable energy, reducing consumption of fossil fuels, producing clean water, and creating self-sustaining communities. Sandia is a leader in research of energy systems and renewable energy technologies. Sandia has enduring relationships with the DOD and with Forest City, operator of military housing in Hawaii. DOD is the largest consumer of energy on the Islands with present rates ranging from 30-47 cents/kwh. Sandia is also a strategic member of the Hawaii Clean Energy Initiative (HCEI). The vision within HCEI is twofold: 1) to engage all parties in Hawaii in creating a path to a sustainable, flexible, and economically vibrant State that uses clean energy resources to supply 70% or more of its energy needs by 2030, and 2) to serve as an integrated model for the U.S. and island communities globally. In essence, Hawaii serves as an excellent testbed for research and demonstration of energy efficient technologies.

The activities under this CRADA Project are reflected in two phases. The first phase addresses the need for a cost benefit analysis of energy efficient technology, particularly insulation, at military housing on Oahu. This need was presented to the Sandia-Forest City team by the Office of Secretary of Defense. The second phase of this CRADA Project includes the implementation of a Solar America Showcase Award (Department of Energy) through photovoltaic systems and integration analysis.

Phase I: The Office of Secretary of Defense (OSD) Power Surety Task Force was officially created in early 2008, after nearly two years of work in demand reduction and renewable energy technologies to support

the Warfighter in Theater. The OSD Power Surety Task Force is tasked with identifying efficient energy solutions that support mission requirements. The task force has conducted demonstrations in power consumption reduction at Ft. Benning, Ft. Irwin, Kuwait, Iraq, and Afghanistan utilizing foam insulation to reduce demand. Sandia National Laboratories (Sandia) and Forest City Residential Group, Inc. (FCRG) are collaborating on this project to support the task force's overall mission: "Current technologies help reduce Utility costs for DOD Installations using already programmed Utility dollars to implement." Foam demonstrations were recently expanded beyond field structures to include military housing at Ft. Belvoir. Initial results to using the foam in both applications were favorable. This addressed the remaining key questions: 1) Can this technology help to reduce utility costs for the Installation Commander? 2) Is the foam cost effective? 3) What application differences in housing affect those key metrics? The critical need for energy solutions in Hawaii and the existing relationships among Sandia, the Department of Defense (DOD), the Department of Energy (DOE), and Forest City, made this location a logical choice for a foam demonstration.

Phase II: FCRG was recently presented with a second Solar Showcase award by the DOE to install photovoltaic (PV) systems at their military community on Oahu, Hawaii. Sandia was selected to provide technical assistance to FCRG under this project in the form of design, integration, and analysis of photovoltaic systems. This collaboration contributes to the ongoing relationship between Sandia and FCRG to facilitate advances in energy savings and efficiency. Continuing to address these challenges in Hawaii, Forest City Military Communities, has been selected to increase the availability of photovoltaic systems for the residences on Oahu. FCRG was recently presented with a second Solar Showcase award by the DOE to install photovoltaic (PV) systems at their military community. Sandia was selected to provide technical assistance to FCRG in the form of design, integration, and analysis of photovoltaic systems. This collaboration contributes to the ongoing relationship between Sandia and FCRG to facilitate advances in energy savings and efficiency. The activities in Phase II facilitated collection of data, analysis, and will pave the way for collaboration on photovoltaic application and renewable energy integration to improve energy efficiency in Hawaii. This project also served as a model for mainland states.

Description:

Each technical activity under the two phases of the project were broken into task areas, which are described below.

Phase I: Foam Analysis Technical activities in this project were divided into three main tasks, including application of the foam, monitoring and analysis, and foundation for further research and demonstration. The project team (OSD Power Surety Task Force, Sandia, and Forest City Hawaii) coordinated on these activities. Waikulu was considered the best location for the initial demo, and project timeframes align well with the neighborhood construction schedule. Critical environmental and consumption data was gathered over a set period of time, and analyzed for cost effectiveness of foam application.

Task I: Foam Application Foam was applied in attic space of a duplex home in Waikulu. The unit is composed of two homes averaging approximately 2000 square feet per home. A commercial foam was applied through SprayFoamHawaii, a local contractor. This commercially available foam meets all safety and fire codes, and its chemical content has been evaluated for public use. The foamed units and controls of the same design and orientation (exposure to sun) were selected for maximum applicability of data. During this phase, an exterior foam product was applied to the roof of a PACOM facility in Hawaii. This facility was not monitored for consumption changes; initial feedback from personnel in the facility indicated a dramatic reduction in temperatures within the building. The facility relies on window air conditioner units and prior to foaming, consisted of a metal roof. Approximately 3900 sq feet was foamed with exterior roof product during this phase.

Task II: Monitoring and Analysis Data collection was performed on the homes through a usage monitoring system operated by Forest City to determine demand and consumption rates. This system gathered daily meter readings, which were collated and sent to Sandia by Forest City. Forest City also collected demographic information and move-in/move-out data over the course of months. Analysis of this data considered the following: demand, peak load times, cost and return on investment, life cycle and maintenance of foam, and utilization in conjunction with other renewable energy technologies.

Task III: Foundation for Future Demonstration Review of the foam data, along with insights gathered during application of the foam, provide a foundation for future work. Sandia, PSTF, and Forest City will discuss a path forward that considers the following: sampling size of future foam applications, commercial and residential benefits and consideration of other structures, viability of future demonstration locations (such as Mesa del Sol in Albuquerque, NM, which is a planned sustainable community), demonstrations that may include additional renewable energy technologies, additional or advanced metrics, and reliability and life cycle issues. This path forward will assist in determining what additional safe, secure, sustainable, reliable and cost effective technologies could be installed in military housing to further drive down energy consumption.

Two foam products were applied in this assessment. An ER Systems 2.7 lb foam designed for roof application was applied on the PACOM facility. A Corbond 2 lb foam, designed for interior use, was applied in the attic space of the Forest City units. SprayFoamHawaii, the installation vendor, selected these products in accordance with objectives and ES&H guidelines. This analysis focuses on the overall applicability of foam in this environment, rather than a specific analysis of the foam products themselves. A variety of products exist that provide benefits in specific application environments.

A final report was drafted by Sandia that outlines the findings of the foam analysis. The report includes data sets provided by FCRG. Several conclusions are presented in the final report. The analysis provided foundational information regarding the use of spray foam insulation in residential applications for unique energy environments. Initial data suggests and impact of spray foam in demand reduction and cost benefit. An additional assessment in a controlled experiment environment is recommended. This study also identified a number of factors in the impact level, primarily location of spray foam in the unit and resident behavior.

It is anticipated that a cost benefit could be realized by spray foam insulation, and calculated accurately with data from unoccupied homes in a closed environment. In Hawaii, this cost benefit may be realized more quickly, given present and forecasted energy costs. Likewise, no significant impacts to construction are created by spray foam. Scheduled accordingly, it can be considered as part of a series of steps to complete the home.

Additional elements for study in the use of spray foam insulation have been suggested. Life-cycle and study in other environments, including harsh or aging infrastructure environments, remote sites, and additional residential studies, would be beneficial to DOE, DOD, and the consumer. While demand reduction may not be as visible in residential units as it is at field sites, spray foam may be a viable solution for many energy environments and an easily obtainable solution for government seeking low cost solutions.

Phase II: Through the Solar America Showcase program, FCRG received technical assistance from Sandia for further deployment of solar photovoltaics to support more than 4,500 homes in Hawaii. Two novel PV approaches were used in two different types of housing developments on two different islands. FCRG Ohana Military Communities placed rooftop PV on 2,317 military housing units in its Marine Corps portfolio on Oahu (Marine Corps Base Housing). FCRG Hawaii Affordable Housing Community have taken steps to construct a 3.6MW solar farm on 10 acres to support 2,206 homes on the Big Island. This technical assistance provided in this phase of the CRADA project facilitated discussions between FCRG and Sandia on advanced monitoring of the Ohana Community and other FCH sites at Kanehoe Marine Corps Base. This includes consideration of a plan to monitor homes with PV against a large control group to analyze demand usage. This project also facilitated discussions about potential implementation of solar technologies (PV, inverters) that may be applicable to FCRG military communities in Hawaii under Sandia's Technology Partnership Program in the next 12-24 months. This effort supports the development of a foundation for future demonstrations, also described under Phase I. Several tasks occurred during this phase.

Task 1: Technical Assistance Sandia provided design and integration analysis of the PV systems in two areas, rooftop and solar farm. For the rooftop PV project, technical assistance was needed to: identify best options for solar PV technology, sizing of PV system, and placement of system, integrate advanced

demand-side management controls, and integrate grid stabilizing technologies for the solar farm. Technical assistance was also needed to: develop a technically-sound business model for partnering with the local utility, identify the best solar technology, site the farm location, select the best design and financing options, and develop a method for optimizing power production/consumption within property boundaries.

Task 2: Monitoring Discussion. The results of this task facilitated discussions between FCRG and Sandia on advanced monitoring of the Ohana Community and other FCRG sites at Kanehoe Marine Corps Base. This includes consideration of a plan to monitor homes with PV against a large control group to analyze demand usage. Discussions included similar details regarding data collection plans as seen in the Foam Analysis portion of the project, such as: demand, peak load times, cost and return on investment, life cycle and maintenance of the PV systems, and utilization in conjunction with other renewable energy technologies.

Task 3: Foundation for Future Demonstration/ Technology Partnerships. This task includes discussion of potential future demonstration work, the viability of technologies potentially available under Sandia's Partnership Program and the suitability of Forest City Military Communities in Hawaii or Mesa del Sol for these emerging technologies. Like Phase I, this path forward will assist in determining what additional safe, secure, sustainable, reliable and cost effective technologies could be installed in military housing to further drive down energy consumption.

Task 4: Final Reports for Phase II. Technical assistance delivered to FCRG via their 2009 Solar America Showcase award resulted in increased technical capacity within the FCRG team and advanced FCRG's development projects. These results were achieved after Sandia delivered a series of technical reports and memos, offering technical guidance that addresses specific problems that need to be overcome to achieve specific FCRG solar installation deployment goals. These specific solar installation goals are listed below, followed by the title of the technical report or memo that advances FCRG's deployment goals. Where a formal report was not developed, a description of the technical assistance delivered is given. Task 1: Rooftop PV on Oahu: -Energy upgrades to make Marine Corps officer housing units net zero energy homes (NZH). Technical memo = Solar Options for Historical Housing Unit at 515 Nimitz Road, Kaneohe Bay Marine Corps Base. -Make Marine Corps Base Hawaii (MCBH) Phase V homes "PV Smart Grid Ready". Technical memo = Forest City Solar America Showcase #2 — Guidelines for PV Smart Grid Ready Homes. -Make Marine Corps Base Hawaii (MCBH) Phase V homes "smart" energy consumers. Technical memo = Forest City Solar America Showcase #2 — Guidelines for PV Smart Grid Ready Homes: Design Guidance and Specifications for Smart Home Energy Consumption. Task 1: Solar Farm on Kona -Develop a technically-sound business model for partnering with the local utility, starting with understanding the requirements of a non-utility generator. Technical guidance = Non-utility Generator Form Glossary. -Design, site, and assist in the procurement of a combined meteorological/solar insolation measurement station. Technical assistance delivered = Development and review of the request for proposals (RFP) for the measurement station, review of the proposals received, and recommendations on design/proposal to accept. -Preliminary analysis of data and guidance on future analysis of data from measurement station. Technical report = Assessing Solar Technology Performance of Kona Solar Field. -Financing options for Kona Solar Farm. Technical report = U.S. Department of Energy 2009 Solar America Cities Solar Financing Case Studies Forest City Housing, delivered in partnership with CH2M Hill. -Identify storage options in light of anticipated storage and ramp rate requirements for the Kona Solar Farm. Technical memo = Forest City Solar America Showcase #2 — Energy Storage Options for a 1- to 3.6-MW Solar Farm at Kamakana Villages at Keahuolu, Kona, Hawaii.

Benefits to the Department of Energy:

This project focused on analysis of a commercially available product utilized to reduce energy demand in a unique energy environment. Previously analyzed in DOD field tests, spray foam insulation dramatically reduced consumption of hard-to-obtain and expensive fuel. The analysis in Hawaii provided an opportunity to consider a common residential unit in a tropical environment. Most importantly, DOD is the largest consumer of energy in Hawaii, and given the cost per Kwh, savings on residential units have the potential for a significant cost impact. Demand reduction and cost analyses benefit the DOD, Hawaii, and residential consumers in all states with rising energy costs. DOE is interested in not only demand reduction and cost benefit, but long term grid stability and integration issues. Coupling commercially available, tested

technologies can provide a sustainable solution meeting long-term energy goals. Benefits to DOE from all activities associated with FCRG's 2009 Solar America Showcase award include the short-term, direct benefit of kW installed as a direct result of DOE dollars invested, and the indirect longer-term benefit of market barrier reduction. Market barrier reduction that has occurred and is imminent as a result of these activities includes (a) integrating PV technologies in all new military developments, forcing the consideration of new residential PV on grids with high existing renewable penetration, (b) integrating smart grid technologies at the home and neighborhood level for all new military developments, (c) discovering and resolving policy and code issues related to deploying solar on historic military homes, (d) identifying and working to resolve the issues of integrating a solar field on a utility grid with 30+% renewables, and (e) understanding the impacts of haze and frequent cloud cover on PV and CSP performance. If successful integration of renewables can be accomplished in Hawaii, these results can easily be transferred to the mainland.

Economic Impact:

Data collected at this site facilitates decision making on demand reduction technologies, efficiencies and effectiveness of specific technologies. Cost effectiveness is an important driver for all energy research and demonstration. Given long-term national energy objectives, as well as short-term guidelines for demand reduction in government buildings, all federal and state agencies, particularly those in unique energy environments, benefit from performance analyses of products such as spray foam insulation. Consumers benefit from analysis of a product/technology that is commercially available, low cost, and easily obtained. Simple, easily installed solutions, that can have impact in environment with energy challenges, provide options for consumers. Likewise, the successful application of photovoltaics for maximum performance can provide a standard for further integration of renewables from a cost benefit standpoint. This data facilitates informed decision making by consumers in all areas, not just those with transmission and cost issues.

Project Status:

Completed

ADDITIONAL INFORMATION

Laboratory/Department of Energy Facility Point of Contact for Information on Project

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Company Size and Points of Contact

N/A

CRADA Intellectual Property

None

Technology Commercialization

No commercialization

Project Examples

SprayFoamHawaii (http://www.sprayfoamhawaii.com)

Forest City Military Communities
(http://www.forestcity.net/properties/live/military_housing/Pages/default.aspx)

Solar America Award
(http://apps1.eere.energy.gov/news/progress_alerts.cfm/pa_id=165)

PROJECT ACCOMPLISHMENTS SUMMARY
Cooperative Research and Development Agreement (SC09/01752.02)
between Sandia National Laboratories and Forest City Residential Group, Inc

This summary has been approved for public release by Sandia and Forest City Residential Group, Inc

Sandia National Laboratories

By _____ 06/30/2011
Annie McIntyre — Date
Principal Investigator

Sandia National Laboratories

By _____ 6/23/2011
Manager — Date
WFO/CRADA Agreements

Forest City Residential Group, Inc

By RONALD RATNER _____ 7/8/11
Title: PRESIDENT — Date

In order to expedite the process, if we do not receive your signed reply by 07/30/2011 we will assume your concurrence for the release of this document to the public.