

Regional Approaches to Monitoring and Verification of Load Management Programs

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- Introductions
 - Analysis Team
 - Participants in the Collaborative Effort
- Impetus for the Project
- Synopsis and Timeline
- PJM-Wide Model for Estimating Air Conditioner and Water Heater Direct Load Control Impacts
 - Analysis Approach
 - Air Conditioner Savings Estimates
 - Water Heater Savings Estimates
- Next Steps and Future Applicability

- Analysis team
 - Curt Puckett and Tim Hennessy of RLW
 - Grayson Heffner and Chuck Goldman of LBNL
- Collaborative participants who donated historical data
 - Mary Straub and Cheryl Hindes, BGE
 - Steve Sunderhauf and Will Lowe, Pepco
 - Fred Lynk and Mike Prendergast, PSE&G
 - Chris Siebens, First Energy/JCP&L
- Additional collaborative participants
 - Craig Grooms of Buckeye Power
 - Erin Puryear of Old Dominion Electric Coop
 - Eugene Bradford of SW Maryland Electric Coop
 - Phil Cervený of Continental Cooperative Services
- PJM leadership and continuity
 - John Reynolds

M&V Requirements for Non-Interval Metered ALM Participants

- ❑ Old School: PURPA-compliant load research-based M&V for all Direct Load Control programs
 - Minimum accuracy of 90% confidence with 10% error.
 - Separate studies of Gross Impacts and Operability Rate
 - Studies must present per-participant impacts in a matrix of hours, PJM Zone, and weather condition
- ❑ Issues associated with the conventional M&V approach:
 - PURPA-compliant Load Research is way too expensive!
 - Every five-years, a \$250,000 load research bill
 - M&V costs can significantly affect cost-effectiveness
 - Previous load research studies yielded comparable per-participant load impacts for similar conditions (e.g., control strategy, time of day, weather) across PJM
 - Assuming technology does not change, it shouldn't be necessary to constantly re-estimate a known quantity – the gross load impact of AC or EWH direct load control
- ❑ New School: Pooled Load Data & Regional Model-based Analysis, adjusted to reflect program-specific characteristics
 - Leverage data from individual load research studies to support regional, pooled analysis
 - Program-specific studies of switch failures & radio coverage to de-rate load impacts
 - New small customer programs could utilize a pooled approach to meeting M&V requirements, thus improving results and saving on program costs

Approach Agreed for Modifying ALM M&V Requirements



- DLC providers collaborate in developing a PJM-wide “deemed savings model” for air conditioner and water heater load control
- The deemed savings model would reflect pertinent variables (weather, customer size, zone) to “customize” the savings estimates
- If successful, other PJM members lacking PURPA-compliant M&V studies could qualify for ALM capacity credits or payments based on the regional deemed savings estimates
- In future, DR providers targeting small customers should be encouraged to field regional load research studies for new programs with emerging technologies

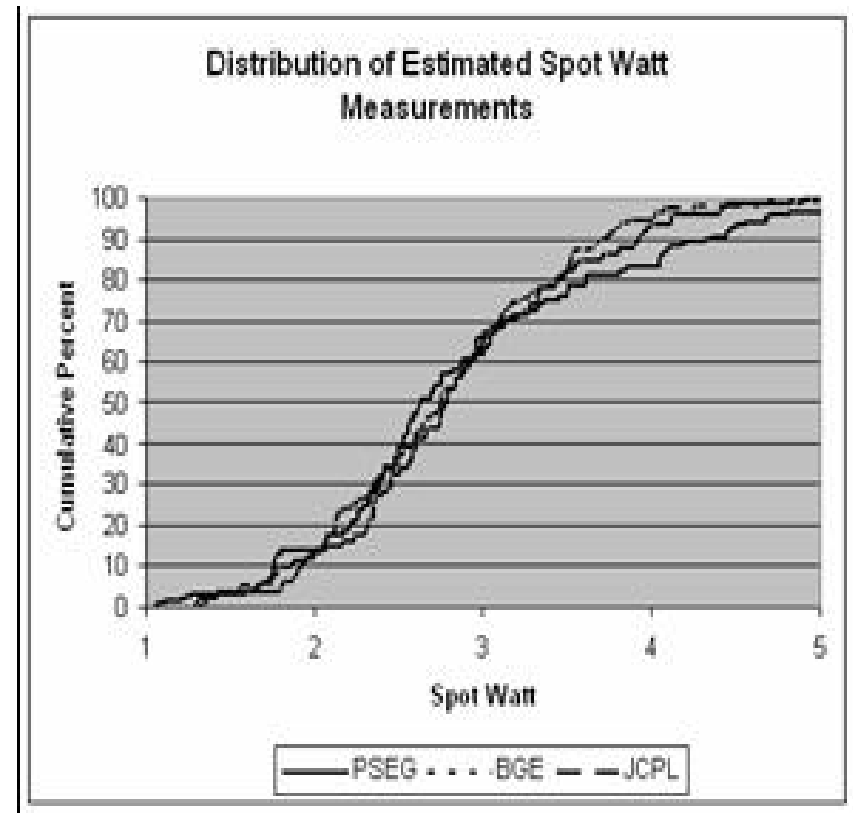
DLC Providers as of May 2007

Distributor	PSE&G	First Energy/JCP&L	BGE
Program Name	Cool Customer	PowerPlus Savers	Riders 5 & 6
Control Points	138,000 AC Switches	78,000 AC Switches & Smart Stats	237,000 AC Switches 74,000 EWH Switches
PJM Capacity Credit	128 MW	56 MW	210 MW
Gross Unit load impact	1.19 kW	0.72 kW	0.94 kW (AC) 0.24 kW (EWH)
Year Started	1990	1991	1988
Program Status	Closed to new customers	Closed to new customers	Closed to new customers
Cycling Limits	Up to 15 per year	Up to 20 per year	No limit (AC) 15 per year (EWH)

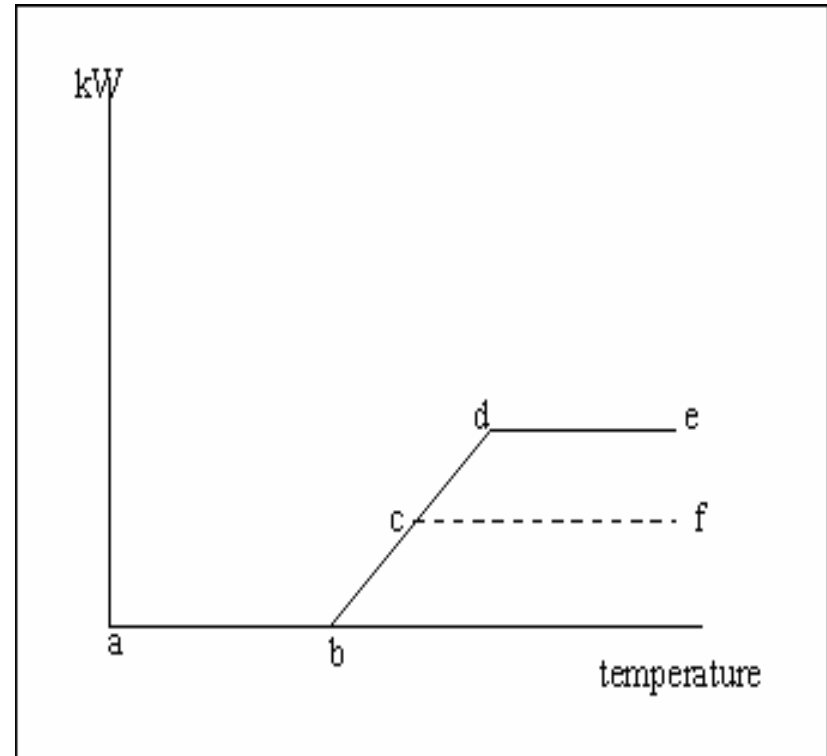
1. Obtain end use monitored loads
2. Estimate connected load (spot watts)
3. Estimate interval savings for each sample customer
4. Combine weather data with savings estimates
5. Estimate average savings for each time of day interval for each THI
6. Develop models to predict the average savings using WTHI for each time period
7. Produce Deemed Savings Estimates by Time period and WTHI

- End-use metered air conditioning data from First Energy/JCP&L, PSE&G, and BGE
- Electric water heater data from BGE
- Summary impact data on air conditioning and water heating from Pepco

- Model estimation begins with characterizing maximum demand, e.g., “spot watts”
- 99th percentile of observed demands was used as a proxy
- Distribution suggest PSE&G customers may have larger air conditioner maximum demands, e.g. larger units



- Duty cycle model used to calculate the effect of control strategy and weather conditions on air conditioner demand
- For example, the effect of 50% load control is to overlay pattern abcf on the normal pattern abcde

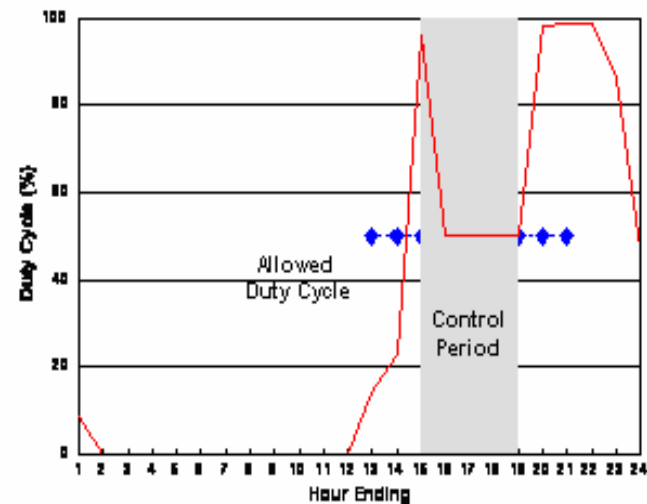


- PJM Manual 19 calls for load impacts to be expressed as a function of time interval and temperature-humidity index (THI)
- The temperature-humidity index is then weighted to reflect the impacts of sustained hot weather on air conditioner demand.
- Baltimore-Washington Airport weather data was used for BGE, while Philadelphia Airport weather was used for PSE&G and JCP&L.

Develop Average Savings Estimates & Predictive Model

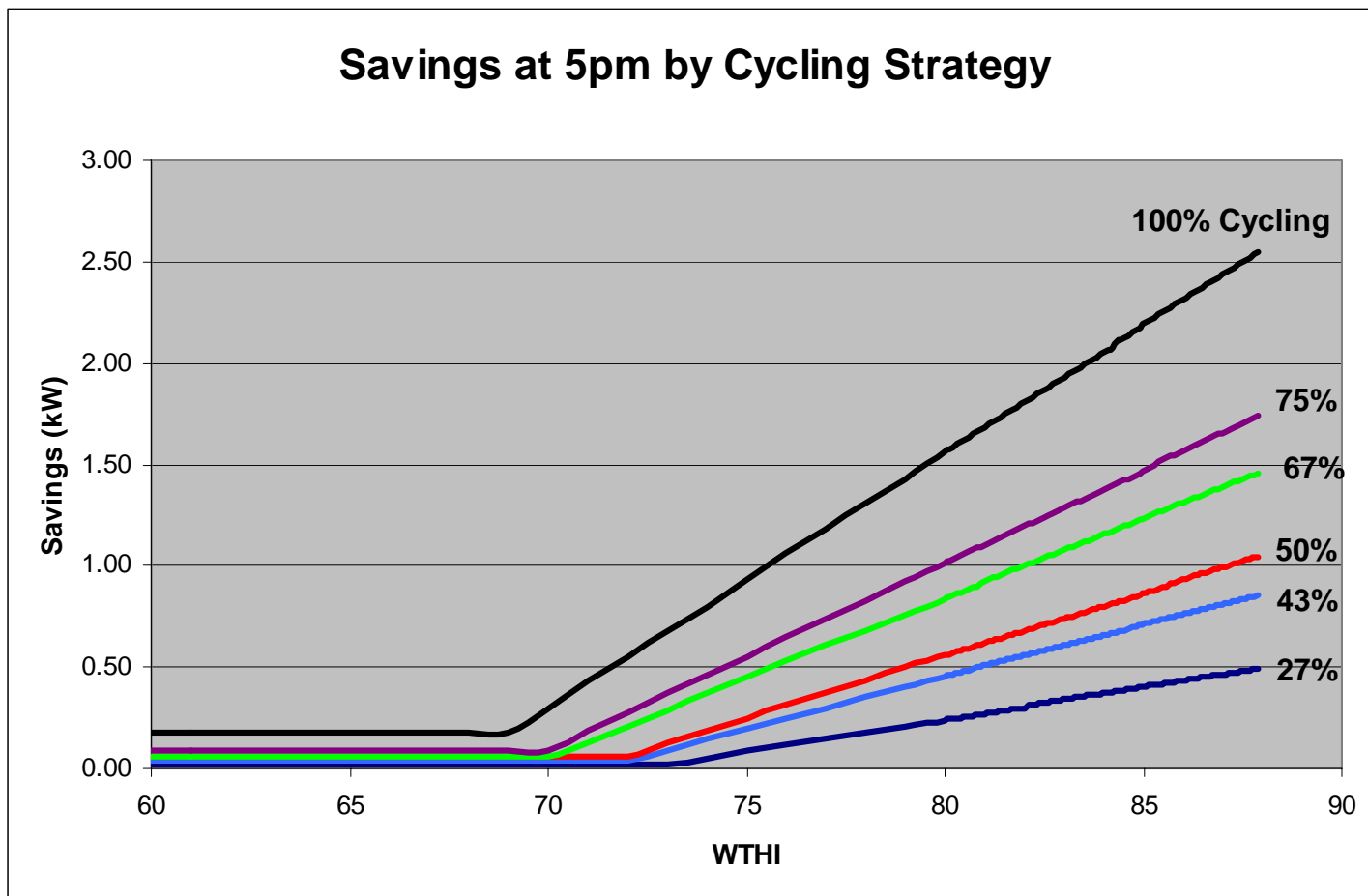
- Average savings were calculated by time of day, for each WTHI that was observed during that time of day period, and for each cycling strategy
- A simple regression model was developed to predict savings for each group, for any time period for any cycling strategy
- The slope of the model is the incremental savings per degree of WTHI

Contributing Participant

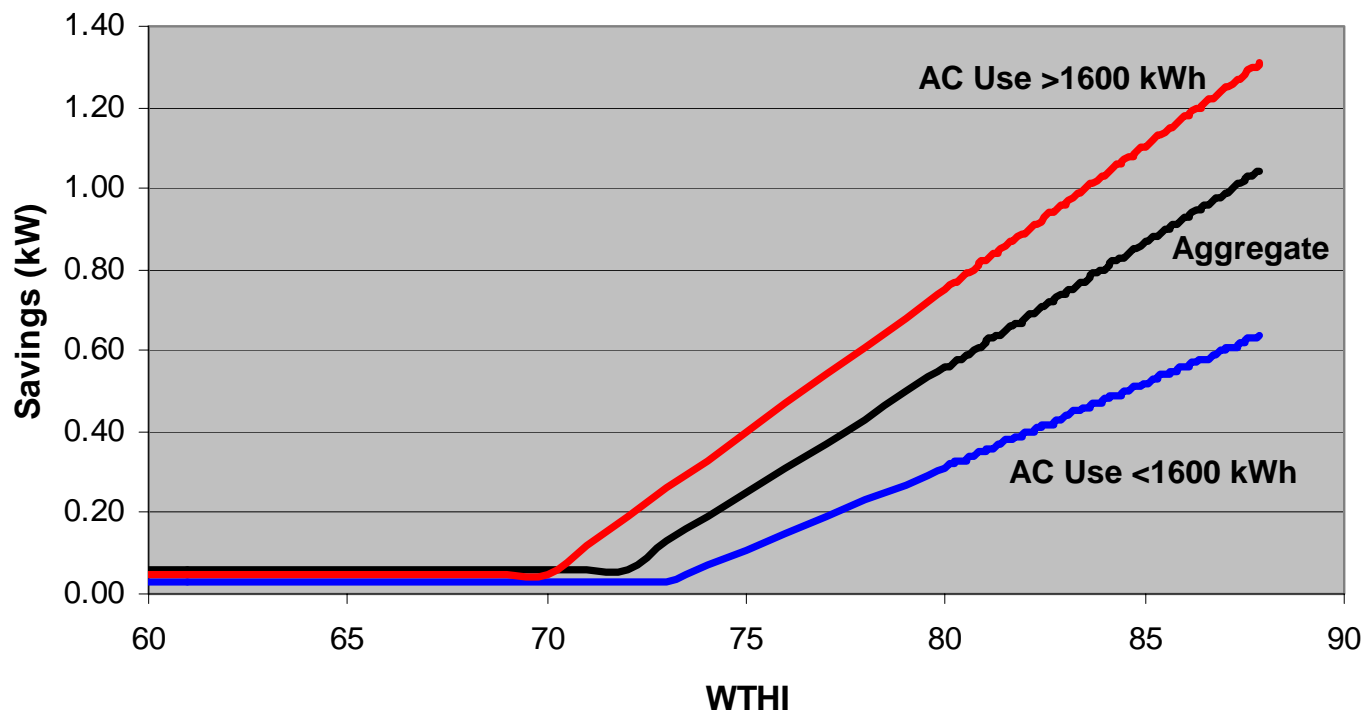


Produce Average Deemed Savings Estimates

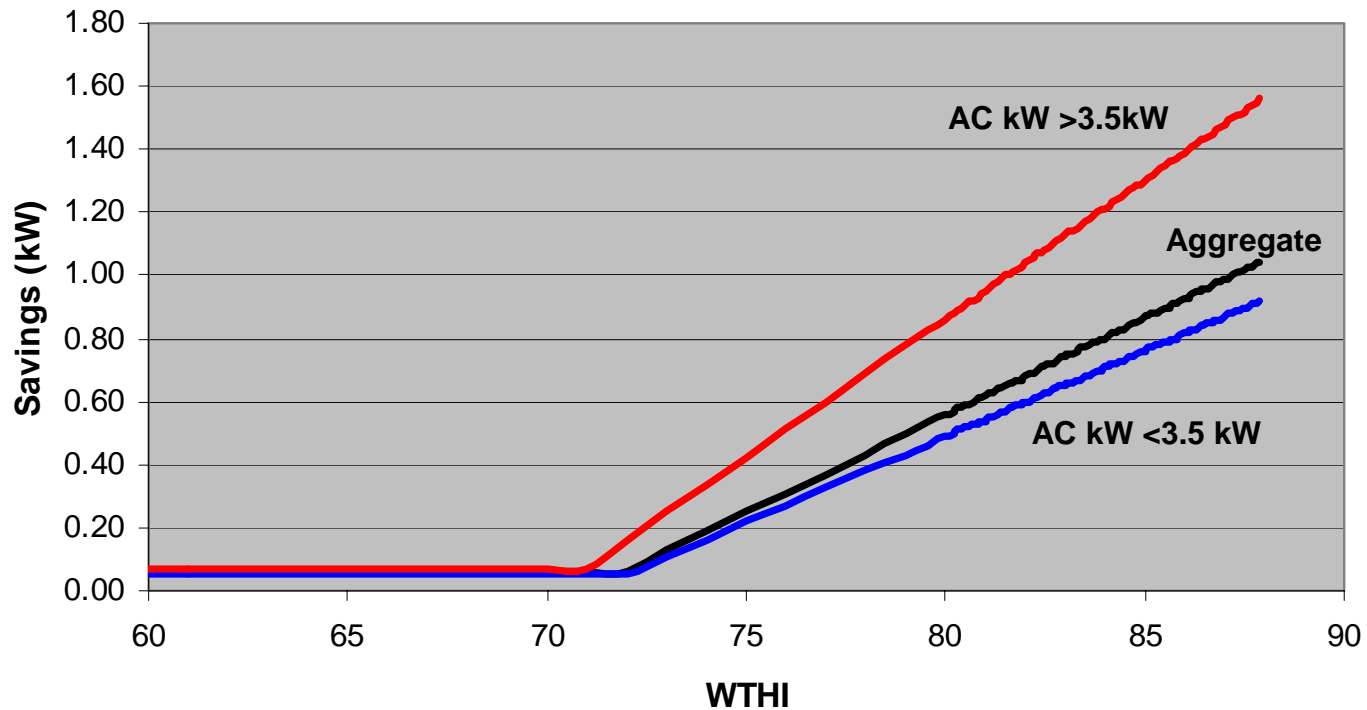
- Aggregate and stratified average results were developed:
 - Aggregate average across all customers
 - Stratified averages across customer subgroups with maximum demand greater or less than 3.5 kW
 - Stratified averages across customer subgroups with annual air conditioning use greater or less than 1,600 kWh
- The predicted average savings for each time of day period was estimated for each of the WTHI between 70°F to 87°F.

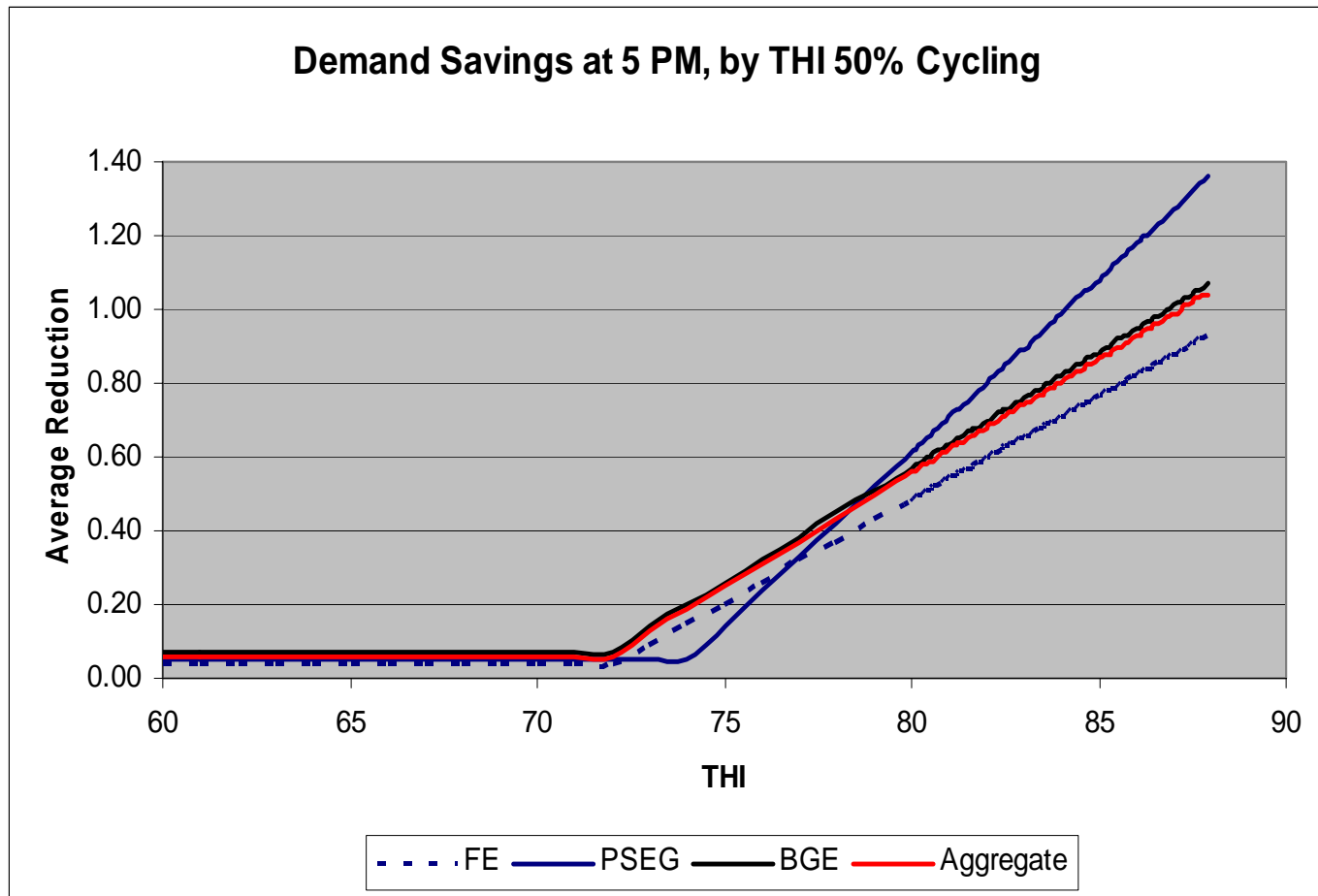


Estimated Savings for 50% Cycling at 5pm by AC Energy Use Stratum



Estimated Savings for 50% Cycling at 5pm by Connected Demand Stratum

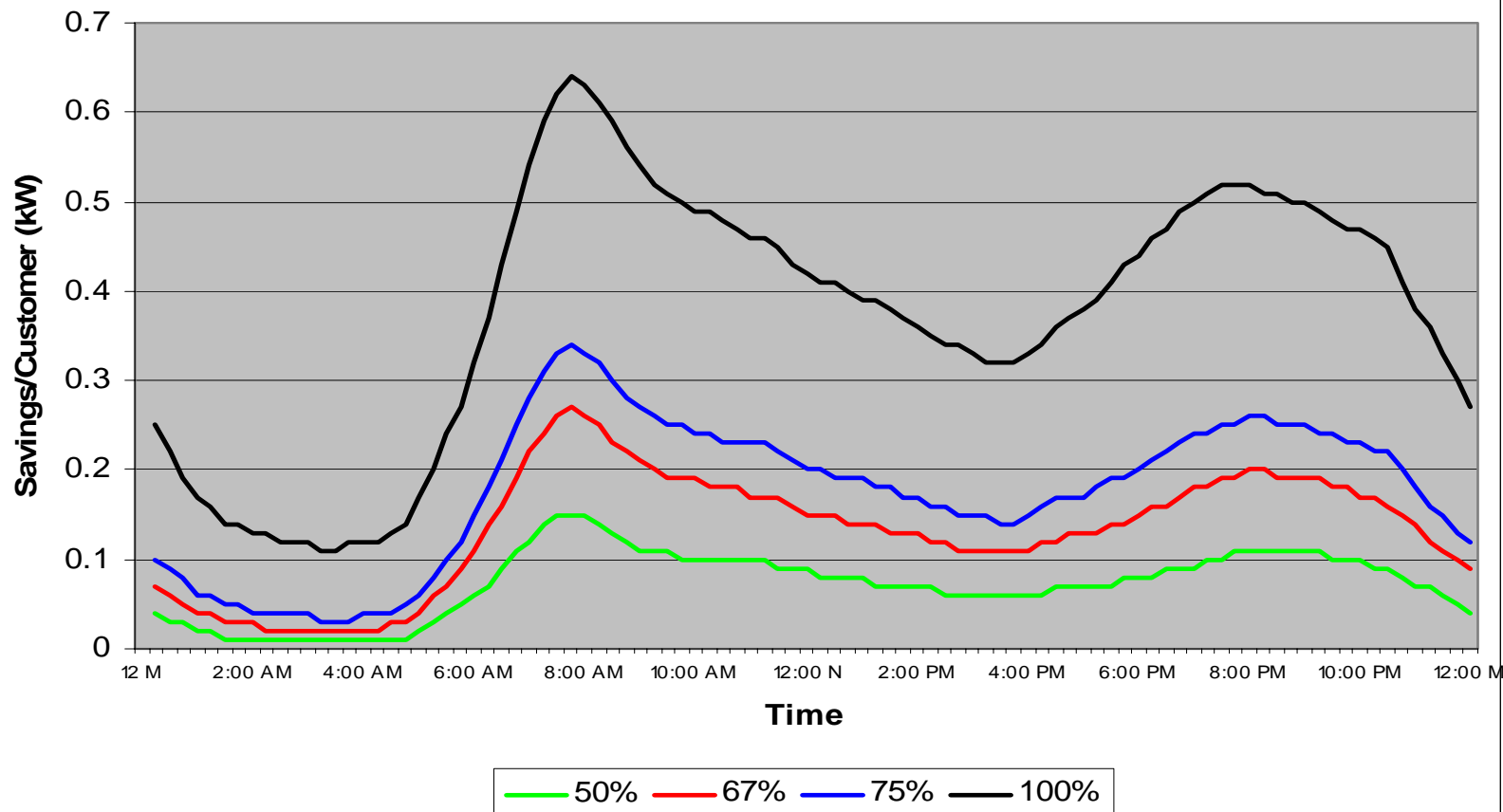




Average Deemed Savings Results

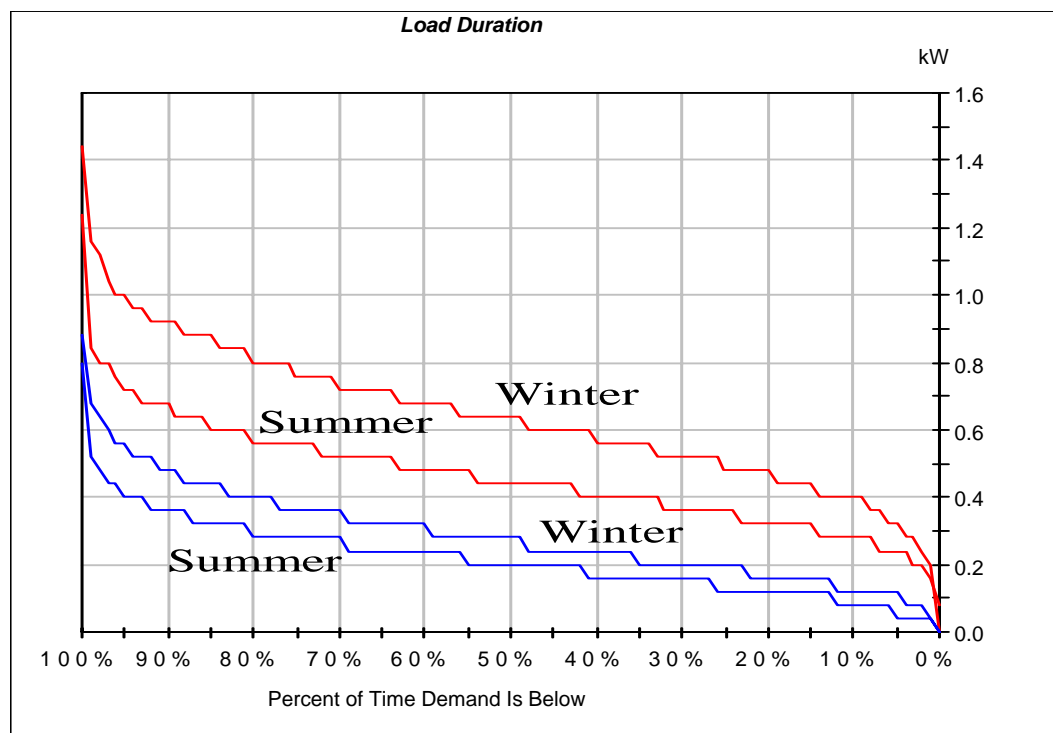
WTHI	Predicted Savings at 5pm For Various Duty Cycle Strategies						
	27%	43%	50%	67%	75%	83%	100%
70.0	0.02	0.04	0.06	0.06	0.09	0.18	0.30
71.0	0.02	0.04	0.06	0.13	0.19	0.28	0.43
72.0	0.02	0.04	0.06	0.21	0.28	0.38	0.55
73.0	0.02	0.09	0.13	0.29	0.37	0.48	0.68
74.0	0.05	0.15	0.19	0.37	0.46	0.58	0.80
75.0	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

Average Hourly Savings





Savings Duration Curve (Hour Ending 7am)



— AE: Weekends 7am
— AF: Weekdays 7am

- Deemed savings estimates are incorporated in PJM Manual 19, effective June 1 2007
- Potential DLC providers in PJM are now be able to certify their air conditioner and water heater load impacts without the expense of a PURPA-compliant load study
- Regional approaches to M&V could apply to new load management programs
- For example, a PURPA-compliant load research sample for “next generation” DLC or “smart thermostat” programs could be drawn on a regional basis and stratified by PJM zone and consumption.
- Such an approach might help resolve retail-wholesale seams issues, perhaps even providing a permanent load research function capable of providing real-time aggregate load reduction data for system operators