

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

Covering Period: October 1, 2004 – December 31, 2004

Date of Report: December 1, 2004

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

Partners: New York State Energy Research and Development Authority (NYSERDA)  
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**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:**

This progress report is prepared by the recipient agency, NYSERDA, and includes activities by all linked partners. Progress under each sub task is delineated by the linked partner responsible for performance.

## **Project Management**

NYSERDA. ACEEE largely completed selecting nominees for the Project Advisory Committee and carried out reviews of CDH, ECW and FSEC reports on activities for the quarter (others have not been received to date).

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

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

NYSERDA. ACEEE. began literature review and interviews with test method experts.

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

No activity.

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

NYSERDA. CDH Energy started to work with ACEEE to develop population-weighted temperature bin-hour distribution that would provide an SEER calculation that is representative of national demographics. Reviewed data sources for population/demographic data, AC sales data, and raw weather data.

#### **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**

ECW. In Quarter 2, the Energy Center and its cost-share subcontractor, Wisconsin Energy Conservation Corporation (WECC), began compiling and cleaning air conditioner test data to be used in Task 1. These data come partly from test data on a random sample of homes recruited under this project (see Task 3.1), and partly from test data gathered under Focus on Energy program activities in Wisconsin. Specifically, Wisconsin Energy Conservation Corporation compiled and analyzed limited contractor-reported test data on 495 new air conditioners installed in Wisconsin under the auspices of Focus on Energy, along with more complete data for 14 systems tested under Task 3.1 of this project, and 40 systems tested under other projects. We expect the data and draft analysis to be complete early in Quarter 3.

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

No activity.

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

NYSERDA. ACEEE continued to work actively with the Energy Star® program and the Consortium for Energy Efficiency (CEE) as they develop specifications for their programs in 2006.

**Task 2.2 Draft specification**

FSEC. No Activity. Task 2 will be primarily completed by other project partners (NYSERDA and its subcontractors). UCF/FSEC will assist on Task 2.1 by developing trial specification sets, assisting with development of the analysis methodology, and reviewing the simulation results. UCF/FSEC will also review the full draft specification developed by NYSERDA (subcontractor ACEEE) for Task 2.2.

**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. The Energy Center has an objective to gather data on airflow, refrigerant charge and cycling behavior for a random sample 50 Wisconsin households with new central air conditioners. A subset of these were tested and monitored in 2004, and the remainder are to be completed during the 2005 cooling season. As noted in the previous progress report, we encountered difficulties recruiting from our initial sample frame, and instead recruited from the pool of participants in the statewide Focus on Energy rewards program to promote high efficiency air conditioners. Fourteen such sites were recruited and tested, mostly in Quarter 1. These sites also had limited monitoring equipment installed to track compressor run-time and indoor conditions. In Quarter 2 Wisconsin Energy Conservation Corporation removed the monitoring equipment and compiled the test data along with other test data described under Task 1. The remainder of the 50 sites will be recruited and monitored in 2005 (Quarters 4 and 5 of the study).

**Task 3.2 Benefits of proper sizing**

The goal of Task 3.2 is to show the benefits of proper air conditioner sizing to contractors, customers and utilities. Field tests will be conducted in 8 case study homes (4 homes in Florida tested by UCF/FSEC and 4 homes in Wisconsin tested by ECW).

FSEC. As reported previously, the Florida A/C changeout work and post-changeout monitoring were significantly affected by hurricanes Charley, Frances and Jeanne. The final Florida A/C changeout (of four) was performed during this quarter on October 8, 2004 and some post-changeout data have now been collected at each of the 4 Florida case study homes.

Higher than expected indoor relative humidity levels with the new, smaller A/C system was previously reported from one homeowner. Another homeowner indicated that they preferred the higher airflow rates of the original system although they were otherwise satisfied with the new unit.

Due to the hurricanes postponing and shortening the post-monitoring period, a letter was sent to all four participants requesting that they allow one month of additional monitoring next summer. All four homeowners agreed to the additional monitoring.

### **Data Analysis**

Some initial data analysis has been completed for three of the homes. Again, due to the limited amount of post-changeout data available, preliminary comparisons were made using just two-day pre- and post-retrofit periods. Comparison dates and Orlando National Climate Data Center conditions data are provided below.

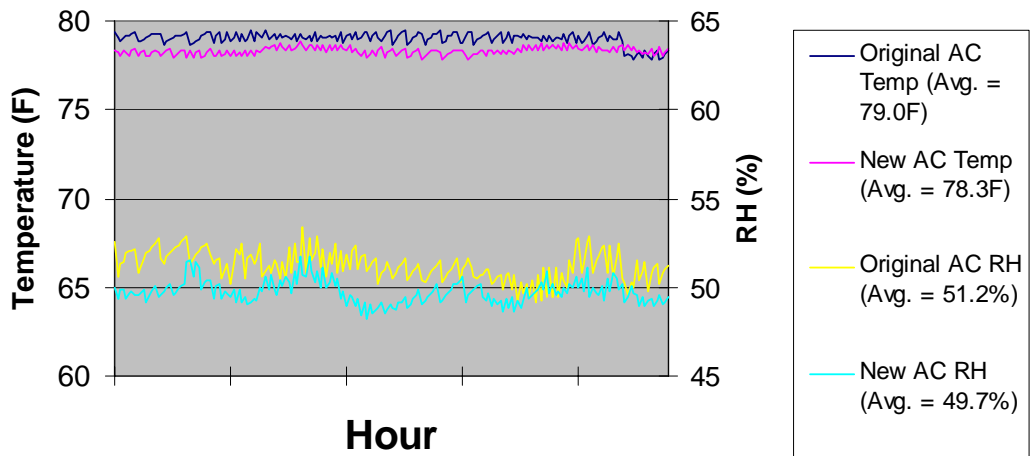
<b>Monitoring Period</b>	<b>Comparison Dates</b>	<b>Orlando NCDC Data Temperatures (F)</b>			
		<b>Max</b>	<b>Min</b>	<b>Avg</b>	<b>Avg Dew Pt</b>
Pre Changeout	8/22/2004	90	73	82	73
	8/23/2004	91	72	82	73
Post Changeout	10/2/2004	90	73	82	71
	10/3/2004	90	71	81	71

Preliminary plots of indoor conditions, power use and supply air temperatures have been completed for the Merritt Island and Lakeland, Florida project homes. For both homes, average daily A/C power use is higher for the new, smaller system. Relative humidity levels at the Lakeland home are higher for the new A/C unit, which may have been at least partially due to a power outage for approximately 5 days at this house after hurricane Jeanne.

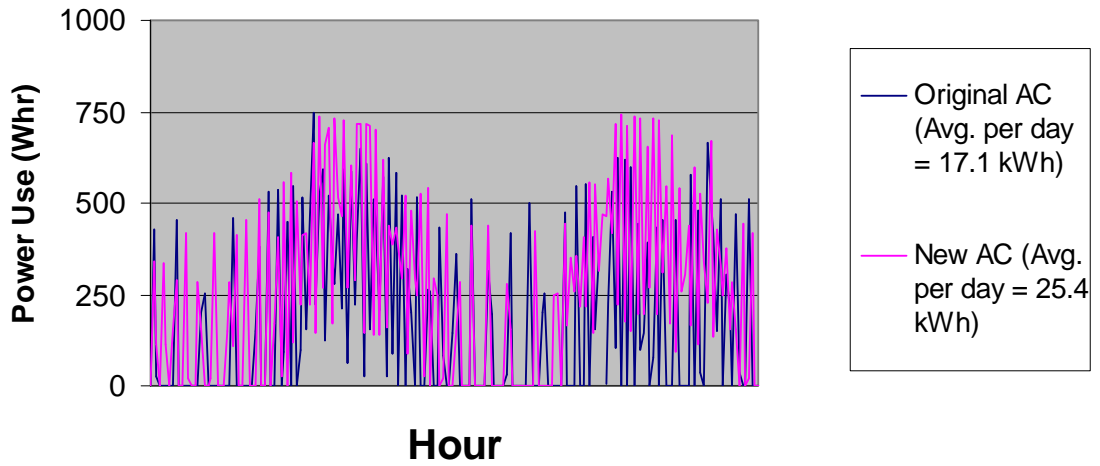
### **Merritt Island**

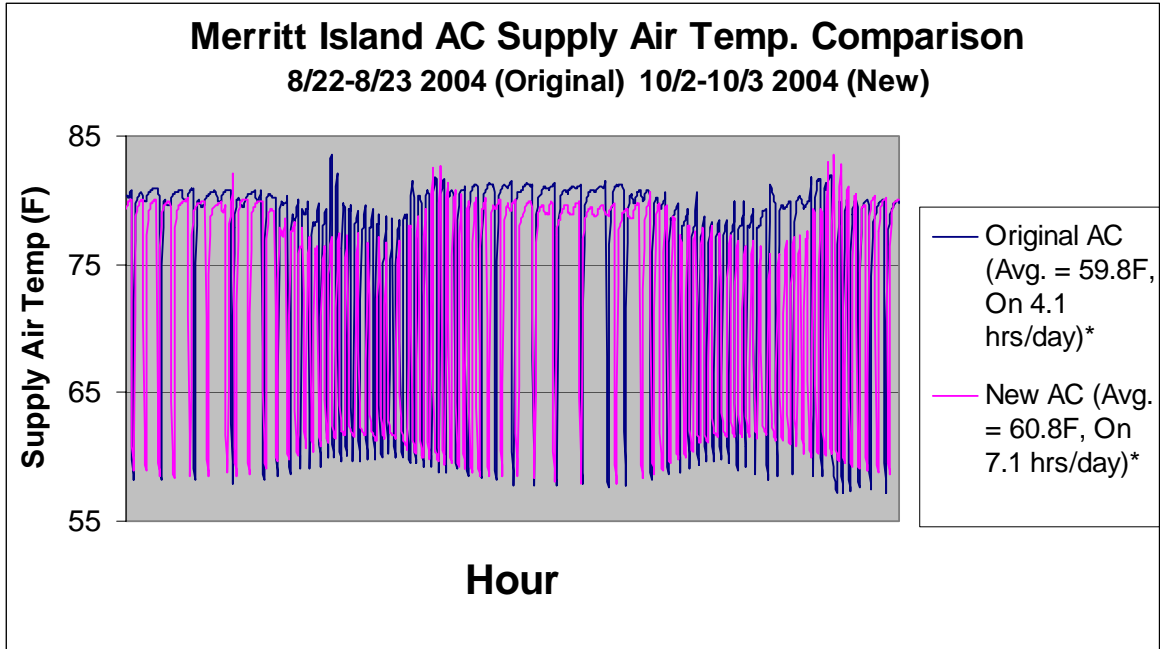
Preliminary plots of indoor conditions, power use and supply air temperatures for the Merritt Island, Florida home are show below.

### Merritt Island Indoor Conditions Comparison 8/22-8/23 2004 (Original) 10/2-10/3 2004 (New)



### Merritt Island AC Power Use Comparison 8/22-8/23 2004 (Original) 10/2-10/3 2004 (New)

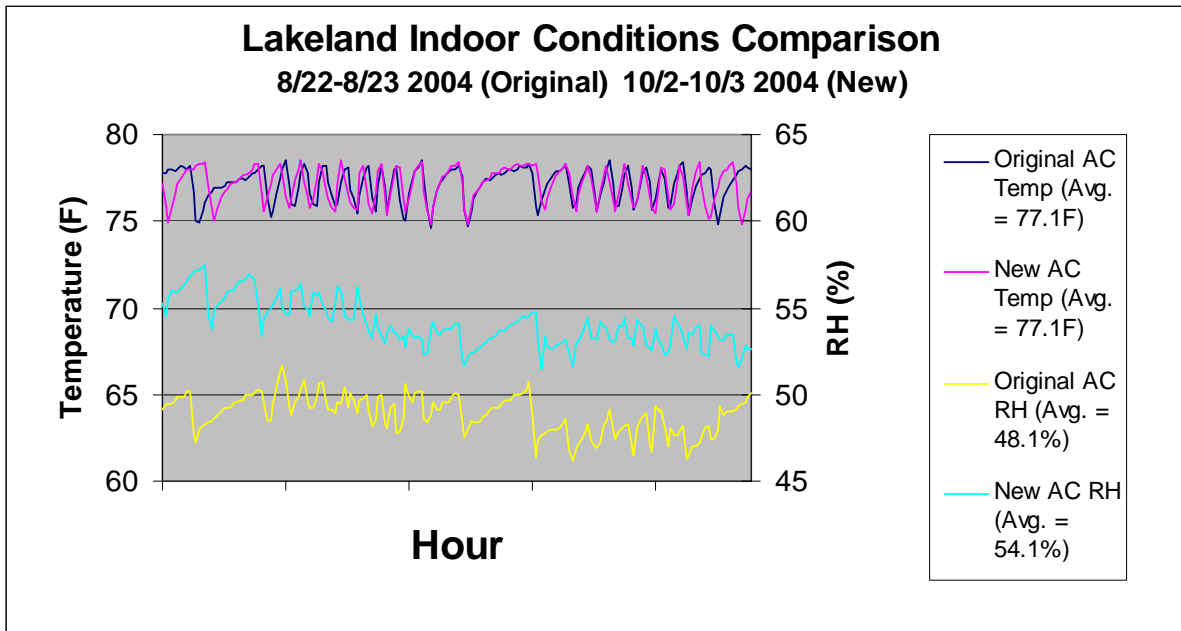


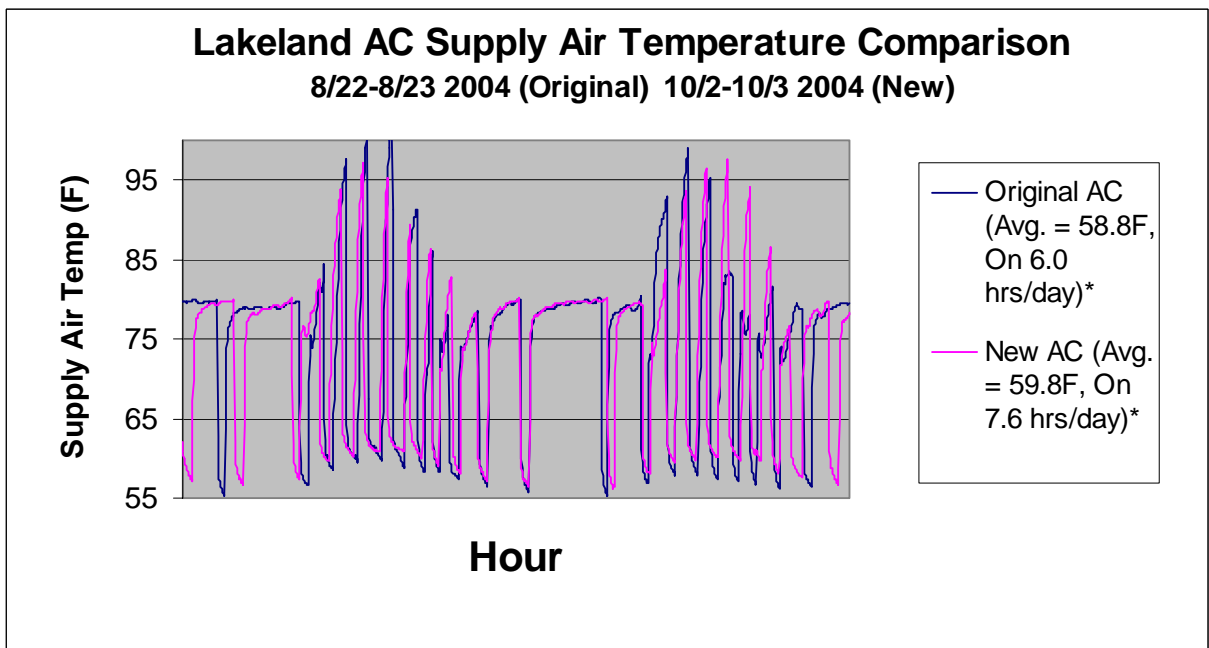
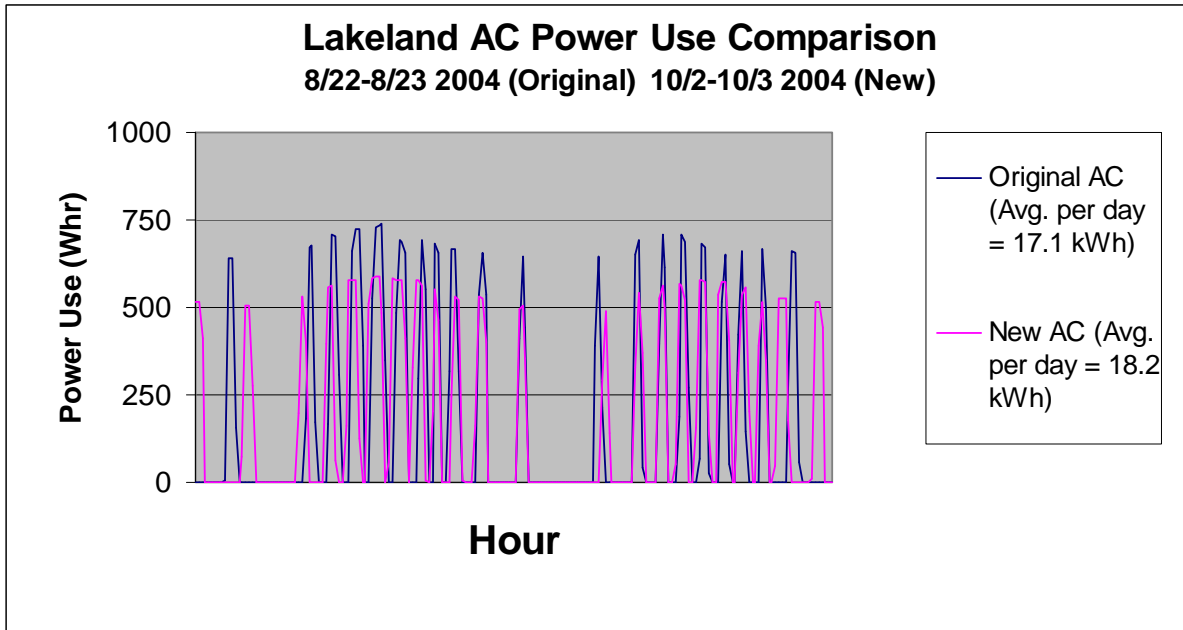


\* All supply temperatures below 63F assumed as system on and used in averages and "on time" estimates.

### Lakeland

Preliminary plots of indoor conditions, power use and supply air temperatures for the Lakeland, Florida home are shown below.





\* All supply temperatures below 63F assumed as system on and used in averages and "on time" estimates.

The table below summarizes the conditions, power use and run time averages shown on the above Merritt Island and Lakeland home plots.

Tstat Temps (F)	Interior RH (%)	AC Power Use (kWh/day)	Supply Temp (F)	Run Time (Hrs/day)
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A/C Unit	Original	New	Original	New	Original	New	Original	New AC	Original	New
Merritt Island	79	78.3	51.2	49.7	17.1	25.4	59.8	60.8	4.1	7.1
Lakeland	77.1	77.1	48.1	54.1	17.1	18.2	58.8	59.8	6	7.6

Both the higher power use at these homes and higher RH levels at the Lakeland home with the new, smaller A/C systems were unexpected. Initial data analysis of one of the other two Florida homes indicates that power use and RH will also be higher for this home with the new system.

Air handler fan flow was also measured for each of the original and new A/C systems. In each home, the original A/C system's airflow per ton was lower than the new system's airflow per ton despite efforts to make them equal by adjusting the fan motor setting for the new system. This difference may be due to the fact that the duct work in these homes were sized for the larger systems and now the smaller systems are operating at lower duct system pressures, allowing more airflow.

Additional data analysis is planned for the next few months to complete preliminary analyses for the other two project homes, verify preliminary results, and study possible reasons for the unexpected power use and RH findings so far. However, again due to the hurricane postponed and shortened post-changeout monitoring period, final data analysis will not be completed until after additional monitoring during Summer 2005.

AE. Advanced Energy and the Hatteras Group consultants continued to gather data for targeted homes in Maricopa County, Arizona to which the customer satisfaction survey will be administered.

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

ECW. The Energy Center is to conduct field monitoring of 20 new two-stage central air conditioning systems to test field performance under different operating modes. Twelve such systems were instrumented for monitoring during Quarters 1 and 2. The remaining systems will be recruited and monitored during the 2005 cooling season. Testing was completed for nine of the twelve 2004 participants during Quarters 1 and 2, and monitoring equipment was removed. The other three participants have agreed to have monitoring extended through the 2005 cooling season. We done some preliminary cleaning and initial data analysis for these sites in Quarter 2, but the bulk of this analysis will occur in Quarter 3 and beyond. Note that 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**

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

FSEC. UCF/FSEC personnel began efforts to design an improved supply air fan control for the hot-humid climate air conditioner being developed as part of this project. The team met to discuss design parameters, control strategies (fan speed and delay), and overall objectives. We also began to document the various measurement points necessary to validate the control performance within an A/B test procedure aimed to evaluate the mocked up control in Summer 2005.

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

FSEC. A new half-day course has been developed. It is tentatively scheduled for five Florida locations in October 2005. The agenda follows:

##### HVAC Systems as If Comfort and Energy Mattered

1:00 Introduction

1:10 Ductwork That Works

- Why Ductwork Matters (10 minutes)
- Doing Ducts Right-- improving duct airtightness (30 minutes)
  - What is an air barrier
  - Creating a continuous air barrier
  - Mechanical fastening vs. sealing
  - Other installation issues
- Testing Duct Systems (30 minutes)
  - Performance testing techniques and criteria
  - Finding leaks
  - Code compliance benefits
- Duct and Air Handler Location (10 minutes)

2:30 Balancing Air Flows (15 minutes)

- Ducted returns
  - Balancing supplies and returns
  - Conduction and air leakage losses
- Return Transfers
  - Sizing to meet code requirement
  - Options for transport pathways

2:45 Break

3:00 Sizing up System Sizing

- Benefits of Correct A/C Sizing (60 minutes)
  - Field data
  - Humidity Control
  - Consequences of oversizing
    - Single family
    - Multifamily
- Sizing it Right (30 minutes)
  - Common practice
  - Using Manual J correctly

4:30 Questions and Answers

4:45 Complete Evaluations

5:00 Adjourn

## 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.  
ECW. Complete the compilation and reporting of test data, and provide labor support.

##### 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. Begin preparations for Task 3 field research in the 2005 cooling season

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

AE. During the next quarter Advanced Energy and the Hatteras Group will focus on the types of information to be gained from the customer satisfaction survey and will plan the pre-survey focus groups.

FSEC. Complete preliminary analysis of field data collected during Summer and early-Fall 2004 for Task 3.2 (Benefits of proper sizing)

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

ECW. Clean and begin analysis of testing and monitoring data for the 2004 subset of Task 3.3 sites.

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

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

FSEC. Continue work on Task 4.1 (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. Print brochures that will include the description and schedule for the new half-day course