# Final Report
# Coincidence Factor Study
# Residential Room Air Conditioners

## Prepared for;
## Northeast Energy Efficiency Partnerships' New England Evaluation and State Program Working Group

**Sponsored by:**
**Cape Light Compact**
**Efficiency Vermont**
**National Grid USA**
**NSTAR Electric**
**Western Massachusetts Electric**
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**Fitchburg Electric**
**New Hampshire Electric Cooperative**
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**Unitil**

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***Prepared by:***
***RLW Analytics***
**179 Main Street**
**Middletown, CT 06457**
**(860) 346-5001**


RLW ANALYTICS

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# Executive Summary

The New England State Program Working Group (SPWG)[1] contracted with RLW to calculate on-peak and seasonal peak coincidence factors for residential room Air Conditioner (RAC) measures that could be consistently applied to energy efficiency programs that may bid into the ISO-NE Forward Capacity Market (FCM) in any of the New England states. The study covered four of the six New England states including Massachusetts, New Hampshire, Rhode Island and Vermont. Maine also sponsored the study although there were no participating units in the state and no on-site metering or survey activity was conducted in the state. Connecticut did not participate in the study because they no longer offer incentives for room AC units.[2]

The study utilized interval metered power data from 93 on-site visits that were nested within a sample of approximately 610 phone surveys. The sample was designed to allocate on-site visits and phone surveys equally by the six ISO-NE load zones with participating room AC units from program years 2005 and 2006. Figure i- 1 shows the actual distribution of data collection activities by load zones, the on-site numbers reflect sites with both a phone survey and site visit.

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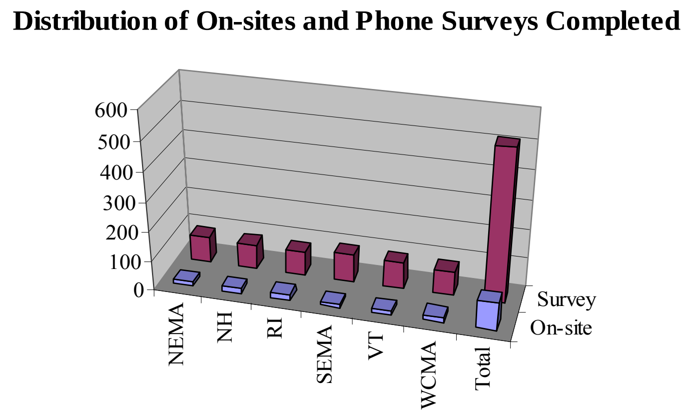
[1] Represented by the state regulatory agencies (CT DPUC, Maine PUC, MA DOER, NH PUC, RI PUC, and VT PSB) and associated energy efficiency program administrators (Cape Light Compact, Maine PUC, Efficiency Vermont, National Grid (MA, NH & RI), Northeast Utilities (CT&MA), NSTAR, PSNH, United Illuminating, and Unitil (MA&NH)).

[2] There are no participant sites in Maine, however results will be provided by adjusting the study results to Maine weather.




| | NEMA | NH | RI | SEMA | VT | WCMA | Total |
|---|---|---|---|---|---|---|---|
| On-site | 15 | 16 | 19 | 10 | 15 | 18 | 93 |
| Survey | 89 | 83 | 81 | 93 | 89 | 82 | 517 |

**Figure i- 1: Distribution of On-site and Phone Surveys**

The analysis of the primary data utilized a two step approach the first step was to create a regression model of the operation of the Room AC units using the real year weather data and actual metered data. The second step was to use the resulting model to predict the operation of the room AC units across the ISO-NE FCM performance hours for 2007 and typical year after adjusting for any bias in the on-site sample. The nested on-site sample technique was used to control for potential bias in the on-site sample, specifically selection bias due to the increased probability that people who are generally home during the day would be over represented in the on-site sample.[3] A multi-variant regression model was constructed using the metered interval power data (for 114 room AC units) and the survey response data along with hourly weather data from the appropriate weather station.

There were six survey variables that were found to have statistically significant impact on the regression model as follows:

- Type of Area Served (i.e. Bedroom vs. Non-bedroom),
- Home During Day,
- Cooling Capacity per Area Served (BTU/ft$^2$),
- Outside Temperature when Cooling Begins,
- Schedule or Continuous Operation, and
- Cooling Setting.

[3] Phone survey results from surveys conducted during evening and weekend hours were used to establish occupancy rates for the population.

Each of these variables were tested to determine if there was a statistically different distribution of the variables within a load zone when compared with the mean values for the whole dataset using a T-test methodology. The largest single change from on-site data occurred in the occupancy variable, which had on-site customers reporting that 73% were generally home during the day as opposed to 53% in the larger survey sample. Both the space type and occupancy variables did not show significant variation between the overall survey results and the load zone level survey results. Table i - 1 provides a summary of the changes to the four remaining variables, which show that unique results were calculated for the NEMA, RI, SEMA and VT load zones. The results for the NH and WCMA load zones were identical to those provided by the model inputs using the average survey response data for all zones.

| Load Zone | BTU/sqft | Outside Temp | Cont_Sched | Cooling Setpoint |
|---|---|---|---|---|
| All Zones | 32.9 | 82.4 | 0.28 | 70.5 |
| NEMA | **35.2** | **83.8** | 0.28 | 70.5 |
| NH | 32.9 | 82.4 | 0.28 | 70.5 |
| RI | 32.9 | **83.9** | **0.35** | **71.5** |
| SEMA | 32.9 | **81.0** | 0.28 | 70.5 |
| VT | **29.7** | 82.4 | 0.28 | 70.5 |
| WCMA | 32.9 | 82.4 | 0.28 | 70.5 |

**Table i - 1: Summary of Zonal Changes to Survey Variables[4]**

The Coincidence Factors (CFs) and Full Load Equivalent Hours (FLEHs) were developed for the 2007 summer season using the operating profiles that had been adjusted for all applicable bias using the phone survey response data as described above. The calculation of the On-Peak CF was relatively straightforward since the performance hours are time dependent and can be calculated without having extreme ambient weather conditions. The calculation of the FLEHs was also straightforward and was calculated from the bias adjusted operating profiles directly. The weather normalized CFs and FLEHs were computed by using the bias adjusted regression model and using Typical Meteorological Year (TMY 2) weather data to calculate the results. Since the results are driven by differences in load zone variables and weather file data the results are reported out at the weather file level using survey inputs for the applicable load zones. The results were calculated by holding the survey variables static and then running the nine different weather files so that the hourly weather variables could be used to provide hourly results. Table i - 2 provides a summary of the results for all weather files using the average

[4] The zone specific responses that are different from the average for all zones are shown in bold font.

survey inputs for all Load zones for the On-Peak performance hours 1:00 PM to 5:00 PM June through August using 2007 and TMY2 weather data.

| | 2007 Weather | | TMY2 Weather | | | |
|---|---|---|---|---|---|---|
| | Average for All Load Zones | | Average for All Load Zones | | Average for All Load Zones | |
| **Weather Files** | **On-Peak CF** | **Seasonal CF** | **On-Peak CF** | **Seasonal CF** | **2007 FLEH** | **TMY2 FLEH** |
| Albany, NY | 0.154 | 0.276 | 0.142 | NA | 224 | 184 |
| Boston, MA | 0.134 | 0.304 | 0.125 | NA | 228 | 175 |
| Burlington, VT | 0.139 | 0.276 | 0.119 | NA | 166 | 141 |
| Caribou, ME | 0.080 | 0.131 | 0.080 | NA | 60 | 42 |
| Concord NH | 0.143 | 0.290 | 0.134 | NA | 171 | 149 |
| Hartford, CT | 0.170 | 0.303 | 0.171 | NA | 272 | 253 |
| Portland, ME | 0.111 | 0.270 | 0.111 | NA | 119 | 102 |
| Providence , RI | 0.159 | 0.296 | 0.144 | NA | 245 | 204 |
| Worcester, MA | 0.131 | 0.261 | 0.113 | NA | 172 | 134 |

**Table i - 2: Summary of CF and FLEH by Weather File using Average Load Zone Data**

Although there were slight differences in CF and FLEHs due to zonal differences in the model inputs the difference in the final results were not much more than ± 0.001 for CF and ± 3 hours for FLEH. Therefore although the zonal differences in survey responses for some of the model variables were statistically significant when these different model input were run the results did not provide numerically significant differences in the results.[5] As a result we recommend that the calculation of DRV for each load zone use the CFs provided in Table i - 2.

The project results are reported out by weather file because the CF and FLEHs were calculated using the regression model and hourly weather data. The optimum method for determining RAC savings for a sponsor that operates in multiple load zones and/or has customers that should be modeled using multiple weather files would be to assign load zones and weather file designations to each rebate based upon the location of the customer by town and or zip code. Once this has been accomplished then capacity or demand reduction weighted allocations can be developed for each load zone where multiple weather files are applicable. If all of the demand reduction within a load zone is associated with one weather file then the sponsor can simply select the appropriate CF for the weather file as given in Table i - 2.

The Seasonal Peak performance hours were calculated by determining the hours when the real-time system load meets or exceeds 90% of the 50/50 CELT forecast for the summer 2007 period of 27,360 MW.[6] There were a total of 24 hours during the summer of 2007 when the real–time system load was 24,624 MW or greater, eight hours during June and 16 hours during August, and the 2007 Seasonal Peak

[5] This was due to a combination of factors primarily the relatively small differences in the variables, and changes in multiple variables canceling each other out.
[6] Data taken from ISO-NE 2007 Capacity, Energy, Load and Transmission (CELT) report dated April 20, 2007.

CFs were calculated during those hours. It was not possible to calculate the TMY 2 Seasonal peak CF values because of the method used to create TMY 2 weather data, which uses "typical" months to create an annual file.[7] The ISO-NE report entitled "Summer 2007 Weather Normal Peak Load" noted that the weather normalized peak load for 2007 was 27,460 MW, 0.4% (100 MW) higher than the April 2007 forecast of 27,360 MW for the summer of 2007. According to the report "The summer of 2007 can be characterized as normal with respect to overall temperature and humidity." Therefore we would defer to ISO-NE characterization of the summer of 2007 as normal with respect to temperature and humidity and recommend that both the 2007 On-Peak CFs and 2007 Seasonal Peak CFs be used for future year DRV calculation by the project sponsors.

> Based on ISO-NE characterization of the summer of 2007 as normal with respect to temperature and humidity, we recommend that both the 2007 On-Peak CFs and 2007 Seasonal Peak CFs be used for future year estimates of Demand Reduction Values.

The relative precision of the estimated impacts provided from the bias adjusted model could not be calculated directly because the model used the average inputs from the survey data and thus provided only one set of numbers depending upon the load zone and weather file selected. A first order approximation of the relative precision is provided by the following equations;

$$Y = f(x) + E \Rightarrow E = Y - f(x)$$

$$Y_{adj} = f(x_o) + E$$

$$Y_{adj} = Y + [f(x_o) - f(x)] \quad \text{Where,}$$

$Y$ = the actual CF for the hour from the metered

$f(x)$ = the predicted value from unadjusted model

$f(x_o)$ = the predicted value after adjusting the model for bias

$E$ = expected error in the adjusted model

$Y_{adj}$ = the predicted output from the adjusted model

[7] For example the June data for Albany could be from 1976, while the Boston data could be from 1980 and Hartford from 1978. In order to develop an accurate typical regional weather model it will be necessary to select typical months from the same year for all of the regional files.

Table i - 3 provides the estimated relative precision of the monthly and summer On-Peak CF values using the methodology explained above. The relative precision ranged from ±14.4% for June to ±10.4% for the summer season. Note that the mean value for June was 0.218, which was higher than expected because most of the June metered data was collected during a heat wave at the end of the month.[8]

| Month | sample (n) | Mean | Standard Deviation | Cv | Relative Precision |
|---|---|---|---|---|---|
| June | 82 | 0.218 | 0.222 | 1.02 | ±14.4% |
| July | 108 | 0.156 | 0.155 | 0.99 | ±12.2% |
| August | 108 | 0.174 | 0.164 | 0.94 | ±11.7% |
| Summer | 114 | 0.175 | 0.152 | 0.87 | ±10.4% |

**Table i - 3: Estimated Relative Precision of On-Peak CF**

[8] The adjusted model results reflect the mean coincident value during the entire month of June and are therefore significantly lower.