

PJM Load Analysis Subcommittee

Deemed Savings Estimates for Legacy Air Conditioning and Water Heating Direct Load Control Programs in PJM Region

Final Report

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Deemed Savings Estimates for Legacy Air Conditioning and Water Heating Direct Load Control Programs in PJM Region

1 EXECUTIVE SUMMARY

1.1 Background

During 2005 and 2006, the PJM's Load Analysis Subcommittee (LAS) examined ways to reduce the costs and improve the versatility of the Measurement and Verification (M&V) protocols now in use for Direct Load Control (DLC).¹ The current protocol, a PURPA-compliant Load Research approach conducted every five years for each Load-Serving Entity (LSE), is expensive to implement and administer particularly for mature load control programs. Many older DLC programs are barely cost-effective, and there was growing evidence that the LSEs were simply dropping² their DLC programs in lieu of incurring the expense associated with the M&V.

This project was initiated to examine the potential for developing deemed savings estimates acceptable to PJM for legacy air conditioning and water heating DLC programs while, at the same time, exploring the development of a collaborative, consensus-based approach for meeting future M&V requirements of new initiatives.

1.2 Approach

The deemed savings estimates are based on historical end-use metered data available across several jurisdictions. Air conditioning end-use metered data were received from Baltimore Gas and Electric, FirstEnergy, and Public Service Electric and Gas. Water heating end-use metered data was secured from Baltimore Gas and Electric. Duty cycle models were constructed to examine a wide range of potential switch cycling strategies, e.g., 27%, 43%, 50%, 67%, 75%, 87% and 100%. Please note, given the models developed, the project team can run any duty cycle strategy desired by the project contributors including those strategies that employ an adaptive algorithm associated with newer, smarter switches. In addition, any segmentation based on air conditioning size, e.g., connected load or seasonal usage, can be accommodated with the model set. Next, the estimates of the customer's demand saving were mapped to their appropriate weather stations. Finally, regression analysis was conducted to predict the demand savings estimates from weighted temperature humidity indices. The demand savings predictions were tabularized for use by the participating utilities.

1.3 Air Conditioning Results

Table Ex 1 presents a sample of the predictive capability of the model. The table displays the time period 15-minutes ending 4pm. The table lists the predicted savings for

¹ PJM Manual 19:Load Data Systems

² Only Baltimore Gas and Electric maintains an active load research sample on their air conditioning and water heating direct load control programs for the purpose of reporting to PJM.

weighted temperature humidity (THI) combinations from 60°F to 88°F. The table lists the savings associated with a 27%, 43%, 50%, 67%, 75%, 83% and 100% duty cycle. At a THI of 84°F the demand reduction estimate ranges from a low of 0.37 kW for the 27% cycling strategy to a high of 2.06kW at 100% cycling. The 50% cycling strategy yields an estimate of 0.80 kW. These tables are available for every 15-minute period throughout the day. Starting at a WTHI of 80°F the savings estimates are available for every 0.1°F increments. Table Ex 2 presents the savings between 84°F and 85°F.

WTHI	Predicted Savings at 5pm For Various Duty Cycle Strategies						
	27%	43%	50%	67%	75%	83%	100%
70.0	0.02	0.04	0.06	0.06	0.09	0.18	0.30
71.0	0.02	0.04	0.06	0.13	0.19	0.28	0.43
72.0	0.02	0.04	0.06	0.21	0.28	0.38	0.55
73.0	0.02	0.09	0.13	0.29	0.37	0.48	0.68
74.0	0.05	0.15	0.19	0.37	0.46	0.58	0.80
75.0	0.09	0.20	0.25	0.45	0.55	0.68	0.93
76.0	0.12	0.25	0.31	0.53	0.65	0.78	1.06
77.0	0.15	0.30	0.37	0.61	0.74	0.87	1.18
78.0	0.18	0.35	0.43	0.68	0.83	0.97	1.31
79.0	0.21	0.40	0.50	0.76	0.92	1.07	1.43
80.0	0.24	0.45	0.56	0.84	1.01	1.17	1.56
81.0	0.27	0.51	0.62	0.92	1.10	1.27	1.68
82.0	0.30	0.56	0.68	1.00	1.20	1.37	1.81
83.0	0.34	0.61	0.74	1.08	1.29	1.47	1.93
84.0	0.37	0.66	0.80	1.16	1.38	1.57	2.06
85.0	0.40	0.71	0.87	1.23	1.47	1.67	2.19
86.0	0.43	0.76	0.93	1.31	1.56	1.77	2.31
87.0	0.46	0.81	0.99	1.39	1.65	1.87	2.44

Table Ex 1 – Deemed Savings Estimates at 15-minute period ending 4pm

WTHI	Predicted Savings at 5pm For Various Duty Cycle Strategies						
	27%	43%	50%	67%	75%	83%	100%
84.0	0.37	0.66	0.80	1.16	1.38	1.57	2.06
84.1	0.37	0.66	0.81	1.16	1.39	1.58	2.07
84.2	0.37	0.67	0.82	1.17	1.40	1.59	2.08
84.3	0.38	0.67	0.82	1.18	1.41	1.60	2.10
84.4	0.38	0.68	0.83	1.19	1.42	1.61	2.11
84.5	0.38	0.68	0.83	1.20	1.43	1.62	2.12
84.6	0.39	0.69	0.84	1.20	1.43	1.63	2.13
84.7	0.39	0.70	0.85	1.21	1.44	1.64	2.15
84.8	0.39	0.70	0.85	1.22	1.45	1.65	2.16
84.9	0.40	0.71	0.86	1.23	1.46	1.66	2.17
85.0	0.40	0.71	0.87	1.23	1.47	1.67	2.19

Table Ex 2 – Demand Savings Estimates between 84°F and 85°F at 4pm

Should the participating utility have the ability to differentiate their direct load control population by size of air conditioner, i.e., based on either connected load or seasonal energy use, then alternative tables can be applied to generate more customized estimates for each utility. The models and analytical methods can support the development of any stratification based on these two variables. Current tables have been constructed for seasonal air conditioning use less than 1,600 kWh and seasonal air conditioning use

greater than 1,600 kWh and for air conditioning connected load less than 3.5kW and air conditioning connected load greater than 3.5kW.

WTHI	Predicted Savings at 5pm For Various Duty Cycle Strategies													
	Stratum 1 AC Usage < 1,600 kWh							Stratum 2 AC Usage > 1,600 kWh						
	27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
70.0	0.01	0.02	0.03	0.04	0.06	0.04	0.05	0.03	0.06	0.05	0.18	0.25	0.39	0.63
71.0	0.01	0.02	0.03	0.04	0.06	0.04	0.14	0.03	0.06	0.12	0.27	0.36	0.51	0.77
72.0	0.01	0.02	0.03	0.04	0.06	0.12	0.23	0.03	0.12	0.19	0.37	0.47	0.63	0.91
73.0	0.01	0.02	0.03	0.09	0.13	0.19	0.33	0.06	0.18	0.26	0.47	0.58	0.74	1.05
74.0	0.01	0.05	0.07	0.15	0.20	0.27	0.42	0.10	0.25	0.33	0.56	0.69	0.86	1.19
75.0	0.03	0.08	0.11	0.21	0.27	0.34	0.51	0.14	0.31	0.40	0.66	0.81	0.98	1.33
76.0	0.05	0.12	0.15	0.27	0.33	0.42	0.60	0.18	0.37	0.47	0.76	0.92	1.09	1.48
77.0	0.07	0.15	0.19	0.33	0.40	0.49	0.69	0.22	0.43	0.54	0.85	1.03	1.21	1.62
78.0	0.09	0.18	0.23	0.38	0.47	0.57	0.79	0.26	0.50	0.61	0.95	1.14	1.33	1.76
79.0	0.11	0.22	0.27	0.44	0.54	0.64	0.88	0.29	0.56	0.68	1.04	1.25	1.44	1.90
80.0	0.13	0.25	0.31	0.50	0.61	0.72	0.97	0.33	0.62	0.75	1.14	1.36	1.56	2.04
81.0	0.15	0.28	0.35	0.56	0.68	0.79	1.06	0.37	0.69	0.82	1.24	1.47	1.68	2.18
82.0	0.17	0.32	0.40	0.62	0.75	0.87	1.15	0.41	0.75	0.89	1.33	1.59	1.80	2.32
83.0	0.19	0.35	0.44	0.67	0.82	0.94	1.25	0.45	0.81	0.96	1.43	1.70	1.91	2.46
84.0	0.21	0.38	0.48	0.73	0.89	1.02	1.34	0.48	0.87	1.03	1.53	1.81	2.03	2.61
84.1	0.22	0.39	0.48	0.74	0.90	1.03	1.35	0.49	0.88	1.04	1.54	1.82	2.04	2.62
84.2	0.22	0.39	0.49	0.74	0.90	1.03	1.36	0.49	0.89	1.05	1.55	1.83	2.05	2.63
84.3	0.22	0.40	0.49	0.75	0.91	1.04	1.37	0.50	0.89	1.06	1.56	1.84	2.06	2.65
84.4	0.22	0.40	0.49	0.76	0.92	1.05	1.37	0.50	0.90	1.06	1.56	1.85	2.08	2.66
84.5	0.22	0.40	0.50	0.76	0.93	1.06	1.38	0.50	0.91	1.07	1.57	1.86	2.09	2.68
84.6	0.23	0.41	0.50	0.77	0.93	1.06	1.39	0.51	0.91	1.08	1.58	1.88	2.10	2.69
84.7	0.23	0.41	0.51	0.77	0.94	1.07	1.40	0.51	0.92	1.08	1.59	1.89	2.11	2.70
84.8	0.23	0.41	0.51	0.78	0.95	1.08	1.41	0.52	0.92	1.09	1.60	1.90	2.12	2.72
84.9	0.23	0.42	0.51	0.78	0.95	1.09	1.42	0.52	0.93	1.10	1.61	1.91	2.13	2.73
85.0	0.23	0.42	0.52	0.79	0.96	1.09	1.43	0.52	0.94	1.10	1.62	1.92	2.15	2.75
86.0	0.25	0.45	0.56	0.85	1.03	1.17	1.52	0.56	1.00	1.18	1.72	2.03	2.26	2.89
87.0	0.27	0.49	0.60	0.91	1.10	1.24	1.61	0.60	1.06	1.25	1.82	2.14	2.38	3.03

Table Ex 3 – Predicted Reduction by Seasonal AC Use

Table Ex 3 presents the same 15-minute ending 5pm period for WTHI in the range between 70°F and 87°F with additional detail provided between 84°F and 85°F. Only this time, the table provides a separate estimate by air conditioning energy usage stratum. For customers with a seasonal air conditioning use over 1,600 kWh the estimated demand savings at a WTHI of 84°F ranges from a low of 0.21 kW for the 27% cycling strategy to 1.34 kW for the 100% cycling strategy. For large users, i.e., those with a seasonal use greater than or equal to 1,600 kWh, the demand savings range from a low of 0.48 kW for the 27% cycling strategy to 2.61 kW for the 100% cycling strategy. To develop a specific estimate, the utility simply selects the WTHI for the appropriate hour and creates a weighted average for the appropriate cycling strategy.

To demonstrate the approach, BGE provided 2006 monthly billing data for the full population of program participants, i.e., more than 220,000 customers. These data were used to develop a model for estimating the air conditioning use of each customer. Next, we calculated the number of participants above and below 1,600 kWh of estimated air

conditioning for the four month period ending September, 2006. Approximately 76% of the current program participants were estimated to have air conditioning usage greater than 1,600 kWh with the remaining 24% using less. Applying the weights to the 84°F estimate presented in Table Ex 3 yields an estimate of 0.90 kW for the hour ending 5pm.

Similarly, Table Ex 4 presents the predicted reduction by connected air conditioning load. The two strata developed for this analysis was less than 3.5 kW and greater than or equal to 3.5 kW. For the 15-minute period ending at 5pm at a THI of 84°F, the predicted demand reduction associated with the smaller air conditioning units ranged from a low of 0.32 kW for the 27% cycling strategy to a high of 1.86 kW for 100% cycling. For the larger air conditioners, the savings are estimated to range from a low of 0.59 kW for the 27% cycling to 2.93 kW for 100% cycling. The aggregate results from Table Ex 1 were 0.80 kW for 50% cycling to 2.06 for 100% cycling. If the utility tracks the connected demand of their program participants then this data can be used to develop a unique estimate. To do this, the utility simply selects the WTHI for the appropriate hour and cycling strategy and creates a weighted average based on the number of units above and below a connected demand of 3.5 kW.

Predicted Savings at 5pm For Various Duty Cycle Strategies														
WTHI	Stratum 1 AC Connected Demand < 3.5 kW							Stratum 2 AC Connected Demand > 3.5 kW						
	27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
70.0	0.02	0.04	0.05	0.05	0.08	0.16	0.28	0.04	0.08	0.07	0.10	0.20	0.27	0.49
71.0	0.02	0.04	0.05	0.12	0.17	0.25	0.39	0.04	0.08	0.07	0.22	0.33	0.41	0.67
72.0	0.02	0.04	0.05	0.19	0.25	0.34	0.50	0.04	0.08	0.16	0.34	0.46	0.56	0.84
73.0	0.02	0.08	0.11	0.26	0.33	0.43	0.61	0.04	0.16	0.25	0.45	0.59	0.71	1.02
74.0	0.05	0.13	0.16	0.33	0.41	0.52	0.73	0.09	0.24	0.34	0.57	0.72	0.85	1.19
75.0	0.07	0.17	0.22	0.40	0.49	0.61	0.84	0.14	0.32	0.42	0.69	0.85	1.00	1.36
76.0	0.10	0.22	0.27	0.47	0.58	0.70	0.95	0.19	0.40	0.51	0.81	0.98	1.15	1.54
77.0	0.13	0.26	0.33	0.54	0.66	0.79	1.07	0.24	0.48	0.60	0.92	1.11	1.29	1.71
78.0	0.16	0.31	0.38	0.61	0.74	0.88	1.18	0.29	0.56	0.69	1.04	1.24	1.44	1.89
79.0	0.18	0.35	0.43	0.68	0.82	0.96	1.29	0.34	0.64	0.78	1.16	1.37	1.58	2.06
80.0	0.21	0.40	0.49	0.75	0.91	1.05	1.41	0.39	0.72	0.86	1.28	1.50	1.73	2.23
81.0	0.24	0.44	0.54	0.82	0.99	1.14	1.52	0.44	0.80	0.95	1.39	1.63	1.88	2.41
82.0	0.26	0.49	0.60	0.89	1.07	1.23	1.63	0.49	0.88	1.04	1.51	1.75	2.02	2.58
83.0	0.29	0.53	0.65	0.96	1.15	1.32	1.75	0.54	0.96	1.13	1.63	1.88	2.17	2.76
84.0	0.32	0.58	0.71	1.03	1.23	1.41	1.86	0.59	1.04	1.21	1.75	2.01	2.32	2.93
84.1	0.32	0.58	0.71	1.04	1.24	1.42	1.87	0.60	1.05	1.22	1.76	2.03	2.33	2.95
84.2	0.32	0.59	0.72	1.04	1.25	1.43	1.88	0.60	1.06	1.23	1.77	2.04	2.35	2.96
84.3	0.33	0.59	0.72	1.05	1.26	1.44	1.89	0.61	1.07	1.24	1.78	2.05	2.36	2.98
84.4	0.33	0.59	0.73	1.06	1.27	1.45	1.91	0.61	1.07	1.25	1.79	2.07	2.37	3.00
84.5	0.33	0.60	0.73	1.06	1.28	1.46	1.92	0.62	1.08	1.26	1.80	2.08	2.39	3.02
84.6	0.34	0.60	0.74	1.07	1.28	1.47	1.93	0.62	1.09	1.27	1.82	2.09	2.40	3.03
84.7	0.34	0.61	0.74	1.08	1.29	1.48	1.94	0.63	1.10	1.28	1.83	2.10	2.42	3.05
84.8	0.34	0.61	0.75	1.09	1.30	1.48	1.95	0.63	1.11	1.29	1.84	2.12	2.43	3.07
84.9	0.34	0.62	0.76	1.09	1.31	1.49	1.96	0.64	1.11	1.29	1.85	2.13	2.45	3.09
85.0	0.35	0.62	0.76	1.10	1.32	1.50	1.97	0.64	1.12	1.30	1.86	2.14	2.46	3.10
86.0	0.37	0.67	0.82	1.17	1.40	1.59	2.09	0.69	1.20	1.39	1.98	2.27	2.61	3.28
87.0	0.40	0.71	0.87	1.24	1.48	1.68	2.20	0.74	1.28	1.48	2.10	2.40	2.76	3.45

Table Ex 4 – Predicted Reduction by Connected kW

1.4 Water Heating Results

A similar duty cycle analysis was conducted on the water heating data provided to the project. Table Ex 5 summarizes the findings for the 100% cycling strategy. The table differentiates between season, namely spring/fall, summer and winter, and day type, i.e., weekday or weekend. The table presents selected hour ending time periods. For the summer weekday period at hour ending 4pm, the demand savings are estimated to be 0.24 kW. Similarly, for the winter weekday at hour ending 7am, the water heating demand savings are estimated to be 0.64 kW.

Season	DayType	Selected Time Periods															
		6am	7am	8am	9am	10am	11am	12N	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm
Spring/Fall	Weekday	0.28	0.56	0.76	0.56	0.44	0.40	0.36	0.32	0.32	0.28	0.28	0.32	0.40	0.48	0.52	0.52
Spring/Fall	Weekend	0.12	0.24	0.44	0.56	0.64	0.62	0.60	0.52	0.48	0.44	0.40	0.44	0.48	0.52	0.52	0.52
Summer	Weekday	0.24	0.44	0.56	0.44	0.36	0.32	0.28	0.28	0.24	0.24	0.24	0.28	0.32	0.36	0.40	0.40
Summer	Weekend	0.12	0.20	0.36	0.48	0.48	0.48	0.48	0.40	0.40	0.36	0.32	0.36	0.36	0.40	0.40	0.40
Winter	Weekday	0.32	0.64	0.84	0.72	0.56	0.48	0.44	0.44	0.40	0.36	0.32	0.40	0.48	0.60	0.64	0.60
Winter	Weekend	0.16	0.28	0.48	0.68	0.80	0.84	0.72	0.68	0.60	0.56	0.52	0.56	0.64	0.64	0.60	0.60

Table Ex 5 – Water Heating Deemed Savings Estimates

1.5 Future Studies

As the PJM utilities explore new demand response initiatives consideration should be given to conducting regional studies that effectively pool the resources of the participating utilities. Figure Ex 1 presents a map of the PJM territory. The figure shows a diverse territory that stretches from the eastern seaboard to the western part of Illinois.

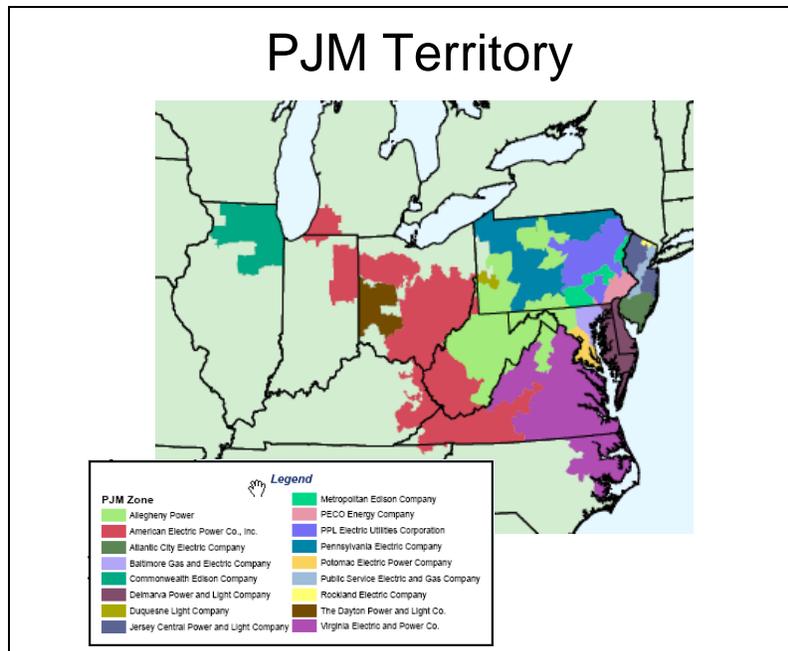


Figure Ex 1 – PJM Service Territory

We recommend a regional stratification for any future studies with sufficient sample points to meet some minimum precision criterion, e.g., 90% confidence $\pm 20\%$ precision, within the region. The utilities should be allowed to pool the data across the PJM

footprint to improve the estimate. The specific utility would be allowed to use either the regional result or the pooled result. The key to any combined analysis is collecting consistent data across the various project components. The data elements to be included in a regional study should be clearly specified and should, at a minimum, include the following:

- End-use metered data on at least a 15-minute basis for the affected appliance;
- Total load metered data on at least an hourly basis for each residence in the end-use metered sample. Depending on the cost of data collection³, consideration should be given to a larger total load sample of participants following a nested sampling strategy;
- Whole house consumption billing data⁴ to use as an analytical link with the respective population billing systems;
- Spot wattage measurements;
- Regional weather data including at a minimum, hourly dry-bulb, hourly wet-bulb readings.

Other supporting information may prove beneficial including billing data on the population of program participants, demographic data on a large sample of program participants, demographic data on the monitored sample.

We believe that the final estimate should take advantage of the wealth of data collected by the contributing utilities while reflecting the unique characteristics of the specific service territory.

1.6 Operability Studies

In the feasibility study, we recommended that each utility be required to conduct periodic operability studies, using a common sampling, testing and reporting methodology. Initially, we recommend that each utility select a simple random sample of 250 program participants and determine the operability of the switch(s) at each sample home.⁵ The testing protocol should verify both signal reception and switch operation, and identify the underlying causes of the problems that are encountered. The utility should report the overall failure rate and the appropriate net to gross ratio to be used to adjust the gross impact.

The utility-specific operability study should be conducted at least every five years, but may be conducted more frequently if a utility believes it has taken steps to mitigate its operability problems and wishes to use an improved net to gross ratio.

³ AMI is making data collection at the whole premise level very affordable for large samples.

⁴ Whole premise billing information was unavailable for some of the participants included in the current analysis. This required the project team to make necessary assumptions in order to combine the data from the three service territories. Some of the concerns raised by this approach are alleviated in the stratum level analysis.

⁵ A sample of 250 will give an error bound of at most ± 0.05 at the 90% level of confidence for the net to gross ratio. If a tighter error bound is desired then a larger sample will be agreed to and selected.

If a utility has been able to demonstrate a net to gross ratio of 90% or higher then it is still required to conduct operability studies at least every five years, but a reduced sample size can be used. In this case the recommended sample is 100 homes.⁶ If the reduced study yields an estimated net to gross ratio less than 90%, then we recommend that a full sample of 250 homes be tested as soon as practical and that the larger sample size be used in subsequent studies until the utility has again demonstrated a net to gross ratio of 90% or higher.⁷

As an initial starting point, we recommend that the utilities use the **minimum** of their last estimate or 60%. This will provide a starting point for utilities that have not conducted an operability study in the past. Here again, the utilities should be required to initiate an operability study prior to their next submittal or face a further write-down of 10% per year until the operability study is completed..

⁶ If the net to gross ratio is 0.90 or larger, a sample of 100 will give an error bound of at most ± 0.05 at the 90% level of confidence for the true net to gross ratio.

⁷ Our recommendations have been informed by ISO 2859-1:1999(E), "Sampling Procedures for Inspection by Attributes" which is the current version of ANSI/ASQC Z1.4.

Deemed Savings Estimates for Legacy Air Conditioning and Water Heating Direct Load Control Programs in PJM Region

Final Report

2 INTRODUCTION AND BACKGROUND

During 2005 and 2006, the PJM's Load Analysis Subcommittee (LAS) examined ways to reduce the costs and improve the versatility of the Measurement and Verification (M&V) protocols now in use for Direct Load Control (DLC).⁸ The current protocol, a PURPA-compliant Load Research approach conducted every five years for each Load-Serving Entity (LSE), is expensive to implement and administer particularly for mature load control programs. Many older DLC programs are barely cost-effective, and there is a concern that the LSEs may simply drop⁹ their DLC programs rather than incur the expense associated with the M&V.

There was a consensus that the current DLC M&V protocol is analytic over-kill considering that the per-active-participant load impacts for programs with static technologies have not significantly changed over time. Almost all the recent downward change in reported net per-unit load impacts has come from de-rating due to failed switches and poor radio coverage. To examine this issue further, Lawrence Berkeley National Laboratory (LBNL) contracted with *RLW Analytics (RLW)*. The project goal was to assist LBNL in examining the feasibility of alternative strategies for meeting the M&V needs of residential air conditioning or heat pump compressor direct load control. As such, *RLW* worked with the various stakeholders to develop deemed savings estimates for legacy air conditioning and water heating DLC programs while exploring the development of a collaborative, consensus-based approach for meeting future M&V requirements of new initiatives.

2.1 Current PJM M&V Requirements

The current PJM M&V requirements are presented in the PJM Manual 19: Load Data Systems in Attachment B: Direct Load Control Load Research Guidelines. The guidelines address the following items:

- **Study Design:** DLC Load research studies will be designed to achieve a minimum accuracy of 90% confidence with 10% error.
- **Failure Rate:** Per-participant impacts must reflect the average impact of all active participants, i.e., net impacts, including those with inoperable switches or switches not receiving the control signal.

⁸ PJM Manual 19:Load Data Systems

⁹ Only Baltimore Gas and Electric maintains an active load research sample on their air conditioning and water heating direct load control programs for the purpose of reporting to PJM.

- **Study Detail:** Load research studies must present estimated per-participant impacts in a matrix which details average impacts on non-holiday weekdays by hour for the hours ending 1pm through 8pm (PJM Eastern Region) or 8am through 9pm (PJM Western Region), and by weather condition (over a range of local conditions under which it can reasonably be expected that the program will be implemented). Separate matrices are required by program and PJM zone.

2.2 Project Background

RLW attended a subgroup meeting of the Load Research Working Group (LRWG) on Thursday, July 28, 2005. The LSEs represented included Public Service Electric and Gas (PSE&G), Baltimore Gas and Electric (BGE), GPU Energy (GPU), and Potomac Electric Power Company (PEPCO). The purpose of the meeting was to introduce *RLW* to the staffs of the LSEs with PJM compliance commitments. Numerous issues were discussed and are summarized in meeting minutes that have been appended to this document as Appendix A.

Prior to attending the meeting, *RLW* staff read through each of the 2001 load impact evaluation studies conducted by the LSEs and the 2002 evaluation conducted by BGE. The reports included:

- Public Service Electric and Gas (PSE&G): Final Report, 2001 Direct Load Control Evaluation, March 7, 2002, prepared by Xenergy Inc.
- Baltimore Gas and Electric (BGE): Evaluation of the Load Impacts of the Residential Air Conditioner Recycling Program, Summer 2002, prepared by BGE staff.
- Baltimore Gas and Electric (BGE): Evaluation of the Load Impacts of the Residential Air Conditioner Recycling Program, Summer 2001, prepared by BGE staff.
- GPU Energy (GPU): GPU Energy's Power Plus Savers Residential Air Conditioning Cycling Load Control Program, Final Evaluation Report, April 2002, prepared by Quantum Consulting Inc.
- Potomac Electric Power Company (PEPCO): 2001 Load Impact Evaluation of PEPCO's Direct Load Control Active Load Management Programs, March 2002, prepared by Dr. Marvin Horowitz of Demand Research.

In addition, pertinent sections of PJM Manual 19: Load Data System as it pertains to the LSE reporting requirements were reviewed. Prior to completing this Feasibility study, the project team received a report from Conectiv Power Delivery entitled "Direct Load Control Deductions in the Delmarva Zone", Summer 2001, Load Research, Planning Finance and Regulation Department, prepared by Quantum Consulting, Inc. This report was reviewed and provided contribution to the final Feasibility study.

The purpose of the historical review was not to critique past efforts but to provide a basic understanding of the approaches used by each LSE establishing a common basis for discussing future impact evaluation strategies and directions.

A second meeting was held on Tuesday, August 30, 2005 in Wilmington, Delaware. The second meeting focused on a review of the feasibility study results. Minutes from that meeting are included in Appendix B. Following this second meeting, the general feasibility study was published and titled “Rethinking M&V Protocols for DLC Programs in the PJM Region”, Feasibility Study for AC Direct Load Control Evaluation, LBNL, September, 2005.

3 FEASIBILITY REVIEW

The prior utility study review suggests that the performance of these legacy programs is more strongly affected by operational problems than by changes in the gross savings. In particular, two categories of operational problems seem to be important – signal reception and the operability of the switch itself. Both of these operational problems are likely to vary from one utility to another. For example, the coverage of the signal depends on the particular communication system of each utility. Problems with operability of the switch itself are often created when an older air conditioner is replaced by a newer one and the switch is not reconnected. Again, the extent of this problem will vary from utility to utility depending on the measures taken by the utility to identify and replace inoperable switches.

The gross savings per unit may also vary from one utility to another. The gross savings is affected by the size and efficiency of the air conditioner. Those utilities that have emphasized the importance of correctly sizing air conditioners rather than over-sizing them can expect greater gross savings per unit. But our review of the prior studies suggests that there may be less variation in gross savings from utility to utility and from year to year than the differences in operational problems. A summary of the gross savings analysis is provided in Appendix C.

This reinforces the appropriateness of the current M&V policy of differentiating the analysis of operational problems from the analysis of gross savings. To the extent that utility-specific assessment of gross savings is required, it might be best to standardize the methodology from one utility to another so that the findings can be directly compared. Standardizing methods of estimating overall operability problems should be considered.

3.1 Recommended Alternative M&V Approach

The approaches taken by the four LSEs present an array of alternative M&V strategies. To summarize, three of the four LSEs used end-use metered and one used whole facility load data. While separate projects are possible, this project was directed at determining whether an alternative approach, e.g., a joint effort by the utilities, could be used to satisfy the requirements outlined in PJM Manual 19 in a more cost-effective manner. Clearly, we believe that pooling the efforts of the four LSEs into some form of regional study would be more cost-effective than conducting four separate studies.

We considered using a nested sampling approach;¹⁰ this approach is often used to cost effectively estimate end-use metered loads. However, we rejected this approach since the

¹⁰ A nested sample would use a small subset of end-use metering points with a larger and cheaper whole facility metering sample to construct the analysis framework.

M&V study is not directed at estimating the total air conditioning load of the participants but at the impacts available across a broad range of time and temperatures. Similarly, while effective in a test/control environment, we rejected whole premise metering in favor of the end-use metering, duty cycle approach. We believe it advisable to focus on the duty cycle approach since this method focuses on the fundamental determinants of gross savings – connected load and natural duty cycle – and since this method is insensitive to the number of actual control days and the temperature conditions on these control days.

As such, we would recommend a data collection and analysis strategy with the objective of constructing a single time-temperature matrix. The project would be conducted across the various service territories of the LSEs with “similar” programs and program control strategies. We envision a sample design that is informed by the historical data and one that uses an optimal allocation based on the LSE’s contribution to the overall resource among the group of participating utilities.

The proposed approach would allow for individual estimates to be developed for each LSE in one of two fashions and tested against the pooled approach. One strategy would calculate the estimate using just the data indigenous to the LSE. Another approach would be to map **all** of the available data into a post-stratification strategy in order to develop LSE specific weights. The various analysis results could be contrasted and compared by LSE. If additional information is available about the populations, e.g., number of AC units, then it may be possible to use this data to help inform the analysis.

While we do not believe that a simple re-analysis of the historical data would satisfy the currently written PJM requirements¹¹, we do believe that the analysis would be an important first step in an effort to test and learn about the proposed approach. At minimum, information could be gleaned about the customer-to-customer variability to properly size the sample for the task at hand. The cross sample analysis would allow for standard data cleaning protocols to be established to ensure that the gross estimates developed are consistent. We would expect that the cross sample analysis will yield significant insight into other data elements that might play an important role in the evaluation.

3.2 Summary

In the feasibility study we recommended conducting a cross jurisdiction analysis of the historical end-use metering data as a *proof of concept*. We believe the insight afforded from the analysis will be extremely valuable for informing the design of a system wide study to meet the upcoming PJM requirement. The analysis will test several evaluation strategies including a post-stratification analysis to the respective zones and a common analysis weighted by the program participants in each zone. We propose using the results

¹¹ An informational meeting was held in Wilmington on August 30, 2005 to review the draft Feasibility study. Minutes of the meeting are attached as Appendix E. During the meeting, John Reynolds, PJM, indicated that it might be possible to change the Manual 19 requirements to view the cross zonal analysis of historical data as a “deemed savings” estimate for the remaining life of the legacy AC-DLC programs. This possibility makes the proposed reanalysis even more important.

of the supplemental analysis to address the litany of issues brought up in the context of this feasibility study.

For future new initiatives, we recommended designing and implementing a single end-use metering study directed at developing the time-temperature matrices required by PJM Manual 19, i.e., time-temperature matrices by PJM zone. Appendix D includes a proposed work plan for these two tasks: 1) Proof of concept study using historical data, and 2) Multi-jurisdictional load control M&V study.

The remainder of this report presents the results of the cross jurisdictional proof-of-concept analysis conducted during the summer of 2006.

4 DEEMED SAVINGS FOR A/C CYCLING

A memorandum of understanding and scope of work for conducting the proof-of-concept analysis was finalized in June 2006. The following parties were participants in the project.

- | | |
|---|---|
| 1) Allegheny Electric Cooperative | 6) Southern Maryland Electric Cooperative |
| 2) Baltimore, Gas and Electric (BGE) | 7) Old Dominion Electric Cooperative |
| 3) First Energy (FE) | 8) Pepco Holdings, Inc. (PHI) |
| 4) Lawrence Berkeley National Laboratory (LBNL) | 9) Public Service Electric and Gas (PSE&G); |
| 5) Buckeye Power | |

4.1 Project Purpose and Objective

The purpose of the project was to eliminate or reduce the need for sponsoring expensive load research for legacy residential air conditioner and water heater direct load control programs. Here again, if the “deemed results” from such a regional model is accepted by PJM, it will reduce both the financial barriers and the complexity of operating and participating in the PJM demand response market.

The project’s stated objective was to develop a statistical model-based alternative to the current Measurement and Verification (M&V) requirements¹² placed by PJM on direct load control program eligibility for Active Load Management capacity credits.¹³

4.2 Scope and Eligibility

The scope of the project was limited to legacy residential air conditioner and water heater load cycling programs and was not to be extended to new programs invoking new enabling technology like “roll-up” thermostats.

Program eligibility was extended to any entity interested in owning or operating residential direct load control technology in the PJM region.

4.3 Project Description

This project develops a regional model, based primarily on previous end-use load research data gathered by three PJM-East electric distribution utilities (BGE, JCP&L, and PSE&G), that is capable of serving as a basis for the development of regression-based, time-temperature/humidity estimates of load impacts for direct load control programs on a zonal basis.¹⁴

¹² PJM’s Active Load Management M&V requirement requires that a load research study be conducted every five years to measure the attributable to direct load control load impacts. The specific input required by PJM is a time-temperature - humidity calculation of load impacts for each direct load control program. For more details see PJM Manual 19.

¹³ The resulting estimates can also be used to determine program energy reduction benefits.

¹⁴ A feasibility study funded by LBNL concluded that such a regional model could be developed through a cross-jurisdictional analysis of the most-recent (2000-2001 end-use metering data available plus any other comparable data

4.4 Results

This section details the substantive results of the proof-of-concept analysis.

4.4.1 Data Used in the Analysis

Interval Load Data. The analysis contained in this section relies on end-use metered data from three participating utilities. First Energy (FE) and Public Service Electric and Gas (PSEG) provided end-use metered air conditioning data while Baltimore Gas and Electric (BGE) provided both water heater and air conditioning data. The First Energy data was from their Jersey Central Power and Light (JCPL) service territory. A fourth participating utility, Potomac Electric Power (PEPCO) provided summary impact data on air conditioning and water heating.

Table 1 recapitulates the source data used for the analysis. Since PEPCO data was not at the individual customer level, it was not used. So that there would be a common basis for the analysis, PSEG data was aggregated to the 15 minutes interval level.

Company	End Use	Units of Measure	Interval	Start Date	End Date	Number of Sample Points	Number of Intervals
BGE	Water Heating	kWh	15 mins	1/1/2001	12/31/2005	82	120,772
BGE	Air Conditioning	kWh	15 mins	6/1/2001	9/30/2005	110	55,632
PSEG	Air Conditioning	KW	2 Mins	7/11/2001	10/11/2001	85	2,991,700
JCPL	Air Conditioning	KW	15 mins	1/1/2001	12/31/2001	77	120,772

Table 1 Summary of Source Data

In the analysis we began by calculating the 99th percentile of observed demands for each sample point. The individual customer's 99th percentile of observed demands was used as a proxy for the equipment's "spot watts", or the maximum amount of load that the customer had available for the interruption. Figure 1 shows a comparison of the cumulative distributions of the spot watts of each sample. This figure shows that the distribution of sample customers from each utility is similar, albeit the First Energy sample tended to be larger.

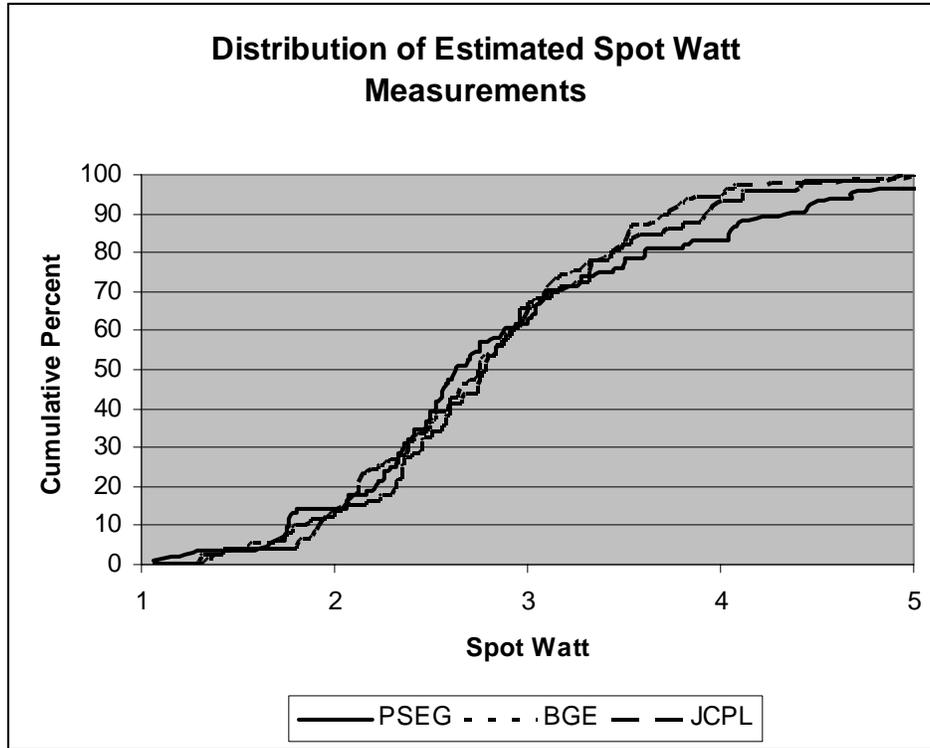


Figure 1 – Cumulative Distribution of Air Conditioning Spot Watts by Company

Weather Data. The final piece of data needed for the analysis was weather data. The analysis was performed using a weighted temperature-humidity index (THI). The THI was defined as:

$$THI_{L,t} = 17.5 + .55 * DB_{L,t} + .2 * WB_{L,t}$$

Where:

$THI_{L,t}$ = The temperature-humidity index for location L for time t

$DB_{L,t}$ = The dry bulb temperature for location L for time t

$WB_{L,t}$ = The wet bulb temperature for location L for time t

For WTHI, the current day's THI gets a weight of 10, the previous day's THI gets a weight of 3, and the weight for two days ago is 1.

Unique locations were used as the temperature basis for each Company:

- For BGE, Baltimore-Washington was used,
- For PSEG, Philadelphia was used,
- For JCPL Philadelphia was used,

4.4.2 Duty Cycle Discussion

In order to model the load relief that can be expected at any time-temperature combination, we utilize the duty cycle model. Using the duty cycle model does not depend on having event calls. But, the duty cycle approach does require special handling of event day interruptions. For this application, the event days were omitted from the analysis. A complete listing of event days is presented in Appendix E.

Figure 2 illustrates the duty cycle model and shows the kW load of an air conditioner at various temperatures. From temperature a to temperature b, there is no demand for air conditioning. From temperature b to temperature d, the uncontrolled air conditioning load increases with the temperature until it reaches full output. At any temperature higher than d, the uncontrolled unit is fully loaded. In short, the segmented line abde represents the load curve for the uncontrolled unit.

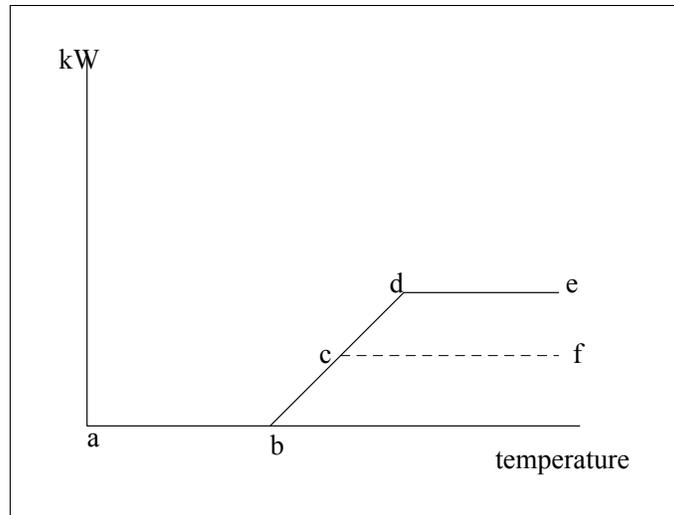


Figure 2 – The Duty Cycle Model for Estimating Load Control Impacts

Now consider a 50% cycling strategy. Under this strategy, the load curve for the unit is lowered to the segmented line abcf. Therefore, above temperature d, the impact is 50% of the full load. Below temperature c, there is no impact. Between c and d there is a partial impact.

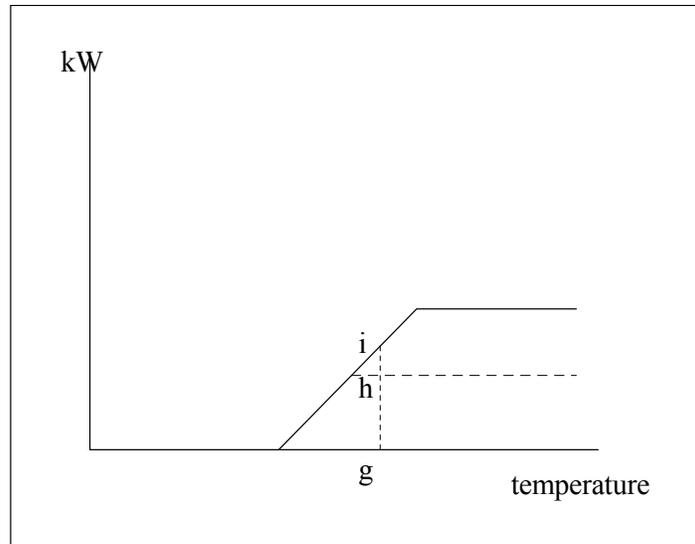


Figure 3 – Duty Cycle Model for Estimating Load Impacts (Cont.)

Figure 3 illustrates the partial impact. At temperature g , if the unit was uncontrolled, its demand would be i . At this temperature, it is operating at only a fraction of its full load, e.g., 70%. In other words, the unit is operating at a 70% duty cycle. Under control, its demand is reduced to point h , which is 50% of full load. Therefore the savings is 70% - 50% or 20% of full load. At a higher temperature the savings would be greater, e.g., if the unit had operating at a 90% duty cycle, the savings of a 50% cycling strategy would be 40% of its full load.

The preceding analysis shows that the impact of a cycling strategy on a particular hour depends on the duty cycle of the units on that hour. The greater the duty cycle of the controlled units, the greater the impact. In particular, full potential impact is only achieved for units that are fully loaded, i.e., would have been operating with a 100% duty cycle.

Returning to Figure 2, the impact of *any cycling strategy* can be predicted by determining the points b and d for each participant. Point b is the lowest temperature for which air conditioning is required. Point d is determined by two parameters: the full kW load of the unit and the lowest temperature at which the unit reaches full load. To summarize, under the duty-cycle model, the impact of any cycling strategy can be predicted by determining the following three parameters for each participant:

- The lowest temperature for which air conditioning is required,
- The full kW load of the AC unit, and
- The lowest temperature at which the unit reaches full load.

The duty cycle analysis will result in the expected impacts at the individual customer level for any selected cycling strategy, i.e., 50%, 53%, etc., up to 100%.

4.4.3 Duty Cycle Application

In this evaluation, savings were calculated to simulate 27%, 43%, 50%, 66.7%, 75% and 100% cycling strategies. The possible savings were defined as:

$$\text{Savings}_{c,s,d,t} = \text{Max}(0, \text{demand}_{c,d,t} - \text{spotwatt}_c * (1 - \text{CS}))$$

Where:

$\text{Savings}_{c,s,d,t}$ = Estimated Savings for customer c, using cycling strategy s, on date d, during time of day period t.

$\text{demand}_{c,d,t}$ = Demand for customer c on date d during time period of day period t,
 spotwatt_c = Estimated spot watts for customer c. Spot watts were not available for all the sites, the spot watts were estimated by assuming that the spot watt rating was equal to the 99th percentile of observed demands for the customer.

CS = Cycling strategy (27%, 43%, 50%, 66.7%, 75%, 83% and 100%), and
t = Time of day period. There were 96 time of day periods, one for each 15 minute period from 12:15 AM to 12:00 M.

For the air conditioning analysis, savings for each customer, for each date for each 15 minute period under each strategy was calculated. The time periods were matched to the appropriate weather stations.

Under each cycling strategy, the average savings were calculated by time of day, for each WTHI that was observed during that time of day period. The average savings for each WTHI during each time of day period were calculated as follows:

$$\text{AverageSavings}_{g,w,s,t} = \frac{\sum_{c=1}^{n_w} \sum_{d_w} \text{Savings}_{g,c,s,d,t}}{(n_{g,w} + d_w)}$$

Where:

Average Savings $_{g,w,s,t}$ = Average savings group g when the WTHI was w, under strategy s during time of day period t.

Savings $_{g,w,s,t}$ = Individual customer savings in group g when the WTHI was w for strategy s during time of day period t,

$n_{g,w}$ = number of customers in group g when WTHI was w during time of day period t,

d_w = the days with WTHI w during time period t.

To model the relationship between savings and WTHI, for each group, for time period for each cycling strategy, a regression model was estimated. The models had the form of:

$$\text{Average Savings}_{g,w,s,t} = \beta_0 + \beta_1 * \text{DH}_{t,sp} + \varepsilon$$

Where:

Average Savings $_{g,s,t}$ = Average savings, for group g, strategy s at time of day period t

$\text{DH}_{t,sp}$ = Degree hours for time of day period t based on WTHI and set point sp.
The degree hours are calculated as:

$$\text{DH}_{t,sp} = \text{Max}(\text{of } \text{WTHI}_t - \text{sp}_t, 0)$$

Where:

$WTHI_t$ = Weighted THI for time of day period t

sp_t = set point for time t. For this analysis, the set points examined ranged from 60° to 85°.

ε = the error term

The model estimated slope term, β_1 , can be interpreted as the incremental savings per degree of WTHI, beginning at the set point WTHI.

To optimize the models, a family of set points was examined for each unique strategy and time of day period. The family of set points were examine to avoid presupposing a set point of when air conditioning usage begins.

The set points ranged from 60° to 85°, incremented by 1°. The model that provided the best fit (i.e., minimized the residual mean squared error) was chosen as the optimal model and used in the prediction of savings.

Models were developed for all customers in aggregate, and for three subgroups. The subgroups included spot watt strata (greater than or less than 3.5 kW), annual air conditioning consumption (greater than or less than or equal to 1,600 kWh), and by Company. For each strategy, for each subgroup group 96 models (one for each time of day period) were chosen to estimate the savings for the range of WTHI.

Using the optimal models, the predicted average savings for each time of day period was estimated for each of the WTHI between 70°F to 87°F. The estimated savings for each WTHI during each time of day period were calculated as follows:

$$EstimatedSavings_{w,t} = b_{0,t} + b_{1,t} * (Max(w_t - sp_t, 0))$$

Where:

Estimated Savings $_{w,t}$ = the estimate of savings at WTHI 'w' during time of day period t,

$b_{0,t}, b_{1,t}$ = The estimated coefficients for time of day period t,

w_t = WTHI during time of day period t. The WTHI ranged from 70°F to 87°F

sp_t = The optimal set point for time of day period t.

4.4.4 Analysis Summary

Table 2 shows the distribution of the annual air conditioning usage by PJM region. Figure 4 illustrates the cumulative distribution of energy usage. The table and figure shows that the analysis is dominated by BGE, with data from 456 summers. The table and figure also shows that FE and BGE have very similar distributions. PSEG has slightly less air conditioning usage that the other two utilities. However, it can be

generally concluded that the distribution of annual air conditioning usage for each Company is similar.

Quantile	JCPL	BGE	PSEG	Aggregate
n	145	456	85	686
Max	7,309	7,676	5,243	7,676
99%	6,563	5,160	5,243	5,429
95%	4,147	3,722	3,500	3,780
90%	2,898	3,039	2,289	2,933
Q3	2,069	2,298	1,686	2,155
Mean	1,629	1,764	1,351	1,684
Median	1,381	1,582	1,117	1,497
Q1	693	1,016	703	914
10%	261	639	417	543
5%	96	483	348	337
1%	-	118	18	18
Min	-	0	18	-

Table 2 – Distribution of Annual Air Conditioning Usage

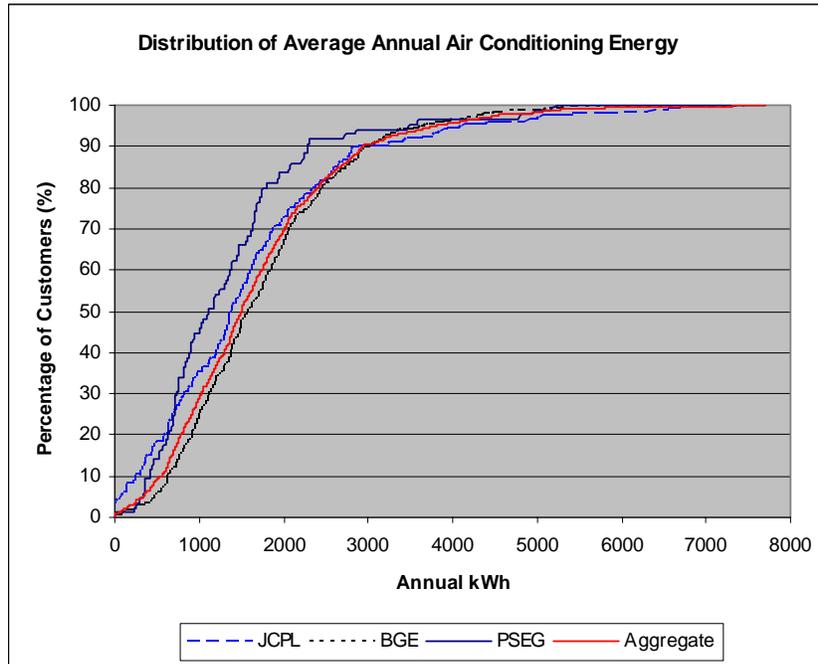


Figure 4 – Distribution of Average Air Conditioning Usage

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50% Cycling					66.7% Cycling				
Quantile	JCPL	BGE	PSEG	Aggregate	Quantile	JCPL	BGE	PSEG	Aggregate
n	145	456	85		n	145	456	85	
Max	2,360	2,246	1,966	2,360	Max	3,904	3,916	2,962	3,916
99%	2,141	1,685	1,966	1,836	99%	3,560	2,718	2,962	2,893
95%	1,058	1,146	926	1,068	95%	1,854	1,918	1,632	1,851
90%	833	793	621	793	90%	1,512	1,317	1,011	1,327
Q3	496	418	433	440	Q3	868	844	743	848
Mean	378	325	336	337	Mean	704	637	588	645
Median	238	212	241	227	Median	533	463	465	483
Q1	112	77	118	88	Q1	262	235	244	242
10%	33	32	46	33	10%	91	116	115	114
5%	7	18	29	19	5%	37	71	100	66
1%	-	3	8	1	1%	-	22	11	10
Min	-	-	8	-	Min	-	-	11	-

75% Cycling					100% Cycling				
Quantile	JCPL	BGE	PSEG	Aggregate	Quantile	JCPL	BGE	PSEG	Aggregate
n	145	456	85		n	145	456	85	
Max	4,695	4,775	3,441	4,775	Max	7,309	7,676	5,243	7,676
99%	4,273	3,246	3,441	3,441	99%	6,563	5,160	5,243	5,429
95%	2,377	2,253	2,009	2,260	95%	4,147	3,722	3,500	3,780
90%	1,809	1,665	1,349	1,667	90%	2,898	3,039	2,289	2,933
Q3	1,144	1,136	936	1,111	Q3	2,069	2,298	1,686	2,155
Mean	896	848	743	845	Mean	1,629	1,764	1,351	1,684
Median	714	687	615	687	Median	1,381	1,582	1,117	1,497
Q1	340	372	337	357	Q1	693	1,016	703	914
10%	118	209	179	186	10%	261	639	417	543
5%	48	138	142	118	5%	96	483	348	337
1%	-	52	13	13	1%	-	118	18	18
Min	-	-	13	-	Min	-	0	18	-

Table 3 – Distribution of Possible Air Conditioning Savings under Various Strategies

Table 3 shows the annual energy savings under the various cycling strategies. Figure 5 shows the cumulative distributions of potential energy savings under the various cycling strategies. Please note these graphs are calculated by assuming that each customer is interrupted daily. Similar to the annual usage distributions, the distribution of maximum energy savings that could be expected is similar for each Company.

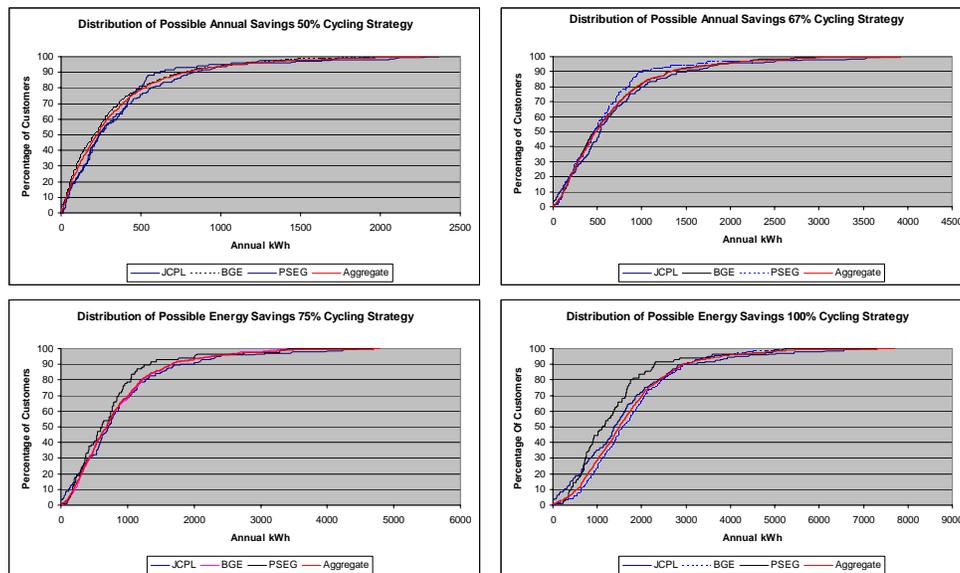


Figure 5 – Cumulative Distributions of Energy Savings Under Various Cycling Strategies

The BGE data provided was based on a stratified sample. The stratification variable was whole house usage. Table 4 shows a comparison by strata of the distribution of air conditioning usage. This table also shows the simple average of the distribution points and the weighted average of the distribution points. This table shows that there is a difference in the distribution of the strata. The simple average of the distribution points is slightly greater than the weighted average.

Quantile	S1	S2	SRS	Weighted
n	248	208	456	456
Max	5,429	7,676	7,676	6,088
99%	3,808	5,284	5,160	4,241
95%	2,885	4,315	3,722	3,305
90%	2,425	3,651	3,039	2,784
Q3	1,879	2,723	2,298	2,127
Mean	1,428	2,164	1,764	1,644
Median	1,343	2,018	1,582	1,541
Q1	839	1,400	1,016	1,003
10%	558	930	639	667
5%	353	751	483	469
1%	87	481	118	202
Min	0	129	0	38

Table 4 Distribution of BGE Annual Air conditioning Usage, By Strata

Unfortunately, JCPL and PSEG did not provide information to map their sample points into the BGE sample design. In addition, the annual air conditioning usage, and the sample design usage were not well correlated. Accordingly, the JCPL and the PSEG information could not be disaggregated using this method.

Although the simple average shows a slight upward bias, the authors concluded that the bias was not material, when weighed against the potential loss of the JCPL and PSEG sample data. Accordingly, the analysis was based on unweighted results from the contributing utilities. To help alleviate any concern regarding the approach, alternatives were conducted that stratified the analysis by air conditioning connected demand and air conditioning seasonal energy use. The utilities could elect to apply these alternative estimates to specific segments of their populations to more uniquely reflect the actual characteristics of their service territories. Of course, this requires information to be available on the connected load through program records or estimated¹⁵ for the seasonal air conditioning use using customer billing information for the respective populations. An example of this analysis was completed using billing data from BGE and is reported on in a later section of this report.

The next step in the process was to merge the savings data with the WTHI data. Based on this information the average savings was calculated, by time period, by WTHI. For each time period, a model was developed to predict the savings for a given WTHI.

¹⁵ The authors believe that the air conditioning seasonal energy use can be effectively estimated for sizing the populations through a PRISM type analysis.

For each cycling strategy 96 models were developed, one for each 15 minute period during the day. An optimal “set point” temperature for each model was chosen. Table 5 shows the average optimal set points and the R-squared statistics from the models. This table shows that the average set point decreases as the cycling strategy increases. This table also shows that there is a high correlation between WTHI and potential energy savings.

Cycling Strategy	Set Point				R-Squared			
	50%	67%	75%	100%	50%	67%	75%	100%
Minimum	67	66	66	64	86%	89%	90%	94%
Mean	72	70	69	67	96%	97%	97%	98%
Median	71	70	69	66	96%	97%	97%	98%
Maximum	74	73	72	70	99%	99%	99%	99%

Table 5 – Average Optimal Set Points and R-Squared Statistics

Figure 6 shows the optimal set points by the time of day. These are the temperature at which demand savings begin. Interesting, for each cycling strategy, the optimal set points follow a uniform pattern, i.e., a drop in the early morning hours and rise in the mid mornings. In addition, the set points dip in the early evening. Interestingly, the set points generally decrease as the cycling strategy increases.

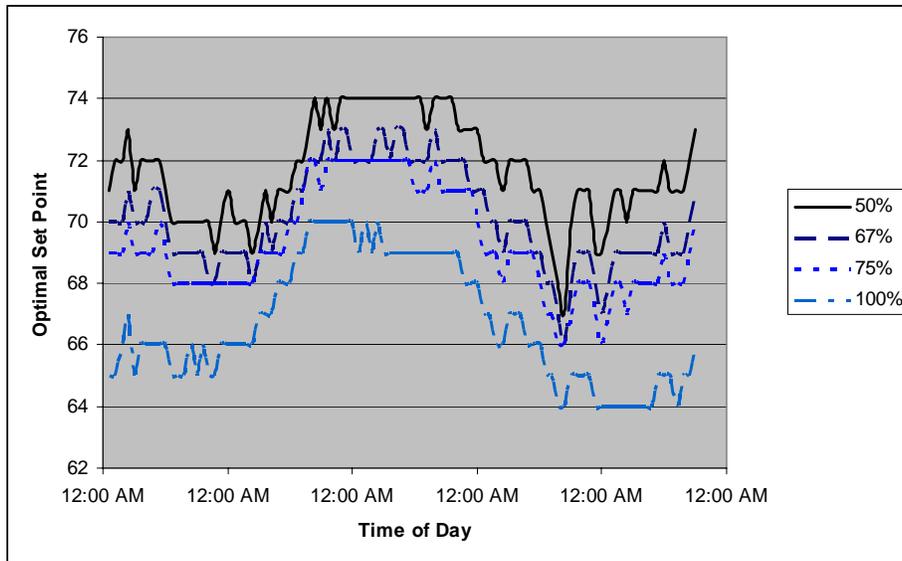


Figure 6 – Optimal Set Points By Time of Day

To verify the aggregate models, for each time period, separate models were developed for each region, and compared to the aggregate values. Figure 7 shows the modeled savings for a 50% cycling strategy, by region. This shows that the expected savings for BGE and PSEG are consistent with the aggregate modeled savings. JCPL modeled savings shows a weaker reaction to WTHI than the other utilities. This pattern is consistent across all cycling strategies.

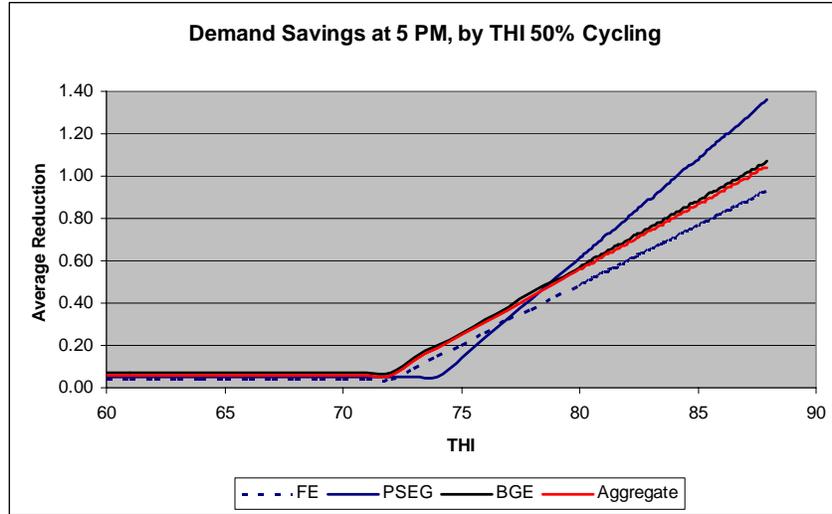


Figure 7 – Modeled Savings by THI for 50% Cycling at 5PM

Tables were prepared for each of the 96 time periods, i.e., 12:15 AM through 12:00 Midnight, for each cycling strategy. An example of the tables is shown in Table 6. The full set of tables is contained in an Excel spreadsheet that accompanies this report. Sample tables for selected times are provided in Appendix G.

WTHI	Predicted Savings at 5pm For Various Duty Cycle Strategies						
	27%	43%	50%	67%	75%	83%	100%
70.0	0.02	0.04	0.06	0.06	0.09	0.18	0.30
71.0	0.02	0.04	0.06	0.13	0.19	0.28	0.43
72.0	0.02	0.04	0.06	0.21	0.28	0.38	0.55
73.0	0.02	0.09	0.13	0.29	0.37	0.48	0.68
74.0	0.05	0.15	0.19	0.37	0.46	0.58	0.80
75.0	0.09	0.20	0.25	0.45	0.55	0.68	0.93
76.0	0.12	0.25	0.31	0.53	0.65	0.78	1.06
77.0	0.15	0.30	0.37	0.61	0.74	0.87	1.18
78.0	0.18	0.35	0.43	0.68	0.83	0.97	1.31
79.0	0.21	0.40	0.50	0.76	0.92	1.07	1.43
80.0	0.24	0.45	0.56	0.84	1.01	1.17	1.56
81.0	0.27	0.51	0.62	0.92	1.10	1.27	1.68
82.0	0.30	0.56	0.68	1.00	1.20	1.37	1.81
83.0	0.34	0.61	0.74	1.08	1.29	1.47	1.93
84.0	0.37	0.66	0.80	1.16	1.38	1.57	2.06
84.1	0.37	0.66	0.81	1.16	1.39	1.58	2.07
84.2	0.37	0.67	0.82	1.17	1.40	1.59	2.08
84.3	0.38	0.67	0.82	1.18	1.41	1.60	2.10
84.4	0.38	0.68	0.83	1.19	1.42	1.61	2.11
84.5	0.38	0.68	0.83	1.20	1.43	1.62	2.12
84.6	0.39	0.69	0.84	1.20	1.43	1.63	2.13
84.7	0.39	0.70	0.85	1.21	1.44	1.64	2.15
84.8	0.39	0.70	0.85	1.22	1.45	1.65	2.16
84.9	0.40	0.71	0.86	1.23	1.46	1.66	2.17
85.0	0.40	0.71	0.87	1.23	1.47	1.67	2.19
86.0	0.43	0.76	0.93	1.31	1.56	1.77	2.31
87.0	0.46	0.81	0.99	1.39	1.65	1.87	2.44

Table 6 – Example of Actual and Modeled Results Table, for Each Strategy at 5 PM

The average savings per customer can be derived by applying the zonal temperatures for a specific time period. Figure 8 displays the THI calculated for two weather stations in the PJM footprint. This figure shows that the THI for the Philadelphia zone was the highest throughout the period. Accordingly, the impacts per customer, under the various scenarios are also the greatest for this zone.

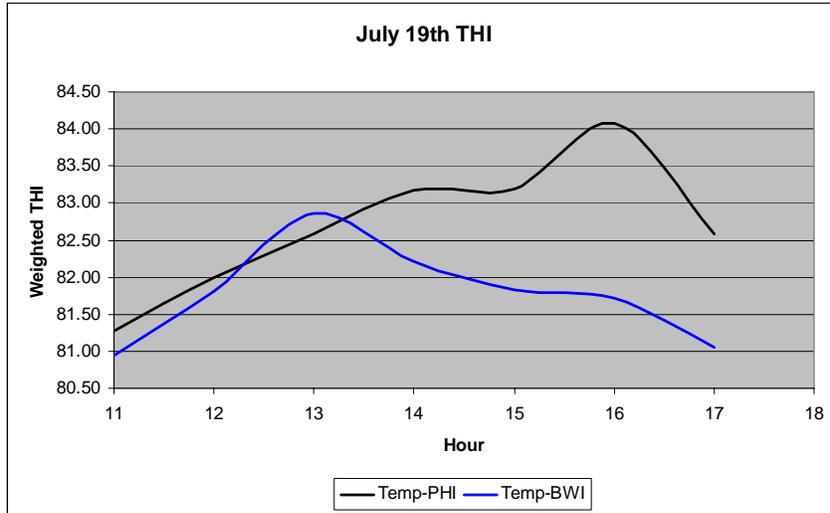
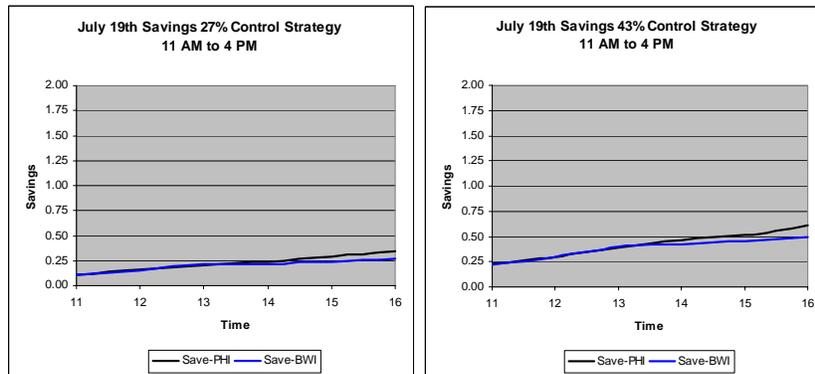


Figure 8 – July 19th Temperature Data

Figure 9 shows the results for a simulated event occurring on July 19th from 11 AM to 4 PM. The figure shows that the savings per customer rise throughout the period under each cycling strategy. The maximum impact was estimated to be 1.90 kW at 4 PM under the 100% cycling strategy in the Philadelphia zone. The THI at this time for this zone was 84⁰F. We can use weather data for other parts of the PJM territory to estimate the demand impact associated with these legacy demand response programs.



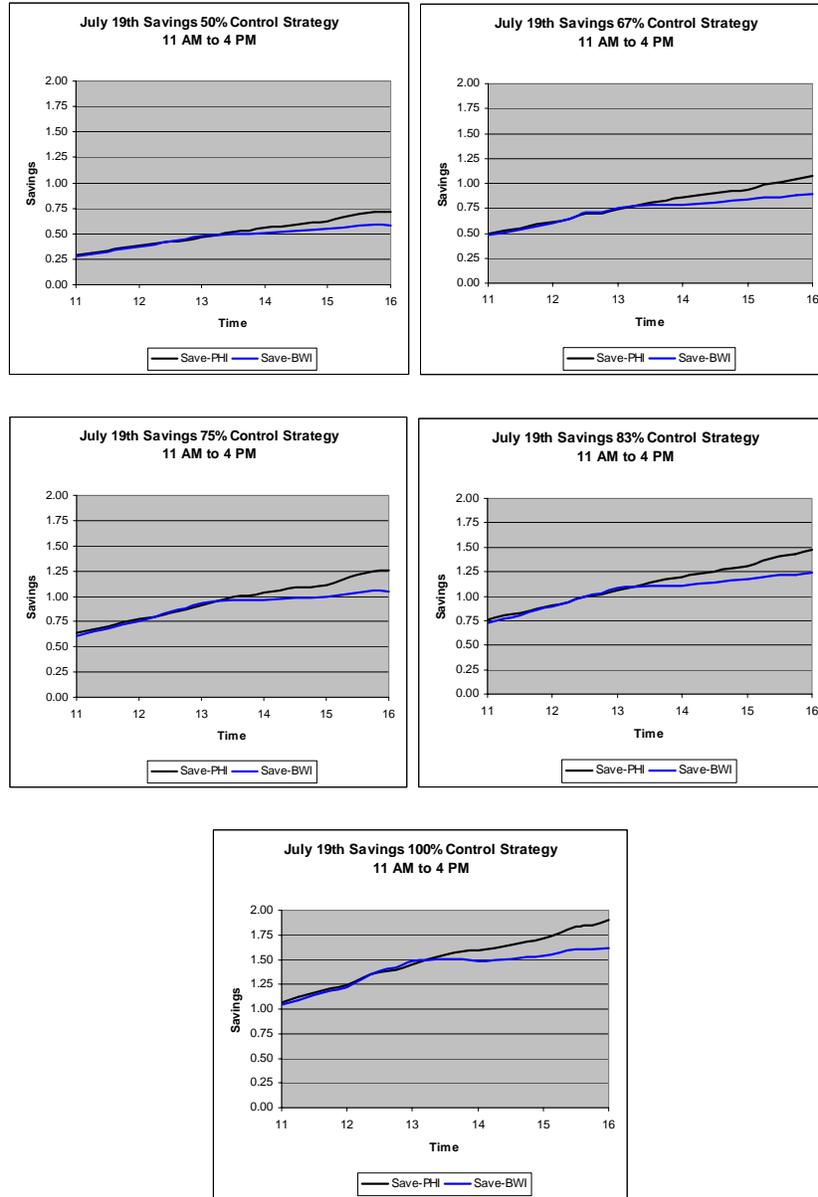


Figure 9 – Example of Savings, By Zone Under Various Cycling Strategies

Please note, given the models developed, the project team can run any duty cycle strategy desired by the project contributors *including strategies that employ an adaptive algorithm associated with newer, smarter switches*. In addition, any segmentation based on air conditioning size, e.g., connected load or seasonal usage, can be accommodated within the model set. These are explored in more detail in the next section.

4.4.5 Deemed Savings by Strata

The authors felt it important to provide information that allows the contributing utilities to apply unique estimates to different portions of their direct load control populations. This allows the estimates to be “customized” to the unique characteristics of the contributing utility’s population of DLC participants. Of course, this requires that the

number of participants by air conditioner size be available or estimated from program tracking data or that seasonal air conditioning use be estimated from customer billing data¹⁶. The same basic strategy discussed above was employed, however the analysis was conducted based on the seasonal air conditioning use, i.e., customer above and below 1600 kWh, and estimated connected demand, i.e., a threshold of 3.5 kW was used for this stratification. Here again, the models and analytical methods can support any cut points desired by the participating utilities.

Table 7 presents a snippet of the results of the analysis by seasonal¹⁷ air conditioning use. The table presents the estimated savings by cycling strategy for various levels of WTHI. The table presents the savings for customers with less than 1600 kWh of seasonal air conditioning use and the savings for customers with more than 1600 kWh of seasonal air conditioning use. At a WTHI of 84°F and cycling strategy of 50%, the estimated savings are 0.48 kW for the low energy use stratum and 1.03 kW for the high energy use stratum. From Table 6 we see that the aggregate average savings were estimated at 0.71 kW. These tables will allow each participating utility to generate a customized estimate for use in reporting the appropriate savings to PJM. The full set of tables is contained in an Excel spreadsheet that accompanies this report. Sample tables for selected times are provided in Appendix I.

¹⁶ The authors believe that a Princeton Scorekeeping Methodology (PRISM) can be effectively employed to estimate the number of participants by seasonal air conditioning use.

¹⁷ Seasonal use defined as June through September.

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WTHI	Predicted Savings at 5pm For Various Duty Cycle Strategies													
	Stratum 1 AC Usage < 1,600 kWh							Stratum 2 AC Usage > 1,600 kWh						
	27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
70.0	0.01	0.02	0.03	0.04	0.06	0.04	0.05	0.03	0.06	0.05	0.18	0.25	0.39	0.63
71.0	0.01	0.02	0.03	0.04	0.06	0.04	0.14	0.03	0.06	0.12	0.27	0.36	0.51	0.77
72.0	0.01	0.02	0.03	0.04	0.06	0.12	0.23	0.03	0.12	0.19	0.37	0.47	0.63	0.91
73.0	0.01	0.02	0.03	0.09	0.13	0.19	0.33	0.06	0.18	0.26	0.47	0.58	0.74	1.05
74.0	0.01	0.05	0.07	0.15	0.20	0.27	0.42	0.10	0.25	0.33	0.56	0.69	0.86	1.19
75.0	0.03	0.08	0.11	0.21	0.27	0.34	0.51	0.14	0.31	0.40	0.66	0.81	0.98	1.33
76.0	0.05	0.12	0.15	0.27	0.33	0.42	0.60	0.18	0.37	0.47	0.76	0.92	1.09	1.48
77.0	0.07	0.15	0.19	0.33	0.40	0.49	0.69	0.22	0.43	0.54	0.85	1.03	1.21	1.62
78.0	0.09	0.18	0.23	0.38	0.47	0.57	0.79	0.26	0.50	0.61	0.95	1.14	1.33	1.76
79.0	0.11	0.22	0.27	0.44	0.54	0.64	0.88	0.29	0.56	0.68	1.04	1.25	1.44	1.90
80.0	0.13	0.25	0.31	0.50	0.61	0.72	0.97	0.33	0.62	0.75	1.14	1.36	1.56	2.04
81.0	0.15	0.28	0.35	0.56	0.68	0.79	1.06	0.37	0.69	0.82	1.24	1.47	1.68	2.18
82.0	0.17	0.32	0.40	0.62	0.75	0.87	1.15	0.41	0.75	0.89	1.33	1.59	1.80	2.32
83.0	0.19	0.35	0.44	0.67	0.82	0.94	1.25	0.45	0.81	0.96	1.43	1.70	1.91	2.46
84.0	0.21	0.38	0.48	0.73	0.89	1.02	1.34	0.48	0.87	1.03	1.53	1.81	2.03	2.61
84.1	0.22	0.39	0.48	0.74	0.90	1.03	1.35	0.49	0.88	1.04	1.54	1.82	2.04	2.62
84.2	0.22	0.39	0.49	0.74	0.90	1.03	1.36	0.49	0.89	1.05	1.55	1.83	2.05	2.63
84.3	0.22	0.40	0.49	0.75	0.91	1.04	1.37	0.50	0.89	1.06	1.56	1.84	2.06	2.65
84.4	0.22	0.40	0.49	0.76	0.92	1.05	1.37	0.50	0.90	1.06	1.56	1.85	2.08	2.66
84.5	0.22	0.40	0.50	0.76	0.93	1.06	1.38	0.50	0.91	1.07	1.57	1.86	2.09	2.68
84.6	0.23	0.41	0.50	0.77	0.93	1.06	1.39	0.51	0.91	1.08	1.58	1.88	2.10	2.69
84.7	0.23	0.41	0.51	0.77	0.94	1.07	1.40	0.51	0.92	1.08	1.59	1.89	2.11	2.70
84.8	0.23	0.41	0.51	0.78	0.95	1.08	1.41	0.52	0.92	1.09	1.60	1.90	2.12	2.72
84.9	0.23	0.42	0.51	0.78	0.95	1.09	1.42	0.52	0.93	1.10	1.61	1.91	2.13	2.73
85.0	0.23	0.42	0.52	0.79	0.96	1.09	1.43	0.52	0.94	1.10	1.62	1.92	2.15	2.75
86.0	0.25	0.45	0.56	0.85	1.03	1.17	1.52	0.56	1.00	1.18	1.72	2.03	2.26	2.89
87.0	0.27	0.49	0.60	0.91	1.10	1.24	1.61	0.60	1.06	1.25	1.82	2.14	2.38	3.03

Table 7 – Savings by Energy Stratum 15-Min Ending 5pm

Table 8 presents a snippet of the results of the analysis by connected air conditioning load. The table presents the estimated savings by cycling strategy for various levels of WTHI. The table presents the savings for customers with less than 3.5 kW of connected air conditioning load and the savings for customers with an air conditioner connected load equal to or greater than 3.5 kW. At a WTHI of 84°F and cycling strategy of 50%, the estimated savings are 0.71 kW for the low connected load stratum and 1.21 kW for the high connected load stratum. From Table 6 we see that the aggregate average savings were estimated at 0.71 kW. These tables will allow each participating utility to generate a customized estimate for use in reporting the appropriate savings to PJM. The full set of tables is contained in an Excel spreadsheet that accompanies this report. Sample tables for selected times are provided in Appendix J.

Predicted Savings at 5pm For Various Duty Cycle Strategies														
	Stratum 1 AC Connected Demand < 3.5 kW							Stratum 2 AC Connected Demand > 3.5 kW						
WTHI	27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
70.0	0.02	0.04	0.05	0.05	0.08	0.16	0.28	0.04	0.08	0.07	0.10	0.20	0.27	0.49
71.0	0.02	0.04	0.05	0.12	0.17	0.25	0.39	0.04	0.08	0.07	0.22	0.33	0.41	0.67
72.0	0.02	0.04	0.05	0.19	0.25	0.34	0.50	0.04	0.08	0.16	0.34	0.46	0.56	0.84
73.0	0.02	0.08	0.11	0.26	0.33	0.43	0.61	0.04	0.16	0.25	0.45	0.59	0.71	1.02
74.0	0.05	0.13	0.16	0.33	0.41	0.52	0.73	0.09	0.24	0.34	0.57	0.72	0.85	1.19
75.0	0.07	0.17	0.22	0.40	0.49	0.61	0.84	0.14	0.32	0.42	0.69	0.85	1.00	1.36
76.0	0.10	0.22	0.27	0.47	0.58	0.70	0.95	0.19	0.40	0.51	0.81	0.98	1.15	1.54
77.0	0.13	0.26	0.33	0.54	0.66	0.79	1.07	0.24	0.48	0.60	0.92	1.11	1.29	1.71
78.0	0.16	0.31	0.38	0.61	0.74	0.88	1.18	0.29	0.56	0.69	1.04	1.24	1.44	1.89
79.0	0.18	0.35	0.43	0.68	0.82	0.96	1.29	0.34	0.64	0.78	1.16	1.37	1.58	2.06
80.0	0.21	0.40	0.49	0.75	0.91	1.05	1.41	0.39	0.72	0.86	1.28	1.50	1.73	2.23
81.0	0.24	0.44	0.54	0.82	0.99	1.14	1.52	0.44	0.80	0.95	1.39	1.63	1.88	2.41
82.0	0.26	0.49	0.60	0.89	1.07	1.23	1.63	0.49	0.88	1.04	1.51	1.75	2.02	2.58
83.0	0.29	0.53	0.65	0.96	1.15	1.32	1.75	0.54	0.96	1.13	1.63	1.88	2.17	2.76
84.0	0.32	0.58	0.71	1.03	1.23	1.41	1.86	0.59	1.04	1.21	1.75	2.01	2.32	2.93
84.1	0.32	0.58	0.71	1.04	1.24	1.42	1.87	0.60	1.05	1.22	1.76	2.03	2.33	2.95
84.2	0.32	0.59	0.72	1.04	1.25	1.43	1.88	0.60	1.06	1.23	1.77	2.04	2.35	2.96
84.3	0.33	0.59	0.72	1.05	1.26	1.44	1.89	0.61	1.07	1.24	1.78	2.05	2.36	2.98
84.4	0.33	0.59	0.73	1.06	1.27	1.45	1.91	0.61	1.07	1.25	1.79	2.07	2.37	3.00
84.5	0.33	0.60	0.73	1.06	1.28	1.46	1.92	0.62	1.08	1.26	1.80	2.08	2.39	3.02
84.6	0.34	0.60	0.74	1.07	1.28	1.47	1.93	0.62	1.09	1.27	1.82	2.09	2.40	3.03
84.7	0.34	0.61	0.74	1.08	1.29	1.48	1.94	0.63	1.10	1.28	1.83	2.10	2.42	3.05
84.8	0.34	0.61	0.75	1.09	1.30	1.48	1.95	0.63	1.11	1.29	1.84	2.12	2.43	3.07
84.9	0.34	0.62	0.76	1.09	1.31	1.49	1.96	0.64	1.11	1.29	1.85	2.13	2.45	3.09
85.0	0.35	0.62	0.76	1.10	1.32	1.50	1.97	0.64	1.12	1.30	1.86	2.14	2.46	3.10
86.0	0.37	0.67	0.82	1.17	1.40	1.59	2.09	0.69	1.20	1.39	1.98	2.27	2.61	3.28
87.0	0.40	0.71	0.87	1.24	1.48	1.68	2.20	0.74	1.28	1.48	2.10	2.40	2.76	3.45

Table 8 – Savings by Connected Load Stratum 15-Min Ending 5pm

5 DEEMED SAVINGS FOR WH CONTROL

During the feasibility phase of the project, the project team prepared a technical memorandum (See Appendix H) on pooling water heating load control estimates. The memorandum was based on a review of work performed by Potomac Electric, Baltimore Gas and Electric and Conectiv. Table 9 presents a summary of the historical water heating load control estimates for each of the three utilities. The estimates are presented for the period from hour ending 1pm to hour ending 8pm. The estimates are fairly stable with the exception of the Conectiv estimates which tended to be substantially higher than the estimates derived by the other two utilities.

Hour Ending	PEPCO	BGE			Conectiv
		1998	2001	2002	
1pm	0.26	0.27	0.26	0.25	0.35
2pm	0.23	0.28	0.23	0.20	0.33
3pm	0.20	0.26	0.22	0.20	0.31
4pm	0.21	0.25	0.20	0.19	0.34
5pm	0.23	0.26	0.23	0.24	0.39
6pm	0.32	0.30	0.31	0.29	0.43
7pm	0.35	0.36	0.35	0.30	0.42
8pm	0.31	0.41	0.37	0.34	0.40
Average	0.27	0.30	0.27	0.25	0.37

Table 9 – Summary of Historical WH Load Control Estimates

In this section, we use five years of historical end-use metering data available for a sample of Baltimore Gas and Electric customers to develop “deemed savings” estimates following a duty cycle strategy.

Similar to the air conditioning analysis, we derive the maximum demand for each water heater contained in the sample. The individual customer’s maximum demand was used as a proxy for the equipment’s “spot watts”, or the maximum amount of load that the customer had available to interrupt. Figure 1 shows a comparison of the cumulative distribution of the spot watts.

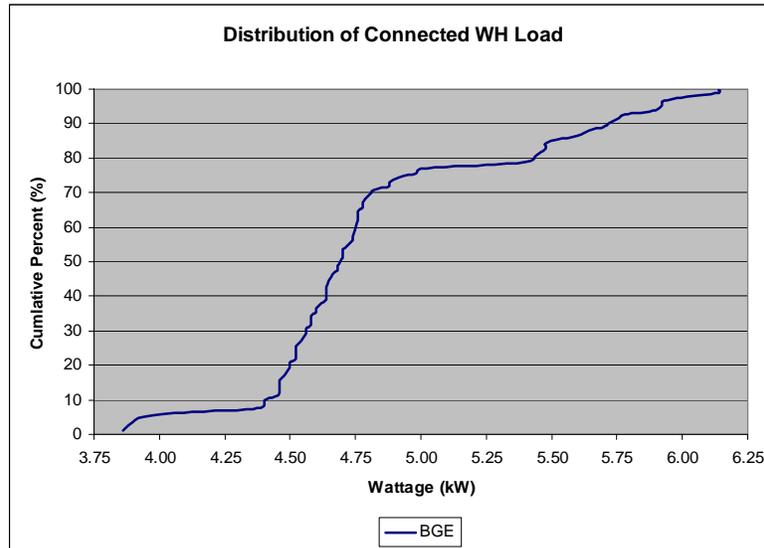


Figure 10 – Cumulative Distribution of Water Heater Spot Watts

Electric water heaters come in a wide variety of configurations and often have an upper and lower element with an interlock that prevents the two elements from operating simultaneously. The element configuration can run the gambit from 750 watt to 6,000 watt rating. A very typical configuration is a 4,500 watt upper and lower element. This is evidenced by the vast majority of the customer loads falling in this range.

Next, the event days were omitted from the analysis. A complete listing of the event days is contained in Appendix J.

For this project, the potential savings were calculated to simulate a 50%, 66.7%, 75% and 100% cycling strategy. The potential savings were defined as:

$$\text{Savings}_{c,S,t} = \text{Max}(0, \text{Demand}_{c,t} - \text{Spotwatt}_c * (1 - \text{CS}))$$

Where:

$\text{Savings}_{c,S,t}$ = Estimated Savings for customer c , using cycling strategy S , at time t ,

$\text{Demand}_{c,t}$ = Demand for customer c during time period t

Spotwatt_c = Spot watts for customer c

CS = Cycling strategy (50%, 66.7%, 75% and 100%).

For the water heating analysis, the savings for each customer, for each 15 minute period under each strategy was calculated. Since, the water heater demand is not terribly weather sensitive, the overall average demands were calculated by time of day.

5.1 Analysis Approach

Figure 11 illustrates the cumulative distribution of energy usage and presents a table with the distribution statistics for annual water heating use. The table and figure shows that the analysis is based on data from 319 annual periods. The median annual water heating energy use is estimated to be 2,986 kWh with a mean annual use of 2,828 kWh.

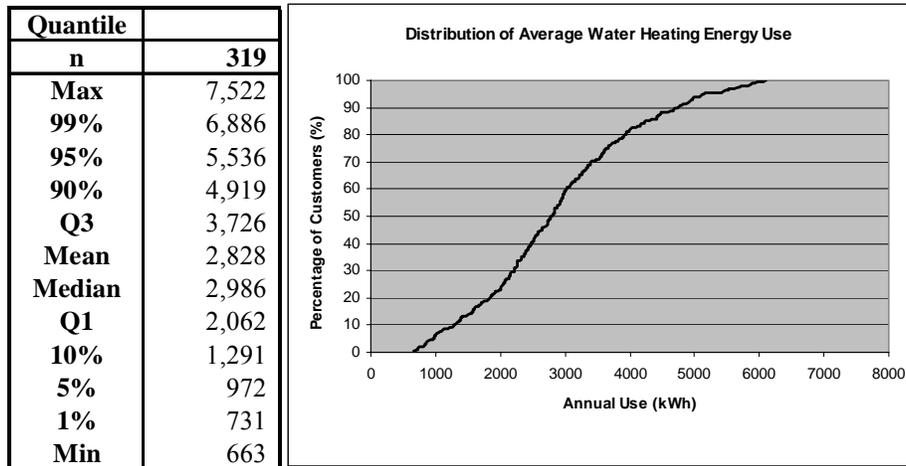


Figure 11 – Distribution of Average Water Heating Usage

Table 10 shows the annual energy savings under the various cycling strategies. Figure 5 shows the cumulative distributions of possible energy savings under the various cycling strategies. Please note the data in Table 10 assumes that the water heater is controlled every day in the year.

	50% Cycling	67% Cycling	75% Cycling	100% Cycling
Percentile	BGE	BGE	BGE	BGE
n	319	319	319	319
Max	2,254	3,581	4,298	7,522
99%	1,883	3,121	3,776	6,886
95%	1,348	2,295	2,866	5,536
90%	1,156	1,996	2,461	4,919
Q3	736	1,390	1,790	3,726
Mean	539	1,022	1,376	2,986
Median	437	864	1,221	2,828
Q1	234	531	803	2,062
10%	96	242	419	1,291
5%	52	182	303	972
1%	19	122	250	731
Min	-	33	72	663

Table 10 – Distribution of Possible Water Savings under Various Strategies

5.2 Analysis Summary

The average 15-minute savings by strategy are illustrated in Figure 9 and presented in Table 11 and Table 12. The average savings associated with the 15-minute ending period 7am is estimated to be 0.59 kW for the 100% cycling approach. For the 15-minute period ending 7pm this estimate is 0.50 kW.

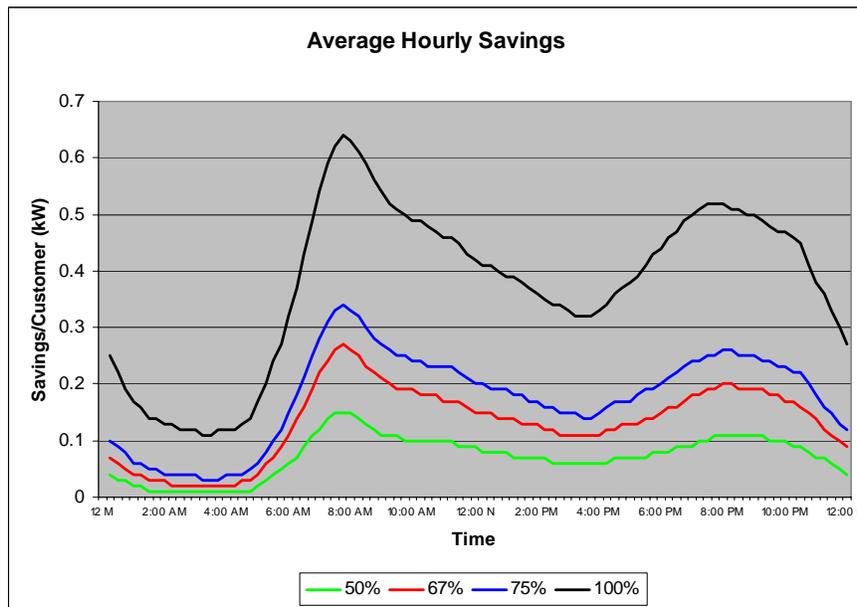


Figure 12 – Water Heating Savings, By Cycling Strategy

Deemed Savings Estimates for
Legacy Residential AC and WH Programs

Period	Time	Cycling Strategy			
		50%	67%	75%	100%
1	12:15 AM	0.04	0.07	0.10	0.25
2	12:30 AM	0.03	0.06	0.09	0.22
3	12:45 AM	0.03	0.05	0.08	0.19
4	1:00 AM	0.02	0.04	0.06	0.17
5	1:15 AM	0.02	0.04	0.06	0.16
6	1:30 AM	0.01	0.03	0.05	0.14
7	1:45 AM	0.01	0.03	0.05	0.14
8	2:00 AM	0.01	0.03	0.04	0.13
9	2:15 AM	0.01	0.02	0.04	0.13
10	2:30 AM	0.01	0.02	0.04	0.12
11	2:45 AM	0.01	0.02	0.04	0.12
12	3:00 AM	0.01	0.02	0.04	0.12
13	3:15 AM	0.01	0.02	0.03	0.11
14	3:30 AM	0.01	0.02	0.03	0.11
15	3:45 AM	0.01	0.02	0.03	0.12
16	4:00 AM	0.01	0.02	0.04	0.12
17	4:15 AM	0.01	0.02	0.04	0.12
18	4:30 AM	0.01	0.03	0.04	0.13
19	4:45 AM	0.01	0.03	0.05	0.14
20	5:00 AM	0.02	0.04	0.06	0.17
21	5:15 AM	0.03	0.06	0.08	0.20
22	5:30 AM	0.04	0.07	0.10	0.24
23	5:45 AM	0.05	0.09	0.12	0.27
24	6:00 AM	0.06	0.11	0.15	0.32
25	6:15 AM	0.07	0.14	0.18	0.37
26	6:30 AM	0.09	0.16	0.21	0.43
27	6:45 AM	0.11	0.19	0.25	0.49
28	7:00 AM	0.12	0.22	0.28	0.54
29	7:15 AM	0.14	0.24	0.31	0.59
30	7:30 AM	0.15	0.26	0.33	0.62
31	7:45 AM	0.15	0.27	0.34	0.64
32	8:00 AM	0.15	0.26	0.33	0.63
33	8:15 AM	0.14	0.25	0.32	0.61
34	8:30 AM	0.13	0.23	0.30	0.59
35	8:45 AM	0.12	0.22	0.28	0.56
36	9:00 AM	0.11	0.21	0.27	0.54
37	9:15 AM	0.11	0.20	0.26	0.52
38	9:30 AM	0.11	0.19	0.25	0.51
39	9:45 AM	0.10	0.19	0.25	0.50
40	10:00 AM	0.10	0.19	0.24	0.49
41	10:15 AM	0.10	0.18	0.24	0.49
42	10:30 AM	0.10	0.18	0.23	0.48
43	10:45 AM	0.10	0.18	0.23	0.47
44	11:00 AM	0.10	0.17	0.23	0.46
45	11:15 AM	0.10	0.17	0.23	0.46
46	11:30 AM	0.09	0.17	0.22	0.45
47	11:45 AM	0.09	0.16	0.21	0.43
48	12:00 N	0.09	0.15	0.20	0.42

Table 11 – Average Savings by Time Period and Cycling Strategy

Deemed Savings Estimates for
Legacy Residential AC and WH Programs

Period	Time	Cycling Strategy			
		50%	67%	75%	100%
49	12:15 PM	0.08	0.15	0.20	0.41
50	12:30 PM	0.08	0.15	0.19	0.41
51	12:45 PM	0.08	0.14	0.19	0.40
52	1:00 PM	0.08	0.14	0.19	0.39
53	1:15 PM	0.07	0.14	0.18	0.39
54	1:30 PM	0.07	0.13	0.18	0.38
55	1:45 PM	0.07	0.13	0.17	0.37
56	2:00 PM	0.07	0.13	0.17	0.36
57	2:15 PM	0.07	0.12	0.16	0.35
58	2:30 PM	0.06	0.12	0.16	0.34
59	2:45 PM	0.06	0.11	0.15	0.34
60	3:00 PM	0.06	0.11	0.15	0.33
61	3:15 PM	0.06	0.11	0.15	0.32
62	3:30 PM	0.06	0.11	0.14	0.32
63	3:45 PM	0.06	0.11	0.14	0.32
64	4:00 PM	0.06	0.11	0.15	0.33
65	4:15 PM	0.06	0.12	0.16	0.34
66	4:30 PM	0.07	0.12	0.17	0.36
67	4:45 PM	0.07	0.13	0.17	0.37
68	5:00 PM	0.07	0.13	0.17	0.38
69	5:15 PM	0.07	0.13	0.18	0.39
70	5:30 PM	0.07	0.14	0.19	0.41
71	5:45 PM	0.08	0.14	0.19	0.43
72	6:00 PM	0.08	0.15	0.20	0.44
73	6:15 PM	0.08	0.16	0.21	0.46
74	6:30 PM	0.09	0.16	0.22	0.47
75	6:45 PM	0.09	0.17	0.23	0.49
76	7:00 PM	0.09	0.18	0.24	0.50
77	7:15 PM	0.10	0.18	0.24	0.51
78	7:30 PM	0.10	0.19	0.25	0.52
79	7:45 PM	0.11	0.19	0.25	0.52
80	8:00 PM	0.11	0.20	0.26	0.52
81	8:15 PM	0.11	0.20	0.26	0.51
82	8:30 PM	0.11	0.19	0.25	0.51
83	8:45 PM	0.11	0.19	0.25	0.50
84	9:00 PM	0.11	0.19	0.25	0.50
85	9:15 PM	0.11	0.19	0.24	0.49
86	9:30 PM	0.10	0.18	0.24	0.48
87	9:45 PM	0.10	0.18	0.23	0.47
88	10:00 PM	0.10	0.17	0.23	0.47
89	10:15 PM	0.09	0.17	0.22	0.46
90	10:30 PM	0.09	0.16	0.22	0.45
91	10:45 PM	0.08	0.15	0.20	0.41
92	11:00 PM	0.07	0.14	0.18	0.38
93	11:15 PM	0.07	0.12	0.16	0.36
94	11:30 PM	0.06	0.11	0.15	0.33
95	11:45 PM	0.05	0.10	0.13	0.30
96	12:00 M	0.04	0.09	0.12	0.27

Table 12 – Average Savings by Time Period and Cycling Strategy (cont.)

5.3 100% Cycling

Typically, a 100% cycling strategy is employed with water heating controls since most water heaters have a tank with sufficient capacity to last several hours during control. In these next sections we will examine the issue of time sensitivity, seasonal sensitivity and weekday/weekend sensitivity.

5.3.1 Time Sensitivity

Figure 13 presents the demand savings duration curves associated with 100% cycling for the following weekday periods:

- Hour ending 8am;
- Hour ending 5pm; and
- Hour ending 7pm.

In this figure we have selected the average weekday demand for the annual period. The average demand in kW is displayed on the y-axis and the percentage of time the load is at or below the specified demand level on the x-axis. For example, if we examine the hour ending 8am profile we see that the load is at or below 0.72 kW for 50% of all weekdays. If we look at the 80th percentile we can estimate that the savings are at or above 0.92 kW 20% of the time or if we examine the 80th percentile we see that the savings are at or above 0.52 kW 80% of the time.

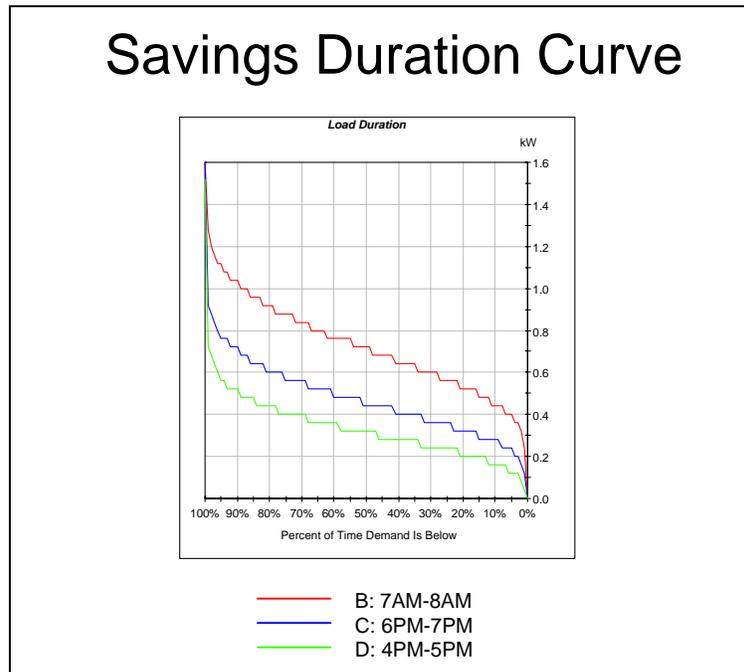


Figure 13 – Savings Duration Curve for Selected Hours (100% Cycling)

Table 13 presented selected distribution statistics for selected hour ending periods.

Percentile (Bin)	Hour Ending								
	7am	8am	9am	2pm	3pm	4pm	5pm	6pm	7pm
1st (0.00-1.00%)	0.16	0.24	0.20	0.08	0.04	0.04	0.04	0.08	0.12
10th (9.00-10.00%)	0.32	0.44	0.32	0.16	0.16	0.12	0.16	0.20	0.28
25th (24.00-25.00%)	0.40	0.56	0.44	0.20	0.20	0.20	0.24	0.28	0.36
50th (49.00-50.00%)	0.52	0.72	0.56	0.32	0.28	0.28	0.32	0.36	0.44
75th (74.00-75.00%)	0.68	0.88	0.72	0.40	0.36	0.36	0.40	0.48	0.56
90th (89.00-90.00%)	0.84	1.04	0.88	0.52	0.48	0.44	0.52	0.60	0.72
95th (94.00-95.00%)	0.92	1.12	1.00	0.60	0.52	0.52	0.56	0.68	0.76
99th (98.00-99.00%)	1.12	1.28	1.20	0.76	0.68	0.68	0.72	0.84	0.92

Table 13 – Savings Duration Curve for Selected Hours (100% Cycling)

5.3.2 Seasonal Sensitivity

There is some inherent seasonality associated with the water heating load. Figure 14 demonstrates the seasonal nature of the load. The lowest levels of load are in the summer with the highest loads in the winter. The Spring/Fall acts as a transition period.

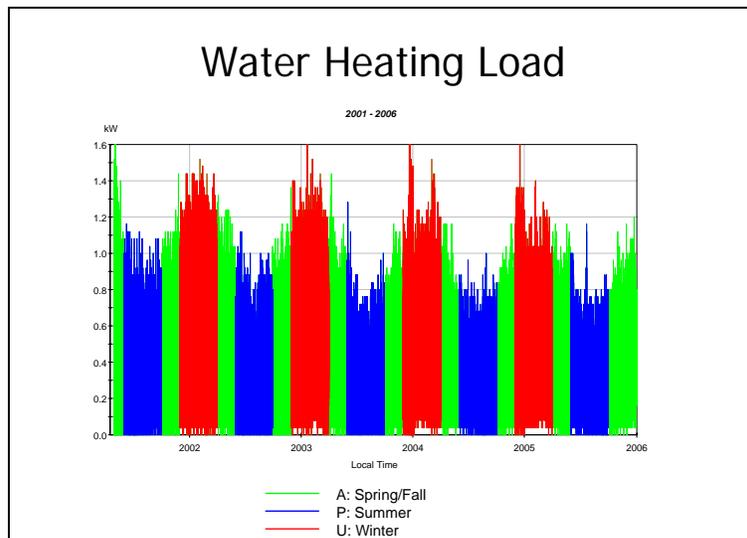


Figure 14 – Seasonal Sensitivity

To reflect this seasonality, we examined the 100% cycling load response by season. Selected distribution statistics for the load, i.e., (anticipated savings under 100% cycling) are presented in Table 14 through Table 16. The distribution statistics are presented for each hour. For example, the median load relief expected at hour ending 7am is 0.48 kW in the Spring/Fall, 0.36 kW in the Summer and 0.52 kW in the Winter. This assumes a signal reception rate of 100%.

Deemed Savings Estimates for
Legacy Residential AC and WH Programs

Season	Hour	n	Mean	Percentiles						
				5th	10th	25th	Median	75th	90th	95th
SPRFAL	1	2,316	0.20	0.04	0.08	0.12	0.20	0.24	0.32	0.36
SPRFAL	2	2,316	0.13	0.04	0.04	0.08	0.12	0.16	0.24	0.24
SPRFAL	3	2,300	0.12	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SPRFAL	4	2,316	0.11	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SPRFAL	5	2,316	0.13	0.04	0.04	0.08	0.12	0.16	0.24	0.28
SPRFAL	6	2,316	0.26	0.08	0.08	0.16	0.24	0.36	0.44	0.48
SPRFAL	7	2,313	0.49	0.12	0.20	0.28	0.48	0.64	0.80	0.88
SPRFAL	8	2,315	0.66	0.28	0.36	0.48	0.68	0.80	0.96	1.04
SPRFAL	9	2,315	0.59	0.32	0.36	0.44	0.56	0.72	0.84	0.92
SPRFAL	10	2,316	0.51	0.24	0.28	0.36	0.48	0.64	0.76	0.84
SPRFAL	11	2,316	0.47	0.20	0.24	0.32	0.44	0.60	0.72	0.84
SPRFAL	12	2,319	0.43	0.16	0.24	0.28	0.40	0.52	0.68	0.76
SPRFAL	13	2,319	0.40	0.16	0.20	0.28	0.36	0.48	0.64	0.72
SPRFAL	14	2,315	0.37	0.16	0.20	0.24	0.36	0.48	0.60	0.68
SPRFAL	15	2,314	0.34	0.12	0.16	0.24	0.32	0.44	0.52	0.60
SPRFAL	16	2,312	0.31	0.12	0.16	0.20	0.28	0.40	0.52	0.56
SPRFAL	17	2,312	0.36	0.16	0.20	0.24	0.36	0.44	0.56	0.64
SPRFAL	18	2,311	0.41	0.20	0.24	0.32	0.40	0.48	0.60	0.68
SPRFAL	19	2,311	0.47	0.24	0.28	0.36	0.48	0.56	0.68	0.72
SPRFAL	20	2,313	0.52	0.28	0.32	0.40	0.52	0.60	0.72	0.80
SPRFAL	21	2,314	0.52	0.28	0.32	0.40	0.52	0.60	0.72	0.80
SPRFAL	22	2,316	0.49	0.24	0.28	0.36	0.48	0.60	0.68	0.76
SPRFAL	23	2,318	0.43	0.20	0.24	0.32	0.40	0.52	0.64	0.68
SPRFAL	24	2,319	0.32	0.12	0.16	0.24	0.32	0.40	0.48	0.52

Table 14 – Spring Fall Average WH Demand Distribution

Season	Hour	Obs	Mean	Percentiles						
				5th	10th	25th	Median	75th	90th	95th
SUMMER	1	2,440	0.17	0.04	0.08	0.12	0.16	0.20	0.28	0.32
SUMMER	2	2,440	0.11	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SUMMER	3	2,440	0.09	0.00	0.04	0.04	0.08	0.12	0.16	0.20
SUMMER	4	2,440	0.09	0.00	0.04	0.04	0.08	0.12	0.16	0.20
SUMMER	5	2,440	0.10	0.02	0.04	0.08	0.08	0.12	0.20	0.20
SUMMER	6	2,440	0.22	0.04	0.08	0.12	0.20	0.28	0.36	0.40
SUMMER	7	2,440	0.38	0.12	0.16	0.24	0.36	0.52	0.64	0.68
SUMMER	8	2,440	0.52	0.24	0.28	0.40	0.52	0.64	0.76	0.84
SUMMER	9	2,440	0.46	0.24	0.28	0.36	0.44	0.56	0.64	0.72
SUMMER	10	2,440	0.41	0.20	0.24	0.32	0.40	0.48	0.60	0.68
SUMMER	11	2,435	0.39	0.16	0.20	0.28	0.36	0.48	0.60	0.64
SUMMER	12	2,401	0.36	0.16	0.20	0.24	0.32	0.44	0.56	0.64
SUMMER	13	2,377	0.33	0.12	0.16	0.24	0.32	0.40	0.52	0.60
SUMMER	14	2,343	0.31	0.12	0.16	0.20	0.28	0.40	0.48	0.56
SUMMER	15	2,312	0.28	0.12	0.12	0.20	0.28	0.36	0.44	0.52
SUMMER	16	2,305	0.27	0.08	0.12	0.20	0.24	0.32	0.40	0.48
SUMMER	17	2,288	0.30	0.12	0.16	0.20	0.28	0.36	0.44	0.48
SUMMER	18	2,292	0.33	0.16	0.20	0.24	0.32	0.40	0.48	0.52
SUMMER	19	2,316	0.38	0.20	0.24	0.28	0.36	0.44	0.56	0.60
SUMMER	20	2,325	0.41	0.20	0.24	0.32	0.40	0.48	0.60	0.64
SUMMER	21	2,360	0.43	0.20	0.24	0.32	0.40	0.52	0.60	0.68
SUMMER	22	2,392	0.42	0.20	0.24	0.32	0.40	0.52	0.60	0.68
SUMMER	23	2,429	0.38	0.16	0.20	0.28	0.36	0.48	0.56	0.64
SUMMER	24	2,440	0.28	0.12	0.16	0.20	0.28	0.36	0.40	0.48

Table 15 – Summer Average WH Demand Distribution

Deemed Savings Estimates for
Legacy Residential AC and WH Programs

Season	Hour	n	Mean	Percentiles						
				5th	10th	25th	Median	75th	90th	95th
WINTER	1	2,064	0.27	0.08	0.12	0.20	0.28	0.36	0.44	0.48
WINTER	2	2,064	0.18	0.04	0.08	0.12	0.16	0.24	0.32	0.36
WINTER	3	2,064	0.16	0.04	0.08	0.12	0.16	0.20	0.28	0.32
WINTER	4	2,064	0.15	0.04	0.08	0.12	0.16	0.20	0.24	0.28
WINTER	5	2,064	0.18	0.04	0.08	0.12	0.16	0.24	0.28	0.32
WINTER	6	2,064	0.30	0.08	0.12	0.20	0.28	0.40	0.48	0.56
WINTER	7	2,064	0.53	0.16	0.20	0.32	0.52	0.72	0.88	0.96
WINTER	8	2,063	0.74	0.28	0.36	0.52	0.76	0.96	1.08	1.20
WINTER	9	2,064	0.73	0.40	0.48	0.60	0.72	0.84	1.00	1.08
WINTER	10	2,063	0.65	0.32	0.40	0.52	0.64	0.80	0.92	1.04
WINTER	11	2,064	0.61	0.28	0.32	0.44	0.56	0.76	0.96	1.04
WINTER	12	2,058	0.57	0.24	0.32	0.40	0.52	0.72	0.88	1.00
WINTER	13	2,064	0.52	0.20	0.28	0.36	0.48	0.64	0.84	0.92
WINTER	14	2,064	0.47	0.20	0.24	0.32	0.44	0.60	0.72	0.80
WINTER	15	2,064	0.43	0.16	0.20	0.28	0.40	0.56	0.68	0.80
WINTER	16	2,064	0.40	0.16	0.20	0.28	0.40	0.52	0.64	0.76
WINTER	17	2,064	0.45	0.20	0.24	0.32	0.44	0.56	0.68	0.76
WINTER	18	2,059	0.52	0.28	0.32	0.40	0.52	0.60	0.72	0.80
WINTER	19	2,060	0.61	0.32	0.40	0.48	0.60	0.72	0.84	0.88
WINTER	20	2,060	0.65	0.36	0.40	0.52	0.64	0.76	0.88	1.00
WINTER	21	2,062	0.60	0.32	0.36	0.48	0.60	0.72	0.84	0.92
WINTER	22	2,061	0.54	0.28	0.32	0.44	0.52	0.64	0.76	0.84
WINTER	23	2,064	0.50	0.24	0.32	0.40	0.48	0.60	0.72	0.80
WINTER	24	2,064	0.38	0.16	0.20	0.28	0.36	0.48	0.56	0.64

Table 16 – Winter Average WH Demand Distribution

5.3.3 Seasonal and Weekday/Weekend Sensitivity

Figure 15 examines hour ending 7am by distinguishing between weekdays and weekends and summer and winter. Clearly, the savings estimates differ by season and average weekday versus weekend. Table 17, Table 18, and Table 19 summarizes the water heater savings distributions for the 100% cycling strategy. We recommend selecting the median point in the distribution as the deemed savings by season and time period. These are presented in Table 20.

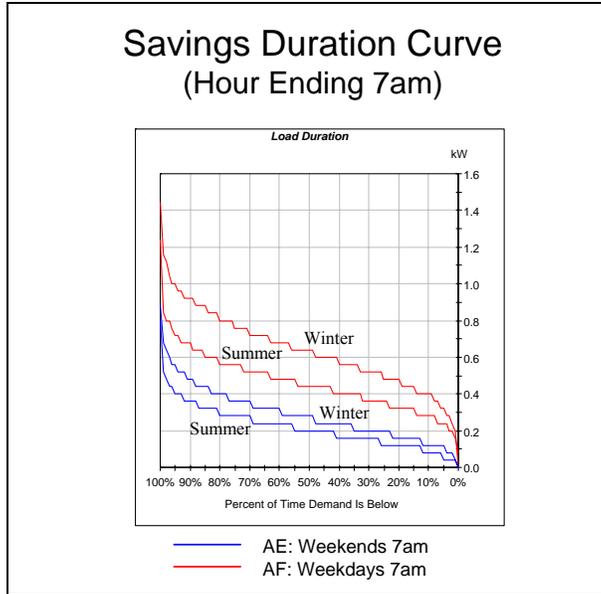


Figure 15 – Savings Duration Curve (7am)

Deemed Savings Estimates for
Legacy Residential AC and WH Programs

Season	Type	Hour	n	Percentiles							
				Mean	5th	10th	25th	Median	75th	90th	95th
SPRFAL	Weekday	1	1,660	0.19	0.04	0.08	0.12	0.16	0.24	0.32	0.36
SPRFAL	Weekday	2	1,660	0.13	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SPRFAL	Weekday	3	1,660	0.11	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SPRFAL	Weekday	4	1,660	0.11	0.04	0.04	0.08	0.12	0.16	0.20	0.20
SPRFAL	Weekday	5	1,660	0.14	0.04	0.04	0.08	0.12	0.20	0.24	0.28
SPRFAL	Weekday	6	1,660	0.31	0.12	0.16	0.24	0.28	0.40	0.48	0.52
SPRFAL	Weekday	7	1,657	0.58	0.28	0.36	0.44	0.56	0.72	0.84	0.92
SPRFAL	Weekday	8	1,659	0.74	0.44	0.52	0.60	0.76	0.88	1.00	1.04
SPRFAL	Weekday	9	1,659	0.59	0.32	0.36	0.44	0.56	0.72	0.84	0.92
SPRFAL	Weekday	10	1,660	0.46	0.24	0.28	0.36	0.44	0.56	0.68	0.74
SPRFAL	Weekday	11	1,660	0.40	0.20	0.24	0.28	0.40	0.48	0.60	0.68
SPRFAL	Weekday	12	1,663	0.36	0.16	0.20	0.28	0.36	0.44	0.56	0.64
SPRFAL	Weekday	13	1,663	0.34	0.12	0.16	0.24	0.32	0.40	0.52	0.60
SPRFAL	Weekday	14	1,659	0.32	0.12	0.16	0.24	0.32	0.40	0.48	0.56
SPRFAL	Weekday	15	1,658	0.29	0.12	0.16	0.20	0.28	0.36	0.44	0.52
SPRFAL	Weekday	16	1,656	0.27	0.12	0.12	0.20	0.28	0.36	0.44	0.48
SPRFAL	Weekday	17	1,656	0.32	0.16	0.16	0.24	0.32	0.40	0.48	0.52
SPRFAL	Weekday	18	1,655	0.39	0.20	0.24	0.28	0.40	0.48	0.56	0.64
SPRFAL	Weekday	19	1,655	0.47	0.24	0.28	0.36	0.48	0.56	0.64	0.72
SPRFAL	Weekday	20	1,657	0.52	0.28	0.32	0.40	0.52	0.60	0.72	0.80
SPRFAL	Weekday	21	1,658	0.51	0.28	0.32	0.40	0.52	0.60	0.72	0.80
SPRFAL	Weekday	22	1,660	0.49	0.24	0.28	0.36	0.48	0.60	0.72	0.76
SPRFAL	Weekday	23	1,662	0.44	0.20	0.24	0.32	0.44	0.52	0.64	0.68
SPRFAL	Weekday	24	1,663	0.31	0.12	0.16	0.20	0.28	0.40	0.48	0.52
Season	Type	Hour	n	Mean	5th	10th	25th	Median	75th	90th	95th
SPRFAL	Weekend	1	656	0.23	0.08	0.12	0.16	0.24	0.28	0.36	0.40
SPRFAL	Weekend	2	656	0.15	0.04	0.04	0.08	0.16	0.20	0.24	0.28
SPRFAL	Weekend	3	640	0.13	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SPRFAL	Weekend	4	656	0.11	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SPRFAL	Weekend	5	656	0.11	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SPRFAL	Weekend	6	656	0.13	0.04	0.04	0.08	0.12	0.16	0.24	0.28
SPRFAL	Weekend	7	656	0.24	0.08	0.12	0.16	0.24	0.32	0.40	0.44
SPRFAL	Weekend	8	656	0.44	0.20	0.24	0.32	0.44	0.52	0.64	0.72
SPRFAL	Weekend	9	656	0.59	0.36	0.40	0.48	0.56	0.68	0.80	0.88
SPRFAL	Weekend	10	656	0.64	0.36	0.40	0.52	0.64	0.76	0.88	0.96
SPRFAL	Weekend	11	656	0.64	0.40	0.44	0.52	0.62	0.76	0.88	0.96
SPRFAL	Weekend	12	656	0.59	0.32	0.40	0.48	0.60	0.68	0.80	0.88
SPRFAL	Weekend	13	656	0.54	0.28	0.36	0.44	0.52	0.64	0.76	0.84
SPRFAL	Weekend	14	656	0.49	0.28	0.32	0.40	0.48	0.60	0.68	0.76
SPRFAL	Weekend	15	656	0.45	0.24	0.28	0.36	0.44	0.52	0.64	0.68
SPRFAL	Weekend	16	656	0.41	0.20	0.24	0.32	0.40	0.52	0.60	0.68
SPRFAL	Weekend	17	656	0.45	0.24	0.28	0.36	0.44	0.56	0.64	0.72
SPRFAL	Weekend	18	656	0.47	0.24	0.28	0.36	0.44	0.56	0.64	0.72
SPRFAL	Weekend	19	656	0.48	0.24	0.32	0.40	0.48	0.56	0.68	0.76
SPRFAL	Weekend	20	656	0.52	0.28	0.32	0.40	0.52	0.64	0.72	0.80
SPRFAL	Weekend	21	656	0.52	0.28	0.32	0.40	0.52	0.64	0.72	0.80
SPRFAL	Weekend	22	656	0.48	0.24	0.28	0.36	0.46	0.56	0.68	0.76
SPRFAL	Weekend	23	656	0.41	0.20	0.24	0.32	0.40	0.52	0.60	0.68
SPRFAL	Weekend	24	656	0.33	0.16	0.20	0.24	0.32	0.40	0.48	0.56

Table 17 – Spring/Fall Average Weekday/Weekend Savings Distribution

Deemed Savings Estimates for
Legacy Residential AC and WH Programs

Season	Type	Hour	n	Percentiles							
				Mean	5th	10th	25th	Median	75th	90th	95th
SUMMER	Weekday	1	1,724	0.16	0.04	0.08	0.12	0.16	0.20	0.28	0.32
SUMMER	Weekday	2	1,724	0.11	0.04	0.04	0.08	0.08	0.12	0.20	0.20
SUMMER	Weekday	3	1,724	0.09	0.00	0.04	0.04	0.08	0.12	0.16	0.20
SUMMER	Weekday	4	1,724	0.09	0.00	0.04	0.04	0.08	0.12	0.16	0.16
SUMMER	Weekday	5	1,724	0.11	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SUMMER	Weekday	6	1,724	0.26	0.12	0.12	0.20	0.24	0.32	0.40	0.44
SUMMER	Weekday	7	1,724	0.45	0.24	0.28	0.36	0.44	0.56	0.64	0.72
SUMMER	Weekday	8	1,724	0.58	0.32	0.40	0.48	0.56	0.68	0.80	0.88
SUMMER	Weekday	9	1,724	0.45	0.24	0.28	0.36	0.44	0.52	0.64	0.72
SUMMER	Weekday	10	1,724	0.37	0.20	0.24	0.28	0.36	0.44	0.52	0.60
SUMMER	Weekday	11	1,719	0.34	0.16	0.20	0.24	0.32	0.40	0.52	0.56
SUMMER	Weekday	12	1,685	0.31	0.12	0.16	0.24	0.28	0.36	0.48	0.52
SUMMER	Weekday	13	1,661	0.28	0.12	0.16	0.20	0.28	0.36	0.44	0.48
SUMMER	Weekday	14	1,627	0.26	0.12	0.12	0.20	0.24	0.32	0.40	0.44
SUMMER	Weekday	15	1,596	0.24	0.08	0.12	0.16	0.24	0.32	0.36	0.44
SUMMER	Weekday	16	1,589	0.23	0.08	0.12	0.16	0.24	0.28	0.36	0.40
SUMMER	Weekday	17	1,572	0.27	0.12	0.16	0.20	0.28	0.32	0.40	0.44
SUMMER	Weekday	18	1,576	0.32	0.16	0.20	0.24	0.32	0.40	0.48	0.52
SUMMER	Weekday	19	1,600	0.38	0.20	0.24	0.28	0.36	0.44	0.52	0.60
SUMMER	Weekday	20	1,609	0.41	0.20	0.24	0.32	0.40	0.48	0.56	0.60
SUMMER	Weekday	21	1,644	0.43	0.20	0.24	0.32	0.40	0.52	0.60	0.68
SUMMER	Weekday	22	1,676	0.42	0.24	0.24	0.32	0.40	0.52	0.60	0.68
SUMMER	Weekday	23	1,713	0.38	0.16	0.24	0.28	0.36	0.48	0.56	0.64
SUMMER	Weekday	24	1,724	0.27	0.12	0.16	0.20	0.28	0.32	0.40	0.44
Season	Type	Hour	n	Mean	5th	10th	25th	Median	75th	90th	95th
SUMMER	Weekend	1	716	0.19	0.08	0.08	0.12	0.16	0.24	0.28	0.36
SUMMER	Weekend	2	716	0.13	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SUMMER	Weekend	3	716	0.10	0.00	0.04	0.04	0.08	0.12	0.16	0.20
SUMMER	Weekend	4	716	0.09	0.00	0.04	0.04	0.08	0.12	0.16	0.20
SUMMER	Weekend	5	716	0.09	0.00	0.04	0.04	0.08	0.12	0.16	0.20
SUMMER	Weekend	6	716	0.11	0.04	0.04	0.08	0.12	0.16	0.20	0.24
SUMMER	Weekend	7	716	0.22	0.04	0.08	0.12	0.20	0.28	0.36	0.40
SUMMER	Weekend	8	716	0.37	0.16	0.20	0.28	0.36	0.44	0.52	0.60
SUMMER	Weekend	9	716	0.48	0.28	0.32	0.36	0.48	0.56	0.68	0.72
SUMMER	Weekend	10	716	0.50	0.28	0.32	0.40	0.48	0.60	0.72	0.80
SUMMER	Weekend	11	716	0.49	0.24	0.32	0.36	0.48	0.56	0.68	0.80
SUMMER	Weekend	12	716	0.47	0.24	0.28	0.36	0.48	0.56	0.64	0.68
SUMMER	Weekend	13	716	0.43	0.24	0.28	0.32	0.40	0.52	0.60	0.68
SUMMER	Weekend	14	716	0.41	0.20	0.24	0.32	0.40	0.48	0.60	0.64
SUMMER	Weekend	15	716	0.37	0.20	0.24	0.28	0.36	0.44	0.52	0.60
SUMMER	Weekend	16	716	0.34	0.16	0.20	0.24	0.32	0.40	0.52	0.56
SUMMER	Weekend	17	716	0.36	0.16	0.20	0.28	0.36	0.44	0.52	0.56
SUMMER	Weekend	18	716	0.36	0.20	0.24	0.28	0.36	0.44	0.52	0.56
SUMMER	Weekend	19	716	0.38	0.20	0.24	0.28	0.40	0.48	0.56	0.60
SUMMER	Weekend	20	716	0.41	0.20	0.24	0.32	0.40	0.52	0.60	0.64
SUMMER	Weekend	21	716	0.43	0.20	0.24	0.32	0.40	0.52	0.64	0.72
SUMMER	Weekend	22	716	0.41	0.20	0.24	0.32	0.40	0.48	0.60	0.68
SUMMER	Weekend	23	716	0.38	0.16	0.20	0.28	0.36	0.48	0.56	0.64
SUMMER	Weekend	24	716	0.28	0.12	0.16	0.20	0.28	0.36	0.44	0.48

Table 18 – Summer Average Weekday/Weekend Savings Distribution

Deemed Savings Estimates for
Legacy Residential AC and WH Programs

Season	Type	Hour	n	Percentiles							
				Mean	5th	10th	25th	Median	75th	90th	95th
WINTER	Weekday	1	1,448	0.26	0.08	0.12	0.16	0.24	0.32	0.40	0.48
WINTER	Weekday	2	1,448	0.17	0.04	0.08	0.12	0.16	0.20	0.28	0.32
WINTER	Weekday	3	1,448	0.16	0.04	0.08	0.12	0.16	0.20	0.24	0.28
WINTER	Weekday	4	1,448	0.15	0.04	0.04	0.12	0.16	0.20	0.24	0.28
WINTER	Weekday	5	1,448	0.19	0.08	0.08	0.12	0.20	0.24	0.32	0.36
WINTER	Weekday	6	1,448	0.35	0.16	0.20	0.28	0.32	0.44	0.52	0.60
WINTER	Weekday	7	1,448	0.63	0.28	0.36	0.48	0.64	0.76	0.92	1.00
WINTER	Weekday	8	1,447	0.85	0.40	0.52	0.72	0.84	1.00	1.16	1.20
WINTER	Weekday	9	1,448	0.74	0.40	0.48	0.60	0.72	0.88	1.04	1.12
WINTER	Weekday	10	1,448	0.59	0.28	0.36	0.48	0.56	0.72	0.84	0.92
WINTER	Weekday	11	1,448	0.51	0.24	0.28	0.40	0.48	0.62	0.76	0.84
WINTER	Weekday	12	1,442	0.48	0.24	0.28	0.36	0.44	0.60	0.72	0.84
WINTER	Weekday	13	1,448	0.44	0.20	0.24	0.32	0.44	0.56	0.68	0.76
WINTER	Weekday	14	1,448	0.41	0.16	0.24	0.28	0.40	0.52	0.64	0.68
WINTER	Weekday	15	1,448	0.37	0.16	0.20	0.28	0.36	0.46	0.56	0.64
WINTER	Weekday	16	1,448	0.35	0.12	0.16	0.24	0.32	0.44	0.56	0.64
WINTER	Weekday	17	1,448	0.41	0.16	0.24	0.32	0.40	0.48	0.60	0.68
WINTER	Weekday	18	1,443	0.49	0.24	0.28	0.40	0.48	0.60	0.68	0.80
WINTER	Weekday	19	1,444	0.60	0.32	0.40	0.48	0.60	0.72	0.80	0.88
WINTER	Weekday	20	1,444	0.65	0.36	0.40	0.52	0.64	0.76	0.88	0.96
WINTER	Weekday	21	1,446	0.60	0.28	0.36	0.48	0.60	0.72	0.84	0.92
WINTER	Weekday	22	1,445	0.55	0.28	0.36	0.44	0.56	0.64	0.76	0.80
WINTER	Weekday	23	1,448	0.51	0.24	0.32	0.40	0.52	0.60	0.72	0.80
WINTER	Weekday	24	1,448	0.37	0.16	0.20	0.28	0.36	0.48	0.56	0.64
Season	Type	Hour	n	Mean	5th	10th	25th	Median	75th	90th	95th
WINTER	Weekend	1	616	0.30	0.12	0.12	0.20	0.28	0.36	0.48	0.52
WINTER	Weekend	2	616	0.21	0.08	0.08	0.16	0.20	0.28	0.36	0.40
WINTER	Weekend	3	616	0.17	0.04	0.08	0.12	0.16	0.24	0.28	0.32
WINTER	Weekend	4	616	0.15	0.04	0.08	0.12	0.16	0.20	0.24	0.28
WINTER	Weekend	5	616	0.15	0.04	0.04	0.08	0.16	0.20	0.24	0.28
WINTER	Weekend	6	616	0.18	0.04	0.08	0.12	0.16	0.24	0.28	0.32
WINTER	Weekend	7	616	0.28	0.08	0.12	0.20	0.28	0.36	0.48	0.56
WINTER	Weekend	8	616	0.50	0.20	0.28	0.36	0.48	0.64	0.76	0.84
WINTER	Weekend	9	616	0.69	0.40	0.44	0.56	0.68	0.80	0.96	1.04
WINTER	Weekend	10	615	0.82	0.48	0.56	0.68	0.80	0.96	1.08	1.20
WINTER	Weekend	11	616	0.83	0.48	0.56	0.68	0.84	0.96	1.12	1.20
WINTER	Weekend	12	616	0.76	0.48	0.52	0.64	0.72	0.88	1.04	1.12
WINTER	Weekend	13	616	0.71	0.44	0.48	0.60	0.68	0.84	0.96	1.04
WINTER	Weekend	14	616	0.62	0.36	0.40	0.50	0.60	0.76	0.84	0.92
WINTER	Weekend	15	616	0.58	0.28	0.36	0.44	0.56	0.68	0.84	0.92
WINTER	Weekend	16	616	0.52	0.24	0.28	0.40	0.52	0.64	0.76	0.84
WINTER	Weekend	17	616	0.57	0.28	0.36	0.44	0.56	0.68	0.80	0.88
WINTER	Weekend	18	616	0.59	0.36	0.40	0.48	0.56	0.68	0.80	0.88
WINTER	Weekend	19	616	0.63	0.32	0.40	0.52	0.64	0.76	0.84	0.92
WINTER	Weekend	20	616	0.66	0.36	0.44	0.56	0.64	0.76	0.88	1.00
WINTER	Weekend	21	616	0.60	0.36	0.40	0.48	0.60	0.72	0.84	0.92
WINTER	Weekend	22	616	0.53	0.28	0.32	0.40	0.52	0.64	0.76	0.84
WINTER	Weekend	23	616	0.48	0.24	0.28	0.38	0.48	0.56	0.68	0.76
WINTER	Weekend	24	616	0.39	0.16	0.24	0.28	0.40	0.48	0.56	0.64

Table 19 – Winter Average Weekday/Weekend Savings Distribution

Season	DayType	Selected Time Periods															
		6am	7am	8am	9am	10am	11am	12N	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm
Spring/Fall	Weekday	0.28	0.56	0.76	0.56	0.44	0.40	0.36	0.32	0.32	0.28	0.28	0.32	0.40	0.48	0.52	0.52
Spring/Fall	Weekend	0.12	0.24	0.44	0.56	0.64	0.62	0.60	0.52	0.48	0.44	0.40	0.44	0.44	0.48	0.52	0.52
Summer	Weekday	0.24	0.44	0.56	0.44	0.36	0.32	0.28	0.28	0.24	0.24	0.28	0.32	0.36	0.40	0.40	0.40
Summer	Weekend	0.12	0.20	0.36	0.48	0.48	0.48	0.48	0.40	0.40	0.36	0.32	0.36	0.36	0.40	0.40	0.40
Winter	Weekday	0.32	0.64	0.84	0.72	0.56	0.48	0.44	0.44	0.40	0.36	0.32	0.40	0.48	0.60	0.64	0.60
Winter	Weekend	0.16	0.28	0.48	0.68	0.80	0.84	0.72	0.68	0.60	0.56	0.52	0.56	0.64	0.64	0.60	0.60

Table 20 – Median Savings Estimates by Season and Day Type

6 FUTURE STUDIES

6.1 Cooperative Projects

As the PJM utilities explore new demand response initiatives consideration should be given to conducting regional studies that effectively pool the resources of the participating utilities. Figure Ex 12 presents a map of the PJM territory. The figure shows a territory that stretches from the eastern seaboard to the western part of Illinois. We would recommend a regional stratification with sufficient sample points to meet some minimum precision criterion, e.g., 90% confidence $\pm 20\%$ precision. Sufficient data should be assembled to allow the pooled metering results to be directly applied to the various service territories. For any end-use metered data collected this would include the whole house consumption information¹⁸ to use as an analytical link with the respective population billing systems. We believe that the final estimate should take advantage of the wealth of data collected by the contributing utilities while reflecting the unique characteristics of the specific service territory.

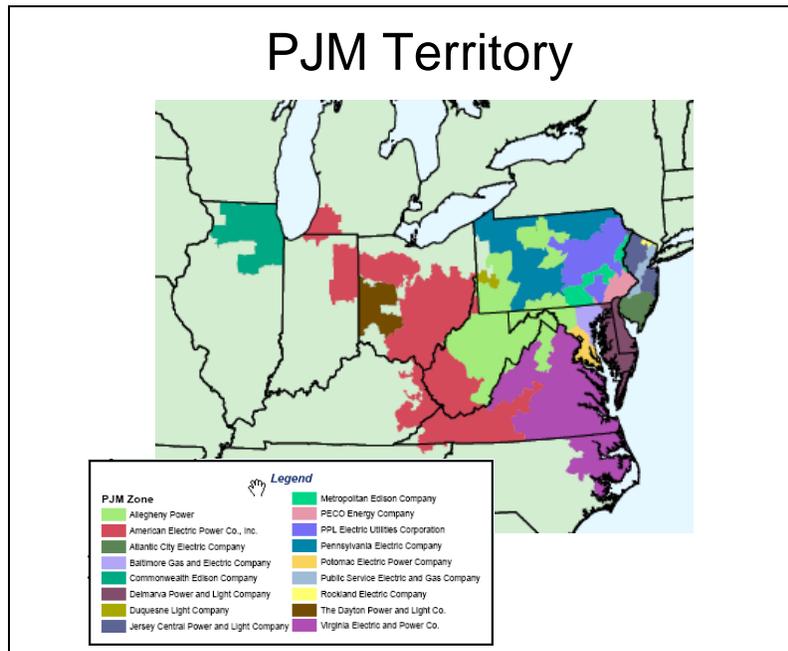


Figure Ex 2 – PJM Service Territory

6.2 Operability Studies

In reviewing the prior studies, we noted that the two utilities that had conducted operability studies in 2001 did find significant operability problems. We recommend that each utility be required to conduct periodic operability studies, using a common sampling, testing and reporting methodology. Initially, we recommend that each utility select a simple random sample of 250 program participants and determine the operability

¹⁸ Whole premise billing information was unavailable for some of the participants included in the current analysis. This required the project team to make necessary assumptions in order to combine the data from the three service territories. Some of the concerns raised by this approach are alleviated in the stratum level analysis.

of the switch(s) at each sample home.¹⁹ The testing protocol should verify both signal reception and switch operation, and identify the underlying causes of the problems that are encountered. The utility should report the overall failure rate and the appropriate net to gross ratio to be used to adjust the gross impact.

The utility-specific operability study should be conducted at least every five years, but may be conducted more frequently if a utility believes it has taken steps to mitigate its operability problems and wishes to use an improved net to gross ratio.

If a utility has been able to demonstrate a net to gross ratio of 90% or higher then it is still required to conduct operability studies at least every five years, but a reduced sample size can be used. In this case the recommended sample is 100 homes.²⁰ If the reduced study yields an estimated net to gross ratio less than 90%, then we recommend that a full sample of 250 homes be tested as soon as practical and that the larger sample size be used in subsequent studies until the utility has again demonstrated a net to gross ratio of 90% or higher.²¹

¹⁹ A sample of 250 will give an error bound of at most ± 0.05 at the 90% level of confidence for the net to gross ratio. If a tighter error bound is desired then a larger sample will be agreed to and selected.

²⁰ If the net to gross ratio is 0.90 or larger, a sample of 100 will give an error bound of at most ± 0.05 at the 90% level of confidence for the true net to gross ratio.

²¹ Our recommendations have been informed by ISO 2859-1:1999(E), "Sampling Procedures for Inspection by Attributes" which is the current version of ANSI/ASQC Z1.4.

7 APPENDIX A: LRWG EDC SUBGROUP MEETING SUMMARY

7/28/2005, Baltimore, MD

A meeting of a subgroup of the recently-formed Load Research Working Group was held on July 28, 2005 in the PHI offices in downtown Baltimore. The subgroup comprised representatives from the four EDCs who reported EWH and AC load impact estimates to PJM in 2002-2003.

Attendees

Name	Position	Organization	Contact Information
Chris Siebens	DR Program Manager	JCP&L	csiebens@gpu.com
John Reynolds	Sr. Engineer	PJM Interconnection	reynolj@pjm.com
Grayson Heffner	Consultant	LBNL	gcheffner@lbl.gov
Mike Prendergast	Mgr- Demand Analysis	PSE&G	Michael.prendergast@pseg.com
Greg Urbin	Program Mgr	BG&E	Gregory.M.Urbin@bge.com
Mary M. Straub	Load Research Specialist	BG&E	Mary.m.straub@bge.com
Chuck Goldman	Program Manage	LBNL	cagoldman@lbl.gov
Curt Puckett	Vice-President	RLW Analytics	Curt.puckett@rlw.com
Steve Sunderhauf	Manager-Pgm Evaluation	PHI	slsunderhauf@pepco.com

Table 21 – LRWG Meeting Attendees: July 28, 2005

Meeting Purpose

The purpose of the meeting was to:

- Discuss and agree a joint plan for meeting the PJM ALM reporting requirements for 2006-2007 and beyond, which John Reynolds can take forward to the LAS and eventually the Operations Committee;
- Discuss the value and feasibility of estimating a PJM East regional model for estimating DLC impacts. Such a regional model would require load data contributions from all four EDCs, and could be done for air conditioners only or for both electric water heaters and air conditioners.

Review of LRWG Work to date

Since the June 23 LRWG kick-off meeting the following progress has been made:

- The Working Group and PJM Staff now agree that load impacts from existing AC and WH DLC programs are static and not subject to change even over long periods; therefore, even a quinquennial requirement for a load research study to re-estimate DLC load impacts may be unnecessary and too costly relative to program benefits.

- PJM staff agreed to propose to LAS and the Planning and Operations Committees a one-year delay in the 2006-2007 quinquennial requirement for load impact estimation, with the understanding that this time would be used to explore and develop new, cost-savings approaches to DLC M&V.
- John Reynolds reported that the Planning Committee at its July 28 meeting approved a suspension of the current load research rules for one year only, only the LRWG can complete its work.
- The EDCs holding load data from 2001-2002 have agreed to study whether a pooled approach to performing load impact estimation in the future, for both existing and new programs, is feasible and economical.
- As a first step the EDCs agreed to share with LBNL detailed information on their 2001-2002 studies.
- LBNL has retained RLW Associates as a load research statistical consultant, at no cost to PJM or the EDCs, to review the various study approaches and impact estimation methods and perform a feasibility study of EDC load data pooling for purposes of meeting PJM's DLC M&V requirements.

Strawman Plan for Meeting the 2006-2007 PJM M&V Requirements

Any changes in ALM M&V requirements, including delays in the M&V reporting schedule, must be approved by stakeholders – i.e., the Load Analysis Subcommittee and the Planning and Markets Committees. LBNL put forward the following strawman plan that PJM Staff could present to these committees in order to gain stakeholder support:

- PJM and stakeholders approve a one-year delay in the quinquennial load impact re-estimation requirement (from 2006-2007 to 2007-2008).
- Each EDC participating in the ALM DLC program proceeds with their switch operability/availability surveys in 2006 per usual.
- All four EDCs reporting DLC load impact estimates in 2001 collaborate in a load data pooling effort resulting in formulation of a PJM Eastern Region-wide model for estimating load impacts of air conditioners and water heaters.
- Based on confidence gained in pooling of data and regional models for estimating DLC load impacts, the EDCs would jointly propose a pooled approach to future load research on DLC impacts of both existing and new programs, including the possibility of fielding a single load research sample across the region rather than individual EDC load research samples.
- Any proposed changes to the load research rules would be available for stakeholder consideration in 2006.

RLW Discussion of Statistical Issues Associated with Pooled M&V Approach for PJM East EDCs

Curt Puckett of RLW Associates described the role of RLW in supporting the LREG efforts. RLW will provide input into the statistical and practical challenges associated with the different levels of M&V cooperation between the PJM East EDCs. RLW will produce a feasibility study of pooling of existing data for purposes of developing a region-wide load impact estimation model. Assuming the nature of the individual EDC

sample design and data holdings is conducive to pooling the data, RLW will draft a Work Plan for developing simplified DLC M&V procedures, including pooling of EDC resources, for 2007-2008 and beyond.

Curt went on to describe some of the challenges to a pooled M&V approach, including:

- Standardizing data associated with differing programs, time periods, cycling strategies, event days, and weather;
- Accommodating data taken at the whole-house vs. end-use level and at different intervals;
- Statistical weighting, ratio estimation techniques, or model specification needed to reflect and adjust for changing population pools, housing characteristics, end-use behavior and appliance characteristics.
- Samples stratified using different variables and with different number of strata and strata thresholds.

Curt described his initial review of the load impact estimation methods taken by the four EDCs, which comprise two generic approaches as follows:

- Duty-cycle modeling with pooled data to develop time-temperature matrices for various duty-cycle strategies. This approach is amenable to data pooling because it would be possible to use all available end-use metering data regardless of LSE, time period or frequency of data collection. The output of the EDC-specific models or a region-wide version would be a time-temperature (or THI) matrix as required by PJM.
- Regression-based event-day approach using pooled data. The event-day model could operate on total facility load data using a customer base line (CBL) or matched day strategy. Using this approach to develop a pooled model would have the advantage of drawing from a large sample of same-day data from across the EDCs and would still yield a time-temperature matrix of probable impacts.

Curt's initial conclusion is that a pooled approach is very promising, both for developing a regional model based on previous data collected and for developing load research strategies in the future. His likely recommendation will be to investigate strategies that combine both the duty-cycle and regression based approaches and see whether it is possible to leverage the end-use data together with the whole house data to develop improved estimates. Such a model specification will likely need additional variables to account for differences by PJM zone and program design.

Discussion

During and after the presentation of the LRWG work to date, the strawman plan, and statistical issues associated with pooled approaches to M&V, the EDC participants made the following comments and suggestions:

- The consideration of pooled approaches and regional model estimation should definitely extend to include EWH as well as AC direct control, even though only two EDCs (BGE and PEPCO) have large EWH programs.

- Similarly, the possibility of considering all participants in similar programs as part of a single PJM East regional population for which one sample could be drawn should logically apply to not only existing but new programs. This would serve the objective of lowering the barriers to entry of new technologies and program designs.
- In developing and submitting plans for the 2006 switch operability survey it would be useful to adopt and share with PJM some standard guidelines for the switch survey design. Each EDC would then be free to meet or exceed these minimum guidelines. It was agreed that the objective of the operability survey is to determine what fraction of the total program population has operable switches. Inspection of operability is at EDC discretion, and may include visual inspection only or use of hand-held transmitters or other devices.
- The possibility of a single operability sample drawn across all the EDCs was discussed. Although the idea of a pooled sample has merit, the individual characteristics and distinctive history of each program, including signal transmission coverage issues, mitigate against trying such an approach for next year.
- In performing its scope of work RLW should separately study the feasibility of and develop a work plan for the AC and EWH programs.
- BGE pointed out that the benefits to them of a pooled approach is likely less than for PSE&G and JCP&L. This is because BGE has a standing load research sample from which they collect and analyze data on an ongoing basis. However, BGE is supportive of the concept, especially if it could be extended to commercial load control programs and residential EWH programs.
- PEPCO asked how widely the results of a regional model for estimating EWH and AC DLC impacts would be shared. This is a threshold issue for agreeing to support such an effort, as EDCs would need to be reassured that such an effort and product would not result in competitive disadvantage for them or their parent companies. This is likely an issue that should be taken to the LWG and LAS.
- RLW indicated that they would not require actual load data for the initial feasibility study and work plan development. LBNL raised the issue of data confidentiality with the utilities as an issue that may have to be addressed depending on the workplan.

Outcomes and Next Steps

The EDCs participating in the meeting endorsed the feasibility study and work plan development, although it was made clear that no commitments were being made in terms of funding any actual pooled regional model estimation work at this time. RLW and LBNL will perform the feasibility study and, if results warrant, work plan development in time for the next meeting of the LRWG in late August. The study and work plan will be circulated to the EDC subgroup (and PJM) for comment before being sent to the full LRWG. The EDCs also expressed thanks for LBL support to development by RLW of some simple survey guidelines for next year's switch operability survey. RLW will develop these guidelines and circulate them within a week, again to the EDCs and PJM for comment first. In anticipation of a positive result of the feasibility study, the EDCs

agreed to locate and ready their 2001-2002 load data for use. The EDCs also agreed to work with LBL and RLW to finish gathering the detailed documentation on their sample designs and data specifications, per the Annex to this Meeting Summary. The next meeting of the full LRWG was rescheduled for Aug. 30 from 10 am to noon in Wilmington. PJM will take care of the announcement and arrangements.

Outcomes

Agree on a proposed 2006-2007 M&V approach to take to LAS and Operations Committee in September

Commission (with LBL funding) a feasibility study & work plan for pooling M&V data for purposes of developing a region-wide load impact model

Agree to share load data from 2002 should a pooled approach be found feasible & economical

Submit plans for 2006 switch availability surveys

Consider pooling resources for other M&V tasks

A second meeting of the Load Research Working Group was scheduled for August 25 to allow discussion of the proposed M&V protocols as well as other issues related to load research collaboration and cooperation.

	JCP&L/GPU/FirstEnergy Air Conditioner Load Control Program	PEPCO KiloWatchers Club and Plus Program	PSE&G's Cool Customer Program	BG&E's Residential Rider 5																				
Date Channels	Recorder # 1: Whole House Recorder # 2: AC Compressor	AC Program: Whole house WH Program: End-use data loggers	Forthcoming	AC Program: Compressor Load WH Program: EWH load																				
Data Collection Intervals	15 minute	15 minute	Forthcoming	15 minute																				
Load Impact Study Contractor	Quantum Consulting	Demand Research (Dr. Marvin Horowitz/Johns Hopkins Univ, President)	Kema/Xenergy	In house																				
Sample Stratification – Air Conditioner Studies	Stratified Random Sample with 4 strata, based on total kWh usage in July-August billing cycled 1999	510 points spread amongst 3 separate sub-populations: DC, Montgomery County, PG County. Other details forthcoming.	Forthcoming	88 useable data points stratified into two equal-sized cells based on monthly energy use August 1999. Threshold: ≤ 1717 kWh \geq <table border="1"> <tr> <td></td> <td>≤ 1717 kWh</td> <td>≥ 1717 kWh</td> </tr> <tr> <td>Pop.</td> <td>184000</td> <td>76335</td> </tr> <tr> <td>Sample</td> <td>TBD</td> <td>TBD</td> </tr> </table>		≤ 1717 kWh	≥ 1717 kWh	Pop.	184000	76335	Sample	TBD	TBD											
	≤ 1717 kWh	≥ 1717 kWh																						
Pop.	184000	76335																						
Sample	TBD	TBD																						
Sample Stratification – Water Heater Studies	N/A	60 points in a Simple Random Sample, no jurisdictional split	N/A	Sample size: 52 useable data points in a four-way strata by TOU vs. non-TOU and greater than or less than a monthly energy use in August 1999 of 1592 kWh <table border="1"> <tr> <td>Strata 1</td> <td></td> <td>≤ 1592</td> <td>≥ 1592</td> </tr> <tr> <td>Non-TOU</td> <td>Pop.</td> <td>34476</td> <td>14755</td> </tr> <tr> <td></td> <td>Sample</td> <td>25</td> <td>18</td> </tr> <tr> <td>TOU</td> <td>Pop.</td> <td>12744</td> <td>10146</td> </tr> <tr> <td></td> <td>Sample</td> <td>10</td> <td>12</td> </tr> </table>	Strata 1		≤ 1592	≥ 1592	Non-TOU	Pop.	34476	14755		Sample	25	18	TOU	Pop.	12744	10146		Sample	10	12
Strata 1		≤ 1592	≥ 1592																					
Non-TOU	Pop.	34476	14755																					
	Sample	25	18																					
TOU	Pop.	12744	10146																					
	Sample	10	12																					
Load Control Strategy	AC: 15 min out of every half hour	AC: 13 min per half hour for 6 hrs (<i>Club</i>) 100% Load shed for up to 6 hours (<i>Plus</i>) WH: 100% Load shed up to 6 hours	Forthcoming	AC: 15 min per half hour WH: 100% load shed																				
Availability of population data	With some difficulty	With some difficulty		With some difficulty																				
Availability of demographic data	# of AC units: NO AC Tonnage: YES Household size (ft ²): NO	# of AC units: NO AC Tonnage: NO Household size (ft ²): NO EWH size (gal): YES	Forthcoming	# of AC units: YES AC Tonnage: NO Household size (ft ²): NO EWH size (gal): NO																				

Annex: Comparison of Load Research Sample Designs & Load Data Specification

8 APPENDIX B: LRWG MEETING SUMMARY

8/30/2005, Wilmington, DE

A meeting of the Load Research Working Group was held on August 30, 2005 at the Spencer Hotel in downtown, Wilmington, Delaware. Table 22 lists the individuals in attendance and their affiliation.

Name	Company Name
At the Meeting In Person	
Blume, Craig	UGI Utilities Inc.
Heffner, Grayson	Lawrence Berkley National Laboratories
Lowe, Will	Potomac Electric Power Company
Miyaji, Wendell	Comverge
Prendergast, Mike	Public Service Electric and Gas
Puckett, Curt	RLW Analytics
Puryear, Erin	Old Dominion Electric Cooperative
Reynolds, John	PJM Interconnection
Slivka, John	PJM Interconnection
On Conference Call In Line	
??	American Electric Power
Bertocchi, John D.	Jersey Central Power and Light Company
Chintapalli, Raj	Customized Energy Solutions, Ltd.
Goldman, Chuck	Lawrence Berkley National Laboratories
Icart, Eric	Public Service Commission of Maryland
Kogut, George	Consolidated Edison of New York
Nowicki, Linda	New Jersey Board of Public Utilities
Siebens, Chris	Jersey Central Power and Light Company
Straub, Mary	Baltimore Gas and Electric Company

Table 22 – LRWG Meeting Attendees: August 30, 2005

Meeting Purpose

The primary purpose of the meeting was to review the work completed to date by the LBNL team on the feasibility of a pooled approach to Active Load Management/Direct Load Control (ALM/DLC) measurement & verification (M&V).

Meeting Notes

John Reynolds, PJM, welcomed everyone to the meeting and initiated the introductions. Grayson Heffner then reviewed the agenda and the steps leading up to the development of the feasibility study, i.e. the June 23, 2005 kick-off meeting establishing the LRWG within the Load Analysis Subcommittee, and an August 28, 2005 meeting of the four PJM LSEs with 2001/2002 ALM/DLC M&V results. Grayson noted recent action by PJM's Operations Committee granting a one year delay in the quinquennial²² requirement for load impact estimation on direct load control programs. There was some discussion among the participants regarding the exact meaning of the delay. There was general agreement that results for the 2006 commitment could be deferred until at least 2007. Grayson reiterated that the goal of the feasibility study was to be forward looking and explore opportunities to pool resources and data to reduce M&V costs across the PJM

²² Every five years.

region. Further he described the project's objective as "work with the various stakeholders to explore and develop a collaborative, consensus based approach to meeting future M&V requirements." At this point, Grayson turned the meeting over to Curt Puckett.

Curt Puckett, of *RLW Analytics* (which has been funded by LBNL) then presented the feasibility study (both the study itself and the summary presentation are available on the PJM website). In general, the consensus was that the differences that existed were not significant enough to prevent a pooled analysis to be completed and a cross zonal study to be developed.

The conclusions of the feasibility study were summarized as follows:

- Program impacts appear to be more strongly affected by operational issues over time than by changes in gross savings/household;
- Current M&V policy of differentiating the analysis of operational performance from the analysis of gross savings is appropriate;
- A simple re-analysis of the historical data may not satisfy PJM's Manual 19 requirements as currently written;
- A DLC M&V study that cuts across the entire PJM footprint is feasible and should be considered as an alternative to continued LSE-specific load research studies; and
- Standardized methods for data collection, analysis and PJM reporting should be pursued.

This portion of the program was closed by describing the results of two additional tasks assigned during the last subgroup meeting, i.e., the development of a straw man work plan for the execution of the recommendations of the project, and the development of a protocol for conducting future operability studies.

The presentation was followed by a general discussion. John Reynolds began by summarizing the alternatives for M&V of these legacy type programs. A low cost solution to the M&V challenge would deal with pooling the historical data to develop a single estimate. At the far end of the cost spectrum was having each LSE implement a new indigenous study. A middle ground might be a cross zonal sample and a pooled estimate.

There was some general discussion regarding these alternatives. The discussion focused on the value of fielding a new load research sample given that these legacy programs were in their declining years and new, innovative technology e.g., "smart" thermostats, was already being discussed by each of the LSEs as future replacement programs. The general conclusion was that it was probably not necessary to conduct another "new" field study but that there were some merits in attempting to pool the available historical data into a combined, region-wide estimation model.

A reanalysis of the historical data was described as a crucial step in the straw man work plan and could reasonably be completed by the end of 2005. The reanalysis would be a useful test of the proposed analysis strategy and would allow the group to reach common ground on a number of the ancillary issues surrounding future projects. Further, if at the conclusion of the reanalysis agreement could be reached to accept the results as a “deemed” savings estimate, then the “new” field study could possibly be cancelled. If the reanalysis failed to yield a reliable estimate then the “new” field study could be launched with data collection slated for as early as the summer 2006. There was some discussion regarding whether or not there was a need to have the results in this relatively short time frame. John Reynolds pointed out that the LRWG needed to report their conclusions to the LAS by the end of the year.

The reanalysis would require several pieces of data from the LSEs including:

- Individual interval load data,
- Corresponding weather data,
- Historical billing consumption data, i.e., July and August use, for the interval load customers used for post-stratification,
- Population tracking data for the current program participants, and
- Billing consumption data, preferably 13-months of use, for the current program participants.

A straw poll was taken to see how difficult securing the requested data would be. Each of the utilities responded that with the exception of the historical July and August billing data that most of the other data should be readily available. Other LSEs in attendance were polled regarding the availability of data. No other data were identified; however, John Reynolds indicated that he would send a solicitation to those LSEs in the PJM area that might have additional data.

Chuck Goldman, LBNL, discussed the issues of confidentiality and disclosure indicating that this could be a potential stumbling block for a project with such a short initial launch. None of the LSEs seemed to view this as much of an issue. Further, Chuck indicated a willingness by LBNL to join the LSEs in financially supporting the pooled model estimation work, provided that LBNL would have the option to publish the results. Grayson Heffner indicated that a separate discussion would need to be held with the LSE subgroup to discuss contractual and procurement issues. There was some general discussion on the willingness of the LSEs to contribute financial resources to the pooled model estimation effort. It was suggested that a pooled model could be completed for less than \$100,000. The LSEs seemed receptive to supporting the effort, as long as the cost was modest.

The meeting concluded with a summary of next steps and action items by Grayson Heffner:

- *RLW* would revise and complete the feasibility study based on the discussion at today’s meeting;

- *RLW* would develop a schedule and cost estimate to perform the work outlined as the reanalysis component of the Work Plan included as Appendix A of the feasibility study (see above);
- LBNL to prepare a letter memo regarding disclosure and confidentiality arrangements for this effort;
- PJM Staff to poll whether other LSEs would like to join the core group of four utilities with either data offerings or resources to support the second phase work;
- A subgroup comprising the four utilities plus any other interested LSEs to meet and arrange all the details for the follow-on effort;
- This subgroup would then advise the work itself; and
- The next full meeting of the LRWG would be after the regional model has been estimated and results available for review and presentation to the LAS.

9 APPENDIX C: COMPARISON OF LSE RESULTS

A supplemental task associated with this project is to perform statistical tests on the estimates to identify whether or not the estimates are statistically different. Table 23, has selected estimates and the associated standard errors.

	Demand Reduction (kW) for Hour Ending							
	PSE&G ¹	GPU ^{1,2}	BGE	Conectiv ³	PEPCO-DC ⁴	PEPCO-DC ⁴	PEPCO-MD ⁴	PEPCO-MD ⁴
WTHI	50%	50%	50%	50%	100%	43%	100%	43%
1pm @ 84	1.19	0.87	0.61	0.60	1.21	0.58	1.46	0.84
Std Error	0.0693	0.1362	0.0688	0.0284	0.0948	0.0523	0.1258	0.0650
5pm @ 84	1.24	0.83	0.92	0.70	1.56	0.86	2.07	1.07
Std Error	0.0693	0.1362	0.0457	0.0243	0.0948	0.0523	0.1258	0.0650

¹ The 1pm estimate is from the 1pm-2pm bin and the 5pm estimate is from the 5pm-6pm bin

² The estimate and standard error for "extreme" temperature days analysis

³ Results from "severe" day analysis

⁴ No standard error estimate was provided so the design precision of 10% was assumed

Table 23 – Reported impacts with standard error estimates

In the PEPCO report, the contractor reported a range of relative precision estimates for hour ending 5pm. The reported range was from $\pm 8.5\%$ to $\pm 26\%$. For this comparative analysis among utility DLC programs, we elected to use $\pm 10\%$, the design precision, as a proxy for the PEPCO estimates. For GPU, relative precision estimates were provided by day type, i.e., extreme, hot, etc. We elected to use the achieved relative precision for hour ending 1pm on the extreme temperature day as the precision proxy. This estimate was $\pm 27\%$.

Demand Reduction (kW) for Hour Ending 1pm						
x_2	PSE&G	GPU	BGE	Conectiv	PEPCO-DC	PEPCO-MD
WTHI/Cycling	50%	50%	50%	50%	43%	43%
84	1.19	0.87	0.61	0.60	0.58	0.84
Std Error	0.0666	0.1428	0.0457	0.0284	0.0353	0.0510
T-Test Values (Ho: $x_1 - x_2 = 0$ Reject if $ Tc > 2.576$)						
x_1		Do Not Reject	Reject			
PSE&G		2.03	7.18	8.16	8.10	4.19
GPU			1.73	1.85	1.97	0.20
BGE				0.19	0.52	3.34
Conectiv					0.44	4.10
PEPCO-DC (43%)						4.18
Demand Reduction (kW) for Hour Ending 5pm						
x_2	PSE&G	GPU	BGE	Conectiv	PEPCO-DC	PEPCO-MD
WTHI/Cycling	50%	50%	50%	50%	43%	43%
84	1.24	0.83	0.92	0.70	0.86	1.07
Std Error	0.0693	0.1362	0.0457	0.0243	0.0523	0.0650
T-Test Values (Ho: $x_1 - x_2 = 0$ Reject if $ Tc > 2.576$)						
x_1		Do Not Reject	Reject			
PSE&G		2.68	3.85	7.35	4.38	1.79
GPU			0.63	0.94	0.21	1.59
BGE				4.25	0.86	1.89
Conectiv					2.78	5.33
PEPCO-DC (43%)						2.52

Table 24 – T-Test Results (43% and 50% Cycling)

For the statistical comparison, a series of T-Tests were used to compare the individual couplets. The results of the T-Test are presented in Table 24 for the 43% and 50% cycling programs and in Table 25 for the 100% cycling programs. The results are mixed. Couplets where the null hypothesis was rejected are displayed as green shaded boxes. For the 50% and 43% cycling programs, the null hypothesis was rejected for the PSE&G estimate when compared to all but the PEPSCO-MD estimate.

Demand Reduction (kW) for Hour Ending 1pm		
x ₂	PEPCO-DC	PEPCO-MD
WTHI	100%	100%
84	1.21	1.46
Std Error	0.0733	0.0887
T-Test Values (Ho: x1-x2=0 Reject if Tc > 2.576)		
x ₁		Do Not Reject
PEPCO-DC (100%)		2.21
Demand Reduction (kW) for Hour Ending 5pm		
x ₂	PEPCO-DC	PEPCO-MD
WTHI	100%	100%
84	1.56	2.07
Std Error	0.0948	0.1258
T-Test Values (Ho: x1-x2=0 Reject if Tc > 2.576)		
x ₁		Reject
PEPCO-DC (100%)		3.24

Table 25 – T-Test Results (100% Cycling)

Since the gross savings were significantly different between many of the programs, one might conclude that the programs cannot be pooled in future impact evaluations. However, we believe this is *not* the only defensible conclusion. The results may reflect differences in the approach to the prior evaluation from utility to utility rather than differences in the gross savings themselves. If this is the case, then the differences may be reduced by using a common analysis approach across all the programs. To shed further light on the advisability of a pooled or common approach, it may be desirable to re-analyze the prior data using a common analytical approach.

10 APPENDIX D: PROPOSED PROJECT WORK PLAN

This appendix provides a strawman work plan for the proposed project. The tasks anticipated include:

Task 0: Project Kick-Off Meeting – The kick-off meeting will provide the research team the opportunity to refine the research objectives and the study design, clarify pertinent issues, discuss data requirements, discuss the draft work plan and the schedule for this project.

Task 1: Re-Analysis of Historical Data – This task is directed at a “proof of concept” to test whether or not the proposed analysis strategy is likely to deliver results that can be supported by the four LSEs. The re-analysis task will be conducted in parallel with other regional project oriented tasks. We anticipate this task to require several subtasks including:

Subtask 1.1: Data Requirements and Transfer – An early task will be the identification and transfer of the utility specific interval load and auxiliary data. It may be possible to incorporate data from multiple years²³ into this aspect of the analysis. This data is expected to include:

- End use monitored data from the individual participant sites,
- Population billing data for the program participants, i.e., monthly or seasonal usage for use in developing the post-stratification weighting strategy,
- Connected load information or spot wattage measurements if available,
- Ancillary data from the program tracking system that helps describe the program and sample participants,
- Weather data,
- Interruption schedules and criteria.

Subtask 1.2: Data Screening – A data screening protocol will be developed and applied to all individual customer load data.

Subtask 1.3: Development of the Aggregate Time-Temperature Matrix – In order to model the load relief that can be expected at any time-temperature combination, we utilize the duty cycle model. Using the duty cycle model does not depend on having event calls. But, the duty cycle approach does require special handling of event day interruptions. For these instances we recommend using regression techniques to recast the load during the event calls.

Duty Cycle Model Discussion

Figure 16 illustrates the duty cycle model and shows the kW load of an air conditioner at various temperatures. From temperature a to

²³ We know that BGE has data for both 2001 and 2002.

temperature b, there is no demand for air conditioning. From temperature b to temperature d, the uncontrolled air conditioning load increases with the temperature until it reaches full output. At any temperature higher than d, the uncontrolled unit is fully loaded. In short, the segmented line abde represents the load curve for the uncontrolled unit.

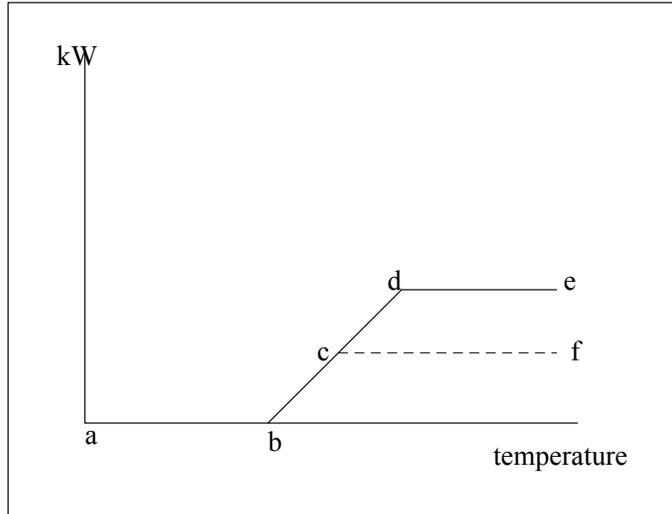


Figure 16 – The Duty Cycle Model for Estimating Load Control Impacts

Now consider a 50% cycling strategy. Under this strategy, the load curve for the unit is lowered to the segmented line abcf. Therefore, above temperature d, the impact is 50% of the full load. Below temperature c, there is no impact. Between c and d there is a partial impact.

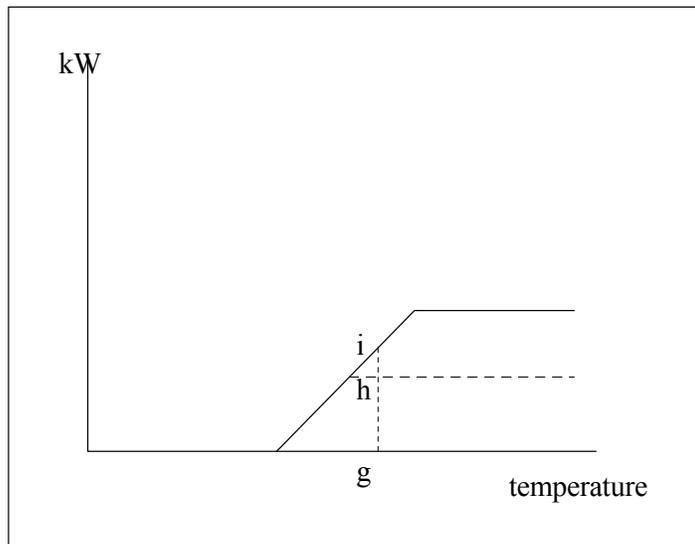


Figure 17 – Duty Cycle Model for Estimating Load Impacts (Cont.)

Figure 17 illustrates the partial impact. At temperature g, if the unit was uncontrolled, its demand would be i. At this temperature, it is operating at only a fraction of its full load, e.g., 70%. In other words, the unit is operating at a 70% duty cycle. Under control, its demand is reduced to point h, which is 50% of full load. Therefore the savings is 70% - 50% or 20% of full load. At a higher temperature the savings would be greater, e.g., if the unit had operating at a 90% duty cycle, the savings of a 50% cycling strategy would be 40% of its full load.

The preceding analysis shows that the impact of a cycling strategy on a particular hour depends on the duty cycle of the units on that hour. The greater the duty cycle of the controlled units, the greater the impact. In particular, full potential impact is only achieved for units that are fully loaded, i.e., would have been operating with a 100% duty cycle.

Returning to Figure 16, the impact of *any cycling strategy* can be predicted by determining the points b and d for each participant. Point b is the lowest temperature for which air conditioning is required. Point d is determined by two parameters: the full kW load of the unit and the lowest temperature at which the unit reaches full load. To summarize, under the duty-cycle model, the impact of any cycling strategy can be predicted by determining the following three parameters for each participant:

- The lowest temperature for which air conditioning is required,
- The full kW load of the AC unit, and
- The lowest temperature at which the unit reaches full load.

The duty cycle analysis will result in the expected impacts at the individual customer level for the selected cycling strategy, i.e., 50%, 53%, etc., up to 100%.

Weather Modeling Discussion

The objective of this analysis is to relate the duty cycle estimated load relief to weather variables allowing the ISO to more accurately predict the load relief that will be achieved under extreme conditions. For this stage of the analysis relevant weather variables, e.g., WTHI, will be added to the aggregate load file from the duty cycle analysis.

The analysis period will be restricted to summer season, i.e., May 1st through September 30th. The analysis periods will correspond to the hours ending 1pm through 8pm.

The dependent variable is the average savings for the period for each individual customer. Average degree-day for the period, based on the temperature humidity index, will be used as the independent variable.

We anticipate that after reviewing the scatter plot of THI versus savings we may determine that the relationship might not be strictly linear. Accordingly, additional variables should be tested. Models will be developed for each control strategy. In addition, the population of program participants for each jurisdiction will be used to weight the respective individual customer data yielding estimates of load response at various times and temperatures. This analysis can be conducted in aggregate or within each service territory and program.

The approach i.e., using the individual customers average savings as the dependent variable, allows for the fair representation of both sampling and modeling variability and will allow the analysis to incorporate weights for each of the respective populations. Accordingly, this yields more accurate confidence intervals around the estimates. Confidence intervals for the various point estimates should be included in the analysis. In addition, the analysis will generate statistics, e.g., the error ratio, required to properly size the future sample.

Table 26 shows an example of a time temperature matrix that was produced for another jurisdiction with 100% cycling.

hour	Temperature							
	60	65	70	75	80	85	90	95
1	-	-	0.08	0.28	0.48	0.68	0.88	1.08
2	-	-	0.10	0.35	0.60	0.85	1.10	1.35
3	-	-	0.10	0.36	0.61	0.87	1.13	1.38
4	-	-	0.11	0.38	0.64	0.91	1.18	1.45
5	-	-	0.10	0.37	0.63	0.89	1.15	1.41
6	-	-	0.09	0.31	0.53	0.75	0.97	1.19
7	-	-	0.07	0.24	0.41	0.59	0.76	0.93
8	-	-	0.02	0.07	0.12	0.17	0.22	0.27
9	-	-	0.01	0.05	0.08	0.11	0.15	0.18
10	-	-	0.04	0.15	0.25	0.36	0.46	0.57
11	-	-	0.08	0.28	0.48	0.67	0.87	1.07
12	-	-	0.10	0.34	0.59	0.83	1.07	1.32
13	-	-	0.12	0.40	0.69	0.98	1.27	1.56
14	-	-	0.13	0.47	0.80	1.14	1.47	1.81
15	-	-	0.14	0.50	0.85	1.21	1.56	1.90
16	-	-	0.13	0.47	0.80	1.14	1.47	1.79
17	-	-	0.14	0.48	0.82	1.16	1.50	1.83
18	-	-	0.12	0.42	0.73	1.03	1.33	1.62
19	-	-	0.09	0.32	0.55	0.78	1.01	1.24
20	-	-	0.09	0.30	0.52	0.73	0.95	1.17
21	-	-	0.08	0.29	0.50	0.71	0.92	1.12
22	-	-	0.08	0.30	0.51	0.72	0.93	1.14
23	-	-	0.08	0.28	0.49	0.69	0.89	1.10
24	-	-	0.08	0.28	0.49	0.69	0.89	1.10

Table 26 – Sample Time Temperature Matrix

Subtask 1.4: Development of Adjustment Factors by PJM Zone – This analysis should be designed to provide results for individual service territories by combining the aggregate PJM area results and the area-specific information. Our

application is an example of a problem called small-area estimation. In these applications, the goal is to provide results for each of several areas using a combined sample across all of the areas, together with available area-specific information. Usually the sample sizes in each individual area are too small to provide reliable results on their own. A variety of related techniques have been used, such as mixed estimation models, Empirical Bayes estimators, and synthetic estimation. The area-specific results are often based on a weighted average of the aggregate results and the area-specific information.

Unfortunately there is little experience with these methods in impact evaluation. Therefore resources will need to be provided to review the literature, to develop and test the most suitable methods, and to document the final approach and the findings.

Subtask 1.5: Reporting – This step will report the findings of the analysis and develop the analysis approach for a new aggregate study. This report will include data collection specifications, sample designs, recommended analysis approaches, and reporting requirements.

Task 2: Develop Revised Research/Analysis Plan – This task will be used to construct a revised research and analysis plan informed by the re-analysis of historical data. The research plan will include the following:

Introduction and Key Issues

The objectives of the study will be presented in this section. Any issues raised during the kick-off or subsequent analysis will be addressed.

Description of Study Requirements

The activities pertinent to the study should be delineated in this section. Any data request stipulated or required will be documented. Procedures for obtaining the data, delivering, documenting and housing the data should be described in this section. The proposed methods of completing the project should be documented in detail as informed by the historical analysis. In essence, the project plan should provide the theoretical road map for completing the project. Therefore, each component of the project should be discussed in detail including the planned project deliverables.

Detailed Work Plan and Schedule

A concise scope of work for each task, including task overlap and deliverables should be delineated and documented in this section. In addition, key staff roles, anticipated staffing hours and project schedules and timelines need to be included.

Project Management Plan

All issues relevant to project management should be outlined for discussion and approval. Issues are expected to include project management reporting schedules,

communication protocols, periodic project reporting, and identification and reporting of critical project milestones.

Detailed Outline of Draft Study Report

The outline and format of the draft final reports should be documented and flow from the re-analysis of the historical data. The “approved” reporting format should be included with the final research plan.

Task 3: PJM Zonal Sample Design and Selection – This section of the work plan should document the assumptions leading to the final sample design. Included will be the theoretical underpinnings, the target variable(s) of interest, the anticipated overall precision, the final proposed sample size, the allocation of the sample across jurisdiction/zone, the anticipated precision by jurisdiction/zone, and the eventual primary sample selection including back-ups.

Task 4: Survey Instruments and Contact Protocols – This section should include a discussion of the various survey data collection forms required to carry out the end-use metering duty cycle analysis. The customer contact protocols should be detailed and are expected to include draft customer letters, telephone recruitment scripts, and tracking data entry forms.

Task 5: Proposed Monitoring Approach – In this section the contractor will outline the data monitoring approach proposed including a detailed description of the equipment planned for deployment. In this section, a standard protocol for data collection needs to be established including variable of interest, frequency of data collection²⁴, period of data collection, type of interrogation strategy, and any other key consideration needed for the metering study.

Task 6: Data Collection and VEE – The work plan should include a listing of the variables that will be available for analysis. In addition, the proposed verification, editing and estimation strategy should be outlined to ensure high quality of data is secured for the majority of sites.

Task 7: Data Analysis Strategy – This section of the work plan should summarize the data analysis strategy planned. We anticipate this section to be informed by the historical re-analysis.

Task 8: Draft and Final Report – As previously discussed, the outline and format of the draft final reports should be documented and flow from the re-analysis of the historical data.

Task 9: Project Management Plan – This section will discuss the project management plan proposed for the project.

²⁴ Typically 15-minute data are collected however, there may be significant advantage gained in identifying the maximum loading of the air conditioner by reducing the data collection interval to 5-minute increments.

11 APPENDIX E: MEMORANDUM OF UNDERSTANDING

Memorandum of Understanding PJM-East Regional Model for Estimating Load Impacts of Active Load Management/Direct Load Control Programs

June 2006

This memorandum establishes a working relationship between the participating utilities and the Lawrence Berkeley National Laboratory to support improved measurement and verification of direct load control programs deemed eligible for inclusion in the PJM existing Active Load Management Program.

This memorandum is made and entered into between and among the following parties:

- 1) Allegheny Electric Cooperative
- 2) Baltimore, Gas and Electric (BGE)
- 3) First Energy
- 4) Lawrence Berkeley National Laboratory (LBNL)
- 5) Buckeye Power
- 6) Southern Maryland Electric Cooperative
- 7) Old Dominion Electric Cooperative
- 8) Pepco Holdings, Inc. (PHI)
- 9) Public Service Electric and Gas (PSE&G);

The undersigned parties agree to the following with respect to this project.

1. Objective. Develop a statistical model-based alternative to the current Measurement and Verification (M&V) requirements²⁵ placed by PJM on direct load control program eligibility for Active Load Management capacity credits.²⁶
2. Purpose. Eliminate or reduce the need for sponsoring expensive load research for residential central air conditioner and water heater direct load control programs. If the “deemed results” from such a regional model is accepted by PJM, it will reduce both the financial barriers and the complexity of operating and participating in the PJM demand response market.
3. Scope/Applicability. Residential air conditioner and water heater load cycling programs.

²⁵ PJM’s Active Load Management M&V requirement requires that a load research study be conducted every five years to measure the attributable to direct load control load impacts. The specific input required by PJM is a time-temperature - humidity calculation of load impacts for each direct load control program. For more details see PJM Manual 19.

²⁶ The resulting estimates can also be used to determine program energy reduction benefits.

4. Eligibility to Participate. Any entity interested in owning or operating residential direct load control technology in the PJM region.
5. Project Description. This project will develop a regional model, based primarily on previous load research data gathered by five PJM-East electric distribution utilities (BGE, Delmarva Power (PHI), JCP&L, Pepco (PHI), and PSE&G), that is capable of serving as a basis for the development of regression-based, time-temperature/humidity estimates of load impacts for direct load control programs on a zonal basis.²⁷ A detailed project description, schedule and budget are shown in Attachment A.
6. General Obligations of Participation. This will be a collaborative effort among the participating entities. Each participant is expected to: co-fund the effort per the allocation schedule described in (9) below; participate in the management of the project, including selecting an analysis consultant, arranging contractual matters with that consultant, providing available direct load control related program data, reviewing and approving the study results.
7. Project Costs. The estimated cost for this project, specifically creating a regional model for both air conditioner and water heater load control, is \$100,000. This does not include the costs incurred by any participants for readying the historical end-use load data for transfer to the analysis consultant or project related staff time.
8. LBNL Role in the Project: Lawrence Berkeley National Laboratory (LBNL) and the US Department of Energy support this effort because it can potentially reduce the costs of load control programs, thus encouraging electric market entities to retain existing programs in place and introduce new ones. LBNL funded the feasibility study of the regional load impact estimation concept and has offered continuing support, including project management and co-funding of the regional DLC load impact model.
9. Project Cost Allocation: A January 5, 2006 conference call to discuss this project included a poll of potential participants and their willingness to financially support this effort. Tentative expressions of support (subject to management approval) have been extended by four electric distribution companies (BGE, First Energy, PSE&G, and PHI), three electric cooperatives (Old Dominion Electric Cooperative, Allegheny Electric Cooperative, North Carolina Membership Electric Corporation), and LBNL. These entities propose to share the project costs according to the following formula:
 - a. Electric Distribution Entities: \$13,000 each
 - b. LBNL: \$10,000

²⁷ A feasibility study funded by LBNL concluded that such a regional model could be developed through a cross-jurisdictional analysis of the most-recent (2000-2001 end-use metering data available plus any other comparable data

10. Special Obligations of Participants with End-use Load Data. Building the regional model will require both end-use load data (2001-2002 and later if available) and billing data (2001 and 2005) for both the load research sample population and the participant population. These data are necessary to develop a regional re-stratification of the sample points and to confirm the stability of the population distributions over time. At present four utilities – BGE, Delmarva Power & Light JCP&L, and PSE&G – are known to have air conditioner and/or water heater end-use load data. The analysis consultant will work with all participating entities to gather all available data that will be useful for the project.
11. Confidentiality of Data. The analysis consultant will enter into confidentiality agreements with each provider of end-use load data. No customer specific data will be disclosed to any other entity, as customer confidentiality will be protected by using numerical identifiers (account number or control number). End-use load data from some 500 customers will be needed, along with summer 2001 and summer 2005 residential energy consumption data from all participants.
12. Reporting. The principal result of this analysis will be a statistical load impact estimation model, including time-temperature-humidity-control cycle PJM zonal load impact estimates. These results will be reviewed and reported by the participants and then reported to PJM. Participants have the option of using the results of this study or the results from their own study to comply with the PJM load impact evaluation requirement. LBNL intends to prepare an LBNL technical report that documents the regional model estimation process, discusses the analytic and practical issues, and present the results in an aggregate form (not necessarily LSE-specific). LBNL agrees to provide the participants with a draft of its technical report for their review and comment and approval to ensure that confidentiality concerns are addressed. LBNL reserves the right to prepare a refereed journal article with other contributors (e.g. consultant, utility staff, and other interested parties).
13. Procurement of Analysis Services. A Statement of Work for Analysis Services is contained in Attachment A. The participants will jointly determine how to procure these services (sole source or competitive procurement).
14. Contracting. For simplicity each participant will directly contract with the selected consultant in the amount of their co-funding share.
15. Availability of Results. The regional model itself and the zonal time-temperature-cycling strategy impact estimates will only be available to participants and PJM staff. However, any entity may submit a request to the original project participants to rely upon the project results for their own use. The original project participants will collectively agree to an appropriate response to the requesting entity.
16. Project Start. The project will officially begin June 1, 2006.

17. Project Completion. This Project shall be completed during 2006 with an anticipated September 2006 completion date for the draft report.

18. Payment Schedule. The project will be billed to each utility in two installments. For the utilities, the first invoice (50% of the budget amount) will be issued in July and will cover work completed in May and June. The second invoice will be issued upon acceptance of the final report (anticipated in September 2006). For LBNL, the first invoice (50%) will be issued upon completion of the draft report (anticipated August 2006) and the second invoice for the remaining 50% issued upon acceptance of the final report.

Signatures of Participating Entities

Utility Representative
Utility

Curt D. Puckett, President
RLW Analytics

Pooled Load Impact Analysis of Residential Air Conditioner and Water Heater Load Control

PJM Load Analysis Subcommittee – Load Research Working Group

SCOPE OF WORK FOR

RLW Analytics
2 Hyde Road
Clarklake, MI 49234
517 529 6277
curt@rlw.com

I. Introduction and Background

Load research data from several air conditioner and water heater load control programs operating in the PJM East region will be pooled together and analyzed by Contractor in an effort to develop a regional load impact model suitable for use as an alternative M&V protocol for non-metered active load management programs. After conducting this analysis, Contractor will report back to the PLM Load Analysis Subcommittee on whether this approach is a suitable replacement for large-scale load research programs fielded at five year intervals.

II. Subcontractor Task and Deliverables

The overall study effort comprises seven tasks:

Task 1: Transfer of data

Contractor will work with utilities to transfer data, including transfer of the interval end-use or premise load data for each load research sample point together with the respective participant population data, including current monthly billing data, load curtailment schedules, and associated weather data for each historical year. The Contractor will work with each utility contributing data to specify data protocols and transfer media.

Task 2: Data review and screening

Contractor will review and screen data including examining each individual interval load site during control days to identify whether or not the end-use was being effectively controlled. During the data review process, contractor will identify selected screening criterion, which will be documented for potential use in future program evaluations. Contractor will also estimate each participant's maximum air conditioning demand for use in the duty cycle analysis.

Task 3: Duty Cycle Analysis

Contractor will conduct duty cycle analysis, including establishing individual "natural" duty cycles for each end-use metering participant. The participant's natural duty cycle

will be used to estimate the amount of load that can be curtailed given at least three duty cycle strategies, i.e., 43%, 50% and 100%. Contractor will develop a “deemed” savings estimate for air conditioning cycling and electric water heating programs.

Task 4: Time-temperature regression analysis

Contractor will conduct a time-temperature regression analysis, including formulation of a time-temperature matrix relating the load available for each of the duty cycle strategies to different weighted temperature-humidity indices.

Task 5: Aggregate research and analysis

Contractor will conduct aggregate research and analysis, including aggregate analysis of PJM area results and comparison with area (zone) specific information. The objective of this task is to develop a regression equation that can be used by zone to calculate deemed savings for the reporting of gross AC-DLC savings to PJM.

Task 6: Technical Reports

Contractor will prepare technical memo for the PJM Load Research Working Group, Load Analysis Subcommittee that documents the analytic approach and summarizes estimates of deemed savings for regional legacy A/C programs given cycling strategy and temperature parameters and WH curtailment program.

Working with Lawrence Berkeley National Laboratory (LBNL), Contractor will prepare technical report that documents analytic methods, presents results of the pooled load impact analysis, and summarizes key findings.

Task 7: Project management

Contractor will manage project, coordinate with project sponsors and funders, and participate in meetings of the PJM Load Research Working Group (as necessary). Contractor will also prepare periodic briefings as needed to the Load Analysis Subcommittee on project progress, interim and final results.

Deliverables

The Contractor will prepare the following deliverables:

- Project memorandum on data transfer, data quality following data review and screening (June 2006);
- Technical memo to Load Analysis Subcommittee of PJM Load Research Working Group that describes and summarizes estimates of deemed savings for regional legacy A/C programs given cycling strategy and temperature parameters and WH curtailment program (August 2006)
- Draft and Final Technical Report (with LBNL) that describes approach, analytic methods, results, key findings, including implications for other utilities and ISOs that want to improve M&V for mass market DR programs (Draft Report; Aug 2006; Final Report Sept 2006).

12 APPENDIX F: EVENT DAY HISTORY

The following tables present the event day history for the various utilities.

Number	Date	Hour Start	Hour Stop	Duration
1	06/13/01	16:00	18:00	2:00
2	06/20/01	15:00	18:00	3:00
3	06/27/01	15:00	19:00	4:00
4	06/28/01	15:00	18:30	3:30
5	07/10/01	15:00	16:00	1:00
6	07/24/01	14:00	17:00	3:00
7	07/25/01	15:00	18:00	3:00
8	08/02/01	14:00	17:00	3:00
9	08/06/01	14:00	18:00	4:00
10	08/07/01	14:00	18:00	4:00
11	08/09/01	12:00	18:30	6:30
12	08/10/01	11:00	18:00	7:00
13	06/27/01	15:00	19:00	4:00
14	06/28/01	15:00	21:30	6:30
15	08/09/01	12:00	20:00	8:00
1	06/24/02	14:00	17:00	3:00
2	06/25/02	14:00	18:00	4:00
3	06/26/02	13:00	18:00	5:00
4	06/27/02	13:00	18:00	5:00
5	07/01/02	15:00	18:00	3:00
6	07/02/02	13:00	17:00	4:00
7	07/03/02	12:00	15:00	3:00
8	07/03/02	15:01	18:00	2:59
9	07/17/02	15:00	19:00	4:00
10	07/18/02	13:00	18:00	5:00
11	07/19/02	14:00	18:00	4:00
12	07/22/02	13:00	18:00	5:00
13	07/23/02	14:00	17:00	3:00
14	07/29/02	13:00	19:00	6:00
15	07/30/00	12:00	18:00	6:00
16	07/31/02	15:00	18:00	3:00
17	08/01/02	15:00	17:00	2:00
18	08/13/02	16:00	18:00	2:00
19	08/14/02	16:00	18:00	2:00
20	08/15/02	16:00	18:00	2:00
21	08/19/02	12:25	20:00	7:35

Table 27 – First Energy Event Dates and Times

Date	Start	Stop	Duration
07/25/01	13:00	18:02	5:02
08/07/01	14:00	18:42	4:42
08/08/01	12:12	18:45	6:33
08/09/01	12:42	19:15	6:33
08/10/01	12:12	14:56	2:44

Table 28 – PSE&G Event Dates and Times

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Number	Date	Start	End	Duration
1	4-May-01	2:05 PM	5:35 PM	3 Hrs 30 Min
2	10-May-01	12:58 PM	7:00 PM	6 Hrs 2 Min
3	13-Jun-01	12:30 PM	6:30 PM	6 Hrs 0 Min
4	20-Jun-01	12:30 PM	6:30 PM	6 Hrs 0 Min
5	28-Jun-01	12:30 PM	6:30 PM	6 Hrs 0 Min
6	29-Jun-01	12:30 PM	6:30 PM	6 Hrs 0 Min
7	10-Jul-01	1:45 PM	4:45 PM	3 Hrs 0 Min
8	17-Jul-01	12:00 PM	5:00 PM	5 Hrs 0 Min
9	24-Jul-01	1:50 PM	7:00 PM	5 Hrs 10 Min
10	25-Jul-01	1:00 PM	5:25 PM	4 Hrs 25 Min
11	6-Aug-01	2:40 PM	8:00 PM	5 Hrs 20 Min
12	7-Aug-01	2:36 PM	3:13 PM	0 Hrs 37 Min
13	8-Aug-01	11:05 AM	7:00 PM	7 Hrs 55 Min
14	9-Aug-01	12:00 PM	8:00 PM	8 Hrs 0 Min
15	10-Aug-01	12:00 PM	4:00 PM	4 Hrs 0 Min
16	31-Aug-01	2:34 PM	3:28 PM	0 Hrs 54 Min
Number	Date	Start	End	Duration
1	6-Jun-02	11:32 AM	3:15 PM	3 Hrs 43 Min
2	25-Jun-02	1:53 PM	6:00 PM	4 Hrs 7 Min
3	26-Jun-02	1:20 PM	4:55 PM	3 Hrs 35 Min
4	2-Jul-02	5:15 PM	7:00 PM	1 Hrs 45 Min
5	3-Jul-02	10:20 AM	6:00 PM	7 Hrs 40 Min
6	9-Jul-02	2:52 PM	5:26 PM	2 Hrs 34 Min
7	17-Jul-02	4:20 PM	6:18 PM	1 Hrs 58 Min
8	19-Jul-02	2:35 PM	3:03 PM	0 Hrs 28 Min
9	22-Jul-02	1:00 PM	7:00 PM	6 Hrs 0 Min
10	23-Jul-02	12:26 PM	6:15 PM	5 Hrs 49 Min
11	29-Jul-02	2:28 PM	6:00 PM	3 Hrs 32 Min
12	2-Aug-02	1:27 PM	7:00 PM	5 Hrs 33 Min
13	3-Aug-02	2:56 PM	4:26 PM	1 Hrs 30 Min
14	4-Aug-02	3:00 PM	7:00 PM	4 Hrs 0 Min
15	12-Aug-02	4:16 PM	5:36 PM	1 Hrs 20 Min
16	13-Aug-02	1:03 PM	5:25 PM	4 Hrs 22 Min
17	14-Aug-02	12:48 PM	5:34 PM	4 Hrs 46 Min
18	19-Aug-02	1:09 PM	5:46 PM	4 Hrs 37 Min
19	22-Aug-02	7:00 PM	8:00 PM	1 Hrs 0 Min
20	3-Oct-02	1:12 PM	2:00 PM	0 Hrs 48 Min
Number	Date	Start	End	Duration
1	12-Jun-03	3:19 PM	5:09 PM	1 Hrs 50 Min
2	26-Jun-03	5:26 PM	6:14 PM	0 Hrs 48 Min
3	6-Jul-03	4:25 PM	6:40 PM	2 Hrs 15 Min
4	21-Jul-03	1:07 PM	6:25 PM	5 Hrs 18 Min
5	14-Aug-03	4:00 PM	8:14 PM	4 Hrs 14 Min
6	15-Aug-03	12:03 PM	6:14 PM	6 Hrs 11 Min
7	21-Aug-03	5:00 PM	8:14 PM	3 Hrs 14 Min
8	22-Aug-03	12:00 PM	4:00 PM	4 Hrs 0 Min
9	26-Aug-03	11:45 AM	4:15 PM	4 Hrs 30 Min

Table 29 – BGE Event Dates and Times

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Number	Date	Start	End	Duration
1	29-Jul-04	1:00 PM	6:00 PM	5 Hrs 0 Min
2	3-Aug-04	3:00 PM	8:00 PM	5 Hrs 0 Min
3	4-Aug-04	2:00 PM	6:00 PM	4 Hrs 0 Min
4	10-Aug-04	12:00 PM	5:00 PM	5 Hrs 0 Min
5	20-Aug-04	12:00 PM	6:00 PM	6 Hrs 0 Min
6	24-Aug-04	2:00 PM	7:00 PM	5 Hrs 0 Min
Number	Date	Start	End	Duration
1	6-Jun-05	2:26 PM	7:00 PM	4 Hrs 34 Min
2	7-Jun-05	5:55 PM	7:00 PM	1 Hrs 5 Min
3	8-Jun-05	1:00 PM	7:00 PM	6 Hrs 0 Min
4	13-Jun-05	2:00 PM	8:00 PM	6 Hrs 0 Min
5	14-Jun-05	1:30 PM	9:00 PM	7 Hrs 30 Min
6	28-Jun-05	1:50 PM	6:15 PM	4 Hrs 25 Min
7	12-Jul-05	12:20 PM	3:20 PM	3 Hrs 0 Min
8	13-Jul-05	2:47 PM	5:35 PM	2 Hrs 48 Min
9	14-Jul-05	3:50 PM	6:03 PM	2 Hrs 13 Min
10	15-Jul-05	2:15 PM	4:40 PM	2 Hrs 25 Min
11	18-Jul-05	12:03 PM	4:00 PM	3 Hrs 57 Min
11	18-Jul-05	5:30 PM	6:45 PM	1 Hrs 15 Min
12	19-Jul-05	10:50 AM	4:00 PM	5 Hrs 10 Min
12	19-Jul-05	5:28 PM	6:55 PM	1 Hrs 27 Min
13	20-Jul-05	11:40 AM	7:00 PM	7 Hrs 20 Min
14	21-Jul-05	12:38 PM	4:00 PM	3 Hrs 22 Min
14	21-Jul-05	4:54 PM	6:29 PM	1 Hrs 35 Min
15	25-Jul-05	11:04 AM	3:45 PM	4 Hrs 41 Min
15	25-Jul-05	6:10 PM	7:45 PM	1 Hrs 35 Min
16	26-Jul-05	10:44 AM	3:46 PM	5 Hrs 2 Min
16	26-Jul-05	6:10 PM	7:40 PM	1 Hrs 30 Min
17	27-Jul-05	10:40 AM	6:10 PM	7 Hrs 30 Min
17	27-Jul-05	6:10 PM	6:50 PM	0 Hrs 40 Min
18	1-Aug-05	3:09 PM	6:25 PM	3 Hrs 16 Min
19	2-Aug-05	12:25 PM	7:55 PM	7 Hrs 30 Min
20	3-Aug-05	12:40 PM	8:22 PM	7 Hrs 42 Min
21	4-Aug-05	12:50 PM	6:47 PM	5 Hrs 57 Min
22	5-Aug-05	12:25 PM	5:31 PM	5 Hrs 6 Min
23	11-Aug-05	12:45 PM	7:20 PM	6 Hrs 35 Min
24	12-Aug-05	12:15 PM	6:55 PM	6 Hrs 40 Min
25	15-Aug-05	12:00 PM	6:41 PM	6 Hrs 41 Min
26	22-Aug-05	1:32 PM	6:03 PM	4 Hrs 31 Min
27	23-Aug-05	2:40 PM	6:47 PM	4 Hrs 7 Min
28	29-Aug-05	1:10 PM	6:51 PM	5 Hrs 41 Min
29	30-Aug-05	12:30 PM	6:45 PM	6 Hrs 15 Min
30	31-Aug-05	11:00 AM	5:30 PM	6 Hrs 30 Min
31	2-Sep-05	12:36 PM	6:22 PM	5 Hrs 46 Min
32	13-Sep-05	2:57 PM	6:25 PM	3 Hrs 28 Min
33	14-Sep-05	3:23 PM	6:00 PM	2 Hrs 37 Min
34	15-Sep-05	1:10 PM	6:15 PM	5 Hrs 5 Min
35	16-Sep-05	11:34 AM	5:59 PM	6 Hrs 25 Min
36	19-Sep-05	2:43 PM	5:53 PM	3 Hrs 10 Min
37	21-Sep-05	3:28 PM	6:22 PM	2 Hrs 54 Min
38	22-Sep-05	2:30 PM	5:36 PM	3 Hrs 6 Min
39	23-Sep-05	12:27 PM	5:45 PM	5 Hrs 18 Min

Table 30 – BGE Event Dates and Times (cont.)

13 APPENDIX G: DEEMED SAVINGS ESTIMATES FOR A/C CYCLING COMBINED RESULTS

This appendix contains the detail tables for selected 15 minute time periods for the AC Cycling savings estimates in aggregate.

Time Of Day	WTHI	Predicted Savings For Various Duty Cycle Strategies						
		27%	43%	50%	67%	75%	83%	100%
1:00 PM	70	0.02	0.03	0.03	0.04	0.07	0.06	0.13
	71	0.02	0.03	0.03	0.04	0.07	0.06	0.13
	72	0.02	0.03	0.03	0.04	0.07	0.14	0.25
	73	0.02	0.03	0.03	0.11	0.15	0.23	0.36
	74	0.02	0.03	0.08	0.17	0.23	0.32	0.47
	75	0.02	0.07	0.12	0.24	0.31	0.40	0.59
	76	0.04	0.12	0.17	0.31	0.39	0.49	0.70
	77	0.07	0.16	0.21	0.37	0.47	0.58	0.82
	78	0.09	0.20	0.26	0.44	0.54	0.66	0.93
	79	0.12	0.24	0.30	0.50	0.62	0.75	1.04
	80	0.14	0.28	0.35	0.57	0.70	0.83	1.16
	81	0.17	0.32	0.39	0.63	0.78	0.92	1.27
	82	0.19	0.36	0.44	0.70	0.86	1.01	1.38
	83	0.22	0.40	0.49	0.76	0.94	1.09	1.50
	84	0.24	0.45	0.53	0.83	1.02	1.18	1.61
	84.1	0.24	0.45	0.54	0.84	1.03	1.19	1.62
	84.2	0.25	0.45	0.54	0.84	1.03	1.20	1.64
	84.3	0.25	0.46	0.54	0.85	1.04	1.20	1.65
	84.4	0.25	0.46	0.55	0.86	1.05	1.21	1.66
	84.5	0.25	0.47	0.55	0.86	1.06	1.22	1.67
	84.6	0.25	0.47	0.56	0.87	1.07	1.23	1.68
	84.7	0.26	0.47	0.56	0.88	1.07	1.24	1.69
	84.8	0.26	0.48	0.57	0.88	1.08	1.25	1.70
	84.9	0.26	0.48	0.57	0.89	1.09	1.26	1.72
	85	0.26	0.49	0.58	0.90	1.10	1.27	1.73
	85.1	0.27	0.49	0.58	0.90	1.11	1.27	1.74
	85.2	0.27	0.49	0.59	0.91	1.11	1.28	1.75
	85.3	0.27	0.50	0.59	0.92	1.12	1.29	1.76
	85.4	0.27	0.50	0.59	0.92	1.13	1.30	1.77
	85.5	0.28	0.51	0.60	0.93	1.14	1.31	1.78
	85.6	0.28	0.51	0.60	0.93	1.14	1.32	1.79
	85.7	0.28	0.52	0.61	0.94	1.15	1.33	1.81
	85.8	0.28	0.52	0.61	0.95	1.16	1.33	1.82
	85.9	0.29	0.52	0.62	0.95	1.17	1.34	1.83
	86	0.29	0.53	0.62	0.96	1.18	1.35	1.84
	87	0.31	0.57	0.67	1.03	1.26	1.44	1.95

Table 31 – Deemed AC Cycling Savings 15-minutes ending 1:00pm

Time Of Day	WTHI	Predicted Savings For Various Duty Cycle Strategies						
		27%	43%	50%	67%	75%	83%	100%
2:00 PM	70	0.01	0.04	0.03	0.05	0.09	0.07	0.09
	71	0.01	0.04	0.03	0.05	0.09	0.07	0.20
	72	0.01	0.04	0.03	0.05	0.09	0.16	0.32
	73	0.01	0.04	0.03	0.12	0.17	0.26	0.43
	74	0.01	0.04	0.09	0.20	0.26	0.35	0.55
	75	0.04	0.09	0.14	0.27	0.34	0.44	0.66
	76	0.06	0.13	0.19	0.34	0.43	0.54	0.77
	77	0.09	0.18	0.24	0.41	0.51	0.63	0.89
	78	0.11	0.22	0.29	0.48	0.60	0.72	1.00
	79	0.14	0.27	0.34	0.56	0.68	0.81	1.12
	80	0.16	0.32	0.39	0.63	0.77	0.91	1.23
	81	0.19	0.36	0.44	0.70	0.85	1.00	1.34
	82	0.21	0.41	0.50	0.77	0.94	1.09	1.46
	83	0.24	0.46	0.55	0.84	1.03	1.19	1.57
	84	0.26	0.50	0.60	0.92	1.11	1.28	1.68
	84.1	0.26	0.51	0.60	0.92	1.12	1.29	1.70
	84.2	0.27	0.51	0.61	0.93	1.13	1.30	1.71
	84.3	0.27	0.52	0.61	0.94	1.14	1.31	1.72
	84.4	0.27	0.52	0.62	0.94	1.15	1.32	1.73
	84.5	0.27	0.53	0.62	0.95	1.15	1.33	1.74
	84.6	0.28	0.53	0.63	0.96	1.16	1.34	1.75
	84.7	0.28	0.53	0.63	0.97	1.17	1.34	1.76
	84.8	0.28	0.54	0.64	0.97	1.18	1.35	1.78
	84.9	0.28	0.54	0.64	0.98	1.19	1.36	1.79
	85	0.29	0.55	0.65	0.99	1.20	1.37	1.80
	85.1	0.29	0.55	0.65	1.00	1.21	1.38	1.81
	85.2	0.29	0.56	0.66	1.00	1.21	1.39	1.82
	85.3	0.29	0.56	0.66	1.01	1.22	1.40	1.83
	85.4	0.30	0.57	0.67	1.02	1.23	1.41	1.84
	85.5	0.30	0.57	0.67	1.02	1.24	1.42	1.86
	85.6	0.30	0.58	0.68	1.03	1.25	1.43	1.87
	85.7	0.30	0.58	0.68	1.04	1.26	1.44	1.88
	85.8	0.31	0.59	0.69	1.05	1.26	1.45	1.89
	85.9	0.31	0.59	0.69	1.05	1.27	1.46	1.90
	86	0.31	0.60	0.70	1.06	1.28	1.47	1.91
	87	0.34	0.64	0.75	1.13	1.37	1.56	2.03

Table 32 – Deemed AC Cycling Savings 15-minutes ending 2:00pm

Time Of Day	WTHI	Predicted Savings For Various Duty Cycle Strategies						
		27%	43%	50%	67%	75%	83%	100%
3:00 PM	70	0.03	0.05	0.04	0.07	0.05	0.09	0.11
	71	0.03	0.05	0.04	0.07	0.05	0.09	0.23
	72	0.03	0.05	0.04	0.07	0.14	0.19	0.35
	73	0.03	0.05	0.04	0.14	0.23	0.29	0.47
	74	0.03	0.05	0.10	0.22	0.31	0.39	0.59
	75	0.03	0.10	0.16	0.30	0.40	0.49	0.72
	76	0.06	0.15	0.21	0.38	0.49	0.59	0.84
	77	0.09	0.20	0.27	0.46	0.58	0.69	0.96
	78	0.12	0.26	0.33	0.54	0.66	0.79	1.08
	79	0.15	0.31	0.39	0.62	0.75	0.89	1.20
	80	0.19	0.36	0.44	0.69	0.84	0.99	1.32
	81	0.22	0.41	0.50	0.77	0.92	1.09	1.44
	82	0.25	0.46	0.56	0.85	1.01	1.19	1.56
	83	0.28	0.51	0.61	0.93	1.10	1.29	1.68
	84	0.31	0.57	0.67	1.01	1.18	1.39	1.81
	84.1	0.32	0.57	0.67	1.02	1.19	1.40	1.82
	84.2	0.32	0.58	0.68	1.02	1.20	1.41	1.83
	84.3	0.32	0.58	0.69	1.03	1.21	1.42	1.84
	84.4	0.33	0.59	0.69	1.04	1.22	1.43	1.85
	84.5	0.33	0.59	0.70	1.05	1.23	1.44	1.87
	84.6	0.33	0.60	0.70	1.05	1.24	1.45	1.88
	84.7	0.34	0.60	0.71	1.06	1.24	1.46	1.89
	84.8	0.34	0.61	0.71	1.07	1.25	1.47	1.90
	84.9	0.34	0.61	0.72	1.08	1.26	1.48	1.91
	85	0.35	0.62	0.73	1.09	1.27	1.49	1.93
	85.1	0.35	0.62	0.73	1.09	1.28	1.50	1.94
	85.2	0.35	0.63	0.74	1.10	1.29	1.51	1.95
	85.3	0.36	0.63	0.74	1.11	1.30	1.52	1.96
	85.4	0.36	0.64	0.75	1.12	1.31	1.53	1.98
	85.5	0.36	0.64	0.75	1.13	1.31	1.54	1.99
	85.6	0.37	0.65	0.76	1.13	1.32	1.55	2.00
	85.7	0.37	0.65	0.77	1.14	1.33	1.56	2.01
	85.8	0.37	0.66	0.77	1.15	1.34	1.57	2.02
	85.9	0.38	0.66	0.78	1.16	1.35	1.58	2.04
	86	0.38	0.67	0.78	1.16	1.36	1.59	2.05
	87	0.41	0.72	0.84	1.24	1.45	1.69	2.17

Table 33 – Deemed AC Cycling Savings 15-minutes ending 3:00pm

Time Of Day	WTHI	Predicted Savings For Various Duty Cycle Strategies						
		27%	43%	50%	67%	75%	83%	100%
4:00 PM	70	0.02	0.05	0.04	0.06	0.05	0.08	0.23
	71	0.02	0.05	0.04	0.06	0.13	0.18	0.34
	72	0.02	0.05	0.04	0.14	0.22	0.28	0.46
	73	0.02	0.05	0.10	0.22	0.30	0.38	0.58
	74	0.02	0.10	0.15	0.29	0.39	0.48	0.70
	75	0.05	0.15	0.21	0.37	0.48	0.57	0.82
	76	0.09	0.20	0.26	0.45	0.56	0.67	0.94
	77	0.12	0.25	0.32	0.52	0.65	0.77	1.06
	78	0.15	0.30	0.38	0.60	0.73	0.87	1.18
	79	0.18	0.35	0.43	0.68	0.82	0.97	1.30
	80	0.21	0.40	0.49	0.76	0.91	1.07	1.42
	81	0.24	0.45	0.54	0.83	0.99	1.16	1.53
	82	0.27	0.50	0.60	0.91	1.08	1.26	1.65
	83	0.31	0.55	0.66	0.99	1.17	1.36	1.77
	84	0.34	0.60	0.71	1.07	1.25	1.46	1.89
	84.1	0.34	0.61	0.72	1.07	1.26	1.47	1.90
	84.2	0.34	0.61	0.72	1.08	1.27	1.48	1.91
	84.3	0.35	0.62	0.73	1.09	1.28	1.49	1.93
	84.4	0.35	0.62	0.73	1.10	1.29	1.50	1.94
	84.5	0.35	0.63	0.74	1.11	1.29	1.51	1.95
	84.6	0.36	0.63	0.75	1.11	1.30	1.52	1.96
	84.7	0.36	0.64	0.75	1.12	1.31	1.53	1.97
	84.8	0.36	0.64	0.76	1.13	1.32	1.54	1.99
	84.9	0.36	0.65	0.76	1.14	1.33	1.55	2.00
	85	0.37	0.65	0.77	1.14	1.34	1.56	2.01
	85.1	0.37	0.66	0.77	1.15	1.35	1.57	2.02
	85.2	0.37	0.66	0.78	1.16	1.35	1.58	2.03
	85.3	0.38	0.67	0.79	1.17	1.36	1.59	2.05
	85.4	0.38	0.67	0.79	1.18	1.37	1.60	2.06
	85.5	0.38	0.68	0.80	1.18	1.38	1.61	2.07
	85.6	0.39	0.68	0.80	1.19	1.39	1.62	2.08
	85.7	0.39	0.69	0.81	1.20	1.40	1.63	2.09
	85.8	0.39	0.69	0.81	1.21	1.41	1.64	2.11
	85.9	0.40	0.70	0.82	1.21	1.41	1.65	2.12
	86	0.40	0.70	0.82	1.22	1.42	1.66	2.13
	87	0.43	0.75	0.88	1.30	1.51	1.76	2.25

Table 34 – Deemed AC Cycling Savings 15-minutes ending 4:00pm

Time Of Day	WTHI	Predicted Savings For Various Duty Cycle Strategies						
		27%	43%	50%	67%	75%	83%	100%
5:00 PM	70	0.02	0.04	0.06	0.06	0.09	0.18	0.30
	71	0.02	0.04	0.06	0.13	0.19	0.28	0.43
	72	0.02	0.04	0.06	0.21	0.28	0.38	0.55
	73	0.02	0.09	0.13	0.29	0.37	0.48	0.68
	74	0.05	0.15	0.19	0.37	0.46	0.58	0.80
	75	0.09	0.20	0.25	0.45	0.55	0.68	0.93
	76	0.12	0.25	0.31	0.53	0.65	0.78	1.06
	77	0.15	0.30	0.37	0.61	0.74	0.87	1.18
	78	0.18	0.35	0.43	0.68	0.83	0.97	1.31
	79	0.21	0.40	0.50	0.76	0.92	1.07	1.43
	80	0.24	0.45	0.56	0.84	1.01	1.17	1.56
	81	0.27	0.51	0.62	0.92	1.10	1.27	1.68
	82	0.30	0.56	0.68	1.00	1.20	1.37	1.81
	83	0.34	0.61	0.74	1.08	1.29	1.47	1.93
	84	0.37	0.66	0.80	1.16	1.38	1.57	2.06
	84.1	0.37	0.66	0.81	1.16	1.39	1.58	2.07
	84.2	0.37	0.67	0.82	1.17	1.40	1.59	2.08
	84.3	0.38	0.67	0.82	1.18	1.41	1.60	2.10
	84.4	0.38	0.68	0.83	1.19	1.42	1.61	2.11
	84.5	0.38	0.68	0.83	1.20	1.43	1.62	2.12
	84.6	0.39	0.69	0.84	1.20	1.43	1.63	2.13
	84.7	0.39	0.70	0.85	1.21	1.44	1.64	2.15
	84.8	0.39	0.70	0.85	1.22	1.45	1.65	2.16
	84.9	0.40	0.71	0.86	1.23	1.46	1.66	2.17
	85	0.40	0.71	0.87	1.23	1.47	1.67	2.19
	85.1	0.40	0.72	0.87	1.24	1.48	1.68	2.20
	85.2	0.41	0.72	0.88	1.25	1.49	1.69	2.21
	85.3	0.41	0.73	0.88	1.26	1.50	1.70	2.22
	85.4	0.41	0.73	0.89	1.27	1.51	1.71	2.24
	85.5	0.41	0.74	0.90	1.27	1.52	1.72	2.25
	85.6	0.42	0.74	0.90	1.28	1.53	1.73	2.26
	85.7	0.42	0.75	0.91	1.29	1.54	1.74	2.27
	85.8	0.42	0.75	0.91	1.30	1.54	1.75	2.29
	85.9	0.43	0.76	0.92	1.31	1.55	1.76	2.30
	86	0.43	0.76	0.93	1.31	1.56	1.77	2.31
	87	0.46	0.81	0.99	1.39	1.65	1.87	2.44

Table 35 – Deemed AC Cycling Savings 15-minutes ending 5:00pm

Time Of Day	WTHI	Predicted Savings For Various Duty Cycle Strategies						
		27%	43%	50%	67%	75%	83%	100%
6:00 PM	70	0.02	0.04	0.06	0.13	0.18	0.27	0.45
	71	0.02	0.04	0.06	0.20	0.27	0.36	0.57
	72	0.02	0.09	0.12	0.28	0.36	0.46	0.68
	73	0.05	0.14	0.18	0.36	0.45	0.56	0.80
	74	0.08	0.19	0.24	0.43	0.54	0.66	0.92
	75	0.11	0.24	0.30	0.51	0.63	0.76	1.04
	76	0.14	0.29	0.36	0.59	0.72	0.85	1.16
	77	0.17	0.34	0.42	0.66	0.81	0.95	1.28
	78	0.20	0.38	0.48	0.74	0.90	1.05	1.40
	79	0.23	0.43	0.53	0.82	0.99	1.15	1.52
	80	0.26	0.48	0.59	0.90	1.08	1.25	1.64
	81	0.29	0.53	0.65	0.97	1.17	1.34	1.76
	82	0.32	0.58	0.71	1.05	1.26	1.44	1.88
	83	0.35	0.63	0.77	1.13	1.35	1.54	1.99
	84	0.38	0.68	0.83	1.20	1.44	1.64	2.11
	84.1	0.38	0.69	0.84	1.21	1.45	1.65	2.13
	84.2	0.38	0.69	0.84	1.22	1.46	1.66	2.14
	84.3	0.39	0.70	0.85	1.23	1.46	1.67	2.15
	84.4	0.39	0.70	0.86	1.23	1.47	1.68	2.16
	84.5	0.39	0.71	0.86	1.24	1.48	1.69	2.17
	84.6	0.39	0.71	0.87	1.25	1.49	1.70	2.18
	84.7	0.40	0.72	0.87	1.26	1.50	1.71	2.20
	84.8	0.40	0.72	0.88	1.26	1.51	1.72	2.21
	84.9	0.40	0.72	0.89	1.27	1.52	1.73	2.22
	85	0.41	0.73	0.89	1.28	1.53	1.74	2.23
	85.1	0.41	0.73	0.90	1.29	1.54	1.75	2.24
	85.2	0.41	0.74	0.90	1.29	1.55	1.76	2.26
	85.3	0.42	0.74	0.91	1.30	1.55	1.76	2.27
	85.4	0.42	0.75	0.92	1.31	1.56	1.77	2.28
	85.5	0.42	0.75	0.92	1.32	1.57	1.78	2.29
	85.6	0.42	0.76	0.93	1.33	1.58	1.79	2.30
	85.7	0.43	0.76	0.93	1.33	1.59	1.80	2.32
	85.8	0.43	0.77	0.94	1.34	1.60	1.81	2.33
	85.9	0.43	0.77	0.95	1.35	1.61	1.82	2.34
	86	0.44	0.78	0.95	1.36	1.62	1.83	2.35
	87	0.47	0.83	1.01	1.43	1.71	1.93	2.47

Table 36 – Deemed AC Cycling Savings 15-minutes ending 6:00pm

Time Of Day	WTHI	Predicted Savings For Various Duty Cycle Strategies						
		27%	43%	50%	67%	75%	83%	100%
7:00 PM	70	0.02	0.03	0.08	0.19	0.25	0.34	0.54
	71	0.02	0.08	0.13	0.26	0.33	0.43	0.65
	72	0.04	0.12	0.18	0.33	0.42	0.53	0.77
	73	0.07	0.17	0.23	0.40	0.50	0.62	0.88
	74	0.09	0.21	0.28	0.47	0.58	0.71	0.99
	75	0.12	0.25	0.33	0.54	0.67	0.80	1.11
	76	0.14	0.30	0.38	0.61	0.75	0.89	1.22
	77	0.17	0.34	0.43	0.68	0.84	0.99	1.33
	78	0.20	0.39	0.48	0.75	0.92	1.08	1.45
	79	0.22	0.43	0.53	0.82	1.00	1.17	1.56
	80	0.25	0.47	0.58	0.89	1.09	1.26	1.67
	81	0.27	0.52	0.62	0.97	1.17	1.35	1.79
	82	0.30	0.56	0.67	1.04	1.25	1.45	1.90
	83	0.32	0.61	0.72	1.11	1.34	1.54	2.01
	84	0.35	0.65	0.77	1.18	1.42	1.63	2.13
	84.1	0.35	0.65	0.78	1.18	1.43	1.64	2.14
	84.2	0.35	0.66	0.78	1.19	1.44	1.65	2.15
	84.3	0.36	0.66	0.79	1.20	1.45	1.66	2.16
	84.4	0.36	0.67	0.79	1.21	1.46	1.67	2.17
	84.5	0.36	0.67	0.80	1.21	1.46	1.68	2.18
	84.6	0.36	0.68	0.80	1.22	1.47	1.69	2.19
	84.7	0.37	0.68	0.81	1.23	1.48	1.70	2.21
	84.8	0.37	0.69	0.81	1.23	1.49	1.70	2.22
	84.9	0.37	0.69	0.82	1.24	1.50	1.71	2.23
	85	0.37	0.69	0.82	1.25	1.51	1.72	2.24
	85.1	0.38	0.70	0.83	1.26	1.51	1.73	2.25
	85.2	0.38	0.70	0.83	1.26	1.52	1.74	2.26
	85.3	0.38	0.71	0.84	1.27	1.53	1.75	2.27
	85.4	0.38	0.71	0.84	1.28	1.54	1.76	2.28
	85.5	0.39	0.72	0.85	1.28	1.55	1.77	2.30
	85.6	0.39	0.72	0.85	1.29	1.56	1.78	2.31
	85.7	0.39	0.73	0.86	1.30	1.56	1.79	2.32
	85.8	0.40	0.73	0.86	1.31	1.57	1.80	2.33
	85.9	0.40	0.73	0.87	1.31	1.58	1.81	2.34
	86	0.40	0.74	0.87	1.32	1.59	1.82	2.35
	87	0.43	0.78	0.92	1.39	1.67	1.91	2.47

Table 37 – Deemed AC Cycling Savings 15-minutes ending 7:00pm

14 APPENDIX H: DEEMED SAVINGS ESTIMATES FOR A/C CYCLING BY SEASONAL A/C USE

This appendix contains the detail tables by 15 minute time period for the AC Cycling savings estimates by seasonal air conditioning usage.

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Day	WTHI	Predicted Savings for Duty Cycle Strategies AC Use < 1600 kWh							Predicted Savings for Duty Cycle Strategies AC Use > 1600 kWh						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
1:00 PM	70	0.01	0.01	0.02	0.03	0.04	0.03	0.07	0.02	0.05	0.04	0.06	0.10	0.09	0.25
	71	0.01	0.01	0.02	0.03	0.04	0.03	0.07	0.02	0.05	0.04	0.06	0.10	0.19	0.38
	72	0.01	0.01	0.02	0.03	0.04	0.03	0.07	0.02	0.05	0.04	0.14	0.20	0.30	0.51
	73	0.01	0.01	0.02	0.03	0.04	0.03	0.07	0.02	0.05	0.10	0.23	0.30	0.41	0.65
	74	0.01	0.01	0.02	0.03	0.04	0.09	0.16	0.02	0.10	0.15	0.31	0.40	0.52	0.78
	75	0.01	0.01	0.02	0.07	0.10	0.15	0.24	0.05	0.15	0.21	0.39	0.50	0.63	0.92
	76	0.01	0.04	0.05	0.11	0.15	0.21	0.33	0.08	0.20	0.27	0.47	0.59	0.73	1.05
	77	0.02	0.06	0.08	0.16	0.21	0.27	0.41	0.11	0.25	0.33	0.56	0.69	0.84	1.18
	78	0.04	0.08	0.11	0.20	0.26	0.34	0.49	0.14	0.30	0.39	0.64	0.79	0.95	1.32
	79	0.05	0.11	0.14	0.25	0.32	0.40	0.58	0.17	0.36	0.45	0.72	0.89	1.06	1.45
	80	0.06	0.13	0.17	0.29	0.37	0.46	0.66	0.20	0.41	0.50	0.81	0.99	1.17	1.58
	81	0.08	0.15	0.20	0.34	0.43	0.52	0.75	0.24	0.46	0.56	0.89	1.09	1.28	1.72
	82	0.09	0.18	0.23	0.38	0.49	0.58	0.83	0.27	0.51	0.62	0.97	1.19	1.38	1.85
	83	0.11	0.20	0.26	0.43	0.54	0.64	0.91	0.30	0.56	0.68	1.06	1.29	1.49	1.98
	84	0.12	0.22	0.29	0.47	0.60	0.70	1.00	0.33	0.61	0.74	1.14	1.39	1.60	2.12
	84.1	0.12	0.23	0.29	0.48	0.60	0.70	1.01	0.33	0.62	0.74	1.15	1.39	1.61	2.13
	84.2	0.12	0.23	0.29	0.48	0.61	0.71	1.01	0.33	0.62	0.75	1.16	1.40	1.62	2.14
	84.3	0.12	0.23	0.30	0.49	0.61	0.72	1.02	0.34	0.63	0.75	1.16	1.41	1.63	2.16
	84.4	0.12	0.23	0.30	0.49	0.62	0.72	1.03	0.34	0.63	0.76	1.17	1.42	1.64	2.17
	84.5	0.13	0.24	0.30	0.49	0.63	0.73	1.04	0.34	0.64	0.77	1.18	1.43	1.65	2.18
	84.6	0.13	0.24	0.31	0.50	0.63	0.73	1.05	0.35	0.65	0.77	1.19	1.44	1.67	2.20
	84.7	0.13	0.24	0.31	0.50	0.64	0.74	1.06	0.35	0.65	0.78	1.20	1.45	1.68	2.21
	84.8	0.13	0.24	0.31	0.51	0.64	0.75	1.06	0.35	0.66	0.78	1.21	1.46	1.69	2.22
	84.9	0.13	0.25	0.32	0.51	0.65	0.75	1.07	0.36	0.66	0.79	1.21	1.47	1.70	2.24
	85	0.13	0.25	0.32	0.52	0.65	0.76	1.08	0.36	0.67	0.79	1.22	1.48	1.71	2.25
	85.1	0.13	0.25	0.32	0.52	0.66	0.76	1.09	0.36	0.67	0.80	1.23	1.49	1.72	2.26
	85.2	0.14	0.25	0.32	0.53	0.66	0.77	1.10	0.36	0.68	0.81	1.24	1.50	1.73	2.28
	85.3	0.14	0.26	0.33	0.53	0.67	0.78	1.11	0.37	0.68	0.81	1.25	1.51	1.74	2.29
	85.4	0.14	0.26	0.33	0.53	0.68	0.78	1.11	0.37	0.69	0.82	1.25	1.52	1.75	2.30
	85.5	0.14	0.26	0.33	0.54	0.68	0.79	1.12	0.37	0.69	0.82	1.26	1.53	1.76	2.32
	85.6	0.14	0.26	0.34	0.54	0.69	0.79	1.13	0.38	0.70	0.83	1.27	1.54	1.77	2.33
	85.7	0.14	0.27	0.34	0.55	0.69	0.80	1.14	0.38	0.70	0.84	1.28	1.55	1.78	2.34
	85.8	0.14	0.27	0.34	0.55	0.70	0.81	1.15	0.38	0.71	0.84	1.29	1.56	1.80	2.36
	85.9	0.15	0.27	0.35	0.56	0.70	0.81	1.16	0.39	0.71	0.85	1.30	1.57	1.81	2.37
	86	0.15	0.27	0.35	0.56	0.71	0.82	1.16	0.39	0.72	0.85	1.30	1.58	1.82	2.38
	87	0.16	0.30	0.38	0.61	0.76	0.88	1.25	0.42	0.77	0.91	1.39	1.68	1.93	2.52

Table 38 – Deemed AC Cycling Savings by Energy Stratum for 15-Minutes Ending 1:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Day	WTHI	Predicted Savings for Duty Cycle Strategies AC Use < 1600 kWh							Predicted Savings for Duty Cycle Strategies AC Use > 1600 kWh						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
2:00 PM	70	-	0.02	0.01	0.03	0.05	0.04	0.09	0.02	0.05	0.04	0.07	0.12	0.11	0.29
	71	-	0.02	0.01	0.03	0.05	0.04	0.09	0.02	0.05	0.04	0.07	0.12	0.22	0.43
	72	-	0.02	0.01	0.03	0.05	0.04	0.09	0.02	0.05	0.04	0.16	0.23	0.34	0.57
	73	-	0.02	0.01	0.03	0.05	0.04	0.09	0.02	0.05	0.11	0.25	0.33	0.45	0.71
	74	-	0.02	0.01	0.03	0.05	0.11	0.18	0.02	0.11	0.17	0.34	0.44	0.57	0.85
	75	-	0.02	0.04	0.08	0.11	0.18	0.27	0.06	0.17	0.24	0.43	0.54	0.68	0.99
	76	0.02	0.04	0.07	0.13	0.17	0.24	0.36	0.09	0.22	0.30	0.52	0.65	0.80	1.12
	77	0.03	0.07	0.10	0.18	0.24	0.31	0.45	0.13	0.28	0.37	0.61	0.76	0.91	1.26
	78	0.05	0.10	0.13	0.23	0.30	0.38	0.54	0.16	0.34	0.43	0.70	0.86	1.03	1.40
	79	0.06	0.13	0.17	0.29	0.36	0.44	0.63	0.20	0.40	0.50	0.79	0.97	1.14	1.54
	80	0.08	0.15	0.20	0.34	0.42	0.51	0.72	0.23	0.45	0.56	0.88	1.07	1.26	1.68
	81	0.09	0.18	0.23	0.39	0.49	0.58	0.82	0.27	0.51	0.62	0.97	1.18	1.37	1.82
	82	0.11	0.21	0.26	0.44	0.55	0.65	0.91	0.30	0.57	0.69	1.06	1.28	1.49	1.96
	83	0.12	0.24	0.29	0.49	0.61	0.71	1.00	0.34	0.63	0.75	1.15	1.39	1.60	2.10
	84	0.13	0.27	0.32	0.54	0.67	0.78	1.09	0.37	0.69	0.82	1.24	1.49	1.72	2.24
	84.1	0.14	0.27	0.32	0.54	0.68	0.79	1.10	0.38	0.69	0.82	1.25	1.51	1.73	2.26
	84.2	0.14	0.27	0.33	0.55	0.68	0.79	1.11	0.38	0.70	0.83	1.26	1.52	1.74	2.27
	84.3	0.14	0.27	0.33	0.55	0.69	0.80	1.11	0.38	0.70	0.84	1.27	1.53	1.75	2.28
	84.4	0.14	0.28	0.33	0.56	0.70	0.81	1.12	0.39	0.71	0.84	1.28	1.54	1.76	2.30
	84.5	0.14	0.28	0.34	0.56	0.70	0.81	1.13	0.39	0.71	0.85	1.29	1.55	1.77	2.31
	84.6	0.14	0.28	0.34	0.57	0.71	0.82	1.14	0.39	0.72	0.86	1.30	1.56	1.79	2.33
	84.7	0.14	0.29	0.34	0.58	0.72	0.83	1.15	0.40	0.73	0.86	1.31	1.57	1.80	2.34
	84.8	0.15	0.29	0.35	0.58	0.72	0.83	1.16	0.40	0.73	0.87	1.31	1.58	1.81	2.35
	84.9	0.15	0.29	0.35	0.59	0.73	0.84	1.17	0.40	0.74	0.88	1.32	1.59	1.82	2.37
	85	0.15	0.29	0.35	0.59	0.73	0.85	1.18	0.41	0.74	0.88	1.33	1.60	1.83	2.38
	85.1	0.15	0.30	0.36	0.60	0.74	0.85	1.19	0.41	0.75	0.89	1.34	1.61	1.84	2.39
	85.2	0.15	0.30	0.36	0.60	0.75	0.86	1.20	0.41	0.75	0.90	1.35	1.62	1.86	2.41
	85.3	0.15	0.30	0.36	0.61	0.75	0.87	1.21	0.42	0.76	0.90	1.36	1.63	1.87	2.42
	85.4	0.15	0.30	0.36	0.61	0.76	0.87	1.21	0.42	0.77	0.91	1.37	1.64	1.88	2.44
	85.5	0.16	0.31	0.37	0.62	0.77	0.88	1.22	0.42	0.77	0.91	1.38	1.65	1.89	2.45
	85.6	0.16	0.31	0.37	0.62	0.77	0.89	1.23	0.43	0.78	0.92	1.39	1.66	1.90	2.46
	85.7	0.16	0.31	0.37	0.63	0.78	0.89	1.24	0.43	0.78	0.93	1.40	1.67	1.91	2.48
	85.8	0.16	0.32	0.38	0.63	0.78	0.90	1.25	0.44	0.79	0.93	1.40	1.68	1.92	2.49
	85.9	0.16	0.32	0.38	0.64	0.79	0.91	1.26	0.44	0.79	0.94	1.41	1.70	1.94	2.51
	86	0.16	0.32	0.38	0.64	0.80	0.91	1.27	0.44	0.80	0.95	1.42	1.71	1.95	2.52
	87	0.18	0.35	0.41	0.69	0.86	0.98	1.36	0.48	0.86	1.01	1.51	1.81	2.06	2.66

Table 39 – Deemed AC Cycling Savings by Energy Stratum for 15-Minutes Ending 2:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Day	WTHI	Predicted Savings for Duty Cycle Strategies AC Use < 1600 kWh							Predicted Savings for Duty Cycle Strategies AC Use > 1600 kWh						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
3:00 PM	70	0.01	0.02	0.03	0.04	0.06	0.05	0.05	0.03	0.04	0.06	0.04	0.09	0.14	0.33
	71	0.01	0.02	0.03	0.04	0.06	0.05	0.05	0.03	0.04	0.06	0.13	0.19	0.26	0.48
	72	0.01	0.02	0.03	0.04	0.06	0.05	0.05	0.03	0.04	0.06	0.22	0.30	0.38	0.63
	73	0.01	0.02	0.03	0.04	0.06	0.05	0.15	0.03	0.10	0.13	0.32	0.41	0.50	0.77
	74	0.01	0.02	0.03	0.04	0.06	0.12	0.24	0.03	0.16	0.20	0.41	0.51	0.62	0.92
	75	0.01	0.02	0.03	0.09	0.13	0.20	0.33	0.07	0.21	0.27	0.50	0.62	0.75	1.06
	76	0.01	0.05	0.07	0.15	0.20	0.27	0.42	0.11	0.27	0.34	0.59	0.73	0.87	1.21
	77	0.03	0.08	0.11	0.21	0.26	0.34	0.51	0.15	0.33	0.41	0.68	0.83	0.99	1.35
	78	0.05	0.12	0.15	0.27	0.33	0.42	0.60	0.19	0.39	0.48	0.78	0.94	1.11	1.50
	79	0.07	0.15	0.19	0.32	0.40	0.49	0.69	0.23	0.45	0.55	0.87	1.05	1.23	1.65
	80	0.09	0.18	0.23	0.38	0.47	0.57	0.78	0.27	0.51	0.62	0.96	1.16	1.36	1.79
	81	0.11	0.21	0.27	0.44	0.54	0.64	0.88	0.30	0.57	0.69	1.05	1.26	1.48	1.94
	82	0.13	0.25	0.31	0.49	0.61	0.71	0.97	0.34	0.62	0.77	1.14	1.37	1.60	2.08
	83	0.15	0.28	0.35	0.55	0.68	0.79	1.06	0.38	0.68	0.84	1.23	1.48	1.72	2.23
	84	0.17	0.31	0.39	0.61	0.75	0.86	1.15	0.42	0.74	0.91	1.33	1.58	1.84	2.37
	84.1	0.17	0.31	0.39	0.61	0.75	0.87	1.16	0.42	0.75	0.91	1.34	1.59	1.85	2.39
	84.2	0.18	0.32	0.40	0.62	0.76	0.88	1.17	0.43	0.75	0.92	1.34	1.61	1.87	2.40
	84.3	0.18	0.32	0.40	0.62	0.77	0.88	1.18	0.43	0.76	0.93	1.35	1.62	1.88	2.42
	84.4	0.18	0.32	0.40	0.63	0.77	0.89	1.19	0.44	0.76	0.93	1.36	1.63	1.89	2.43
	84.5	0.18	0.33	0.41	0.64	0.78	0.90	1.20	0.44	0.77	0.94	1.37	1.64	1.90	2.45
	84.6	0.18	0.33	0.41	0.64	0.79	0.91	1.20	0.44	0.78	0.95	1.38	1.65	1.92	2.46
	84.7	0.19	0.33	0.42	0.65	0.80	0.91	1.21	0.45	0.78	0.96	1.39	1.66	1.93	2.48
	84.8	0.19	0.34	0.42	0.65	0.80	0.92	1.22	0.45	0.79	0.96	1.40	1.67	1.94	2.49
	84.9	0.19	0.34	0.43	0.66	0.81	0.93	1.23	0.46	0.79	0.97	1.41	1.68	1.95	2.51
	85	0.19	0.34	0.43	0.66	0.82	0.94	1.24	0.46	0.80	0.98	1.42	1.69	1.96	2.52
	85.1	0.19	0.35	0.43	0.67	0.82	0.94	1.25	0.46	0.81	0.98	1.43	1.70	1.98	2.54
	85.2	0.20	0.35	0.44	0.68	0.83	0.95	1.26	0.47	0.81	0.99	1.44	1.71	1.99	2.55
	85.3	0.20	0.35	0.44	0.68	0.84	0.96	1.27	0.47	0.82	1.00	1.45	1.72	2.00	2.56
	85.4	0.20	0.36	0.45	0.69	0.84	0.97	1.28	0.47	0.82	1.00	1.45	1.73	2.01	2.58
	85.5	0.20	0.36	0.45	0.69	0.85	0.97	1.29	0.48	0.83	1.01	1.46	1.74	2.02	2.59
	85.6	0.20	0.36	0.45	0.70	0.86	0.98	1.30	0.48	0.84	1.02	1.47	1.76	2.04	2.61
	85.7	0.21	0.37	0.46	0.70	0.86	0.99	1.30	0.49	0.84	1.03	1.48	1.77	2.05	2.62
	85.8	0.21	0.37	0.46	0.71	0.87	0.99	1.31	0.49	0.85	1.03	1.49	1.78	2.06	2.64
	85.9	0.21	0.37	0.47	0.72	0.88	1.00	1.32	0.49	0.85	1.04	1.50	1.79	2.07	2.65
	86	0.21	0.38	0.47	0.72	0.89	1.01	1.33	0.50	0.86	1.05	1.51	1.80	2.09	2.67
	87	0.23	0.41	0.51	0.78	0.95	1.08	1.42	0.54	0.92	1.12	1.60	1.91	2.21	2.81

Table 40 – Deemed AC Cycling Savings by Energy Stratum for 15-Minutes Ending 3:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Day	WTHI	Predicted Savings for Duty Cycle Strategies AC Use < 1600 kWh							Predicted Savings for Duty Cycle Strategies AC Use > 1600 kWh						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
4:00 PM	70	0.01	0.02	0.03	0.04	0.03	0.05	0.05	0.03	0.03	0.05	0.09	0.18	0.25	0.51
	71	0.01	0.02	0.03	0.04	0.03	0.05	0.05	0.03	0.03	0.05	0.18	0.29	0.37	0.65
	72	0.01	0.02	0.03	0.04	0.03	0.05	0.14	0.03	0.09	0.12	0.28	0.40	0.49	0.79
	73	0.01	0.02	0.03	0.04	0.09	0.12	0.23	0.03	0.15	0.19	0.37	0.50	0.61	0.92
	74	0.01	0.02	0.03	0.09	0.15	0.19	0.32	0.07	0.20	0.26	0.47	0.61	0.73	1.06
	75	0.01	0.05	0.06	0.15	0.21	0.26	0.41	0.10	0.26	0.33	0.57	0.71	0.85	1.20
	76	0.03	0.08	0.10	0.20	0.27	0.33	0.50	0.14	0.32	0.40	0.66	0.82	0.97	1.34
	77	0.05	0.11	0.14	0.26	0.33	0.41	0.59	0.18	0.38	0.47	0.76	0.93	1.09	1.48
	78	0.07	0.14	0.18	0.31	0.40	0.48	0.68	0.22	0.44	0.54	0.85	1.03	1.21	1.62
	79	0.09	0.18	0.22	0.37	0.46	0.55	0.77	0.26	0.50	0.61	0.95	1.14	1.33	1.76
	80	0.11	0.21	0.26	0.42	0.52	0.62	0.85	0.30	0.56	0.68	1.04	1.24	1.45	1.89
	81	0.13	0.24	0.30	0.48	0.58	0.69	0.94	0.33	0.62	0.75	1.14	1.35	1.57	2.03
	82	0.15	0.27	0.34	0.53	0.64	0.77	1.03	0.37	0.67	0.82	1.24	1.45	1.69	2.17
	83	0.17	0.30	0.38	0.59	0.70	0.84	1.12	0.41	0.73	0.89	1.33	1.56	1.81	2.31
	84	0.18	0.33	0.42	0.65	0.76	0.91	1.21	0.45	0.79	0.96	1.43	1.67	1.93	2.45
	84.1	0.19	0.34	0.42	0.65	0.77	0.92	1.22	0.45	0.80	0.97	1.44	1.68	1.94	2.46
	84.2	0.19	0.34	0.42	0.66	0.78	0.92	1.23	0.46	0.80	0.98	1.45	1.69	1.95	2.48
	84.3	0.19	0.34	0.43	0.66	0.78	0.93	1.24	0.46	0.81	0.98	1.46	1.70	1.97	2.49
	84.4	0.19	0.35	0.43	0.67	0.79	0.94	1.25	0.46	0.81	0.99	1.47	1.71	1.98	2.50
	84.5	0.19	0.35	0.44	0.67	0.80	0.95	1.26	0.47	0.82	1.00	1.48	1.72	1.99	2.52
	84.6	0.20	0.35	0.44	0.68	0.80	0.95	1.27	0.47	0.83	1.01	1.48	1.73	2.00	2.53
	84.7	0.20	0.36	0.44	0.68	0.81	0.96	1.27	0.48	0.83	1.01	1.49	1.74	2.01	2.55
	84.8	0.20	0.36	0.45	0.69	0.81	0.97	1.28	0.48	0.84	1.02	1.50	1.75	2.03	2.56
	84.9	0.20	0.36	0.45	0.69	0.82	0.98	1.29	0.48	0.84	1.03	1.51	1.76	2.04	2.57
	85	0.20	0.37	0.46	0.70	0.83	0.98	1.30	0.49	0.85	1.03	1.52	1.77	2.05	2.59
	85.1	0.21	0.37	0.46	0.71	0.83	0.99	1.31	0.49	0.86	1.04	1.53	1.78	2.06	2.60
	85.2	0.21	0.37	0.46	0.71	0.84	1.00	1.32	0.50	0.86	1.05	1.54	1.79	2.07	2.62
	85.3	0.21	0.38	0.47	0.72	0.84	1.00	1.33	0.50	0.87	1.05	1.55	1.80	2.09	2.63
	85.4	0.21	0.38	0.47	0.72	0.85	1.01	1.34	0.50	0.87	1.06	1.56	1.81	2.10	2.64
	85.5	0.21	0.38	0.47	0.73	0.86	1.02	1.35	0.51	0.88	1.07	1.57	1.82	2.11	2.66
	85.6	0.22	0.39	0.48	0.73	0.86	1.03	1.35	0.51	0.89	1.08	1.58	1.84	2.12	2.67
	85.7	0.22	0.39	0.48	0.74	0.87	1.03	1.36	0.51	0.89	1.08	1.59	1.85	2.13	2.68
	85.8	0.22	0.39	0.49	0.74	0.88	1.04	1.37	0.52	0.90	1.09	1.60	1.86	2.15	2.70
	85.9	0.22	0.39	0.49	0.75	0.88	1.05	1.38	0.52	0.90	1.10	1.61	1.87	2.16	2.71
	86	0.22	0.40	0.49	0.76	0.89	1.05	1.39	0.53	0.91	1.10	1.62	1.88	2.17	2.73
	87	0.24	0.43	0.53	0.81	0.95	1.13	1.48	0.56	0.97	1.17	1.71	1.98	2.29	2.86

Table 41 – Deemed AC Cycling Savings by Energy Stratum for 15-Minutes Ending 4:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Day	WTHI	Predicted Savings for Duty Cycle Strategies AC Use < 1600 kWh							Predicted Savings for Duty Cycle Strategies AC Use > 1600 kWh						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
5:00 PM	70	0.01	0.02	0.03	0.04	0.06	0.04	0.05	0.03	0.06	0.05	0.18	0.25	0.39	0.63
	71	0.01	0.02	0.03	0.04	0.06	0.04	0.14	0.03	0.06	0.12	0.27	0.36	0.51	0.77
	72	0.01	0.02	0.03	0.04	0.06	0.12	0.23	0.03	0.12	0.19	0.37	0.47	0.63	0.91
	73	0.01	0.02	0.03	0.09	0.13	0.19	0.33	0.06	0.18	0.26	0.47	0.58	0.74	1.05
	74	0.01	0.05	0.07	0.15	0.20	0.27	0.42	0.10	0.25	0.33	0.56	0.69	0.86	1.19
	75	0.03	0.08	0.11	0.21	0.27	0.34	0.51	0.14	0.31	0.40	0.66	0.81	0.98	1.33
	76	0.05	0.12	0.15	0.27	0.33	0.42	0.60	0.18	0.37	0.47	0.76	0.92	1.09	1.48
	77	0.07	0.15	0.19	0.33	0.40	0.49	0.69	0.22	0.43	0.54	0.85	1.03	1.21	1.62
	78	0.09	0.18	0.23	0.38	0.47	0.57	0.79	0.26	0.50	0.61	0.95	1.14	1.33	1.76
	79	0.11	0.22	0.27	0.44	0.54	0.64	0.88	0.29	0.56	0.68	1.04	1.25	1.44	1.90
	80	0.13	0.25	0.31	0.50	0.61	0.72	0.97	0.33	0.62	0.75	1.14	1.36	1.56	2.04
	81	0.15	0.28	0.35	0.56	0.68	0.79	1.06	0.37	0.69	0.82	1.24	1.47	1.68	2.18
	82	0.17	0.32	0.40	0.62	0.75	0.87	1.15	0.41	0.75	0.89	1.33	1.59	1.80	2.32
	83	0.19	0.35	0.44	0.67	0.82	0.94	1.25	0.45	0.81	0.96	1.43	1.70	1.91	2.46
	84	0.21	0.38	0.48	0.73	0.89	1.02	1.34	0.48	0.87	1.03	1.53	1.81	2.03	2.61
	84.1	0.22	0.39	0.48	0.74	0.90	1.03	1.35	0.49	0.88	1.04	1.54	1.82	2.04	2.62
	84.2	0.22	0.39	0.49	0.74	0.90	1.03	1.36	0.49	0.89	1.05	1.55	1.83	2.05	2.63
	84.3	0.22	0.40	0.49	0.75	0.91	1.04	1.37	0.50	0.89	1.06	1.56	1.84	2.06	2.65
	84.4	0.22	0.40	0.49	0.76	0.92	1.05	1.37	0.50	0.90	1.06	1.56	1.85	2.08	2.66
	84.5	0.22	0.40	0.50	0.76	0.93	1.06	1.38	0.50	0.91	1.07	1.57	1.86	2.09	2.68
	84.6	0.23	0.41	0.50	0.77	0.93	1.06	1.39	0.51	0.91	1.08	1.58	1.88	2.10	2.69
	84.7	0.23	0.41	0.51	0.77	0.94	1.07	1.40	0.51	0.92	1.08	1.59	1.89	2.11	2.70
	84.8	0.23	0.41	0.51	0.78	0.95	1.08	1.41	0.52	0.92	1.09	1.60	1.90	2.12	2.72
	84.9	0.23	0.42	0.51	0.78	0.95	1.09	1.42	0.52	0.93	1.10	1.61	1.91	2.13	2.73
	85	0.23	0.42	0.52	0.79	0.96	1.09	1.43	0.52	0.94	1.10	1.62	1.92	2.15	2.75
	85.1	0.24	0.42	0.52	0.80	0.97	1.10	1.44	0.53	0.94	1.11	1.63	1.93	2.16	2.76
	85.2	0.24	0.43	0.53	0.80	0.97	1.11	1.45	0.53	0.95	1.12	1.64	1.94	2.17	2.77
	85.3	0.24	0.43	0.53	0.81	0.98	1.12	1.46	0.53	0.96	1.13	1.65	1.95	2.18	2.79
	85.4	0.24	0.43	0.54	0.81	0.99	1.12	1.47	0.54	0.96	1.13	1.66	1.96	2.19	2.80
	85.5	0.24	0.44	0.54	0.82	1.00	1.13	1.48	0.54	0.97	1.14	1.67	1.98	2.20	2.82
	85.6	0.25	0.44	0.54	0.83	1.00	1.14	1.49	0.55	0.97	1.15	1.68	1.99	2.22	2.83
	85.7	0.25	0.44	0.55	0.83	1.01	1.15	1.49	0.55	0.98	1.15	1.69	2.00	2.23	2.85
	85.8	0.25	0.45	0.55	0.84	1.02	1.15	1.50	0.55	0.99	1.16	1.70	2.01	2.24	2.86
	85.9	0.25	0.45	0.56	0.84	1.02	1.16	1.51	0.56	0.99	1.17	1.71	2.02	2.25	2.87
	86	0.25	0.45	0.56	0.85	1.03	1.17	1.52	0.56	1.00	1.18	1.72	2.03	2.26	2.89
	87	0.27	0.49	0.60	0.91	1.10	1.24	1.61	0.60	1.06	1.25	1.82	2.14	2.38	3.03

Table 42 – Deemed AC Cycling Savings by Energy Stratum for 15-Minutes Ending 5:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Day	WTHI	Predicted Savings for Duty Cycle Strategies AC Use < 1600 kWh							Predicted Savings for Duty Cycle Strategies AC Use > 1600 kWh						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
6:00 PM	70	0.01	0.01	0.02	0.03	0.02	0.04	0.14	0.02	0.05	0.11	0.26	0.37	0.49	0.74
	71	0.01	0.01	0.02	0.03	0.09	0.12	0.23	0.02	0.11	0.18	0.35	0.48	0.60	0.88
	72	0.01	0.01	0.02	0.09	0.15	0.19	0.32	0.06	0.17	0.24	0.45	0.58	0.72	1.02
	73	0.01	0.05	0.06	0.15	0.22	0.27	0.42	0.09	0.23	0.31	0.54	0.69	0.83	1.16
	74	0.03	0.08	0.10	0.21	0.28	0.34	0.51	0.13	0.29	0.38	0.63	0.79	0.95	1.30
	75	0.05	0.11	0.15	0.26	0.34	0.42	0.60	0.17	0.35	0.45	0.73	0.89	1.06	1.44
	76	0.07	0.15	0.19	0.32	0.41	0.49	0.69	0.20	0.41	0.52	0.82	1.00	1.18	1.58
	77	0.09	0.18	0.23	0.38	0.47	0.57	0.78	0.24	0.47	0.58	0.92	1.10	1.29	1.72
	78	0.11	0.21	0.27	0.44	0.54	0.64	0.87	0.27	0.53	0.65	1.01	1.21	1.41	1.86
	79	0.13	0.25	0.31	0.50	0.60	0.72	0.97	0.31	0.59	0.72	1.10	1.31	1.52	2.00
	80	0.15	0.28	0.35	0.55	0.66	0.79	1.06	0.35	0.65	0.79	1.20	1.42	1.64	2.14
	81	0.17	0.31	0.39	0.61	0.73	0.87	1.15	0.38	0.71	0.86	1.29	1.52	1.75	2.28
	82	0.19	0.35	0.43	0.67	0.79	0.94	1.24	0.42	0.77	0.92	1.38	1.63	1.87	2.42
	83	0.21	0.38	0.47	0.73	0.86	1.01	1.33	0.45	0.83	0.99	1.48	1.73	1.98	2.56
	84	0.23	0.41	0.51	0.78	0.92	1.09	1.43	0.49	0.89	1.06	1.57	1.84	2.10	2.70
	84.1	0.23	0.42	0.52	0.79	0.93	1.10	1.44	0.49	0.90	1.07	1.58	1.85	2.11	2.71
	84.2	0.23	0.42	0.52	0.80	0.93	1.10	1.44	0.50	0.91	1.07	1.59	1.86	2.12	2.73
	84.3	0.24	0.42	0.52	0.80	0.94	1.11	1.45	0.50	0.91	1.08	1.60	1.87	2.13	2.74
	84.4	0.24	0.43	0.53	0.81	0.95	1.12	1.46	0.50	0.92	1.09	1.61	1.88	2.15	2.76
	84.5	0.24	0.43	0.53	0.81	0.95	1.13	1.47	0.51	0.92	1.09	1.62	1.89	2.16	2.77
	84.6	0.24	0.43	0.54	0.82	0.96	1.13	1.48	0.51	0.93	1.10	1.63	1.90	2.17	2.78
	84.7	0.24	0.44	0.54	0.82	0.97	1.14	1.49	0.51	0.94	1.11	1.64	1.91	2.18	2.80
	84.8	0.25	0.44	0.54	0.83	0.97	1.15	1.50	0.52	0.94	1.11	1.65	1.92	2.19	2.81
	84.9	0.25	0.44	0.55	0.84	0.98	1.16	1.51	0.52	0.95	1.12	1.66	1.93	2.20	2.83
	85	0.25	0.45	0.55	0.84	0.99	1.16	1.52	0.53	0.95	1.13	1.67	1.94	2.22	2.84
	85.1	0.25	0.45	0.56	0.85	0.99	1.17	1.53	0.53	0.96	1.13	1.67	1.95	2.23	2.85
	85.2	0.25	0.45	0.56	0.85	1.00	1.18	1.54	0.53	0.97	1.14	1.68	1.96	2.24	2.87
	85.3	0.26	0.45	0.56	0.86	1.00	1.19	1.55	0.54	0.97	1.15	1.69	1.97	2.25	2.88
	85.4	0.26	0.46	0.57	0.86	1.01	1.19	1.56	0.54	0.98	1.15	1.70	1.98	2.26	2.89
	85.5	0.26	0.46	0.57	0.87	1.02	1.20	1.56	0.54	0.98	1.16	1.71	1.99	2.27	2.91
	85.6	0.26	0.46	0.58	0.88	1.02	1.21	1.57	0.55	0.99	1.17	1.72	2.00	2.28	2.92
	85.7	0.26	0.47	0.58	0.88	1.03	1.22	1.58	0.55	1.00	1.18	1.73	2.01	2.30	2.94
	85.8	0.27	0.47	0.58	0.89	1.04	1.22	1.59	0.55	1.00	1.18	1.74	2.02	2.31	2.95
	85.9	0.27	0.47	0.59	0.89	1.04	1.23	1.60	0.56	1.01	1.19	1.75	2.03	2.32	2.96
	86	0.27	0.48	0.59	0.90	1.05	1.24	1.61	0.56	1.01	1.20	1.76	2.05	2.33	2.98
	87	0.29	0.51	0.63	0.96	1.11	1.31	1.70	0.60	1.07	1.26	1.85	2.15	2.45	3.12

Table 43 – Deemed AC Cycling Savings by Energy Stratum for 15-Minutes Ending 6:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Day	WTHI	Predicted Savings for Duty Cycle Strategies AC Use < 1600 kWh							Predicted Savings for Duty Cycle Strategies AC Use > 1600 kWh						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
7:00 PM	70	0.01	0.02	0.02	0.03	0.05	0.10	0.18	0.02	0.10	0.14	0.33	0.45	0.57	0.84
	71	0.01	0.02	0.02	0.08	0.11	0.17	0.27	0.05	0.15	0.20	0.41	0.54	0.68	0.98
	72	0.01	0.02	0.06	0.13	0.18	0.25	0.37	0.08	0.21	0.27	0.50	0.64	0.78	1.11
	73	0.01	0.06	0.09	0.19	0.24	0.32	0.46	0.11	0.26	0.33	0.59	0.74	0.89	1.24
	74	0.03	0.09	0.13	0.24	0.31	0.39	0.56	0.14	0.32	0.40	0.67	0.84	1.00	1.38
	75	0.05	0.12	0.16	0.29	0.37	0.46	0.65	0.17	0.37	0.46	0.76	0.93	1.11	1.51
	76	0.07	0.15	0.20	0.35	0.43	0.53	0.75	0.21	0.42	0.53	0.85	1.03	1.22	1.64
	77	0.09	0.19	0.24	0.40	0.50	0.60	0.84	0.24	0.48	0.59	0.93	1.13	1.32	1.77
	78	0.11	0.22	0.27	0.45	0.56	0.67	0.94	0.27	0.53	0.66	1.02	1.22	1.43	1.91
	79	0.13	0.25	0.31	0.51	0.63	0.74	1.03	0.30	0.58	0.72	1.11	1.32	1.54	2.04
	80	0.15	0.28	0.35	0.56	0.69	0.81	1.13	0.33	0.64	0.79	1.19	1.42	1.65	2.17
	81	0.17	0.32	0.38	0.61	0.76	0.88	1.22	0.36	0.69	0.85	1.28	1.52	1.76	2.31
	82	0.19	0.35	0.42	0.67	0.82	0.96	1.31	0.39	0.75	0.92	1.37	1.61	1.86	2.44
	83	0.21	0.38	0.45	0.72	0.89	1.03	1.41	0.42	0.80	0.99	1.45	1.71	1.97	2.57
	84	0.22	0.41	0.49	0.77	0.95	1.10	1.50	0.45	0.85	1.05	1.54	1.81	2.08	2.71
	84.1	0.23	0.42	0.49	0.78	0.96	1.11	1.51	0.46	0.86	1.06	1.55	1.82	2.09	2.72
	84.2	0.23	0.42	0.50	0.78	0.97	1.11	1.52	0.46	0.86	1.06	1.56	1.83	2.10	2.73
	84.3	0.23	0.42	0.50	0.79	0.97	1.12	1.53	0.46	0.87	1.07	1.56	1.84	2.11	2.75
	84.4	0.23	0.43	0.50	0.79	0.98	1.13	1.54	0.47	0.88	1.08	1.57	1.85	2.12	2.76
	84.5	0.23	0.43	0.51	0.80	0.99	1.13	1.55	0.47	0.88	1.08	1.58	1.86	2.13	2.77
	84.6	0.24	0.43	0.51	0.80	0.99	1.14	1.56	0.47	0.89	1.09	1.59	1.87	2.15	2.79
	84.7	0.24	0.44	0.52	0.81	1.00	1.15	1.57	0.47	0.89	1.10	1.60	1.88	2.16	2.80
	84.8	0.24	0.44	0.52	0.82	1.01	1.15	1.58	0.48	0.90	1.10	1.61	1.89	2.17	2.81
	84.9	0.24	0.44	0.52	0.82	1.01	1.16	1.59	0.48	0.90	1.11	1.62	1.89	2.18	2.83
	85	0.24	0.45	0.53	0.83	1.02	1.17	1.60	0.48	0.91	1.12	1.63	1.90	2.19	2.84
	85.1	0.25	0.45	0.53	0.83	1.02	1.18	1.61	0.49	0.91	1.12	1.63	1.91	2.20	2.85
	85.2	0.25	0.45	0.53	0.84	1.03	1.18	1.62	0.49	0.92	1.13	1.64	1.92	2.21	2.87
	85.3	0.25	0.46	0.54	0.84	1.04	1.19	1.63	0.49	0.92	1.14	1.65	1.93	2.22	2.88
	85.4	0.25	0.46	0.54	0.85	1.04	1.20	1.64	0.50	0.93	1.14	1.66	1.94	2.23	2.89
	85.5	0.25	0.46	0.54	0.85	1.05	1.20	1.65	0.50	0.93	1.15	1.67	1.95	2.24	2.91
	85.6	0.26	0.46	0.55	0.86	1.06	1.21	1.66	0.50	0.94	1.16	1.68	1.96	2.25	2.92
	85.7	0.26	0.47	0.55	0.86	1.06	1.22	1.66	0.51	0.95	1.16	1.69	1.97	2.26	2.93
	85.8	0.26	0.47	0.56	0.87	1.07	1.23	1.67	0.51	0.95	1.17	1.69	1.98	2.28	2.95
	85.9	0.26	0.47	0.56	0.87	1.08	1.23	1.68	0.51	0.96	1.17	1.70	1.99	2.29	2.96
	86	0.26	0.48	0.56	0.88	1.08	1.24	1.69	0.51	0.96	1.18	1.71	2.00	2.30	2.97
	87	0.28	0.51	0.60	0.93	1.15	1.31	1.79	0.55	1.02	1.25	1.80	2.10	2.40	3.10

Table 44 – Deemed AC Cycling Savings by Energy Stratum for 15-Minutes Ending 7:00pm

15 APPENDIX I: DEEMED SAVINGS ESTIMATES FOR A/C CYCLING BY DEMAND STRATA

This appendix contains the detail tables by 15 minute time period for the AC Cycling savings estimates by connected demand.

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Time Of Day	WTHI	Predicted Savings by Duty Cycle Strategies AC Demand < 3.5 kW							Predicted Savings by Duty Cycle Strategies AC Demand > 3.5 kW						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
1:00 PM	70	0.01	0.03	0.04	0.04	0.06	0.05	0.12	0.02	0.04	0.05	0.07	0.04	0.07	0.07
	71	0.01	0.03	0.04	0.04	0.06	0.05	0.12	0.02	0.04	0.05	0.07	0.04	0.07	0.24
	72	0.01	0.03	0.04	0.04	0.06	0.13	0.22	0.02	0.04	0.05	0.07	0.16	0.21	0.41
	73	0.01	0.03	0.04	0.09	0.13	0.20	0.32	0.02	0.04	0.05	0.18	0.28	0.35	0.58
	74	0.01	0.03	0.04	0.15	0.20	0.28	0.42	0.02	0.10	0.14	0.29	0.41	0.49	0.75
	75	0.01	0.06	0.08	0.21	0.27	0.35	0.52	0.06	0.17	0.22	0.40	0.53	0.63	0.92
	76	0.03	0.10	0.12	0.26	0.34	0.43	0.62	0.10	0.24	0.30	0.51	0.65	0.77	1.09
	77	0.05	0.13	0.17	0.32	0.40	0.50	0.72	0.14	0.31	0.38	0.62	0.77	0.91	1.26
	78	0.07	0.16	0.21	0.37	0.47	0.58	0.82	0.18	0.37	0.46	0.73	0.89	1.05	1.43
	79	0.09	0.20	0.25	0.43	0.54	0.65	0.92	0.22	0.44	0.54	0.84	1.01	1.19	1.59
	80	0.11	0.23	0.29	0.49	0.61	0.73	1.02	0.27	0.51	0.62	0.95	1.13	1.33	1.76
	81	0.13	0.27	0.34	0.54	0.68	0.80	1.12	0.31	0.57	0.70	1.06	1.25	1.47	1.93
	82	0.15	0.30	0.38	0.60	0.74	0.88	1.22	0.35	0.64	0.79	1.17	1.37	1.61	2.10
	83	0.17	0.33	0.42	0.65	0.81	0.95	1.32	0.39	0.71	0.87	1.28	1.49	1.75	2.27
	84	0.19	0.37	0.46	0.71	0.88	1.03	1.42	0.43	0.78	0.95	1.39	1.62	1.89	2.44
	84.1	0.20	0.37	0.47	0.72	0.89	1.04	1.43	0.43	0.78	0.96	1.40	1.63	1.90	2.46
	84.2	0.20	0.37	0.47	0.72	0.89	1.04	1.44	0.44	0.79	0.96	1.41	1.64	1.92	2.48
	84.3	0.20	0.38	0.48	0.73	0.90	1.05	1.45	0.44	0.80	0.97	1.43	1.65	1.93	2.49
	84.4	0.20	0.38	0.48	0.73	0.91	1.06	1.46	0.45	0.80	0.98	1.44	1.66	1.94	2.51
	84.5	0.20	0.38	0.48	0.74	0.91	1.07	1.47	0.45	0.81	0.99	1.45	1.68	1.96	2.53
	84.6	0.21	0.39	0.49	0.74	0.92	1.07	1.48	0.45	0.82	1.00	1.46	1.69	1.97	2.55
	84.7	0.21	0.39	0.49	0.75	0.93	1.08	1.49	0.46	0.82	1.00	1.47	1.70	1.99	2.56
	84.8	0.21	0.39	0.50	0.75	0.94	1.09	1.50	0.46	0.83	1.01	1.48	1.71	2.00	2.58
	84.9	0.21	0.40	0.50	0.76	0.94	1.09	1.51	0.47	0.84	1.02	1.49	1.72	2.01	2.60
	85	0.21	0.40	0.51	0.77	0.95	1.10	1.52	0.47	0.84	1.03	1.50	1.74	2.03	2.61
	85.1	0.22	0.40	0.51	0.77	0.96	1.11	1.53	0.48	0.85	1.04	1.51	1.75	2.04	2.63
	85.2	0.22	0.41	0.51	0.78	0.96	1.12	1.54	0.48	0.86	1.05	1.52	1.76	2.06	2.65
	85.3	0.22	0.41	0.52	0.78	0.97	1.12	1.55	0.48	0.86	1.05	1.54	1.77	2.07	2.66
	85.4	0.22	0.41	0.52	0.79	0.98	1.13	1.56	0.49	0.87	1.06	1.55	1.79	2.08	2.68
	85.5	0.22	0.42	0.53	0.79	0.98	1.14	1.57	0.49	0.88	1.07	1.56	1.80	2.10	2.70
	85.6	0.23	0.42	0.53	0.80	0.99	1.15	1.58	0.50	0.89	1.08	1.57	1.81	2.11	2.72
	85.7	0.23	0.43	0.53	0.81	1.00	1.15	1.59	0.50	0.89	1.09	1.58	1.82	2.13	2.73
	85.8	0.23	0.43	0.54	0.81	1.00	1.16	1.60	0.50	0.90	1.09	1.59	1.83	2.14	2.75
	85.9	0.23	0.43	0.54	0.82	1.01	1.17	1.61	0.51	0.91	1.10	1.60	1.85	2.15	2.77
	86	0.24	0.44	0.55	0.82	1.02	1.18	1.62	0.51	0.91	1.11	1.61	1.86	2.17	2.78
	87	0.26	0.47	0.59	0.88	1.08	1.25	1.72	0.55	0.98	1.19	1.72	1.98	2.31	2.95

Table 45 – Deemed AC Cycling Savings by Connected kW for 15-Minutes Ending 1:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Time Of Day	WTHI	Predicted Savings by Duty Cycle Strategies AC Demand < 3.5 kW							Predicted Savings by Duty Cycle Strategies AC Demand > 3.5 kW						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
2:00 PM	70	0.02	0.03	0.05	0.04	0.07	0.06	0.15	0.02	0.05	0.07	0.09	0.07	0.11	0.12
	71	0.02	0.03	0.05	0.04	0.07	0.06	0.15	0.02	0.05	0.07	0.09	0.07	0.11	0.29
	72	0.02	0.03	0.05	0.04	0.07	0.15	0.25	0.02	0.05	0.07	0.09	0.19	0.25	0.46
	73	0.02	0.03	0.05	0.11	0.15	0.23	0.36	0.02	0.05	0.07	0.21	0.32	0.40	0.64
	74	0.02	0.03	0.05	0.17	0.22	0.31	0.47	0.02	0.12	0.15	0.32	0.45	0.54	0.81
	75	0.02	0.07	0.09	0.23	0.30	0.39	0.57	0.07	0.19	0.24	0.44	0.57	0.68	0.98
	76	0.04	0.11	0.14	0.30	0.37	0.47	0.68	0.11	0.26	0.33	0.55	0.70	0.83	1.15
	77	0.06	0.15	0.19	0.36	0.45	0.56	0.78	0.16	0.33	0.41	0.67	0.82	0.97	1.33
	78	0.09	0.19	0.24	0.42	0.52	0.64	0.89	0.20	0.40	0.50	0.78	0.95	1.11	1.50
	79	0.11	0.23	0.29	0.48	0.60	0.72	1.00	0.25	0.47	0.58	0.90	1.07	1.26	1.67
	80	0.13	0.27	0.34	0.55	0.67	0.80	1.10	0.29	0.55	0.67	1.01	1.20	1.40	1.85
	81	0.16	0.31	0.38	0.61	0.75	0.88	1.21	0.33	0.62	0.75	1.12	1.32	1.54	2.02
	82	0.18	0.35	0.43	0.67	0.82	0.97	1.32	0.38	0.69	0.84	1.24	1.45	1.69	2.19
	83	0.20	0.39	0.48	0.73	0.90	1.05	1.42	0.42	0.76	0.92	1.35	1.58	1.83	2.36
	84	0.23	0.42	0.53	0.80	0.97	1.13	1.53	0.47	0.83	1.01	1.47	1.70	1.98	2.54
	84.1	0.23	0.43	0.53	0.80	0.98	1.14	1.54	0.47	0.84	1.02	1.48	1.71	1.99	2.55
	84.2	0.23	0.43	0.54	0.81	0.99	1.15	1.55	0.48	0.84	1.02	1.49	1.73	2.00	2.57
	84.3	0.24	0.44	0.54	0.82	1.00	1.15	1.56	0.48	0.85	1.03	1.50	1.74	2.02	2.59
	84.4	0.24	0.44	0.55	0.82	1.00	1.16	1.57	0.48	0.86	1.04	1.51	1.75	2.03	2.61
	84.5	0.24	0.44	0.55	0.83	1.01	1.17	1.58	0.49	0.87	1.05	1.53	1.76	2.05	2.62
	84.6	0.24	0.45	0.56	0.83	1.02	1.18	1.59	0.49	0.87	1.06	1.54	1.78	2.06	2.64
	84.7	0.24	0.45	0.56	0.84	1.03	1.19	1.60	0.50	0.88	1.07	1.55	1.79	2.08	2.66
	84.8	0.25	0.46	0.57	0.85	1.03	1.19	1.62	0.50	0.89	1.07	1.56	1.80	2.09	2.68
	84.9	0.25	0.46	0.57	0.85	1.04	1.20	1.63	0.51	0.89	1.08	1.57	1.81	2.11	2.69
	85	0.25	0.46	0.58	0.86	1.05	1.21	1.64	0.51	0.90	1.09	1.58	1.83	2.12	2.71
	85.1	0.25	0.47	0.58	0.87	1.06	1.22	1.65	0.52	0.91	1.10	1.59	1.84	2.13	2.73
	85.2	0.26	0.47	0.59	0.87	1.06	1.23	1.66	0.52	0.92	1.11	1.61	1.85	2.15	2.74
	85.3	0.26	0.48	0.59	0.88	1.07	1.24	1.67	0.52	0.92	1.12	1.62	1.87	2.16	2.76
	85.4	0.26	0.48	0.60	0.88	1.08	1.24	1.68	0.53	0.93	1.13	1.63	1.88	2.18	2.78
	85.5	0.26	0.48	0.60	0.89	1.09	1.25	1.69	0.53	0.94	1.13	1.64	1.89	2.19	2.80
	85.6	0.27	0.49	0.61	0.90	1.09	1.26	1.70	0.54	0.94	1.14	1.65	1.90	2.21	2.81
	85.7	0.27	0.49	0.61	0.90	1.10	1.27	1.71	0.54	0.95	1.15	1.66	1.92	2.22	2.83
	85.8	0.27	0.50	0.62	0.91	1.11	1.28	1.72	0.55	0.96	1.16	1.67	1.93	2.23	2.85
	85.9	0.27	0.50	0.62	0.92	1.12	1.28	1.73	0.55	0.97	1.17	1.69	1.94	2.25	2.87
	86	0.28	0.50	0.63	0.92	1.12	1.29	1.74	0.56	0.97	1.18	1.70	1.95	2.26	2.88
	87	0.30	0.54	0.67	0.98	1.20	1.37	1.85	0.60	1.04	1.26	1.81	2.08	2.41	3.06

Table 46 – Deemed AC Cycling Savings by Connected kW for 15-Minutes Ending 2:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Time Of Day	WTHI	Predicted Savings by Duty Cycle Strategies AC Demand < 3.5 kW							Predicted Savings by Duty Cycle Strategies AC Demand > 3.5 kW						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
3:00 PM	70	0.02	0.04	0.04	0.05	0.04	0.08	0.10	0.03	0.06	0.05	0.06	0.10	0.06	0.17
	71	0.02	0.04	0.04	0.05	0.04	0.08	0.21	0.03	0.06	0.05	0.06	0.10	0.20	0.34
	72	0.02	0.04	0.04	0.05	0.12	0.16	0.32	0.03	0.06	0.05	0.17	0.23	0.34	0.52
	73	0.02	0.04	0.04	0.12	0.20	0.25	0.43	0.03	0.06	0.13	0.28	0.36	0.49	0.70
	74	0.02	0.04	0.08	0.19	0.28	0.34	0.53	0.03	0.14	0.21	0.40	0.49	0.63	0.88
	75	0.02	0.08	0.13	0.26	0.35	0.43	0.64	0.08	0.21	0.30	0.51	0.62	0.77	1.05
	76	0.05	0.13	0.18	0.33	0.43	0.52	0.75	0.13	0.29	0.38	0.62	0.75	0.91	1.23
	77	0.08	0.17	0.23	0.40	0.51	0.61	0.86	0.18	0.37	0.47	0.73	0.88	1.05	1.41
	78	0.10	0.22	0.28	0.47	0.59	0.70	0.97	0.22	0.44	0.55	0.85	1.02	1.19	1.59
	79	0.13	0.26	0.33	0.54	0.66	0.79	1.08	0.27	0.52	0.63	0.96	1.15	1.33	1.76
	80	0.16	0.31	0.38	0.61	0.74	0.88	1.19	0.32	0.59	0.72	1.07	1.28	1.48	1.94
	81	0.19	0.35	0.43	0.68	0.82	0.97	1.30	0.37	0.67	0.80	1.19	1.41	1.62	2.12
	82	0.21	0.40	0.48	0.75	0.90	1.06	1.41	0.42	0.75	0.88	1.30	1.54	1.76	2.30
	83	0.24	0.44	0.53	0.82	0.97	1.15	1.51	0.46	0.82	0.97	1.41	1.67	1.90	2.47
	84	0.27	0.49	0.58	0.89	1.05	1.24	1.62	0.51	0.90	1.05	1.52	1.80	2.04	2.65
	84.1	0.27	0.49	0.58	0.90	1.06	1.25	1.63	0.52	0.91	1.06	1.54	1.82	2.05	2.67
	84.2	0.27	0.50	0.59	0.90	1.07	1.26	1.65	0.52	0.91	1.07	1.55	1.83	2.07	2.69
	84.3	0.28	0.50	0.59	0.91	1.07	1.26	1.66	0.52	0.92	1.08	1.56	1.84	2.08	2.70
	84.4	0.28	0.50	0.60	0.92	1.08	1.27	1.67	0.53	0.93	1.09	1.57	1.85	2.10	2.72
	84.5	0.28	0.51	0.60	0.92	1.09	1.28	1.68	0.53	0.94	1.09	1.58	1.87	2.11	2.74
	84.6	0.28	0.51	0.61	0.93	1.10	1.29	1.69	0.54	0.94	1.10	1.59	1.88	2.13	2.76
	84.7	0.29	0.52	0.61	0.94	1.11	1.30	1.70	0.54	0.95	1.11	1.60	1.89	2.14	2.78
	84.8	0.29	0.52	0.62	0.94	1.11	1.31	1.71	0.55	0.96	1.12	1.62	1.91	2.15	2.79
	84.9	0.29	0.53	0.62	0.95	1.12	1.32	1.72	0.55	0.97	1.13	1.63	1.92	2.17	2.81
	85	0.30	0.53	0.63	0.96	1.13	1.33	1.73	0.56	0.97	1.14	1.64	1.93	2.18	2.83
	85.1	0.30	0.54	0.63	0.96	1.14	1.34	1.74	0.56	0.98	1.14	1.65	1.95	2.20	2.85
	85.2	0.30	0.54	0.64	0.97	1.14	1.35	1.75	0.57	0.99	1.15	1.66	1.96	2.21	2.86
	85.3	0.30	0.54	0.64	0.98	1.15	1.35	1.77	0.57	1.00	1.16	1.67	1.97	2.22	2.88
	85.4	0.31	0.55	0.65	0.99	1.16	1.36	1.78	0.58	1.00	1.17	1.68	1.99	2.24	2.90
	85.5	0.31	0.55	0.65	0.99	1.17	1.37	1.79	0.58	1.01	1.18	1.69	2.00	2.25	2.92
	85.6	0.31	0.56	0.66	1.00	1.17	1.38	1.80	0.59	1.02	1.19	1.71	2.01	2.27	2.94
	85.7	0.31	0.56	0.66	1.01	1.18	1.39	1.81	0.59	1.03	1.19	1.72	2.03	2.28	2.95
	85.8	0.32	0.57	0.67	1.01	1.19	1.40	1.82	0.60	1.04	1.20	1.73	2.04	2.29	2.97
	85.9	0.32	0.57	0.67	1.02	1.20	1.41	1.83	0.60	1.04	1.21	1.74	2.05	2.31	2.99
	86	0.32	0.58	0.68	1.03	1.21	1.42	1.84	0.61	1.05	1.22	1.75	2.06	2.32	3.01
	87	0.35	0.62	0.73	1.10	1.28	1.51	1.95	0.65	1.13	1.30	1.86	2.20	2.46	3.18

Table 47 – Deemed AC Cycling Savings by Connected kW for 15-Minutes Ending 3:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Time Of Day	WTHI	Predicted Savings by Duty Cycle Strategies AC Demand < 3.5 kW							Predicted Savings by Duty Cycle Strategies AC Demand > 3.5 kW						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
4:00 PM	70	0.02	0.04	0.03	0.05	0.04	0.07	0.20	0.03	0.06	0.08	0.11	0.09	0.14	0.33
	71	0.02	0.04	0.03	0.05	0.12	0.16	0.31	0.03	0.06	0.08	0.11	0.22	0.28	0.51
	72	0.02	0.04	0.03	0.12	0.19	0.25	0.42	0.03	0.06	0.08	0.23	0.35	0.43	0.68
	73	0.02	0.04	0.08	0.19	0.27	0.34	0.53	0.03	0.13	0.17	0.35	0.47	0.57	0.86
	74	0.02	0.08	0.13	0.26	0.35	0.42	0.63	0.07	0.20	0.26	0.46	0.60	0.72	1.03
	75	0.05	0.13	0.18	0.32	0.42	0.51	0.74	0.12	0.28	0.35	0.58	0.73	0.87	1.20
	76	0.07	0.17	0.23	0.39	0.50	0.60	0.85	0.17	0.35	0.43	0.70	0.86	1.01	1.38
	77	0.10	0.21	0.28	0.46	0.58	0.69	0.95	0.21	0.42	0.52	0.82	0.99	1.16	1.55
	78	0.13	0.26	0.33	0.53	0.65	0.78	1.06	0.26	0.50	0.61	0.93	1.12	1.30	1.73
	79	0.15	0.30	0.38	0.60	0.73	0.86	1.17	0.30	0.57	0.70	1.05	1.25	1.45	1.90
	80	0.18	0.35	0.42	0.67	0.81	0.95	1.27	0.35	0.65	0.78	1.17	1.38	1.59	2.07
	81	0.21	0.39	0.47	0.74	0.88	1.04	1.38	0.40	0.72	0.87	1.28	1.50	1.74	2.25
	82	0.24	0.43	0.52	0.81	0.96	1.13	1.49	0.44	0.79	0.96	1.40	1.63	1.89	2.42
	83	0.26	0.48	0.57	0.87	1.04	1.22	1.59	0.49	0.87	1.05	1.52	1.76	2.03	2.60
	84	0.29	0.52	0.62	0.94	1.11	1.30	1.70	0.53	0.94	1.13	1.64	1.89	2.18	2.77
	84.1	0.29	0.53	0.63	0.95	1.12	1.31	1.71	0.54	0.95	1.14	1.65	1.90	2.19	2.79
	84.2	0.29	0.53	0.63	0.96	1.13	1.32	1.72	0.54	0.96	1.15	1.66	1.92	2.21	2.80
	84.3	0.30	0.54	0.64	0.96	1.14	1.33	1.73	0.55	0.96	1.16	1.67	1.93	2.22	2.82
	84.4	0.30	0.54	0.64	0.97	1.14	1.34	1.74	0.55	0.97	1.17	1.68	1.94	2.24	2.84
	84.5	0.30	0.54	0.65	0.98	1.15	1.35	1.75	0.56	0.98	1.18	1.69	1.95	2.25	2.86
	84.6	0.31	0.55	0.65	0.98	1.16	1.36	1.77	0.56	0.99	1.19	1.71	1.97	2.26	2.87
	84.7	0.31	0.55	0.66	0.99	1.17	1.37	1.78	0.57	0.99	1.19	1.72	1.98	2.28	2.89
	84.8	0.31	0.56	0.66	1.00	1.17	1.38	1.79	0.57	1.00	1.20	1.73	1.99	2.29	2.91
	84.9	0.31	0.56	0.67	1.01	1.18	1.38	1.80	0.57	1.01	1.21	1.74	2.01	2.31	2.93
	85	0.32	0.57	0.67	1.01	1.19	1.39	1.81	0.58	1.02	1.22	1.75	2.02	2.32	2.94
	85.1	0.32	0.57	0.67	1.02	1.20	1.40	1.82	0.58	1.02	1.23	1.76	2.03	2.34	2.96
	85.2	0.32	0.57	0.68	1.03	1.21	1.41	1.83	0.59	1.03	1.24	1.78	2.04	2.35	2.98
	85.3	0.32	0.58	0.68	1.03	1.21	1.42	1.84	0.59	1.04	1.25	1.79	2.06	2.37	2.99
	85.4	0.33	0.58	0.69	1.04	1.22	1.43	1.85	0.60	1.05	1.26	1.80	2.07	2.38	3.01
	85.5	0.33	0.59	0.69	1.05	1.23	1.44	1.86	0.60	1.05	1.27	1.81	2.08	2.40	3.03
	85.6	0.33	0.59	0.70	1.05	1.24	1.45	1.87	0.61	1.06	1.27	1.82	2.10	2.41	3.05
	85.7	0.34	0.60	0.70	1.06	1.24	1.45	1.88	0.61	1.07	1.28	1.83	2.11	2.43	3.06
	85.8	0.34	0.60	0.71	1.07	1.25	1.46	1.89	0.62	1.07	1.29	1.85	2.12	2.44	3.08
	85.9	0.34	0.61	0.71	1.07	1.26	1.47	1.90	0.62	1.08	1.30	1.86	2.13	2.45	3.10
	86	0.34	0.61	0.72	1.08	1.27	1.48	1.92	0.62	1.09	1.31	1.87	2.15	2.47	3.12
	87	0.37	0.65	0.77	1.15	1.34	1.57	2.02	0.67	1.16	1.40	1.99	2.28	2.61	3.29

Table 48 – Deemed AC Cycling Savings by Connected kW for 15-Minutes Ending 4:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Time Of Day	WTHI	Predicted Savings by Duty Cycle Strategies AC Demand < 3.5 kW							Predicted Savings by Duty Cycle Strategies AC Demand > 3.5 kW						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
5:00 PM	70	0.02	0.04	0.05	0.05	0.08	0.16	0.28	0.04	0.08	0.07	0.10	0.20	0.27	0.49
	71	0.02	0.04	0.05	0.12	0.17	0.25	0.39	0.04	0.08	0.07	0.22	0.33	0.41	0.67
	72	0.02	0.04	0.05	0.19	0.25	0.34	0.50	0.04	0.08	0.16	0.34	0.46	0.56	0.84
	73	0.02	0.08	0.11	0.26	0.33	0.43	0.61	0.04	0.16	0.25	0.45	0.59	0.71	1.02
	74	0.05	0.13	0.16	0.33	0.41	0.52	0.73	0.09	0.24	0.34	0.57	0.72	0.85	1.19
	75	0.07	0.17	0.22	0.40	0.49	0.61	0.84	0.14	0.32	0.42	0.69	0.85	1.00	1.36
	76	0.10	0.22	0.27	0.47	0.58	0.70	0.95	0.19	0.40	0.51	0.81	0.98	1.15	1.54
	77	0.13	0.26	0.33	0.54	0.66	0.79	1.07	0.24	0.48	0.60	0.92	1.11	1.29	1.71
	78	0.16	0.31	0.38	0.61	0.74	0.88	1.18	0.29	0.56	0.69	1.04	1.24	1.44	1.89
	79	0.18	0.35	0.43	0.68	0.82	0.96	1.29	0.34	0.64	0.78	1.16	1.37	1.58	2.06
	80	0.21	0.40	0.49	0.75	0.91	1.05	1.41	0.39	0.72	0.86	1.28	1.50	1.73	2.23
	81	0.24	0.44	0.54	0.82	0.99	1.14	1.52	0.44	0.80	0.95	1.39	1.63	1.88	2.41
	82	0.26	0.49	0.60	0.89	1.07	1.23	1.63	0.49	0.88	1.04	1.51	1.75	2.02	2.58
	83	0.29	0.53	0.65	0.96	1.15	1.32	1.75	0.54	0.96	1.13	1.63	1.88	2.17	2.76
	84	0.32	0.58	0.71	1.03	1.23	1.41	1.86	0.59	1.04	1.21	1.75	2.01	2.32	2.93
	84.1	0.32	0.58	0.71	1.04	1.24	1.42	1.87	0.60	1.05	1.22	1.76	2.03	2.33	2.95
	84.2	0.32	0.59	0.72	1.04	1.25	1.43	1.88	0.60	1.06	1.23	1.77	2.04	2.35	2.96
	84.3	0.33	0.59	0.72	1.05	1.26	1.44	1.89	0.61	1.07	1.24	1.78	2.05	2.36	2.98
	84.4	0.33	0.59	0.73	1.06	1.27	1.45	1.91	0.61	1.07	1.25	1.79	2.07	2.37	3.00
	84.5	0.33	0.60	0.73	1.06	1.28	1.46	1.92	0.62	1.08	1.26	1.80	2.08	2.39	3.02
	84.6	0.34	0.60	0.74	1.07	1.28	1.47	1.93	0.62	1.09	1.27	1.82	2.09	2.40	3.03
	84.7	0.34	0.61	0.74	1.08	1.29	1.48	1.94	0.63	1.10	1.28	1.83	2.10	2.42	3.05
	84.8	0.34	0.61	0.75	1.09	1.30	1.48	1.95	0.63	1.11	1.29	1.84	2.12	2.43	3.07
	84.9	0.34	0.62	0.76	1.09	1.31	1.49	1.96	0.64	1.11	1.29	1.85	2.13	2.45	3.09
	85	0.35	0.62	0.76	1.10	1.32	1.50	1.97	0.64	1.12	1.30	1.86	2.14	2.46	3.10
	85.1	0.35	0.63	0.77	1.11	1.32	1.51	1.99	0.65	1.13	1.31	1.87	2.16	2.48	3.12
	85.2	0.35	0.63	0.77	1.11	1.33	1.52	2.00	0.65	1.14	1.32	1.89	2.17	2.49	3.14
	85.3	0.36	0.64	0.78	1.12	1.34	1.53	2.01	0.66	1.15	1.33	1.90	2.18	2.51	3.16
	85.4	0.36	0.64	0.78	1.13	1.35	1.54	2.02	0.66	1.15	1.34	1.91	2.19	2.52	3.17
	85.5	0.36	0.64	0.79	1.13	1.36	1.55	2.03	0.67	1.16	1.35	1.92	2.21	2.54	3.19
	85.6	0.36	0.65	0.79	1.14	1.37	1.56	2.04	0.67	1.17	1.36	1.93	2.22	2.55	3.21
	85.7	0.37	0.65	0.80	1.15	1.37	1.57	2.05	0.68	1.18	1.36	1.94	2.23	2.56	3.23
	85.8	0.37	0.66	0.80	1.16	1.38	1.57	2.06	0.68	1.19	1.37	1.96	2.25	2.58	3.24
	85.9	0.37	0.66	0.81	1.16	1.39	1.58	2.08	0.69	1.19	1.38	1.97	2.26	2.59	3.26
	86	0.37	0.67	0.82	1.17	1.40	1.59	2.09	0.69	1.20	1.39	1.98	2.27	2.61	3.28
	87	0.40	0.71	0.87	1.24	1.48	1.68	2.20	0.74	1.28	1.48	2.10	2.40	2.76	3.45

Table 49 – Deemed AC Cycling Savings by Connected kW for 15-Minutes Ending 5:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Time Of Day	WTHI	Predicted Savings by Duty Cycle Strategies AC Demand < 3.5 kW							Predicted Savings by Duty Cycle Strategies AC Demand > 3.5 kW						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
6:00 PM	70	0.02	0.03	0.05	0.11	0.16	0.24	0.41	0.03	0.07	0.05	0.19	0.26	0.39	0.63
	71	0.02	0.03	0.05	0.18	0.24	0.33	0.52	0.03	0.07	0.14	0.31	0.39	0.53	0.80
	72	0.02	0.08	0.10	0.25	0.32	0.42	0.62	0.03	0.15	0.22	0.42	0.53	0.67	0.97
	73	0.04	0.12	0.16	0.32	0.40	0.51	0.73	0.08	0.22	0.31	0.54	0.66	0.81	1.14
	74	0.07	0.16	0.21	0.39	0.48	0.59	0.84	0.13	0.30	0.39	0.65	0.79	0.96	1.31
	75	0.09	0.21	0.26	0.46	0.56	0.68	0.95	0.17	0.37	0.48	0.76	0.92	1.10	1.49
	76	0.12	0.25	0.31	0.53	0.64	0.77	1.06	0.22	0.45	0.56	0.88	1.06	1.24	1.66
	77	0.15	0.29	0.37	0.59	0.73	0.86	1.16	0.27	0.52	0.65	0.99	1.19	1.39	1.83
	78	0.17	0.34	0.42	0.66	0.81	0.95	1.27	0.31	0.60	0.73	1.11	1.32	1.53	2.00
	79	0.20	0.38	0.47	0.73	0.89	1.04	1.38	0.36	0.68	0.81	1.22	1.45	1.67	2.17
	80	0.23	0.43	0.53	0.80	0.97	1.12	1.49	0.41	0.75	0.90	1.34	1.58	1.81	2.34
	81	0.25	0.47	0.58	0.87	1.05	1.21	1.59	0.45	0.83	0.98	1.45	1.72	1.96	2.51
	82	0.28	0.51	0.63	0.94	1.13	1.30	1.70	0.50	0.90	1.07	1.56	1.85	2.10	2.68
	83	0.30	0.56	0.68	1.01	1.21	1.39	1.81	0.55	0.98	1.15	1.68	1.98	2.24	2.85
	84	0.33	0.60	0.74	1.08	1.29	1.48	1.92	0.59	1.06	1.24	1.79	2.11	2.38	3.03
	84.1	0.33	0.60	0.74	1.08	1.30	1.49	1.93	0.60	1.06	1.25	1.80	2.13	2.40	3.04
	84.2	0.34	0.61	0.75	1.09	1.31	1.49	1.94	0.60	1.07	1.25	1.82	2.14	2.41	3.06
	84.3	0.34	0.61	0.75	1.10	1.32	1.50	1.95	0.61	1.08	1.26	1.83	2.15	2.43	3.08
	84.4	0.34	0.62	0.76	1.10	1.32	1.51	1.96	0.61	1.09	1.27	1.84	2.17	2.44	3.09
	84.5	0.34	0.62	0.76	1.11	1.33	1.52	1.97	0.62	1.09	1.28	1.85	2.18	2.45	3.11
	84.6	0.35	0.63	0.77	1.12	1.34	1.53	1.98	0.62	1.10	1.29	1.86	2.19	2.47	3.13
	84.7	0.35	0.63	0.77	1.12	1.35	1.54	1.99	0.63	1.11	1.30	1.87	2.21	2.48	3.15
	84.8	0.35	0.63	0.78	1.13	1.36	1.55	2.00	0.63	1.12	1.30	1.88	2.22	2.50	3.16
	84.9	0.35	0.64	0.78	1.14	1.36	1.56	2.01	0.63	1.12	1.31	1.90	2.23	2.51	3.18
	85	0.36	0.64	0.79	1.14	1.37	1.57	2.02	0.64	1.13	1.32	1.91	2.25	2.53	3.20
	85.1	0.36	0.65	0.79	1.15	1.38	1.57	2.04	0.64	1.14	1.33	1.92	2.26	2.54	3.21
	85.2	0.36	0.65	0.80	1.16	1.39	1.58	2.05	0.65	1.15	1.34	1.93	2.27	2.55	3.23
	85.3	0.36	0.66	0.80	1.17	1.40	1.59	2.06	0.65	1.16	1.35	1.94	2.29	2.57	3.25
	85.4	0.37	0.66	0.81	1.17	1.40	1.60	2.07	0.66	1.16	1.35	1.95	2.30	2.58	3.27
	85.5	0.37	0.66	0.82	1.18	1.41	1.61	2.08	0.66	1.17	1.36	1.96	2.31	2.60	3.28
	85.6	0.37	0.67	0.82	1.19	1.42	1.62	2.09	0.67	1.18	1.37	1.98	2.33	2.61	3.30
	85.7	0.37	0.67	0.83	1.19	1.43	1.63	2.10	0.67	1.19	1.38	1.99	2.34	2.63	3.32
	85.8	0.38	0.68	0.83	1.20	1.44	1.64	2.11	0.68	1.19	1.39	2.00	2.35	2.64	3.33
	85.9	0.38	0.68	0.84	1.21	1.44	1.64	2.12	0.68	1.20	1.40	2.01	2.37	2.65	3.35
	86	0.38	0.69	0.84	1.21	1.45	1.65	2.13	0.69	1.21	1.41	2.02	2.38	2.67	3.37
	87	0.41	0.73	0.89	1.28	1.53	1.74	2.24	0.73	1.28	1.49	2.14	2.51	2.81	3.54

Table 50 – Deemed AC Cycling Savings by Connected kW for 15-Minutes Ending 6:00pm

Deemed Savings Estimates
Legacy AC/WH DLC Programs

Time Of Day	WTHI	Predicted Savings by Duty Cycle Strategies AC Demand < 3.5 kW							Predicted Savings by Duty Cycle Strategies AC Demand > 3.5 kW						
		27%	43%	50%	67%	75%	83%	100%	27%	43%	50%	67%	75%	83%	100%
7:00 PM	70	0.02	0.03	0.05	0.14	0.22	0.31	0.49	0.03	0.06	0.12	0.28	0.37	0.49	0.72
	71	0.02	0.07	0.09	0.21	0.30	0.39	0.60	0.03	0.13	0.20	0.39	0.49	0.63	0.90
	72	0.02	0.11	0.14	0.28	0.37	0.47	0.70	0.07	0.20	0.28	0.50	0.62	0.77	1.07
	73	0.05	0.14	0.19	0.34	0.45	0.56	0.80	0.11	0.27	0.36	0.61	0.75	0.91	1.24
	74	0.07	0.18	0.23	0.41	0.52	0.64	0.90	0.16	0.34	0.44	0.72	0.87	1.04	1.42
	75	0.10	0.22	0.28	0.48	0.60	0.72	1.00	0.20	0.41	0.52	0.83	1.00	1.18	1.59
	76	0.12	0.26	0.33	0.54	0.67	0.80	1.10	0.24	0.48	0.60	0.93	1.13	1.32	1.76
	77	0.15	0.30	0.37	0.61	0.75	0.89	1.21	0.28	0.56	0.68	1.04	1.25	1.46	1.94
	78	0.17	0.33	0.42	0.68	0.82	0.97	1.31	0.33	0.63	0.76	1.15	1.38	1.59	2.11
	79	0.19	0.37	0.47	0.74	0.89	1.05	1.41	0.37	0.70	0.84	1.26	1.50	1.73	2.28
	80	0.22	0.41	0.51	0.81	0.97	1.13	1.51	0.41	0.77	0.92	1.37	1.63	1.87	2.46
	81	0.24	0.45	0.56	0.88	1.04	1.21	1.61	0.45	0.84	1.00	1.47	1.76	2.01	2.63
	82	0.27	0.49	0.61	0.94	1.12	1.30	1.71	0.49	0.91	1.07	1.58	1.88	2.14	2.80
	83	0.29	0.53	0.65	1.01	1.19	1.38	1.82	0.54	0.98	1.15	1.69	2.01	2.28	2.98
	84	0.32	0.56	0.70	1.08	1.27	1.46	1.92	0.58	1.05	1.23	1.80	2.14	2.42	3.15
	84.1	0.32	0.57	0.71	1.08	1.28	1.47	1.93	0.58	1.06	1.24	1.81	2.15	2.43	3.17
	84.2	0.32	0.57	0.71	1.09	1.28	1.48	1.94	0.59	1.07	1.25	1.82	2.16	2.44	3.18
	84.3	0.32	0.57	0.72	1.10	1.29	1.49	1.95	0.59	1.07	1.26	1.83	2.17	2.46	3.20
	84.4	0.33	0.58	0.72	1.10	1.30	1.49	1.96	0.60	1.08	1.26	1.84	2.19	2.47	3.22
	84.5	0.33	0.58	0.72	1.11	1.30	1.50	1.97	0.60	1.09	1.27	1.85	2.20	2.49	3.24
	84.6	0.33	0.59	0.73	1.12	1.31	1.51	1.98	0.61	1.09	1.28	1.86	2.21	2.50	3.25
	84.7	0.33	0.59	0.73	1.12	1.32	1.52	1.99	0.61	1.10	1.29	1.88	2.23	2.51	3.27
	84.8	0.34	0.59	0.74	1.13	1.33	1.53	2.00	0.61	1.11	1.30	1.89	2.24	2.53	3.29
	84.9	0.34	0.60	0.74	1.14	1.33	1.53	2.01	0.62	1.12	1.30	1.90	2.25	2.54	3.31
	85	0.34	0.60	0.75	1.14	1.34	1.54	2.02	0.62	1.12	1.31	1.91	2.26	2.55	3.32
	85.1	0.34	0.61	0.75	1.15	1.35	1.55	2.03	0.63	1.13	1.32	1.92	2.28	2.57	3.34
	85.2	0.35	0.61	0.76	1.16	1.36	1.56	2.04	0.63	1.14	1.33	1.93	2.29	2.58	3.36
	85.3	0.35	0.61	0.76	1.16	1.36	1.57	2.05	0.63	1.14	1.34	1.94	2.30	2.60	3.38
	85.4	0.35	0.62	0.77	1.17	1.37	1.58	2.06	0.64	1.15	1.34	1.95	2.31	2.61	3.39
	85.5	0.35	0.62	0.77	1.18	1.38	1.58	2.07	0.64	1.16	1.35	1.96	2.33	2.62	3.41
	85.6	0.36	0.62	0.78	1.18	1.39	1.59	2.08	0.65	1.17	1.36	1.97	2.34	2.64	3.43
	85.7	0.36	0.63	0.78	1.19	1.39	1.60	2.09	0.65	1.17	1.37	1.98	2.35	2.65	3.44
	85.8	0.36	0.63	0.79	1.20	1.40	1.61	2.10	0.66	1.18	1.38	1.99	2.36	2.66	3.46
	85.9	0.36	0.64	0.79	1.20	1.41	1.62	2.11	0.66	1.19	1.38	2.01	2.38	2.68	3.48
	86	0.37	0.64	0.79	1.21	1.42	1.63	2.12	0.66	1.19	1.39	2.02	2.39	2.69	3.50
	87	0.39	0.68	0.84	1.28	1.49	1.71	2.22	0.71	1.27	1.47	2.12	2.52	2.83	3.67

Table 51 – Deemed AC Cycling Savings by Connected kW for 15-Minutes Ending 7:00pm

16 APPENDIX J: TECHNICAL MEMO – POOLING WH CYCLING PROGRAM ESTIMATES

This memo presents the contractor’s opinion regarding the potential to pool future efforts to assess water heating impacts. Currently, three of the LRWG members, PEPCO, BGE and Conectiv, indicated active data collection programs for their water heating load management reporting efforts.

Sample Design and Deployment. In 2001, PEPCO installed end-use monitoring on a simple random sample of 60 program participants. Similarly, Conectiv installed end-use metering on a sample of 73 sites. BGE deployed end-use monitoring on a two-dimensional stratified sample of program participants. The BGE sample is stratified by time-of-use versus non time-of-use. One might assume that time-of-use customers may have altered their consumption patterns, e.g., do laundry and dishwashing in the evening, to take economic advantage of the time-of-use rate. Prior to pooling the data, statistical test could be run on the water heating profiles by TOU domain to examine similarities and differences. Comparisons could be conducted by hour or time-of-use period.

Cycling Strategy. The water heating control programs invoke 100% cycling of the water heaters for the selected control period. The water heater tank provides sufficient storage capacity to allow these units to be cycled off for extended periods of time, e.g., several hours, without inconveniencing the customer.

Monitoring Strategy. There were differences in the monitoring techniques deployed. PEPCO used a simple run-time logger to gather information on the amount of time the water heater was on in any given 15-minute period. The run time information was coupled with nameplate data to estimate the kW loading of the water heater. BGE installed 15-minute load recorders on the water heaters to directly measure the load impacts. The differences in data collection strategy should not hinder the development of a cross sample estimate.

Gross and Net Impacts. Similar to the discussion on AC-DLC, the evaluation can be directed at assessing the gross or net impacts of the program. This depends on the analysis construct. Since the load interruption is 100%, the anticipated gross impacts can be estimated from a simplified end-use metering study. This study could be implemented across the PJM footprint and provide a robust dataset for estimating the water heating load of the respective jurisdictions. Zonal specific weights could be constructed and applied based on some known characteristic of the population, e.g., monthly, seasonal, or annual energy use, to derive the zonal estimates. Net estimates would be developed by implementing a separate operability study similar to those proposed for the AC-DLC evaluation. Alternatively net impacts could be estimated by observing the actual performance of the monitored units on event and non-event days, similar to the analysis completed by BGE.

Water Heating Sensitivity to External Variables. At issue is the sensitivity of the water heating load to external variables. We have examined a substantial amount of electric water heating end-use data over the years. One of our current projects involves the collection of more than 200 end-use metering points allocated by varying tank capacities and water heating element configurations. While there are certainly differences at the individual customer level, in aggregate water heating load is quite stable. There is some seasonality in the load but the load is much more time dependent than weather dependent. Figure 18 presents a plot of average diversified water heating demand for the hours 7am through 8pm versus temperature²⁸. In Figure 19 a load duration curve for specific hours are presented. Clearly the most load is available in the early morning and early evening hours when compared to the 1pm period. We may be able to condense the time-temperature matrix to a simple time dependent matrix.

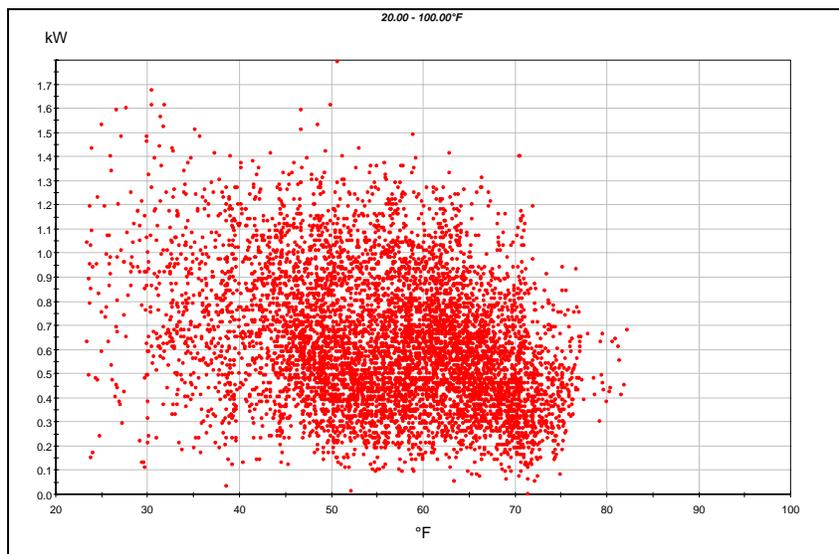


Figure 18 – Water Heating Demand Versus Temperature

²⁸ The data in Figure 18 is not from the mid-Atlantic region and is shown for illustrative purposes only.

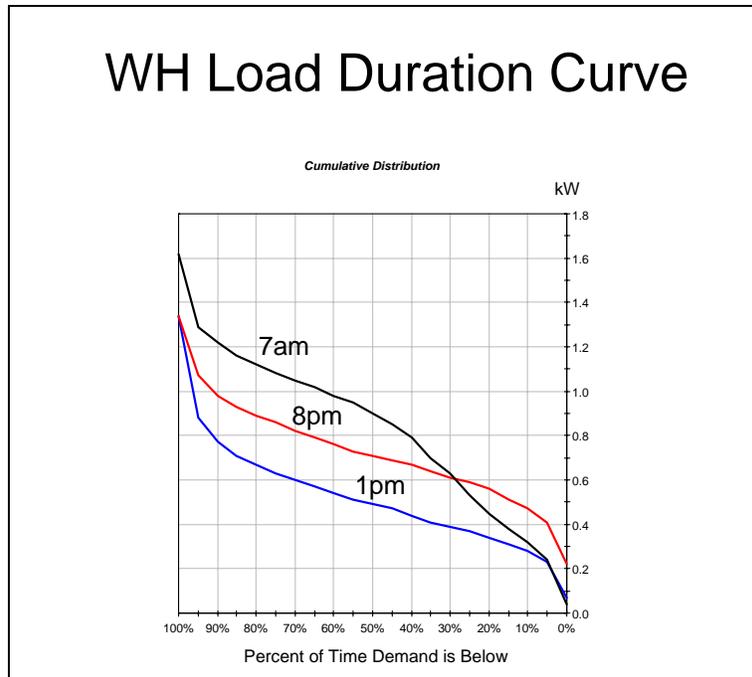


Figure 19 – WH Load Duration Curve

Variables of Interest. Average weekday loads for the period 1pm through 8pm could be used for developing the appropriate sample size for a PJM zonal water heating study. Under this construct, no events would need to be called to estimate the 100% cycling impacts associated with a planned control. If, however, ancillary variables like payback were of interest then actual events would need to be observed in order to estimate the amount of payback.

Estimated Savings. Table 52 presents a summary of the estimated kW impact per switch for the three service territories. Savings estimates for 1998, 2001 and 2002 are presented for BGE. As evidenced by the table, these estimates appear very stable.

Hour Ending	PEPCO	BGE			Conectiv
		1998	2001	2002	
1pm	0.26	0.27	0.26	0.25	0.35
2pm	0.23	0.28	0.23	0.20	0.33
3pm	0.20	0.26	0.22	0.20	0.31
4pm	0.21	0.25	0.20	0.19	0.34
5pm	0.23	0.26	0.23	0.24	0.39
6pm	0.32	0.30	0.31	0.29	0.43
7pm	0.35	0.36	0.35	0.30	0.42
8pm	0.31	0.41	0.37	0.34	0.40
Average	0.27	0.30	0.27	0.25	0.37

Table 52 – Water Heating Estimated Savings

M&V Recommendation. The project team believes that a PJM zonal study could be planned and conducted across the various jurisdictions with water heating programs. The analysis could include a pooled analysis that reflects the unique characteristics of the individual participant populations. Here again, the project team does not believe the

estimates will change dramatically with new data and a historical reanalysis of the existing data should be sufficient to develop “deemed” savings estimates.