

Project Title: Closing the Gap: Getting Full Performance from Residential Central Air Conditioners

Covering Period: July 1, 2004 – September 30, 2004

Date of Report: October 14, 2004

Recipient Organization: New York State Energy research and Development Authority (NYSERDA)

Partners: New York State Energy Research and Development Authority (NYSERDA)  
University of Central Florida- Florida Solar Energy Center (FSEC)  
Energy Center of Wisconsin (ECW)  
Advanced Energy (AE)

Technical Contact: Peter W. Douglas, NYSERDA  
17 Columbia Circle, Albany, New York 12203-6399  
(518) 862 1090 x3214 phone,(518) 862 1091 fax  
[pwd@nyserda.org](mailto:pwd@nyserda.org)

Business Contact: Patricia Aiello, NYSERDA  
17 Columbia Circle, Albany, New York 12203-6399  
(518) 862 1090 x3263 phone,(518) 862 1091 fax  
[paa@nyserda.org](mailto:paa@nyserda.org)

**1. Project Objective:**

Improve the performance of residential central air conditioners by: (i) addressing performance rating methodologies; (ii) developing robust feature specifications to improve operating efficiencies; (iii) assessing field performance and developing innovative sizing and operating strategies; (iv) developing new climate sensitive air conditioner designs; and (v) disseminate project results through peer-reviewed papers, presentations, training classes and stakeholder workshops.

**2. Background:**

The field performance of central air conditioning (CAC) falls short of expectations from laboratory-based federal efficiency ratings. On average, these units use 10-30% more electricity than expected. This project will address key factors leading to these shortfalls. The end result of this work effort will be next generation rating methods and technically-feasible climate sensitive designs of air-conditioning systems. In addition, field-installed CAC systems will be monitored and evaluated to better understand how to optimize performance in terms of proper installation, sizing, and advanced control methods. The project results will be widely disseminated through various avenues, including half-day training classes, web-based homeowner guides, and stakeholder workshops.

**3. Patents:**

None

**4. Publications/Presentations:**

None

## 5. Progress in Past Quarter and Current Status:

### Project Management

The project kick-off meeting on August 26 (annotated agenda attached) during the ACEEE Summer Study on Buildings. The following issues were discussed and actions taken:

- The start dates for some linked partners were different and some work (approved by NASEO ) has already been undertaken.
- Consensus on membership in the Steering Committee was reached.
- Outside Advisory Committee responsibilities, activities and nominations were discussed. The Advisory Committee will be set up in the second project quarter.
- Reviewed and reached final agreement on the project deliverables and dependencies among organizations for these deliverables.
- ACEEE, the project Technical Director and NYSERDA subcontractor, assigned a research staff member to track and coordinate deliverables, facilitate review of manuscripts produced by all the project partners.

#### **Task 1            Improve central air conditioner performance ratings**

##### **Task 1.1        Review present standards and method of testing**

No activity.

##### **Task 1.2        Field performance data review**

No activity.

##### **Task 1.3        Develop population weighted temperature bin-hour distributions**

No activity.

##### **Task 1.4        Preliminary proposed rating procedures**

No activity.

##### **Task 1.5        Simulate benefits of alternative metrics for diverse climates**

No activity.

##### **Task 1.6        Analysis and recommendations**

#### **Task 2            Robust Feature Set for Residential Air Conditioners**

##### **Task 2.1        Develop trial specification sets**

NYSERDA. ACEEE has been working actively with the Energy Star® program and the Consortium for Energy Efficiency (CEE) as they develop specifications for their programs in 2006. The challenge they face is that the new Federal minimum performance specification, SEER 13, replaces the present SEER 10 standard in January, 2006. Current programs typically provide incentives for SEER 13 and/or SEER 14 equipment. This suggested a performance improvement of about 23% (SEER 13). Getting comparable performance gains cost-effectively will require moving from simple equipment efficiency specifications to considerations of efficiency in operation, and installation requirements. We have drawn much from preliminary draft *Robust* specifications in ACEEE's suggestions for the 2006

Energy Star and CEE specifications, and will continue this work as a way to quickly introduce as many features as possible to the marketplace.

**Task 2.2 Draft specification**

No activity.

**Task 2.3 Consensus building workshop**

No activity.

**Task 2.4 Coordinate with manufacturers**

No activity.

**Task 3 Field Performance Data and Innovation**

**Task 3.1 Comparison of ratings with field performance**

ECW. Recruited 13 households with new central air conditioners (from an Focus on Energy program) to participate in data gathering. WECC field staff conducted site visits to measure refrigerant charge and airflow; installed monitoring equipment to track the operation of the system and will swap data loggers (by mail) during the course of the cooling season. An additional 37 sites will be recruited for monitoring during the 2005 cooling season.

**Task 3.2 Benefits of proper sizing**

FSEC conducted a search (e-mail and utility contacts) and selected four case study homes for field performance data collection. The desired criteria included square foot size, age, owner-occupied, typical occupancy usage, single AC system. The homes are located throughout the Florida peninsula in Merritt Island (east central), Jacksonville (northeast), North Port (southwest) and Lakeland (30 miles southwest of Orlando). Energy audits were performed to pre-qualify the homes and included measurement or verification of building components (wall and floor construction types, window orientations/types/areas/overhangs, ceiling insulation levels, etc.) along with building envelope and duct air tightness measurements. An Air Conditioning Contractors of America (ACCA) Manual J load calculation was then run for each home to determine if/how much the present A/C system was oversized. A monitoring plan was designed to cover three modes of operation: "as is" oversized, tune-up and properly sized units. To compare the performance of the original (oversized) and properly-sized air-conditioning systems, various operating conditions and electricity usage must be monitored at each home. The monitoring plan includes: Electricity use (15-minute data for total house, A/C condenser and A/C air handler); Air temperature and relative humidity at the thermostat (15-minute data); Supply register air temperature (2-minute data); Air temperatures entering and leaving the cooling coil (2-minute data); and outdoor air temperature, relative humidity and solar radiation (15-minute data). Monitoring equipment was purchased and installed in each of the sites. Post-tune up monitoring began in July for three homes and in early August for the fourth home. Note that while it appears that adequate time was available for post-tune up data collection; both this monitoring phase and the post A/C change out phase were significantly affected by hurricanes Charley, Frances and Jeanne. A/C change outs were also delayed because of lost workdays and significantly increased A/C contractor workloads due to the hurricanes. The new systems were properly sized according to ACCA Manual J, and were the same manufacturer and model number (as close as possible) as the oversized units that were replaced. Proper sizing proved to be a bit of a challenge while trying to hold manufacturer, equipment model, and SEER consistent between the oversized units and the

properly-sized systems being installed. The table below shows original and new A/C system cooling capacities and efficiencies.

Site	Original Size (Btu/h Cooling)	Original SEER / HSPF	New System Size (Btu/h Cooling)	New System SEER / HSPF
Jacksonville	47,000	12.05 / 7.3	33,000	12.05 / 7.5
Merritt Island	44,500	12.75 / NA	29,400	12.50 / NA
Lakeland	58,500	11.60 / NA	41,500	12.00 / NA
North Port	41,000	13.15 / 8.65	27,800	13.75 / 8.25

Three A/C change outs were performed in September (16th, 17<sup>th</sup> and 24th), with the final change out to be completed in early-October 2004. In two cases a performance check of the new A/C system was completed at the time of the change out, while in the third home the performance check was performed five days later. With the exception of higher than expected relative humidity levels in one home, initial feedback from homeowners indicates overall satisfaction with the new, smaller A/C systems.

AE has selected a market, Phoenix, Arizona, in which to conduct the customer satisfaction survey, as well as an HVAC contractor to provide information about the two levels of homes (baseline and guarantee). AE staff hired the Hatteras Group to assist with the satisfaction survey, and approved a scope of work.

**Task 3.3 Research strategies for enhanced field performance**

ECW. Recruited and instrumented for monitoring 11 sites having new two-stage central air conditioning systems. Timers were used to control compressor staging in order to assess the energy and dehumidification performance of the systems in low versus high stage. Two types of thermostats were used in the participating homes: a Honeywell two-stage thermostat, and a Carrier/Bryant Thermidistat™. The latter can respond to humidity as well as temperature. The monitoring for each of these sites included outdoor temperature; temperature and relative humidity at the thermostat; temperature of return airflow; compressor amps; furnace (air handler) amps and on/off status; and status of dehumidification calls (for sites with Thermidistats™). Monitoring and testing was completed for four of the participants during Quarter 1. The remainder of the 11 sites will be completed in Quarter 2. An additional nine systems will be recruited and monitored during the 2005 cooling season. Wisconsin experienced an unusually cool summer in 2004. This may have an adverse impact on the ability to draw conclusions from the data gathered during this time period.

**Task 4 Develop New Climate-Sensitive Air Conditioner Designs**

**Task 4.1 System Configuration: identification, simulation and cost-benefit analysis**

CDH (NYSERDA subcontractor) fine tuned heat pump and AC models for FSEC’s Energy Gauge building simulation program to ensure accuracy between temperature/humidity levels vs. COP efficiency.

**Task 4.2 Prototype System: design, construction, laboratory and field testing**

No activity.

**Task 5 Information Dissemination and HVAC Contractor Training**

FSEC began development of its 2005 UCF/FSEC training schedule.

## 6. Plans for Next Quarter

### Project Management

Establish Advisory Committee

#### Task 1            **Improve central air conditioner performance ratings**

##### Task 1.1        **Review present standards and method of testing**

NYSERDA. Develop trial specification sets for improved performance.

##### Task 1.2        **Field performance data review**

NYSERDA. Review present standards and test methods for central air conditioner ratings.

##### Task 1.3        **Develop population weighted temperature bin-hour distributions**

FSEC. Assist NYSERDA (subcontractor CDH Energy) with development of the analysis methodology for Task 1.3 (Develop population weighted temperature bin-hour distributions)

##### Task 1.4        **Preliminary proposed rating procedures**

##### Task 1.5        **Simulate benefits of alternative metrics for diverse climates**

##### Task 1.6        **Analysis and recommendations**

#### Task 2            **Robust Feature Set for Residential Air Conditioners**

##### Task 2.1        **Develop trial specification sets**

FSEC. Develop trial specification sets for Task 2.1

##### Task 2.2        **Draft specification**

##### Task 2.3        **Consensus building workshop**

##### Task 2.4        **Coordinate with manufacturers**

#### Task 3            **Field Performance Data and Innovation**

##### Task 3.1        **Comparison of ratings with field performance**

ECW. Complete removal of monitoring equipment from 2004 test sites and initiate data analysis of 2004 monitoring data. Compile test data and a working paper on 300 systems evaluated as part of the Focus on Energy Best Practices program.

##### Task 3.2        **Benefits of proper sizing**

AE. Work with the Phoenix HVAC contractor to obtain necessary data from targeted homes and the Hatteras Group to design the customer satisfaction survey.

FSEC. Collect and analyze field data collected during summer and early-Fall 2004 for Task 3.2 (Benefits of proper sizing). Plans will also be developed to continue post A/C change out monitoring summer 2005 if/as necessary.

**Task 3.3          Research strategies for enhanced field performance**

**Task 4            Develop New Climate-Sensitive Air Conditioner Designs**

**Task 4.1          System Configuration: identification, simulation and cost-benefit analysis**  
FSEC. Begin work System Configuration: identification, simulation and cost-benefit analysis

**Task 4.2          Prototype System: design, construction, laboratory and field testing**

**Task 5            Information Dissemination and HVAC Contractor Training**  
FSEC. Finalize 2005 UCF/FSEC training schedule.