

**RESIDENTIAL
CENTRAL AC
REGIONAL
EVALUATION**

Final Report

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Prepared for:

**NSTAR Electric and Gas Corporation
National Grid MA & RI
Connecticut Energy Conservation Management Board
Connecticut Light & Power
United Illuminating**

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EXECUTIVE SUMMARY

This report presents and discusses results from a regional evaluation of residential central air conditioning systems installed in existing and new houses in Massachusetts, Connecticut, and Rhode Island. The purpose of the study was to assess energy savings and demand impacts associated with the installation of efficient central air conditioning (CAC) systems.

ES.1 DESCRIPTION OF PROGRAMS

NSTAR, National Grid, CL&P and UI all offered programs in 2008 through which residential customers could receive rebate incentives for purchasing high efficiency—rather than standard efficiency—central air conditioning systems or heat pumps. Eligible equipment included units with an Energy Efficiency Rating (EER¹) greater than 11 or a Seasonal Energy Efficiency Rating (SEER) greater than 14. Rebates ranged from \$300 to \$500.

NSTAR and National Grid offered rebates for installation of high efficiency CAC equipment in existing and new houses through the jointly-sponsored COOL SMART Program. This program is a market transformation initiative designed to increase consumer awareness and the market share of ENERGY STAR–labeled split, central air conditioning units and air source heat pumps and to promote quality cooling equipment installations by HVAC technicians and contractors. This program was offered to NSTAR residential electric customers in Massachusetts and to National Grid residential customers in Massachusetts and Rhode Island.

In Connecticut, CL&P and UI offered rebates for high efficiency residential air conditioning equipment through the Home Energy Solutions Program (for existing houses) and the Residential New Construction Program (for new houses). All residential customers adding or replacing central air conditioning systems were eligible for the incentives. Both market-driven replacement upgrades and early retirement of older, inefficient systems were promoted through the programs.

ES.2 OBJECTIVES OF THE STUDY

The overall objective of this study was to provide estimates for the following:

- Annual energy savings from installation of a qualifying CAC rather than a baseline CAC

On-peak demand savings

Seasonal peak demand savings

Coincidence factors

Load shapes for new CAC units

¹ EER = BTU of cooling at 95° F / Watts Used at 95° F

ES.3 METHODS USED FOR STUDY

Data for the assessment were collected through post-installation monitoring of the operation of CAC systems installed by a sample of households selected from participants in programs sponsored by NSTAR Electric and Gas Corporation (NSTAR), National Grid Massachusetts and Rhode Island (National Grid MA and RI), Connecticut Light & Power (CL&P), and United Illuminating (UI). The evaluation is based on data collected for a sample 96 units installed by participants in the programs during 2008.

Site-specific information (e.g., housing characteristics) was collected for each residence in the sample. Field staff took one-time power measurements of the new CAC unit's compressor and air handler to determine its kW load and installed loggers to monitor indoor temperature and run time of the CAC compressor.

The data collected for the sample of 96 central air conditioning units were used to develop a statistical regression model for each unit whereby a unit's hourly kW measurements were correlated to weather variables (hourly outdoor air temperatures, both dry bulb and wet bulb) over the monitoring period – typically for 4-6 weeks. Weather data for 2008 was used in developing the model for each sampled unit. The result was a model of kW and kWh usage in the study year (2008).

The model for each site then was used along with Typical Meteorological Year (TMY) weather data appropriate to that site to predict air conditioning energy use for the installed CAC system for a typical year. Following the calculation of annual energy use and load shapes for the installed system, energy consumption had the program participant instead installed an 11 EER unit was then calculated. The difference between these two usage estimates provided estimates of the savings resulting from installation of a higher efficiency CAC unit.

For the load shape analysis, the hourly forecasts were analyzed in order to calculate coincidence factors over on-peak periods defined by the New England ISO as non-holiday weekdays from 1-5 PM over the months of June-August. This definition yields a total of 260 peak hours in the average year.

Coincidence factors were calculated as the percentage of total peak hours in which the compressor for the CAC system of sampled residences was running.

In addition, seasonal peak kW reductions were calculated during hours in 2008 where the New England system load exceeded 90% of the New England ISO 50/50 System Peak Load Forecast.

ES.4 SUMMARY OF FINDINGS

Table ES-1 summarizes the estimated savings for ISO Load Zone level forecasts for all monitored sites. These estimates have been derived under the following assumptions.

The baseline was established by determining what energy use would have been under the same operating hours if a participant had instead installed a 11 EER air conditioner or heat pump.

On-Peak demand is defined as non-holiday weekdays from 1-5 PM in the months of June, July, and August.

Seasonal Peak: Non-holiday week days when the Real-Time System Hourly Load is equal to or greater than 90% of the most recent “50/50” System Peak Load Forecast for the summer season. Estimates of kWh savings are derived using Typical Meteorological Year (TMY) weather data.

*Table ES-1. Per-Site kWh Savings Summary
for Residential Central Air Conditioning Regional Evaluation
(Based on TMY Weather Data)*

ISO Load Zone	Annual kWh Savings	Annual kWh Savings/Ton	On-Peak kWh Savings	On-Peak kWh Savings/Ton
NEMA	71	25	12.3	4.4
SEMA	95	34	18.8	6.8
WCMA	57	20	9.5	3.4
RI	87	31	16.1	5.8
CT	111	40	20.5	7.5

Estimates of kW reductions during seasonal peak hours were developed using actual weather data for 2008. These estimates of per-site kW reductions and coincidence factors are summarized in Table ES-2. On-peak kW reductions and coincidence factors were calculated using TMY weather data.

*Table ES-2. Per-Site On-Peak & Seasonal Peak kW Reductions Summary
for Residential Central Air Conditioning Regional Evaluation*

Load Zone	Average On-Peak kW	Average On-Peak kW Savings	On-Peak Coincidence Factor	9-Hour Total Seasonal Peak kW	Total Seasonal Peak kW Savings	Seasonal Peak Coincidence Factor
NEMA	.97	.11	32%	8.69	.98	43%
SEMA	1.47	.17	42%	13.32	1.52	76%
WCMA	1.35	.15	26%	12.16	1.38	73%
RI	1.61	.19	38%	14.53	1.7	80%
CT	1.42	.16	44%	12.74	1.44	72%

Following calculation of per-site averages, program-level totals were determined for each load zone. These were calculated by weighting per-site averages by unit size, then multiplying these averages by the unit sizes’ representation in the overall program. The estimates of annual kWh reductions are presented in Table ES-3 below. As with the per-site averages, program level

annual reductions are calculated using TMY weather data. Figures with asterisks are per-site averages for the participant population.

Table ES-3 Program-Level kWh Savings Summary for Residential Central Air Conditioning Regional Evaluation

ISO Load Zone	Annual kWh Savings	Annual kWh Savings/Ton	Average On-Peak kW Savings	Average On- Peak kW Savings/Ton
NEMA	59,972	26*	40.5	.018*
SEMA	17,996	32*	14.1	.027*
WCMA	12,562	20*	8.3	.014*
RI	18,425	30*	13.3	.024*
CT	368,531	39*	265.5	.031*

In addition, program-level on-peak and seasonal peak kW reductions were calculated, extrapolating per-site averages to the participant population by load zone in a similar manner. These totals are presented in Table ES-4.

Table ES-4 Zone-Level On-Peak & Seasonal Peak kW Reduction Summaries

Load Zone	Average On-Peak kW	Average On-Peak kW Savings	On-Peak Coincidence Factor	9-Hour Total Seasonal Peak kW	Total Seasonal Peak kW Savings	Seasonal Peak Coincidence Factor
NEMA	367.2	40.5	22%	5,697	630	33%
SEMA	127.4	14.1	29%	2,952	326	64%
WCMA	74.9	8.3	16%	3,094	344.9	62%
RI	118.8	13.3	26%	3747	424.4	70%
CT	2,405.4	265.5	32%	50,295	5,610	59%

ES.5 ORGANIZATION OF REPORT

This report presents and discusses the methodology used and results achieved through this study. The report is organized into the following chapters:

Chapter 1 provides an introduction and overview for the study.

Chapter 2 describes the sampling plan and the methods used to collect the data on air conditioning electricity use.

Chapter 3 describes the modeling approach for estimating annual, kWh savings, on-peak kW reduction, and seasonal peak kW reduction.

Chapter 4 presents the savings for monitored sites at the site level, and at the zone level for each ISO Load Zone.

Chapter 5 provides analysis of daily and annual load shapes and peak demand reduction. In addition, there is a comparison against the conditions of the “50/50” System Peak Load

Forecast, analyzing savings on days where the actual New England system load exceeded 90% of the ISO New England's Peak Load Forecast.

Chapter 6 contains a brief summary of and conclusions from the study.

Appendix A contains copies of the forms used for the data collection.

Appendix B provides further background on alternative models considered, as well as on statistical methodologies applied in this report.

Appendix C presents input and output data used in developing the Tobit models.

Appendix D provides graphs showing the variation in AC loads throughout the monitoring period.

Appendix E provides predictions of load reductions for different NE ISO load zones, disaggregated by size of CAC unit.