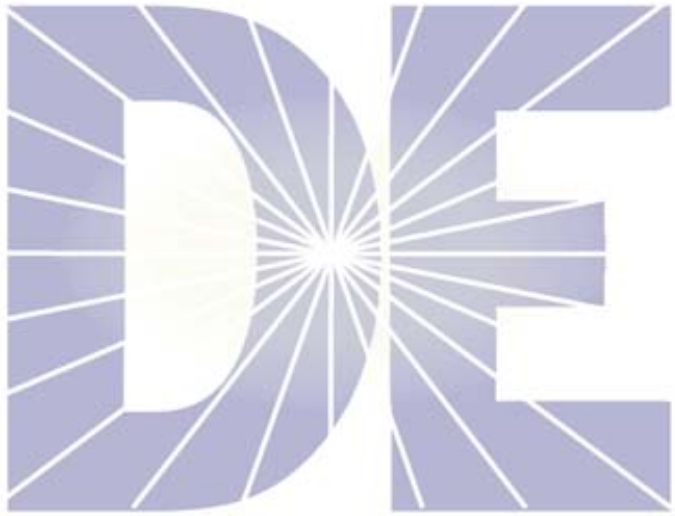
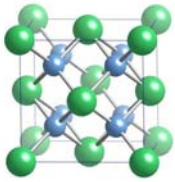


Distributed Energy Program

DE Quarterly Progress Report
For the Period
October 1, 2006 to December 31, 2006



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 have been completed. 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.

Preliminary analysis of the data shows 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.*** Further analysis of the data will continue in Q2 FY07 including full analysis of the baseline and post characterization data.

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 and reporting pending).

Industry Interactions

- A paper summarizing FY06 results on sulfur effects on partial oxidation and reforming catalysts was published and presented at the special ARES-ARICE session of the ASME Fall Technical Conference on Internal Combustion Engines in Sacramento, CA on November 7-8, 2006.

Subtask 4.1.2 - Spark Plug Erosion and Failure

Mike Kass, kassmd@ornl.gov, (865) 946-1241
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

Spark plugs manufactured from conventionally available electrode alloys and precious metal insert pad alloys, selected for improved materials compatibility, were NG engine tested for 250 h. Post-test analysis of the plugs indicated that the benefits of the more oxidation-resistant electrode alloy base used were negated by decreased thermal conductivity. A new, high thermal conductivity base electrode alloy was developed and delivered to Federal Mogul (FM) for spark plug manufacture and engine testing.

Technical Progress

NG spark plugs using Ir/Pt insert pads and Ni and Fe electrode alloys selected to improve materials compatibility between electrode alloy/insert pad and oxidation resistance was manufactured in collaboration with FM. The electrode alloy was Ni-15Cr base for the improved oxidation resistance relative to the conventionally use 95% Ni base alloys, with a range of Ir and Ir-Pt composition insert pads. Severe degradation of the electrodes was observed after only 250 h on NG engine testing. Post-test analysis of the plugs suggested that they reached a sufficiently high temperature for Ir oxidation to ensue. These high temperatures, and subsequent degradation, were linked to the lower thermal conductivity of the Ni-15Cr base electrode alloy used. A plan for an additional set of NG spark plugs was made with FM, with the range of Ir and Pt insert pads previously selected, but using a conventional, high thermal conductivity 95% Ni base electrode alloy. Alloy development efforts for an improved high thermal conductivity Ni base electrode alloy were also completed. Rods of two developmental alloys were delivered to FM for manufacture into spark plugs and laboratory engine testing at FM. Discussions are also underway with Woodward for manufacture and NG testing of the new Ni base electrode alloys, utilizing the Woodward prechamber NG spark plug design.

Status of Milestone(s)

(1) Submit an open literature paper reporting on the engine test results of developmental spark plug electrode alloys. (September 2007): - On Track

Industry Interactions

Conference calls and email communications with Jim Lykowski at Federal Mogul to discuss the results of the NG testing at ORNL, and the manufacture of an additional set of NG plugs. Communications with Dr. Luigi Tozzi at Woodward regarding evaluation of the new ORNL Ni-base electrode alloys in the Woodward NG spark plug design.

Subtask 4.1.3 - Reliability, Availability, and Maintainability (RAM) for Reciprocating Engines

Tim Theiss, theisstj@ornl.gov, (865) 946-12348
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) Assess key issues with Reliability, Availability, and Maintainability (RAM) of Reciprocating Engines and specifically address potential impact of emissions compliance difficulties on engine availability. (September 2007): On Track

Industry Interactions

N/A

Subtask 4.2.1 – Microstructural Characterization of CFCCs and Protective Coatings

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

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.

Highlights

The engine-exposure of an ATK-COIC oxide/oxide ceramic matrix composite outer liner, designated A/N720 CMC+FGI, ended in December 2006 after 25,404 h with 109 starts. In addition, a GE MI Pre-preg SiC/SiC+BSAS inner liner, accumulated a total of 12,822 h with 46 starts during the final stages of the same engine test in Bakersfield, CA. The engine was returned to Solar Turbines but has not been disassembled yet.

Technical Progress

The status of the combustor liners from the most recent ChevronTexaco engine test (Bakersfield, CA) was recently provided by Mark van Roode and Jeffrey Price of Solar Turbines. When the engine was finally shut down in mid-December 2006, 25,404 total hours (109 starts) were accumulated on the A/N720 CMC+FGI (hybrid) outer liner and 12,822 total hours (46 starts) were accumulated on the pre-preg MI SiC/SiC+BSAS inner liner. The hybrid outer liner ran successfully in the longest Solar Turbines engine-test to date, which was ~10,000 hours longer than the SiC/SiC+BSAS liners ran. Long-term Keiser Rig exposure data (including microstructural observations, weight change data, and mechanical properties data) that has been accumulated at ORNL during the past fiscal year (on the same materials used in the hybrid outer liner) will be compared with observations from the ~25,000 h engine-exposed A/N720 CMC liner. The "characterization team" comprised of representatives from Solar Turbines, Oak Ridge National Laboratory, ATK-COI Ceramics, Argonne National Laboratory, and GE, will meet in San Diego in February 2007 to formulate a plan for mechanical and microstructural characterization of the two CFCC liners.

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 (June 2007): In progress

Industry Interactions

1. Correspondence with Solar Turbines and ATK-COI Ceramics continues regarding meeting schedule to plan characterization effort for A/N 720 CMC liner evaluation.

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

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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

Studies of the effect of externally applied cyclic stress on the mechanical properties as well as material recession of SiC-SiC CMC with EBC under steam environment at 1200°C were initiated during this reporting period. The applied stress levels were close to the proportional limit of composite. The applied load was held constant for 8h and then unloaded (R ratio is 0.1) for 10 min. prior to the reloading. The test conditions employed simulate the environments encountered by CMC components in the combustion engine. The first 500h test was successfully completed and initial optical examinations showed permanent deformation of samples probably due to creep process and there was no visible EBC dadradation. The high-temperature steam jet test at 1288°C for 500h for a pre-strained FGI oxide-oxide CMC specimen (up to 0.25%) was also completed during this reporting period. The exposure tests conducted will provide important insight into the effect of pre-existing damages (i.e., micro cracking) introduced by the pre-mechanical tests on the microstructure stability of FGI layer under a more realistic test condition and also whether there is an accelerated environmental attack due to the increased temperature.

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 progress of the setup of steam exposure test system as well as the status of testing.
2. Communication with Xiaoqun Chen, Mark van Roode, and Jeff Price at Solar Turbines on the up-to-date status on the thermal properties characterization of TBC discs with different compositions and heat treatment history, and discussions on the new TBC test plans.
3. Communications with Chris Campbell and Jay Morrison at Siemens Power Generation on the updates of SEM and steam test results of on the FGI oxide-oxide CMC.

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

Objective

In order to be cost competitive, microturbines will have to meet aggressive durability targets. 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

Slurry development of collaborators' material systems continue. Different processing and sintering approaches are currently being evaluated to improve coated sample densities and adhesion. Formulations and the resulting coatings that meet the collaborator's specifications will be submitted for simulated exposure and characterization.

Technical Progress

Work (rheology, dipping, and sintering studies) on the candidate material systems was put on hold due to equipment issues.

Status of Milestone(s)

(1) Evaluate the corrosion resistance and mechanisms of corrosion of an industrial partner's EBC system after exposure to a simulated combustion atmosphere (September 2007): On track

Industry Interactions

- Collaboration with Honeywell continues.
- A presentation was given to staff at Siemens-Westinghouse regarding potential research collaboration on coatings and slurry infiltration development.

Subtask 4.2.4 – Spark Plug Electrode Alloy Development

H-T Lin, linh@ornl.gov, (865) 576-8857
Mike Brady 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

Spark plugs manufactured from conventionally available electrode alloys and precious metal insert pad alloys, selected for improved materials compatibility, were NG engine tested for 250 h. Post-test analysis of the plugs indicated that the benefits of the more oxidation-resistant electrode alloy base used were negated by decreased thermal conductivity. A new, high thermal conductivity base electrode alloy was developed and delivered to Federal Mogul (FM) for spark plug manufacture and engine testing.

Technical progress

NG spark plugs using Ir/Pt insert pads and Ni and Fe electrode alloys selected to improve materials compatibility between electrode alloy/insert pad and oxidation resistance was manufactured in collaboration with FM. The electrode alloy was Ni-15Cr base for the improved oxidation resistance relative to the conventionally use 95% Ni base alloys, with a range of Ir and Ir-Pt composition insert pads. Severe degradation of the electrodes was observed after only 250 h on NG engine testing. Post-test analysis of the plugs suggested that they reached a sufficiently high temperature for Ir oxidation to ensue. These high temperatures, and subsequent degradation, were linked to the lower thermal conductivity of the Ni-15Cr base electrode alloy used. A plan for an additional set of NG spark plugs was made with FM, with the range of Ir and Pt insert pads previously selected, but using a conventional, high thermal conductivity 95% Ni base electrode alloy. Alloy development efforts for an improved high thermal conductivity Ni base electrode alloy were also completed. Rods of two developmental alloys were delivered to FM for manufacture into spark plugs and laboratory engine testing at FM. Discussions are also underway with Woodward for manufacture and NG testing of the new Ni base electrode alloys, utilizing the Woodward prechamber NG spark plug design.

Status of Milestone(s)

(1)Deliver spark plugs using optimized electrode alloy(s) to at least one external collaborator for field testing in an industrial natural gas engine (September 2007): On track

Industry Interactions

Conference calls and email communications with Jim Lykowski at Federal Mogul to discuss the results of the NG testing at ORNL, and the manufacture of an additional set of NG plugs. Communications with Dr. Luigi Tozzi at Woodward regarding evaluation of the new ORNL Ni-base electrode alloys in the Woodward NG spark plug design.

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

Characterization was completed on Fe-15Cr-15Ni-4Al alloy specimens exposed in humid air at 700° and 800°C. An Al-rich external oxide was formed at both temperature and no appreciable Al depletion was detected at either temperature indicating that the Al-rich oxide is more stable than Cr-rich oxides.

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. Oxidation testing and characterization was completed on first generation Fe-15Cr-15Ni-4Al sheet (0.6mm) specimens. Current results have shown outstanding behavior for up to15,000h at 800°C in humid air with little depletion or degradation noted. The next step is to fabricate foil of the Fe-15Cr-15Ni-4Al second generation alloys for long-term testing and characterization. An annealing procedure has been identified to produce a foil grain size comparable to previous material.

Status of Milestone(s)

(1) Submit an open literature publication reviewing the potential for A1 alloying additions and/or low-cost coatings to improve oxidation lifetimes of recuperator alloys (September 2007): On track

Industry Interactions

Discussed protective oxide coatings for recuperators with N. Garrett, consultant for C3 International, Alpharetta, GA and sent a sample of commercial 347 foil for trial coatings.

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

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.

Highlights

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

A modified Capstone C65 engine was delivered on Sept. 30th, 2006. Installation and initial testing were finished in October 2006. A 1000-hour recuperator material test has been completed to continue the long term evaluation of AL-625, HR120-3.2mils, and 2025-3.2mils. Gas sampling was undertaken in December 2006. The design of the Controlled Environment Test Chamber (CETC) was finalized. The 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 parts of the test chamber are in the process of being machined.

Status of Milestone(s)

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

Industry Interactions

Analyzing the specimens sent by Ingersoll Rand.

Preparing a grant proposal with the Chinese Coal Information Institute (CCII), entitled, “Demonstration of Power Generation Using Low Quality Coal Mine Methane, Emission Monitoring, and Engine Performance Analysis”. ORNL will participate as a subcontractor to CCII. The proposal was submitted on Dec. 26, 2006, in response to United State EPA's RFIF entitled, “Activities That Advance Methane Recovery and Use as a Clean Energy Source,” (EPA-OAR-CCD-06-08).

Subtask 4.3.1a – Packaged/Modular IES Development

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

Objective

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 - The complete system has passed a UTC PWR stage –gate process and will be offered for commercial sale by March, 2007.

Testing of a new microturbine from Ingersoll Rand, the IR250 was performed during this reporting period.

Technical Progress

The recip engine/hybrid chiller system has demonstrated a cooling capacity of 115 RT at ARI rated conditions. Cooling water return temperatures have been varied from 61 °F to 105 °F. Chilled water return temperatures have been varied between 61 °F to 51 °F. Transient tests have been performed where the cooling water has been ramped from 85 °F to 68 °F in 23 minutes to determine if the chiller control system can maintain stable operation during this rapid thermal transient. Chiller operation has been verified from 25% to 100% of rated capacity.

The performance of the Cummins QSK19 engine has been verified at engine air inlet temperatures ranging from near 60 °F to 105 °F. The data collected has shown that engine outlet power and efficiency is not affected by the inlet air temperature in the range tested. In applications where the prime mover would be operating at high ambient temperatures, such as in tropical regions, the system performance would not be adversely affected.

UTRC has accumulated 3000 hours of engine operation and approximately 1800 hours of chiller operation up to this reporting period. Generator efficiency has been measured as 31%, with high engine reliability. The chiller system has operated over a wide range of conditions.

The initial PureComfort systems were powered by 4, 5, or 6 Capstone microturbines. A modified PureComfort M system was evaluated this quarter using the Ingersoll Rand (IR) 250 kW microturbine. The advantage of this PureComfort 250M system is a reduced footprint through the use of a single microturbine, plus this microturbine meets the CARB2007 emissions requirements. Engine output power and efficiency as measured at UTRC closely matches the performance specified in IR literature. The engine was run independently of the chiller to obtain “electrical mode only” data, and then run integrated with the 16DNP chiller. Due to a slightly lower exhaust temperature, the cooling capacity was lower than expected. This is due primarily to the long exhaust duct used in our facility to connect the turbine to the chiller. When corrected for a short duct length, our predicted chiller capacity is approximately 105 RT. The microturbine efficiency has been measured at 29.2% (HHV) which agrees with IR published data. The IR250 microturbine was run independently of the chiller to obtain “electrical mode only” data. This microturbine is rated at 250 kW electrical output at ISO conditions. The microturbine has demonstrated a maximum power of 303 kW at 0ºF.

Status of Milestone(s)

(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

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.

Highlights

- The draft close-out plan was completed and is undergoing review.
- The draft annual report was completed and is undergoing review.
- The next CHP Consortia Meeting will be held the week of March 20, 2007

Technical Progress

Integrated Energy Systems Testing with Project Partner University of Maryland: Testing of the prototype low-flow conditioner liquid desiccant system, developed by AIL in conjunction with NREL, was completed in the fall. Under similar outdoor air conditions, the prototype AIL low-flow conditioner has comparable performance with the original Kathabar conditioner. The outdoor air humidity ratio has considerable effect on AIL conditioner performance. With 75kW engine load, when humidity ratio increases 25%, dehumidification level increases 30% and total cooling capacity increases by 12%. The effect of outdoor air temperature also could not be ignored. With a 50kW engine load, when humidity ratio decreases 4% and temperature increases 7.6 ℉, dehumidification level increases 12% and total cooling capacity increases 40%. A final report, including lessons learned, was submitted to ORNL.

Status of Milestone(s)

(1) Complete close-out plan for system shutdown (April 2007): (1) Complete close-out plan for system shutdown (April 2007): A draft closeout plan has been prepared and is undergoing review.

Industry Interactions

Partners are: Kathabar, Capstone, Broad, DTE, and AIL

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. [The equipment at the University of Maryland is incorporated into an occupied building, which limits the test conditions that can be exercised.] 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 are continuing in the environmental chambers. Data is available on the password protected web site for remote monitoring by the manufacturer using Web Control.

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. The 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

Evaluation of the new 10-ton packaged rooftop heat pump unit (GEDAC #16) is continuing with the performance data available to the manufacturer using Automated Logic Control (ALC) and Web Control for remote monitoring. This is on a password protected site.

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 including the manufacturer of this unit.

Status of Milestone(s)

(1) Complete draft report on testing of InterRotex heat pump (April 2007): Evaluation of the GEDAC #16 with re-designed indoor/outdoor coils and new defrost cycle for optimum utilization of recovered heat is continuing. This evaluation will be completed by March 2007.

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 finalized by 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

Dell Children's Hospital Ribbon Cutting (Burns & McDonnell) was held in Austin, Texas on October 17th.

The Mega Development Study Final Report was presented to DOE on November 17th (Blue Mountain Energy and Southwest Gas Company).

Technical Progress

(see individual project reports)

Industry Interactions

In addition to numerous e-mails and telephone calls, meetings were held with a number of industry organizations. Meetings with industry included:

- Dell Children's Hospital Ribbon Cutting.
- Review meetings with Blue Mountain Energy and Southwest Gas Company in Washington, D.C. for the presentation of the Mega Development Study Final Report.

Subtask 4.3.13 – Research Survey/History of DOE Program

Steve Fischer, fischersk@ornl.gov, (865) 574-2017
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.
Over 500 reports are included in the database.

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

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 Ritz Carlton system continued to operate this quarter and data collection and analysis activities were underway. Significant system optimization opportunities were identified for future installations at similar sites.

Technical Progress
At the Ritz Carlton, data analysis revealed that the CHP system's operating hours were limited by the large size of the backup chillers used to augment the CHP chiller. The analysis may be used to modify the existing system and will certainly guide improved designs for future systems.

Status of Milestone(s)
(1)Complete final project documentation (September 2007): On track

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

At the Basin Electric site, all of the major equipment has been installed and the system was commissioned. Initial data collection has begun and additional data monitoring hardware has been ordered.

Technical Progress

Data analysis from the Basin Electric site has not shown the expected relationship between outdoor temperature and capacity, but has shown a possible impact of part-load use of the pipeline's gas turbine.

Status of Milestone(s)

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

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 kickoff meeting for the New York grid integration study was held, bringing together DOE, NYSERDA, New York City administration, Con Edison, and others to review the project plan and scope.

Technical Progress

For the New York grid study, data regarding building application and size has been provided for the Hudson Yards redevelopment area along with utility-provided grid investment plans.

Status of Milestone(s)

(1)Complete assessment (September 2007): On track

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.

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

The start-up and commissioning of the Eastern Maine Medical Center Combined Heat & Power plant officially began on July 27, 2006 with a successful first fire of the combustion turbine. During the next four weeks, major control and operating systems were completed to allow for the formal commissioning to begin on August 28, 2006. Commissioning of the plant lasted for seven weeks, and on the evening of October 16, 2006 the plant was considered fully commissioned and one hundred percent operational. Operations data are being collected by CDH Energy, and performance statistics are available for review on the web at http://www.emmccogen.org. For the month of December, the plant provided 93% of the hospital's electricity, generating 1,857 MWh of electricity, while recovering 9,832 MMBtu of useful heat. The average CHP efficiency during this period was 73.7 percent.

Status of Milestone(s)

(1)Complete final project documentation (September 2007): Remaining milestones relate to project information dissemination and final project documentation. It is expected that all milestones will be completed well before the due date of September 2007.

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
A ribbon-cutting celebrating the completion of construction and the beginning of full-time operation was held on September 18, 2006 at the school.

Technical Progress
The East Hartford High School system operated well during 4Q06, generating a total of 428,176 kWh during the quarter. During the period, the chiller was operating in Heating Mode, providing hot water for space conditioning. The microturbine run time availability was 100%; the chiller run time availability was 98.6%.

Status of Milestone(s)
(1)Complete final project documentation (September 2007): A project profile is being prepared by SENTECH.

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 for at least 12 months.

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.

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

Industry Interactions

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 draft report was issued for comments: Potential Impact of Renewable Portfolio Standards on Biomass Combined Heat and Power Applications.
- The following draft report was issued for comments: "Project Considerations for Distributed Generation using Opportunity Fuels"

Technical Progress

The following report is undergoing technical review by USCHPA, NYSERDA and other industrial stakeholders. Project Considerations for Distributed Generation Using Opportunity Fuels. The report highlights unique issues for opportunity fuels related to fuel characteristics, fuel treatment, costs and special considerations.

The following report is undergoing technical review by ACEEE, EPA, USCHPA, NYSERDA and other industrial Stakeholders: Potential Impact of Renewable Portfolio Standards on Biomass Combined Heat and Power Applications. The report focuses on the potential impact of renewable portfolio standards on biomass of 15 states' renewable portfolio standards.

Status of Milestone(s)

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

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

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

- The final peer-reviewed version of the following report was completed: *Combined Heat and Power Action Plan - 2007*, Created at the October 2006 7th National CHP Roadmap Workshop, held in Seattle, Washington.
- The following report was published: ORNL/TM-2006/592, *2006 Update of Business Downtime Costs.*
- The following summary technical report was received from project partner Energy Solutions Center: *Evaluating the ASERTTI Long Term Monitoring Protocol at Arrow Linen.*
- The following report was issued: *Environmental Regulatory Barriers to Combined Heat and Power.*
- A presentation on *DG/CHP for Energy Security* was given at the Army Installation Energy Security and Independence Conference held in Greensboro South Carolina on December, 2006.

Technical Progress

CHP Roadmap The CHP Roadmap Workshop was held in Seattle, Washington, September 13-15, 2006. The purpose of the meeting was to revisit the progress of doubling CHP capacity by 2010 and to identify an Action Plan for CHP for the coming year. The 2006 Workshop was held in conjunction with the National Association of State Energy Officials (NASEO) Annual Meeting. In preparation for the meeting, the 2006 Action Agenda: 2006 Combined Heat & Power Action Plan: Positioning CHP Value: Solutions for National, Regional and Local Energy Issues was prepared by ORNL, in conjunction with Discovery Insights and Energy & Environmental Analysis.

Integrated Energy Systems Test and Verification Project with Partner Energy Solutions Center: The twelve month data evaluation campaigns at both the Higgins Brick plant and the Arrow Linen facility were completed. Work will now focus on the preparation of a draft and final case history report for both sites.

Status of Milestone(s)

(1) Complete report on 2006 RAC accomplishments and lessons learned (January 2007): Complete.
(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

Steve Fischer, fischersk@ornl.gov, (865) 574-2017
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

- The ORNL-developed BCHP Screening Tool is being utilized for the final design project of the Introduction to CHP Mechanical Engineering Course, University of Illinois, Chicago. The class has 4 groups of students working on 4 separate buildings and CHP applications. Previously, the class utilized the student version of the GTI Building Energy Analyzer.
- Version 2 of the HUD screening tool for CHP screening tool for multi-family housing has been posted to the ORNL CHP website: http://www.ornl.gov/sci/engineering_science_technology/cooling_heating_power/success_analysis_HUD.htm

Technical Progress

Users of the HUD CHP Screening Tool need to type in data from their monthly power and fuel bills for one consecutive 12 month period as well as some utility rate information. The program uses these data to estimate fuel use for space and water heating and power consumption for air conditioning. The utility costs and rate information are combined with correlations for costs of generator equipment, installation, and maintenance to estimate simple payback periods for a hypothetical CHP system relative to the non-CHP system reflected in the utility data. Sites with low estimated simple payback periods are encouraged to look more seriously into CHP for both its energy savings and cost savings opportunities. Sites with high simple payback periods can save the time and effort of examining CHP in detail with assurances that they are not missing a great opportunity.

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

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
A formal report detailing updated estimates of outage costs for commercial and industrial subsectors, previously analyzed in support of the Energy Policy Act 1817 report, was published.

A preliminary assessment of the grid impact of plug-in-hybrid vehicles was prepared and presented to DOE.

Technical Progress
The latest version of NEMS was obtained and installed and the data bases used by the grid dispatch model were updated.

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.

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

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

A formal report detailing updated estimates of outage costs for commercial and industrial subsectors, previously analyzed in support of the Energy Policy Act 1817 report, was published.

A preliminary assessment of the grid impact of plug-in-hybrid vehicles was prepared and presented to DOE.

Technical Progress

Plug-in hybrid vehicles (PHEVs) are being developed around the world; much work is going on to optimize engine and battery operations for efficient operation, both during discharge and when grid electricity is available for recharging. However, there has generally been the expectation that the grid will not be greatly affected by the use of the vehicles, because the recharging would only occur during offpeak hours, or the number of vehicles will grow slowly enough that capacity planning will respond adequately. But this expectation does not incorporate that endusers will have control of the time of recharging and the inclination for people will be to plug in when convenient for them, rather than when utilities would prefer.

It is important to understand the ramifications of introducing a number of plug-in hybrid vehicles onto the grid. Depending on when and where the vehicles are plugged in, they could cause local or regional constraints on the grid. They could require both the addition of new electric capacity along with an increase in the utilization of existing capacity. Local distribution grids will see a change in their utilization pattern, and some lines or substations may become overloaded sooner than expected. Furthermore, the type of generation used to recharge the vehicles will be different depending on the region of the country and timing when the PHEVs recharge.

We conducted an analysis of what the grid impact may be in 2018 with one million PHEVs added to the VACAR sub-region of the Southeast Electric Reliability Council, a region that includes South Carolina, North Carolina, and much of Virginia. To do this, we used the Oak Ridge Competitive Electricity Dispatch model, which simulates the hourly dispatch of power generators to meet demand for a region over a given year.

Depending on the vehicle, its battery, the charger voltage level, amperage, and duration, the impact on regional electricity demand varied from 1,400 to 6,000 MW. If recharging occurred in the early evening, then peak loads were raised and demands were met largely by combustion turbines and combined cycle plants. Nighttime recharging had less impact on peak loads and generation adequacy, but the increased use of coal-fired generation changed the relative amounts of air emissions. Costs of generation also fluctuated greatly depending on the timing. However, initial analysis shows that even charging at peak times may be less costly than using gasoline to operate the vehicles.

Even if the overall region may have sufficient generating power, the region's transmission system or distribution lines to different areas may not be large enough to handle this new type of load. A largely residential feeder circuit may not be sized to have a significant proportion of its customers adding 1.4 to 6 kW loads that would operate continuously for two to six hours beginning in the early evening. On a broader scale, the transmission lines feeding the local substations may be similarly constrained if they are not sized to respond to this extra growth in demand.

This initial analysis identifies some of the complexities in analyzing the integrated system of PHEVs and the grid. Depending on the power level, timing, and duration of the PHEV connection to the grid, there could be a wide variety of impacts on grid constraints, capacity needs, fuel types used, and emissions generated.

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

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
The latest version of NEMS was obtained and installed and the data bases used by the grid dispatch model were updated.

Technical Progress
A letter report describing a possible Galvin Initiative application was prepared.

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.

Industry Interactions
N/A

Subtask 4.6.6 – MADRI Support Activities

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

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 MADRI project is having a broad impact. A new DG\DR working group met in Maryland for the first time this quarter and involved most utilities working in that state.

Technical Progress

A detailed study of the impact of a 3% reduction in PJM peak load on locational marginal prices was completed and presented to the MADRI group. An Action Plan has been drafted and works with the local PUCs and their staffs continue.

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.

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

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; we are getting the confidentiality agreement signed now. 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 about half of the new inverter cooling system installed.

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.

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

Tom Rizy, rizydt@ornll.gov, (865) 574-5203
John Kueck, Jeremy Campbell, Fran Li, and Y. We
Oak Ridge National Laboratory

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 are currently upgrading the cooling system for the inverter and will be restarting testing again either this week or next.

Technical Progress

The upgrading of the inverter cooling system is underway with half of it done. We expect to have the rest of it finished by this week with us possibly restarting the testing at the end of the week. We will start with a new temperature characterization of the inverter operation to establish the critical operating amperage (the current level at which the heat sink reaches 75C) of the inverter.

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 will be restarting our testing as soon as the inverter cooling system upgrade is complete. Next week, we will be starting up the 30kW Capstone to ensure its working condition and to familiarize ourselves with its remote control software. The inverter temperature characterization with the new cooling system in place will be conducted either the end of this week or the beginning of next week.

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.

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

A. Wereszczak, wereszczakaa@ornl.gov, (865) 576-1169
H.-T. Lin
Oak Ridge National Laboratory

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.

Highlights

Dissection of a 1400V-600A and 6500V-600A IGBT occurred and its interior is presently being cross-sectioned for subsequent examinations of its micro-architecture.

Technical Progress

High-voltage, high-amperage IBGTs (Insulated Gate Bipolar Transistors) and thyristors were recently acquired with the intention to dissect them, study their interior architecture for subsequent thermomechanical stress modeling and reliability evaluations, and work toward increasing their service temperature through the substitution of alternate, higher-operating-temperature materials. These contemporary power grid devices are based on silicon semiconductor technology, and therefore, are not capable of operating at temperatures above 125-150°C. A goal of this project is to interrogate the interior architecture of these baseline devices through “reverse engineering” and modeling of its service thermal and stress fields, and then ultimately use design sensitivity methods to enable the confident transition to silicon carbide semiconductor technology (and the higher temperature capability its use affords).

Status of Milestone(s)

Demonstrate the use of *μ-FEA* for modeling the thermal-mechanical stresses prevalent in a current SiC-package (September 2007): On schedule.

Industry Interactions

None yet - this quarter was this project’s first.