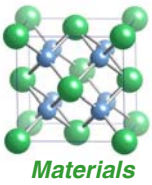
Distributed Energy Program

DE Quarterly Progress Report
For the Period
January 1, 2007 – March 31, 2007



OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Subtask 4.1.1 - Lean NO_x Trap (LNT) Development

Jim Parks, parksjeii@ornl.gov, (865) 946-1283
Oak Ridge National Laboratory

Objective

The main objective of this project is to study lean NOx trap catalysis for emissions control from natural gas (NG) engines. Key emission control areas of interest include: NOx reduction efficiency, operational (fuel) penalty, durability, and cost basis of lean NOx traps for ARES applications. Experiments for the study are performed on a Cummins C8.3G NG engine dynamometer platform at ORNL.

- In FY04, NOx reduction in engine exhaust was demonstrated. **ARES program target emission levels of <0.1 g/bhp-hr NOx were demonstrated**, and NOx reduction efficiencies of >90% were obtained with the lean NOx trap catalyst.
- In FY05, full characterization of the utilization of NG (**fuel efficiency**) for catalyst regeneration was performed. Methane oxidation and reforming chemistries were characterized for various conditions.
- In FY06, the focus shifted to **durability issues** and the impact of sulfur on the *partial oxidation and reforming catalysts* was investigated. Results indicated levels of sulfur commonly found in NG could be tolerated.
- In FY07, a catalyst service process will be investigated as a potential solution of the negative effects of sulfur on the durability of *lean NOx trap catalyst system*.

Highlights

Engine-based experiments for the FY07 task to study servicing of lean NOx traps to remove sulfur accumulated during accelerated aging were completed in Q1. Results were positive and indicated that catalyst washing is a feasible technique for maintaining catalyst durability against sulfur poisoning.

Technical Progress

The goal for FY07 is to determine the feasibility of increasing catalyst durability and lifetime via a catalyst wash service process for the removal of sulfur poisons. Experiments toward this goal have been conducted on the Cummins C8.3G+ engine dynamometer platform at ORNL during Q1FY07. The following experimental phases were completed:

1. Baseline Characterization: Baseline lean NOx trap catalyst system performance was characterized.
2. Rapid Sulfur Aging: Accelerated Sulfur aging of the catalysts was conducted using bottled SO_2.
3. Catalyst Washing: The lean NOx trap catalysts were washed with aqueous based solutions, and new sorbate media were applied to effectively refurbish the lost sulfur poisoned components.
4. Post Characterization: Repeat of catalyst performance characterization performed for baseline.

Results show that the catalyst washing process is extremely effective in restoring lost NOx reduction performance due to sulfur poisoning. The sulfur aging degraded NOx performance from >90% NOx reduction efficiency to ~50% NOx reduction efficiency, but the washing process recovered performance to >90% NOx reduction efficiency levels. ***Thus, the washing process is a feasible technique for maintaining catalyst durability against sulfur poisoning in lean NG engine applications.***

Detailed analysis of the data obtained in Q1 continued in Q2 FY07. The analysis is ongoing with expectations that report generation will begin in Q3.

Status of Milestone(s)

(1) Complete the Lean NOx Trap (LNT) development work with the conclusion of the sulfur poisoning study and disseminate the results to the engine community (September 2007): - On Track (engine experimental work completed; analysis ongoing and reporting pending).

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Industry Interactions

- An abstract entitled “Mitigation of Sulfur Effects on a Lean NOx Trap Catalyst by Sorbate Reapplication” has been submitted for the ASME Fall Technical Conference on Internal Combustion Engines in Charleston, SC on October 14-17, 2007.

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Subtask 4.1.2 - Spark Plug Erosion and Failure

Mike Brady, bradymp@ornl.gov, (865) 574-5153
Oak Ridge National Laboratory

Objective

Spark plug lifetimes in advanced natural gas (NG) engines are on the order of only 1000-4000 h, which result in loss of performance and necessitate frequent, costly downtime maintenance. Spark plug durability will become even more critical as future engines are pushed to leaner-burn conditions to reduce emissions. The goals of this effort are to gain insight into spark plug life-limiting wear processes, and to use this understanding to develop new electrode alloys to achieve lifetimes of ≥ 8000 h.

Highlights

Two new ORNL developmental high thermal conductivity electrode alloys were manufactured and delivered to Woodward for NG spark plug manufacture.

Technical Progress

Plates of two ORNL developmental high thermal conductivity Ni-base electrode alloys were manufactured and delivered to Woodward for manufacture into NG spark plugs. These plugs will utilize a prototype Woodward design. NG engine testing is planned to establish 1) the viability of the current Woodward design and 2) whether the ORNL alloys offer improved performance over conventional Ni-electrode alloys. The Woodward spark plug design is not available in a size amenable to the ORNL Cat NG engine. Discussions have therefore been initiated to collaborate for the engine testing of these spark plugs at Colorado State.

Status of Milestone(s)

(1) Submit an open literature paper reporting on the engine test results of developmental spark plug electrode alloys (September 2007): Status uncertain (see below)

Significant delays have been encountered at Federal Mogul (FM) in manufacture of NG spark plugs for testing at ORNL, as well as in completion of laboratory engine testing at FM. These delays may impact our ability to complete the milestone on schedule and are beyond our control. Collaborations with Woodward may result in a suitable alternative path to meet this milestone.

Industry Interactions

Conference calls and email communications with Dan Tribble of Woodward regarding manufacture of Woodward NG spark plugs from ORNL alloys. Conference calls and email with Jim Lykowski at FM to discuss progress in collaborative work at FM.

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Subtask 4.1.3 – Siloxane Mitigation for Advanced Natural Gas Engines

John Storey, storeyjm@ornl.gov, (865) 946-1232
Tim Theiss, theisstj@ornl.gov, (865) 946-1348
Oak Ridge National Laboratory

Objective

Reciprocating engines remain the most logical distributed generation choice for reducing the peak demand on an electrical feeder due to their ease of siting and good economics. However, utilities and distributors are often reluctant to interconnect or rely on reciprocating engines for peak load reduction due to a real or perceived lack of reliability, availability, maintainability (RAM) and/or emissions concerns. The objective of this project is to consider the use of reciprocating engines from an end-user perspective and address their long-term reliability, availability, and maintainability under peak-load-reduction conditions. Initial work will focus on a thorough assessment of the RAM of reciprocating engines and specific areas that need improvement. The assessment will include both existing and new products and will consider engine control and perceived lack of availability. A key issue is to determine if existing engines can be used on congested feeders for peak demand reduction and the necessary developments (emissions reduction, remote controls and dispatching, etc.) for utilities to rely on and control these existing resources.

Highlights

Work has not yet begun during this reporting period.

Technical Progress

Work has not yet begun during this reporting period.

Status of Milestone(s)

(1) Investigate engine conditions at which burning landfill/digester gas in reciprocating engines produces siloxane deposits which may damage the engine. (September 2007): On Track

Industry Interactions

- Waukesha Engine Dresser (WED) has expressed interest in the siloxone issue in reciprocating engines and discussed potential mitigation strategies with ORNL.
- ORNL is discussing the siloxane issues with a firm who specialize in the design of waste-water treatment plants.

Subtask 4.2.1 – Microstructural Characterization of CFCCs and Protective Coatings

Karren More, morekl1@ornl.gov, (865) 574-7788
Peter Tortorelli, tortorellipf@ornl.gov, (865) 574-5119
Oak Ridge National Laboratory

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Objective

SiC/SiC continuous-fiber ceramic composite (CFCC) combustor liners with a BSAS-based environmental barrier coating (EBC) have been exposed in several Solar Turbines engine tests for >10,000 h. The engine-exposed combustor liners have been characterized microstructurally and mechanically at ORNL to evaluate degradation of both CFCC liner materials and the EBC system. Simulated exposures of analogous materials systems were previously conducted in ORNL's Keiser Rigs at high water-vapor pressures. More recently, an oxide/oxide outer liner, A/N720 CMC + FGI, and a GE SiC/SiC MI pre-preg + BSAS inner liner, have been exposed in a Solar Turbines Centaur 50S gas turbine at the ChevronTexaco engine test site in Bakersfield, CA. Coupons of the same materials were exposed in the Keiser Rig and were evaluated post-exposure. The primary objective of this project in FY2007 will be to characterize damage and elucidate degradation mechanisms of the two long-term engine-exposed CFCC liners for comparison with previous engine-exposed liners and laboratory-exposed coupons.

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Highlights

The engine-exposed ATK-COIC oxide/oxide ceramic matrix composite outer liner, designated hybrid A/N720 CMC+FGI, was received at ORNL for characterization on March 14, 2007. This hybrid liner was exposed in the Solar Turbines Centaur 50S turbine for a total of 25,404 h with 109 starts. Thus far, the fully-intact outer liner and a quarter arc of a similarly-processed (but not engine-exposed hybrid outer liner, i.e., baseline material) have been photographed and are currently being subjected to thickness measurements using the coordinate measurement machine (CMM). In addition to thickness measurements, the liner will be sectioned for extensive microstructural and mechanical characterization during the next Quarter.

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Technical Progress

Since the engine-exposed hybrid liner and its unexposed baseline counterpart, have just been received at ORNL, a liner sectioning plan has only recently been sent out to all interested parties for approval. The sectioning plan for the liner includes representative samples from areas exhibiting surface recession of the FGI, regions of exposed CMC, "patched" FGI areas that show improved behavior, and a through-thickness hole. Each region of interest will be examined closely using electron microscopy and tensile test from representative areas will also be conducted and compared to the baseline material. It is anticipated that thickness measurements and sectioning of the liner will be completed by early May 2007.

Status of Milestone(s)

(1) Report results from the analysis of >25,000 h engine-exposed ceramic matrix composite combustor liners (oxide/oxide+FGI and/or GE Pre-Preg) and compare with data for similarly-exposed composite material in the Keiser Rig (August 2007): In progress

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Industry Interactions

1. Attended meeting at ATK-COI Ceramics on February 15, 2007, to discuss sectioning plan for hybrid outer liner. Representatives from Solar Turbines Inc. and Siemens Westinghouse were also in attendance.

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Subtask 4.2.2 – Mechanical Reliability Evaluation of Ceramic Composites and Components with Environmental Barrier Coatings

H-T Lin, linh@ornl.gov, (865) 574-8857
Oak Ridge National Laboratory

Objective

The objective of this subtask is thus to evaluate the protection performance of oxide-based EBC systems with ceramic composite substrates under a combined applied stress and steam environment. The results of this work will allow end users to verify their component design and probabilistic lifetime prediction methodologies, facilitate the implementation of ceramic and composite components, and further optimize the EBC performance.

Highlights

The setup of a flexure test system capable of externally applying a low cycle fatigue stress during the high temperature steam exposure has been successfully completed. The objective of the system setup is to provide a facility that would allow end users to evaluate the effect of externally applied stress on the material recession and degradation, and thus mechanical performance of SiC-SiC or oxide CMC with EBCs under a simulated combustion environment. Also, it would provide important database for life prediction of the CMC components.

Technical Progress

Detailed microstructure analysis of SiC-SiC CMC with an oxide EBC after 500h low-cycle fatigue test under a low-speed steam environment at 1200°C was successfully completed. Note that the applied stress levels were close to the proportional limit of composite. SEM examinations showed that the CMC without EBC experienced substantial environmental attack in both the fibers and matrices and thus significant loss in mechanical performance as anticipated due to the steam exposure. On the contrary, the CMC with EBC did not show any material change even under the low-cycle mechanical loading condition. The post fracture surfaces still exhibit pullout of reinforcing fibers and no reaction layer observed at the fiber-matrix interface due to oxidation. Observations suggest the EBC system employed could have long-term potential to protect the oxide CMC under a combined steam and applied stress condition. Nonetheless, much longer test time up to 2000h will be carried out to ensure its long-term stability and performance. SEM analysis of a pre-strained FGI oxide-oxide CMC specimen (up to 0.25%) after 500h steam jet exposure at 1288°C was also completed during this reporting period. Observations showed that there was minor recession in the subsurface FGI region, which was similar to those observed in specimen after 500h exposure at 1200°C. Results suggest that the FGI could have potential for much higher temperature applications, but more extensive studies are needed.

Status of Milestone(s)

(1) Complete characterization of EBC-composite systems under a combined stress and steam jet test condition (September 2007): On track

Industry Interactions

1. Communications and conference calls with Venkata Vendula and David Jarmon at UTRC on the results of SEM examinations of those SiC-SiC CMCs after 500h steam exposure.
2. Communications with Chris Campbell and Jay Morrison at Siemens Power Generation on the updates of SEM analysis and steam test results of on the FGI oxide-oxide CMC at 1288°C.
3. Communication and conference calls with Xiaogun Chen, Mark van Roode, and Jeff Price at Solar Turbines on the results of thermal properties characterization of TBC discs with different compositions and heat treatment history, and discussions on the new TBC test plans.

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Subtask 4.2.3 – Environmental Protection Systems for Ceramics in Microturbines and Industrial Gas Turbine Applications

Beth Armstrong, armstrongbl@ornl.gov, (865) 241-5862
Kevin Cooley, Mike Brady, and H.-T. Lin
Oak Ridge National Laboratory

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Objective

In order to be cost competitive, microturbines will have to meet aggressive durability targets. Currently ceramic components without an EBC will not be able to meet the goals of > 20,000 operation hours. An EBC may enable these components to meet the expected lifetimes provided the EBC can be applied at low cost. The goal of this project is to continue to develop a low cost, slurry-based process to apply protective coatings for silicon based ceramic materials for use in microturbine and/or industrial gas turbine applications. This effort will be coordinated with industrial partners to assist in the development of an ideal coating material or material system for steam and high velocity resistance

Highlights

A study of the effect of contamination(s) upon slurry and coating properties has been initiated. Slurry development of a partners' material systems will continue.

Technical Progress

Work (rheology, dipping, and sintering studies) began to ramp up again on the candidate material systems. Work was put on hold last quarter due to equipment issues. Due to contamination issues identified previously on collaborators' material system development, the focus of the slurry development for the remainder of the fiscal year will be on evaluating the effect of common elements of contamination from water and additive sources on zeta potential, rheology, dipping behavior, coating thickness, and coating microstructure. This work will compare the effects of deionized and deionized and distilled water as well as the effects of varying and known concentrations of contaminant species. Sodium, potassium, barium, calcium, chlorine and fluorine have been selected as the candidate species for initial studies. Two coating material systems, yttrium monosilicate and yttrium disilicate, will be used to evaluate the sensitivity of the material system's structure with contamination.

Status of Milestone(s)

(1) Evaluate the effect of contamination upon slurry and resulting coating properties for a doped rare-earth silicate system (September 2007): On track.

Industry Interactions

- Collaboration with Honeywell continues.

Subtask 4.2.4 – Spark Plug Electrode Alloy Development

Mike Brady, bradymp@ornl.gov, (865) 574-5153
H.-T. Lin and Mike Kass
Oak Ridge National Laboratory

Objective

Spark plug lifetimes in advanced natural gas (NG) engines are on the order of only 1000-4000 h, which result in loss of performance and necessitate frequent, costly downtime maintenance. Spark plug durability will become even more critical as future engines are pushed to leaner-burn conditions to reduce emissions. The goals of this effort are to gain insight into spark plug life- limiting wear processes, and to use this understanding to develop new electrode alloys to achieve lifetimes of ≥ 8000 h.

Highlights

Two new ORNL developmental high thermal conductivity electrode alloys were manufactured and delivered to Woodward for NG spark plug manufacture.

Technical progress

Plates of two ORNL developmental high thermal conductivity Ni-base electrode alloys were manufactured and delivered to Woodward for manufacture into NG spark plugs. These plugs will utilize a prototype Woodward design. NG engine testing is planned to establish 1) the viability of the current Woodward design and 2) whether the ORNL alloys offer improved performance over conventional Ni-electrode alloys. The Woodward spark plug design is not available in a size amenable to the ORNL Cat NG engine. Discussions have therefore been initiated to collaborate for the engine testing of these spark plugs at Colorado State.

Status of Milestone(s)

(1) Submit an open literature paper reporting on the engine test results of developmental spark plug electrode alloys (September 2007): Status uncertain (see below)

Significant delays have been encountered at Federal Mogul (FM) in manufacture of NG spark plugs for testing at ORNL, as well as in completion of laboratory engine testing at FM. These delays may impact our ability to complete the milestone on schedule and are beyond our control. Collaborations with Woodward may result in a suitable alternative path to meet this milestone.

Industry Interactions

Conference calls and email communications with Dan Tribble of Woodward regarding manufacture of Woodward NG spark plugs from ORNL alloys. Conference calls and email with Jim Lykowski at FM to discuss progress in collaborative work at FM.

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Subtask 4.2.5 – Alloy Development and Optimization for Increased Corrosion Resistance in High Temperature Exhaust Gas Environments

Bruce Pint, pintba@ornl.gov, (865) 576-2897

Objective

The goal is to finalize experimental work designed to improve the understanding of alloy composition effects on corrosion resistance of stainless steel components used in microturbine recuperators. Due to the linear kinetics of Cr loss by evaporation in the presence of water vapor in the exhaust gas, the maximum operating temperature and lifetime of high-alloy steels is limited. Encouraging results have been obtained with Al additions to Fe-base alloys. The focus is on acquiring sufficient laboratory experimental results on Al additions and/or low-cost Al coatings for this application.

Highlights

Foil was produced from Fe-14Cr-16Ni+Al and Fe-14Cr-20Ni+Al alloys. Testing of these and similar materials are continuing in humid air at 650°-800°C in order to compare their behavior with conventional austenitic alloys.

Technical Progress

Laboratory testing is continuing on various model alloys in order to better understand the effect of water vapor in exhaust gas on oxidation of Al-containing steels over a range of temperatures and compare their behavior to chromia-forming steels. The laboratory-rolled foil material has not performed well, likely due to problems controlling the surface chemistry and finish.

Status of Milestone(s)

(1) Submit an open literature publication reviewing the potential for Al alloying additions and/or low-cost coatings to improve oxidation lifetimes of recuperator alloys (September 2007): Completed by:

B. A. Pint, J. P. Shingledecker, M. P. Brady and P. J. Maziasz, (2007) "Alumina-Forming Austenitic Alloys for Advanced Recuperators," ASME Paper #GT2007-27916, presented at the International Gas Turbine & Aeroengine Congress & Exhibition, Montreal, Canada, May 14-17, 2007.

Y. Yamamoto, M. P. Brady, Z. P. Lu, P. J. Maziasz, C. T. Liu, B. A. Pint, K. L. More, H. M. Meyer and E. A. Payzant, "Creep-Resistant, Al_2O_3-Forming Austenitic Stainless Steels," *Science*, 316 433 (2007).

Industry Interactions

Completed laboratory testing of protective oxide coatings on commercial type 347 foil specimens for N. Garrett with C3 International, Alpharetta, GA.

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Subtask 4.2.6 – Materials Selection for Hostile Microturbine/Engine Environments

Jane Howe, howej@ornl.gov, (865) 241-9745
Rosa Trejo and Edgar Lara-Curzio
Oak Ridge National Laboratory

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Objective

The project is to carry out corrosion and mechanical property studies as a function of the test environment (i.e. natural gas byproducts, and with additional contaminants, such as SOx), and report gas sampling of exhaust gases as a function of operation time.

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Highlights

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The ORNL Microturbine Recuperator Test Facility with Fuel-Flexible Environment (MRTFFE) is designed to perform the following tasks for a given type of fuel:

- Measure the temperature and gas species at selected locations inside the microturbine
- Evaluate materials degradation by placing coupons inside the microturbine
- Measure the SOx, NOx, CO/CO_2, etc in the exhaust
- Evaluate the degradation of candidate turbine/microturbine structural materials by exposing samples in a natural gas exhaust stream that is maintained at the desired test temperature, and doped with toxic species or components that make the gas stream characteristic of the exhaust when nontraditional fuels are burned.

Technical Progress

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A 1000-hour recuperator material test started in end of March 2007 to continue the long term evaluation of 2025-3.2mils, HR120-3.2mils, and AL-625-4mils. The Controlled Environment Test Chamber (CETC) is an extension to the microturbine, as a slip stream of the exhaust gas will be diverted out of the microturbine from the aft removable dome, controlled by a gate valve, then into a 2"-dia test chamber. The gate valve and the main part of the CETC assembly was attached to the microturbine. Designing of the sample holders of CETC was finished. Gas sampling and analysis were carried out with assistance of NTRC collaborators. Alumina forming alloy samples, which have been developed at ORNL, are being prepared to be evaluated in the microturbine.

Status of Milestone(s)

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(1) Complete a report summarizing the results of corrosion and mechanical property studies a function of the test environment (September 2007): On track

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Industry Interactions

- A technical report of Ingersoll Rand's microturbine specimens was delivered and received positive feedbacks.
- Communication with Chinese Coal Information Institute (CCII) regarding the proposal entitled, "Demonstration of Power Generation Using Low Quality Coal Mine Methane, Emission Monitoring, and Engine Performance Analysis". The proposal was revised upon EPA's request.

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Subtask 4.3.1a – Packaged/Modular IES Development

Robert DeVault, devaultrc@ornl.gov, (865) 574-2020
Oak Ridge National Laboratory

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Objective

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The objective of this proposed subtask is to develop and deploy highly efficient IES and include these as an essential element within the scope of the OE/DE Program. IES focuses on technologies that have broad utilization potential such as cooling, dehumidification, humidification, water heating, steam heating, drying, and shaft power from heat energy. Key program elements are packaged/modular IES development, DG thermal recovery research, IES field evaluations and end-use integration, and analytical tools/validation.

Highlights

UTRC – Plans for facility modifications to enable testing of the Simultaneous Chiller in the UTRC CHP Facility were developed.

Technical Progress

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UTRC is developing plans for facility modifications to integrate the simultaneous chiller into its microturbine-based CHP facility. Modifications include adding the capability to process hot water (175 F) and chilled water (44 F) simultaneously and return each stream to the chiller at appropriate temperatures. The simultaneous (or "tri-generation") chiller is expected to arrive at UTRC in July once tests are completed at Carrier Korea (CKO) in June. The Capstone C60 microturbines will be used for power generation and to provide thermal energy into the new chiller. This "Trigeneration" capability is advantageous for buildings with multiple zones having independent thermal loads, e.g., buildings where some zones have constant cooling loads while other zones of the building have seasonally-varying thermal loads. Another application benefiting from this technology is buildings that are located in climates requiring daytime cooling and nighttime heating.

Status of Milestone(s)

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(1)Complete draft report on the UTRC Phase II readiness assessment of performance, cost, and reliability for a reciprocating engine/hybrid chiller system (TBD [when UTRC submits task description]): On schedule.

(2) Draft case study Seton Dell Children's Hospital IES system (September 2007): On schedule

Industry Interactions

N/A

Subtask 4.3.2a,b – DG Thermal Recovery and Integration Research at University of Maryland

Patti Garland, garlandpw@ornl.gov, (865) 574-0738
Dr. Reinhard Radermacher, University of Maryland

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Objective

The objectives of the integration research being conducted at ORNL and at the University of Maryland are:

- Demonstrate the benefits of integrated CHP systems in commercial building applications
- Identify and help resolve problems that occur when combining different components into an integrated system
- Identify, develop and demonstrate system improvements
- Provide educational opportunities

This project will be completed in 2007, with the following work activites:

- Completion of testing of the newly designed low-flow conditioner components for liquid desiccant dehumidifier [work to be done in partnership with NREL]
- Completion of testing of the newly installed Broad absorption chiller with internal cooling tower
- Development of course material on absorption chiller systems operation and integration into CHP Systems for Buildings

ORNL works closely with the project team at the University of Maryland to analyze system data, to prepare presentations on test results and lessons learned, to write peer-reviewed technical papers, to provide project updates to DOE, to update the U of M website, and to find opportunities to disseminate lessons learned to the public. ORNL will facilitate cooperation and test plan development with other DOE national labs.

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Highlights

- The close-out plan was completed and the contract is being modified to include the final work.
- ORNL comments on the annual report were provided to U of M. Comments are being incorporated into the final report.
- The CHP Consortia Meeting was held March 22nd at the University.

Technical Progress

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The March 22nd Consortia Meeting was open to members only. Founding members include: U of M, DOE, and ORNL. Supporting members include: Broad Air Conditioning, Inc, Baltimore Aircoil, Capstone Turbine Corporation, Daikin Industries, LTD, U.S. Environmental Protection Agency, Honeywell International Inc., Kathabar Inc, Propane Exceptional Energy, Tridium, Trigen, Trion Inc, and StulzATS. Information on the consortia and work activities can be found at: http://www.enme.umd.edu/ceee/chp/

Status of Milestone(s)

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Complete close-out plan for system shutdown (April 2007): complete

Deleted: DG Thermal Recovery and Integration Research at University of Maryland (April 2007):¶

Industry Interactions

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Partners include members noted above.

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Subtask 4.3.2c,d – DE Integration Lab and Analysis

Abdi Zaltash, zaltasha@ornl.gov, (865) 574-4571)
Oak Ridge National Laboratory

Objective

It is essential to industrial partners that we understand technical issues related to optimal integration of components as well as optimal operating conditions for DE and HVAC equipment and systems. ORNL offers the unique capability of benchmarking equipment throughout the full range of operating conditions in a closely controlled laboratory environment or in precisely controlled environmental test chambers. Equipment from manufacturers can be operated and tested in precisely controlled environmental conditions to assist those manufacturers in optimizing equipment and component matching and operational control of the equipment. This work can also be used to help develop or test rating/certification test procedures and standards.

Highlights

Performance and emission tests on GEDAC #16 have been completed in the environmental chambers. Data is available on the password protected web site for remote monitoring by our industry partner using Web Control and web camera (to monitor the frosting pattern on the outdoor coil during heating tests).

Performance evaluation of the hot water-fired Rotartica lithium bromide/water air-cooled absorption unit (1.3-ton or 4.5 kW chiller) with rotating heat exchanger has been completed. Automated Logic Control and Web Control have been used successfully for sharing performance evaluations with the manufacturer. A draft report entitled “Performance Evaluation of a 4.5 kW (1.3 Refrigeration Tons) Air-Cooled Lithium Bromide/Water Solar Powered (Hot-Water-Fired) Absorption Unit” has been prepared and is under review. This report will be submitted to the 2007 ASME conference. Future plans are to document performance improvement for rotating heat (and heat/mass) exchangers based on the Rotartica unit and then assess the technical potential for using rotating heat exchangers in other applications.

Technical Progress

Performance and emissions of GEDAC #16 unit (10-ton packaged rooftop heat pump unit) has been completed in the ORNL environmental chamber at various heating and cooling modes Evaluation is following ARI Standard 210/240 with the cooling mode in the range of 67ºF to 120ºF at intermediate speed and at high speed. The heating mode is conducted in the range of 17ºF to 62ºF at intermediate speed and 17ºF to 47ºF at high speed.

After initial evaluations of GEDAC #16 with its original indoor coil (3 rows), GEDAC was evaluated with a modified indoor coil (4 rows) received from our industry partner. This change was to improve GEDAC performance in both heating and cooling modes. The capacity in heating mode increased by approximately 14% at high speed and 47ºF rating condition. The gas COP at 47ºF rating condition exceeded the goal of 1.6 at both high and intermediate speeds. Improvement in cooling capacity at 95ºF rating condition was found to be approximately 4% at high speed and 8% at intermediate speed. Gas COP in cooling mode also exceeded the goal of 1.2 at 95ºF rating condition.

Defrost cycle was also evaluated at 35ºF outdoor dry-bulb (DB) temperatures. GEDAC is currently using time cycle for the defrost cycle. Results suggest that this timed defrost may cause a number of unnecessary defrost cycles which reduces the energy efficiency of GEDAC #16. The plans are to investigate a demand defrost method. Demand defrost method could be easily integrated into the PLC.

Based on the results of the CFD modeling that showed potential energy savings by using one fan instead of the two fans for the outdoor coil, the two outdoor fans were replaced with a single fan. These evaluations have also been completed in both cooling and heating modes. Results showed no significant difference in the performance and total power used by the GEDAC unit.

Performance evaluation of the Rotartica unit has been completed. A draft report entitled

“Performance Evaluation of a 4.5 kW (1.3 Refrigeration Tons) Air-Cooled Lithium Bromide/Water Solar Powered (Hot-Water-Fired) Absorption Unit” has been prepared and is under review.

Status of Milestone(s)
(1) Completed performance and emissions evaluation of the GEDAC #16 (March 2007).

(2) Complete draft report on testing of InterRotex (Rotartica unit) heat pump (April 2007).

Industry Interactions
• Partners include: Southwest Gas, Team Consulting, BME, and Rotartica.

Subtask 4.3.8 – Industry Collaboration, Crosscutting Activities

Robert DeVault, devaultrc@ornl.gov, (865) 574-2020
Oak Ridge National Laboratory

Objective

ORNL will monitor the progress of the various CHP projects and provide technical direction to the subcontractors. As the tasks progress, lessons learned and technical results will be compiled and disseminated to the stakeholder community. In addition, ORNL will facilitate dialogue with industry stakeholders to encourage the consideration and use of DE in high-tech applications. Barriers to application of DE/CHP will be identified with the intent of reducing or removing them. ORNL will continue working with existing CHP design and evaluation software tools and will work with stakeholders to ensure their awareness of the tools and to assist in their use in studying potential DER/CHP applications. ORNL will continue to assist DOE with participation at crosscutting conferences and events such as PowerGen, ASHRAE, ASHE, etc. This work activity supports the technical guidance and analysis provided by the CHP Group Leader.

Highlights

None.

Technical Progress

No progress this quarter.

Status of Milestone(s)

(1) Provide summary of all IES projects with lessons learned (June 2007): On schedule.

Industry Interactions

Subtask 4.3.13 – Research Survey/History of DOE Program

Mike MacDonald, macdonaldjm@ornl.gov, (865) 574-5187
Oak Ridge National Laboratory

Objective

Over the last few decades, DOE has provided considerable funding in support of development of technologies for improving energy efficiency. There have been several technical analyses completed on potential for energy savings in a variety of technology applications. Although documentation on previous work activities has been completed, it can be difficult to find the relevant work because of passing time or lack of a centralized reference list. In 2006, ORNL created a database that contains over 300 reports. In 2007, the following activities will be completed: an additional 75+ reports on ORNL BCHP work will be included, enhanced search capabilities will be added, and copyright questions will be resolved.

Highlights

Work on the database was completed in December 2006.
No progress to report this quarter.

Technical Progress

There are abstracts for over 500 reports on-line with links to PDF files for all of the publicly available publications (copyrighted material does not have links to the journal articles, although PDF files for those publications are on-line, they just are not available to the public; they can easily be made available if ASHRAE and ASME gave ORNL/DOE permission to do so).

The publications cover the time frame of 1974-2006 including electrically driven heat pumps, thermally-activated technologies, advanced appliance research, distributed energy and CHP, district heating, and a few lesser categories.

The reports can be accessed at:
http://www.ornl.gov/sci/engineering_science_technology/eere_research_reports/index.html
As well as through Google type searches (turns up better if EERE is included in the search string).

There is a site map as well as a keyword index.

Status of Milestone(s)

(1) Add additional ~75 technical papers as requested by DOE sponsor on September 7, 2006 (April 2007): Complete

Deleted: Research survey/history of DOE program (April 2007):

Industry Interactions

N/A

Subtask 4.4.1a – Ritz Carlton Hotel/GTI, San Francisco, California

Therese Stovall, stovalltk@ornl.gov, (865) 574-0329
Oak Ridge National Laboratory

Objective

The FY04 solicitation sought proposals for projects that utilized pre-engineered, packaged IES systems that both generate electricity and make effective use of the thermal energy produced. Target applications for this procurement were healthcare and education facilities, hotels, and supermarkets. Two of these projects, under subcontract to GTI, are included in this subtask: (1) The Ritz Carlton Hotel, San Francisco, California has installed a UTC Pure Comfort System (with four Capstone microturbines) to generate 240 kilowatts and operate a 110 ton absorption chiller. Partners on this project are UTC Power, Pacific Gas & Electric, Carrier Commercial Systems, and Ritz Carlton. (2) Basin Electric, North Dakota will utilize waste heat from an existing pipeline compressor station's gas turbine to generate electricity via an organic Rankine cycle. Due to a change in DOE priorities, two other projects were replaced with a new effort focused on grid integration in a New York utility area with a fully networked (as opposed to radial) grid topology.

Highlights

The draft final report was completed by the subcontractor and delivered to ORNL..

Technical Progress

The draft final report was completed by the subcontractor and delivered to ORNL..

Status of Milestone(s)

(1)Complete final project documentation (September 2007): On track

Deleted: Ritz Carlton/GTI (September 2007):

Industry Interactions

N/A

Subtask 4.4.1b – Basin Electric/GTI, Flasher, North Dakota

Therese Stovall, stovalltk@ornl.gov, (865) 574-0329
Oak Ridge National Laboratory

Objective

The FY04 solicitation sought proposals for projects that utilized pre-engineered, packaged IES systems that both generate electricity and make effective use of the thermal energy produced. Target applications for this procurement were healthcare and education facilities, hotels, and supermarkets. Two of these projects, under subcontract to GTI, are included in this subtask: (1) The Ritz Carlton Hotel, San Francisco, California has installed a UTC Pure Comfort System (with four Capstone microturbines) to generate 240 kilowatts and operate a 110 ton absorption chiller. Partners on this project are UTC Power, Pacific Gas & Electric, Carrier Commercial Systems, and Ritz Carlton. (2) Basin Electric, North Dakota will utilize waste heat from an existing pipeline compressor station's gas turbine to generate electricity via an organic Rankine cycle. Due to a change in DOE priorities, two other projects were replaced with a new effort focused on grid integration in a New York utility area with a fully networked (as opposed to radial) grid topology.

Highlights

Data collection is complete and the final report is in progress.

Technical Progress

The site's installation and data collection has been completed.

Status of Milestone(s)

(1) Complete final project documentation (September 2007): On track

Deleted: Basin Electric/GTI, Flasher, North Dakota (September 2007):

Industry Interactions

N/A

Subtask 4.4.1c – Grid Integration Study for Two Feeders in New York

Therese Stovall, stovalltk@ornl.gov, (865) 574-0329
Oak Ridge National Laboratory

Objective

The FY04 solicitation sought proposals for projects that utilized pre-engineered, packaged IES systems that both generate electricity and make effective use of the thermal energy produced. Target applications for this procurement were healthcare and education facilities, hotels, and supermarkets. Two of these projects, under subcontract to GTI, are included in this subtask: (1) The Ritz Carlton Hotel, San Francisco, California has installed a UTC Pure Comfort System (with four Capstone microturbines) to generate 240 kilowatts and operate a 110 ton absorption chiller. Partners on this project are UTC Power, Pacific Gas & Electric, Carrier Commercial Systems, and Ritz Carlton. (2) Basin Electric, North Dakota will utilize waste heat from an existing pipeline compressor station's gas turbine to generate electricity via an organic Rankine cycle. Due to a change in DOE priorities, two other projects were replaced with a new effort focused on grid integration in a New York utility area with a fully networked (as opposed to radial) grid topology.

Highlights

The advisory committee, including members from NYSERDA, the New York City administration, Con Edison, ORNL, and others, completed their review of the project analysis assumptions, including the selection of the six buildings for detailed modeling. Applicable building codes were also identified and reviewed.

Technical Progress

Six buildings, out of the 50 in the Harvard Yards Development Project, were selected as representative of the development in terms of building size, type, and occupancy. The applicable gas and electric rate structures were modeled and used to complete a preliminary screening of combined heat and power economics.

Status of Milestone(s)

(1) Complete assessment (September 2007): Significant utility data has been received but a few critical billing records for residential buildings are still expected. If these data are delivered within a reasonable time period, the project will be completed according to the schedule.

Deleted: Grid integration study for two feeders in New York (September 2007):¶

Industry Interactions

Hudson Yard developers, CHP project developers, and Con Edison are all actively participating in the New York grid project.

Subtask 4.4.2 – Butler Hospital/Providence, Rhode Island

Randy Hudson, hudsoncrii@ornl.gov, (865) 574-0578
Oak Ridge National Laboratory

Objective
Provide field data on and analyze use of a UTC Pure Comfort System (with four Capstone microturbines) to generate 240 kilowatts and operate a 110 ton absorption chiller. Partners on this project are UTC Power, Carrier Corporation, Witham & Associates, New England Gas, and CDH Energy Corp.

Highlights
The final report documenting the project was submitted, and the final invoice has been paid.

Technical Progress
The final report was submitted to ORNL on November 13, 2006 and has been provided to DOE-HQ.

Status of Milestone(s)
(1) Complete final project documentation (September 2007): All milestones have been completed.

Deleted: Butler Hospital in Providence, Rhode Island (September 2007):¶

Industry Interactions
N/A

Subtask 4.4.3 – Eastern Maine Medical Center in Bangor, Maine

Randy Hudson, hudsoncrii@ornl.gov, (865) 574-0578
Oak Ridge National Laboratory

Objective
Complete construction and begin testing of a Solar gas turbine to generate 4.4 MW, generate 24,000 lb/hour of steam and drive a 500 ton absorption chiller. Partners are Solar Turbines, Cianbro Corporation, Vanderweil Engineers, University of Maine, and International District Energy Association.

Highlights
The system was fully operational on October 16, 2006, following a ribbon-cutting open house on site to celebrate completion of construction and startup. Operations data are being collected by CDH Energy, and performance statistics are available for review on the web at http://www.emmccogen.org.

Technical Progress
For the first quarter of 2007, the plant provided 98.5% of the hospital's electricity, generating 5,967 MWh of electricity, while recovering 33,402 MMBtu of useful heat. The overall total CHP efficiency during this period was 78.2 percent.

Status of Milestone(s)
(1)Complete final project documentation (September 2007): As plant operations did not start until October 2006, a final report including a full year of operating data, per the contract, will not be available until the first quarter of FY08. A report on operational results will be prepared in September to cover the period of operations through that point.

Industry Interactions
N/A

Subtask 4.4.4 – East Hartford High School

Randy Hudson, hudsoncrii@ornl.gov, (865) 574-0578
Oak Ridge National Laboratory

Objective
Install a UTC Pure Comfort system in the East Hartford (Connecticut) High School that will have black-start capability. United Technologies Research Center is the subcontract partner.

Highlights
The system had an 85% capacity utilization, generating 442,000 kWh at an average electric efficiency of 28% during the first quarter of 2007. Overall fuel efficiency, including heat recovery, was 70%.

Technical Progress
System performing as expected.

Status of Milestone(s)
(1)Complete final project documentation (September 2007): A project profile has been prepared by SENTECH and is being reviewed by the subcontractor prior to posting on the DOE website and completing the subtask.

Industry Interactions
N/A

Subtask 4.4.5 – Madera Hospital/RealEnergy

Randy Hudson, hudsoncrii@ornl.gov, (865) 574-0578
Oak Ridge National Laboratory

Objective
Install an integrated reciprocating engine and absorption chiller system at the Madera Community Hospital in Madera, California. The system will have capacities of 600 kW and 115 RT. The subcontract partner is RealEnergy, LLC.

Highlights
Due to hospital facility expansion (independent of the CHP system), the CHP plant construction has been postponed.

Technical Progress
None

Status of Milestone(s)
(1) Initiate on-site construction (September 2007): It is not clear at this time when, or if, the project will be completed.

Deleted: Madera Hospital/RealEnergy (September 2007):¶

Industry Interactions
N/A

Subtask 4.4.6 – SEMCO Incorporated/Lindale, Georgia

Randy Hudson, hudsoncrii@ornl.gov, (865) 574-0578
Oak Ridge National Laboratory

Objective

Utilize a 200 kilowatt reciprocating engine generator coupled with an integrated active desiccant system in a high school in Floyd County, Georgia. Partners are C&M Engineering, Floyd County Schools, Deutz Engines, and WW Williams electrical generation equipment. Develop an islanded Integrated Energy System (IES) design that will function independently of the grid to provide adequate building air conditioning and ventilation in the event of a local disaster, blackout, or terrorist attack.

Highlights

The system was commissioned in September, 2006 at the new high school. The rooftop desiccant systems have been running well, but problems with the Deutz engine controls and electronics have resulted in only being able to run the engine for short periods of time. Fortunately, the desiccant units do not require the engine to be operating in order for them to function.

Technical Progress

The system is now operational. Problems with engine controls and electronics are being investigated.

Status of Milestone(s)

(1) Complete final project documentation (September 2007): On schedule

Deleted: SEMCO (September 2007):¶

Industry Interactions

N/A

Subtask 4.5.12 – Evaluation of CHP Market Potential As It Relates to Renewable Portfolio Standards

Patti Garland, garlandpw@ornl.gov, (865) 574-0738
Oak Ridge National Laboratory

Objective

This project consisted of several tasks: Collect and summarize opportunity fuels information for fuels that already are or could be used in CHP applications, Evaluate CHP Technology Options, and Analyze Potential Market Impacts and Develop Recommendations. This work was completed in FY05 with publication of the final task report, which can be found on the DOE DE website.

In FY06, one task was added to the contract: Satisfying of Renewable Portfolio Standards with Opportunity Fuels and CHP. In this effort, a state-by-state analysis of the impact of state level renewable portfolio standards will be performed, using state target dates and impacts as well as emerging values of renewable energy certificates (RECs). This analysis will build off of the Phase I work. It will analyze the potential capacity from opportunity fuels that would satisfy the state renewable portfolio standards, based on availability of fuel, economics of opportunity fueled CHP, and prospects for wind and solar renewables.

Highlights

- The following white paper was completed: "Project Considerations for Distributed Generation using Opportunity Fuels"
- The report “Potential Impact of Renewable Portfolio Standards on Biomass Combined Heat and Power Applications” has been drafted.

Technical Progress

The report “Project Considerations for Distributed Generation using Opportunity Fuels” was completed. This white paper outlines the differences between the each of the four primary opportunity fuels (biomass gas, anaerobic digester gas, landfill gas, and solid wood waste) and their natural gas and coal counterparts, highlighting any special considerations that must be made for opportunity fueled distributed generation (DG) projects. The information was collected from research on opportunity fuels, as well as interviews with manufacturers and discussions with project developers and operators. In addition, whenever possible, actual cases with project experience are used as examples to illustrate how these differences can affect real-world DG applications. The first section of this paper discusses the differences in fuel properties, such as composition, heat rate, pressure and flow rate. The next section addresses the contaminants typically found in these fuels, and their potential effect on prime mover systems and DG projects in general. Then, considering the differences in the fuels and the contaminants they contain, the necessary modifications and additional maintenance for prime mover equipment is analyzed. In the final section of the memorandum, the current market considerations for opportunity fuels are examined, including how the purchase of specialized equipment, fuel treatment systems, warranties, and O&M contracts can affect businesses.

Status of Milestone(s)

(1)Complete final report on barriers to Installing CHP associated with renewable portfolio standards (September 2007): On schedule

Deleted: Barriers

Industry Interactions

This project is being completed in partnership with Resource Dynamics.

Subtask 4.5.16 – Coordination of Regional CHP Application Centers
Subtask 4.5.17 – Project Direction and Technical Support

Patti Garland, garlandpw@ornl.gov, (865) 574-0738
Oak Ridge National Laboratory
Ted Bronson, tlbronsonpea@aol.com, (630) 248-8778
Power Equipment Associates

Objective

ORNL is working the DOE CHP Regional Application Centers and with Power Equipment Associates, Energetics, EEA, Discovery Insights, USCHPA, Sentech, and Resource Dynamics to provide oversight and guidance of continued CHP Projects. ORNL will provide a critical technical review and provide analysis for verification of subcontracted activities. As the tasks progress, lessons learned and technical results will be compiled and disseminated to the stakeholder community. Results of these projects will be disseminated through the use of the DOE DE Website or the DOE CHP Regional Application Centers.

As part of the CHP Roadmap activities, ORNL supports development and updates of the CHP Action Plan in response to the Roadmap.

Highlights

- A CHP RAC face-to-face meeting has been scheduled for May 24-25, 2007 in Golden, Colorado.
- A compilation of Metrics for CHP RAC progress over through the history of the program has been compiled and provided to DOE Program Sponsors.

Technical Progress

Due to an increased interest in the CHP RACs, several meetings have been held with DOE's Industrial Technologies Program to discuss activities and capabilities.

Status of Milestone(s)

(1) Complete report on 2006 RAC accomplishments and lessons learned (April 2007): Completed as part of the Historical Metrics Report to DOE.
(2) Publish monthly financial reports on subcontracted and in-house activities (On-going): On going.

Industry Interactions

See above

Subtask 4.5.18 – CHP Regional Application Center Technical Support
Subtask 4.5.19 – Provide Support to HUD on an "As-Needed" Basis

Mike MacDonald macdonaldjm@ornl.gov (865) 574- 5187
Patti Garland, garlandpw@ornl.gov, (865) 574-0738
Oak Ridge National Laboratory

Objective

ORNL is providing technical assistance in performing screening and optimization calculations on an as-needed basis to the CHP Regional Application Centers. ORNL will train CHP Regional Application Center staff on the use of the BCHP screening tool.

ORNL also provides technical support to Bob Groberg at Housing and Urban Development (HUD) on an as-needed basis. Current work includes recommendations on the accuracy of the CHP calculator based on for the Cogen Manual for Multi-Family Housing, Appendix A. Additional work will include collaboration with HUD, and HUD "partners", in identifying and applying the best tools for evaluating CHP in multi-family housing. Among others, these partners include Sebesta Blomberg & Associates of Arlington, Virginia and Dougherty and Associates of Alexandria, Virginia who are under contract to HUD to evaluate combined heat and power for multifamily housing. A data template and utility data files will be produced for use with the BCHP Screening Tool to assess its potential for use in studying combined cooling, heating, and power in multifamily housing.

Highlights

- Version 2 of the HUD CHP screening tool was provided to the Regional Application Centers for comment and suggestions.
- Steve Fischer has retired from ORNL. Mike MacDonald, who has experience with the BCHP screening tool as it relate to Federal Facilities, is taking over Steve's role in supporting the CHP Regional Application Centers and HUD.

Technical Progress

Mike MacDonald and Patti Garland have held teleconferences with Bob Groberg of HUD to discuss recommended changes to the HUD screening tool. Mike is making those changes.

Mike MacDonald and Patti Garland have held several meetings with Steve Fischer to transfer the source code of both the BCHP and HUD screening tools. Further meetings are scheduled to complete the knowledge transfer.

Status of Milestone(s)

(1)Provide technical support to the CHP Regional Application Centers (RACs) (On-going): On going
(2) Provide support to HUD on an as-needed basis (On-going): On going.

Industry Interactions

N/A

Subtask 4.6.1 – Distributed Resources Grid Integration Impact on Power Quality and Reliability

Therese Stovall, stovalltk@ornl.gov, (865) 574-0329
Stan Hadley, hadleysw@ornl.gov, (865) 574-8018
Oak Ridge National Laboratory

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Objective
Perform DE benefit analyses to: (1) provide the foundation for informed program management decisions, (2) facilitate the deployment of advanced technologies developed under the program mantle by conveying the full extent of potential benefits and the role of DE in the energy market, and (3) support cooperation and partnership with other DOE offices and other government agencies.

Highlights
The public comment version of the Energy Policy Act 1817 report was reviewed and a lengthy report describing necessary revisions was submitted.

Technical Progress
A number of significant problems in the Energy Policy Act 1817 report were discovered after the reports processing by a variety of editing teams. These errors include attribution omissions (i.e., plagiarism) and technical errors.

Status of Milestone(e)
(1)Complete the calculation tool that defines the value of the grid-integrated DE's contribution of improved power quality and reliability (August 2007): Work is underway to meet the milestones, although we delayed starting some portions of the work due to congressional budget uncertainties.

Deleted: Distributed resources grid integration impact on power quality and reliability (August 2007):¶

Industry Interactions
N/A

Subtask 4.6.2 – Diversified Capacity Valuation Protocol Development for Grid-Integrated DE

Therese Stovall, stovalltk@ornl.gov, (865) 574-0329
Stan Hadley, hadleysw@ornl.gov, (865) 574-8018
Oak Ridge National Laboratory

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Objective

Perform DE benefit analyses to: (1) provide the foundation for informed program management decisions, (2) facilitate the deployment of advanced technologies developed under the program mantle by conveying the full extent of potential benefits and the role of DE in the energy market, and (3) support cooperation and partnership with other DOE offices and other government agencies.

Highlights

Plug-in hybrid vehicles have been a topic of interest and a preliminary analysis was previously reported.

Technical Progress

Progress has been made to expand the modeling tool used for these analyses to more accurately represent changes in demand. The model has also been updated to more easily model all 13 NERC regions.

Status of Milestone(e)

(1)Complete a report describing the protocol and calculation methodology to accurately calculate the diversified reliability contribution of grid-integrated DE (September 2007): Work is underway to meet the milestones, although we delayed starting some portions of the work due to congressional budget uncertainties.

Industry Interaction

N/A

Deleted: <#>Diversified capacity valuation protocol development for grid-integrated DE (September 2007):¶

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Subtask 4.6.5 – Coordinate Industry Efforts with the DOE/OE Program

Therese Stovall, stovalltk@ornl.gov, (865) 574-0329
Oak Ridge National Laboratory

Objective
Perform DE benefit analyses to: (1) provide the foundation for informed program management decisions, (2) facilitate the deployment of advanced technologies developed under the program mantle by conveying the full extent of potential benefits and the role of DE in the energy market, and (3) support cooperation and partnership with other DOE offices and other government agencies.

Highlights
Discussions were held discussing a possible joint venture. The status is still exploratory.

Technical Progress
Discussions were held discussing a possible joint venture. The status is still exploratory.

Status of Milestone(s)
(1)Complete subcontractor report describing industry coordination efforts (September 2007):
Work is underway to meet the milestones, although we delayed starting some portions of the work due to congressional budget uncertainties.

Deleted: <#>Coordinate industry efforts with the DOE/OE program (September 2007):¶
¶

Industry Interactions
N/A

Subtask 4.6.6 – MADRI Support Activities

Therese Stovall, stovalltk@ornl.gov, (865) 574-0329
Brad Johnson, Consultant

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Objective

Perform DE benefit analyses to: (1) provide the foundation for informed program management decisions, (2) facilitate the deployment of advanced technologies developed under the program mantle by conveying the full extent of potential benefits and the role of DE in the energy market, and (3) support cooperation and partnership with other DOE offices and other government agencies.

Highlights

Participated in PJM metering sub-group focused on developing metering interoperability standards in support of DR program settlement activities. Planned workshop with DC public utility commissioners to focus on advanced meter infrastructure business case considerations and dynamic pricing.

Technical Progress

Worked with the MADRI Steering Committee to finalize the public release of Brattle Locational Marginal Pricing study; refine and coordinate state input for the 3% DR goal; and address interconnection standards.

Coordinated key MADRI activities through Maryland working group activities regarding advanced meter infrastructure and distributed resources business case and cost/effectiveness criteria.

Status of Milestone(s)

(1) Complete a report describing MADRI advances and how they can be applied to other regions (August 2007): Work is underway to meet the milestones, although we delayed starting some portions of the work due to congressional budget uncertainties.

Deleted: support activities

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Industry Interactions

N/A

Subtask 4.7.1 – Evaluate Methods for Voltage Regulation and Analyze Techniques for Voltage Collapse

John Kueck kueckjd@ornl.gov, (865) 574-5178
Fran Li, and Y. We
Oak Ridge National Laboratory

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Objective

Develop methods for local, independent control of Distributed Energy (DE) Resources so that they may provide dynamic voltage regulation with minimal communication requirements for a distributed control system.

Highlights

Several technical papers are in preparation or have been recently accepted describing our methods for dynamic, DE-based, voltage regulation. We are proposing the development of a controlled voltage droop characteristic for DE which will actually increase the margin to voltage collapse. We will be testing our methods here in the Distributed Energy Communications and Controls (DECC) Laboratory

Technical Progress

We have prepared a detailed test plan for the year. We also have agreement from Southern California Edison (SCE) to use the WECC GE PSLF model in combination with our DE control algorithm; the confidentiality agreement has been signed and DECC staff members have taken PSLF training. This will allow us to perform simulations of our voltage control method to increase the margin to voltage collapse and assess its effective for micro-voltage collapse events experienced by SCE during the summer. In regards to restarting testing at DECC, we have the new inverter cooling system installed and we have tested the inverter up to 100 amps peak. We have also operated the Capstone microturbine and we are installing data acquisition on the Capstone.

Status of Milestone(s)

(1) Evaluate analytical techniques for using independently controlled DE sources in parallel to supply dynamic reactive power (June 2007): We are on track in evaluating our analytical techniques. Reports of analysis are in various stages: complete and waiting for publication, in preparation, and only in outline form. The following is a brief summary of each:

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Deleted: voltage collapse

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Dynamic Voltage Regulation in Multiple Distributed Energy Resources Systems, Abstract has been prepared and accepted at an IEEE conference, the report is in preparation and due in September 07. Lead Author: Yan Xu

The Use of Distributed Energy Resources to Extend the Margin to Voltage Collapse This report has been prepared based on simulations, the report is under review for publication in IEEE Transactions. Lead Author: Shawn Henry

Nonactive-Power-Related Ancillary Services Provided by Distributed Energy Resources This report of analysis and simulation at the reactive power lab has been prepared and accepted for publication at an IEEE conference. Lead Author: Yan Xu

Use of a Voltage Schedule and Independent DER Control Algorithm to Increase Margin to Voltage Collapse This paper will be prepared based on simulations run in PSLF. An outline has been prepared for a paper to be co-authored by ORNL and SCE. The paper will be targeted for policymakers. Lead Author: John Kueck

Voltage and Current Unbalance Compensation Using a Parallel Active Filter This paper has been prepared and accepted for publication at an IEEE conference. Lead Author: Yan Xu

Industry Interactions

We are coordinating with Southern California Edison to simulate our DE methods for voltage control using their distribution system model. We will examine the impact of our method on the “micro voltage collapse” events they have had in their system. They have provided us with a number of technical papers they have written on the subject from past events. The most number of these events was experienced this summer.

Subtask 4.7.2 – Conventional Control and New Methods in Parallel

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John Kueck, Jeremy Campbell, Fran Li, and Y. We
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Objective

The objective of this milestone is to test the simultaneous operation of multiple reactive power producing distributed energy (DE) resources at the DECC Laboratory with them connected in parallel and providing local dynamic voltage and power factor regulation at their local power panels on the ORNL distribution system. The 150A inverter and 300kVar synchronous condenser at the DECC laboratory will use our control schemes to provide dynamic voltage regulation while operated in parallel with a 30kW commercial Capstone microturbine.

Highlights

Last Fiscal Year (2006), we began operating our 150A inverter in parallel with our 300kVar synchronous condenser and were successful in operating them simultaneously. We pushed the inverter to 45A rms (or 64A peak) and were limited by the operating temperature of the inverter. The temperature of the inverter's heat sink must be kept to around 75C in order to ensure that the integrated bipolar-gate transistor (IBGT) junctions of the inverter are within 100C. We have upgraded the cooling system for the inverter allowing us to produce higher inverter currents which we needed for higher dynamic voltage regulation.

Technical Progress

The inverter cooling system has been improved with higher air flow fans on the input and on the exhaust end of the cooling system. The inverter is operational again but now at higher current output levels. We have performed a new temperature characterization of the inverter operation at different loadings to establish the critical inverter operating amperage (the current level at which the heat sink reaches 75C). With the new fans in place, we are able to achieve over 73Arms (or 100A peak) from the inverter which is nearly 50% of the inverter rating. We can now regulate voltage at its local power panel from 0.5 to 2.0 V by controlling inverter current output from 20 to 100A peak. The 30kW Capstone microturbine has been operated a couple of times to check its working condition and instrumentation has been installed for measuring its current and voltage. Dr. Li and his student are simulating a localized, non-communication-based voltage regulation control scheme for two DERs in a distribution network of 13-buses and will expand to more DERs shortly.

Status of Milestone(s)

(1) Operate multiple DE sources in parallel using the control methods developed in subtask 4.5.1 (September 2007): The milestone is on track. We plan to proceed with running all three devices (inverter, synchronous condenser and microturbine) in the next few weeks.

Deleted: Conventional and new systems in parallel

Industry Interactions

We have developed a complete test matrix for our planned CY07 DECC laboratory testing activities and it has been provided to our industry partners for review and comment. This milestone has been identified as high priority. Southern California Edison (SCE) has provided us with data from last summer's micro-voltage collapses (stalling of air conditioning motors) for analysis. We are proceeding with GE PSLF simulations to understand the dynamics of the SCE network and how voltage dynamic control via DER can mitigate these events.

Subtask 4.7.6 – Modeling of Reliability of High Temperature Packaging of SIC

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Objective

SiC-based power electronics can enable module size and weight reductions, operating temperatures of up to 500°C, loss factor reductions of an order of magnitude, and increase power capabilities by two orders of magnitude. Even though the SiC has very attractive electrical capabilities and attributes for power converters, it remains a brittle ceramic (i.e., a class of material in which a deterministic approach to structural design is not reliable) that would be subjected to thermomechanical stresses during device manufacturing and high temperature service - conditions that can limit or decrease device operation and lifetime. The present subtask combines the use of established probabilistic design and lifetime prediction methods developed for structural ceramics, microstructural-scale finite element analysis, micromechanical characterization, and sensitivity analysis methods and adapts them to the analysis of lifetime and design optimization of SiC-containing power converter devices (e.g., insulated gate bipolar transducers or IGBTs)

Highlights

Temperature and current increases as a function of time were quantified up through (intended) short-circuiting in a (Si-diode-containing) 1200V/100A IGBT module.

Technical Progress

Commercially available (Powerex) high-voltage, high-amperage (silicon-diode-containing) IGBTs were dissected, sectioned, and optically imaged. These IGBTs are not capable of operating with junction temperatures above 125-150°C because their diodes are silicon. Their photos are now being prepared for input into *μ-FEA* and ANSYS for thermomechanical stress modeling, reliability evaluations, and for guidance of transitioning to the use of silicon carbide semiconductor technology (and the higher temperature capability its use affords).

To enable the study of a material failure associated with device malfunction, an uncooled Powerex (Si-diode-containing) 1200V/100A IGBT module was subjected to simultaneous constant collector emitter voltage and gate voltage until it electronically failed. Temperature and collector current were continuously monitored. The collector current increased from 10 to ~70 Amperes in approximately 45 minutes while the temperature had increased from 20 to 190°C. The silicone gel inside this module had discolored. Its removal is underway and postmortem analysis will enable the source of the device failure to be identified.

Status of Milestones

Demonstrate the use of *μ-FEA* for modeling the thermal-mechanical stresses prevalent in a current SiC-package. *On schedule.*

Industry Interactions

None during present quarter. Met with staff in ORNL's Cooling, Heating, and Power Group to discuss their inverter work, its thermal management, and the potential use of alternative materials to improve its cooling.

Highlights

Technical Progress