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Auto-DR and Pre-cooling of Buildings at Tri-City Corporate Center

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CONTENTS

FIGURES

TABLES

EQUATIONS

ABSTRACT

Over the several past years, Lawrence Berkeley National Laboratory (LBNL) has conducted field tests for different pre-cooling strategies in different commercial buildings within California. The test results indicated that pre-cooling strategies were effective in reducing electric demand in these buildings during peak periods. This project studied how to optimize pre-cooling strategies for eleven buildings in the Tri-City Corporate Center, San Bernardino, California with the assistance of a building energy simulation tool – the Demand Response Quick Assessment Tool (DRQAT) developed by LBNL's Demand Response Research Center funded by the California Energy Commission's Public Interest Energy Research (PIER) Program. From the simulation results of these eleven buildings, optimal pre-cooling and temperature reset strategies were developed. The study shows that after refining and calibrating initial models with measured data, the accuracy of the models can be greatly improved and the models can be used to predict load reductions for automated demand response (Auto-DR) events. This study summarizes the optimization experience of the procedure to develop and calibrate building models in DRQAT. In order to confirm the actual effect of demand response strategies, the simulation results were compared to the field test data. The results indicated that the optimal demand response strategies worked well for all buildings in the Tri-City Corporate Center.

This study also compares DRQAT with other building energy simulation tools (eQUEST and BEST). The comparison indicate that eQUEST and BEST underestimate the actual demand shed of the pre-cooling strategies due to a flaw in DOE2's simulation engine for treating wall thermal mass. DRQAT is a more accurate tool in predicting thermal mass effects of DR events.

Key words: Pre-cooling, Demand response, Thermal mass, Auto-DR, Building energy simulation tool.

EXECUTIVE SUMMARY

INTRODUCTION

The potential for utilizing building thermal mass for load shifting and peak demand reduction has been demonstrated by LBNL by many field experiments. Through the California Energy Commission's PIER-funded Demand Response Research Center, a building energy simulation tool, Demand Response Quick Assessment Tool (DRQAT), was developed to estimate the DR potential and optimize DR strategies in buildings. As part of a pilot project to demonstrate the usefulness of DRQAT, the tool was used to optimize the temperature control strategies in eleven buildings at the Tri-City Corporate Center, San Bernardino, California in 2008. By comparing the pre-cooling strategies' simulation results with measured field data, optimal demand response strategies are proposed to maximize demand response savings for these buildings.

The research team based their work on SCE's Auto-DR program activities managed by Global Energy Partners (GEP). GEP conducted the building audits and worked with local contractors to automate the participation of the buildings in SCE's DR programs.

PURPOSE

The purpose of this research project was to demonstrate how to use the Demand Response Quick Assessment Tool (DRQAT) to predict the effects of various pre-cooling strategies for buildings. Field tests were conducted in eleven buildings at the Tri-City Corporate Center. The measured data from these Auto-DR events were compared to the simulation results. The product of this research study was to develop a general procedure to estimate potential peak demand reductions of various DR strategies.

PROJECT OBJECTIVES

The primary objective of this research was to develop pre-cooling and temperature reset strategies that are most effective for the eleven buildings and to support the long term strategic goal of evaluation and deployment of control strategies to reduce peak demand in California. The demand response strategies used in this study can be programmed into the control systems of these buildings and be used in future DR events.

PROJECT OUTCOMES

Optimal pre-cooling and temperature reset strategies were developed based on the simulation results of these eleven buildings. Both "pre-cooling with exponential temp set up" and "pre-cooling with step temp set up" were determined to be optimal control strategies to achieve maximum demand savings. Of these two strategies, "pre-cooling with step temp set up" was implemented during the field tests. The study showed that after refining and calibrating the initial models with measured data, the accuracy of the models could be greatly improved and the models could be used to predict load reductions in these buildings on Auto-DR event days within ±5% of accuracy. This report summarizes the optimization experience and the procedure to develop and calibrate building models in DRQAT.

INTRODUCTION

BACKGROUND AND OVERVIEW

The potential for utilizing building thermal mass for load shifting and peak demand reduction has been demonstrated by LBNL in many field experiments (Xu et al. 2005, Xu and Yin 2006, Xu and Zagreus 2007). Over the past five years, a series of research studies have been conducted to investigate strategies for using building thermal mass to shift building cooling load in cooperation with three utilities in California (PG&E, SCE and SMUD). In these studies and tests, significant demand reduction in large commercial buildings has been demonstrated with relatively small impacts on occupant comfort.

The California Energy Commission's Public Interest Energy Research (PIER) PRogram has funded LBNL's Demand Response Research Center's (DRRC) studies regarding how to use pre-cooling strategies to reduce building peak electricity demand. As part of this CEC-funded research, LBNL tested the pre-cooling strategy in one office building at the Tri-City Corporate Center in San Bernardino, Southern California. The strategy involved maintaining zone temperatures at the lower end of the comfort range (72 °F) during the occupied hours before the peak period and floating the zone temperatures up to the high end of the comfort range (78 °F) during the peak period. With this strategy, the cooling plant-related electricity demand was reduced by 30 to 50% during peak hours from 12 pm to 5 pm without any thermal comfort complaints submitted to the operations staff.

The DR and pre-cooling strategies worked well on test days with peak outside air temperatures as high as 110 °F. The load sheds in hot climates were more predictable and stable than for load sheds in cooler climates, primarily because electricity used for cooling on hot days tend to be a larger portion of the whole building electricity load than that for cooler days.

In 2006, with support from the California Energy Commission's PIER Demand Response Research Center, a quick assessment simulation tool was developed that could be used to predict demand reduction, operating cost savings, and occupant thermal comfort impacts associated with using building thermal mass control. The tool is the Demand Response Quick Assessment Tool (DRQAT). The tool incorporates prototypical buildings and equipment and allows the user to specify a relatively small number of important parameters in order to determine a quick assessment for building thermal mass strategies. The tool compares peak power demand, operating costs, and comfort between conventional and building thermal mass control strategies. The input parameters of the tool include building type, floor area, location, occupancy schedule, utility rates, and few other variables that change the demand-limiting strategy. These parameters are believed to have the greatest influence on demand reduction and cost savings. Since the release of the beta version of the tool, more than 100 users from all over the world have requested copies of the tool and have used it.

With the help of the simulation tool and the previous field test experience, the pre-cooling tests were expanded to all eleven buildings in the Tri-City Corporate Center in 2008. All of these buildings participated in SCE's automated DR (Auto-DR) programs. In 2008, the buildings participated in the Critical Peak Pricing (CPP)

Program manually and continued to enable automation of DR in their facilities. Auto-DR is a DR signaling infrastructure that delivers DR event related information to the customers' energy management and controls systems (EMCS). The technology platform has been developed by the California Energy Commission's PIER Demand Response Research Center and it is currently being considered to be an open, interoperable standard to deliver DR signals to end uses. The eleven buildings in this study are the first buildings in SCE's service territory that will be automated through an embedded software client within their EMCS. The embedded software client "listens" to the DR event information being published by the DR automation server (DRAS) and calls for pre-programmed strategies when the DR event is called. All the other participants are using a device that is external to their system that listens to the DR event related information and converts these to relay closures to indicate price information (Piette et al. 2008). Regardless of which client is being used, the customers have the flexibility to opt-out at anytime before or during the event.

Field tests and simulation analyses were conducted for all eleven buildings. The simulation activity involved developing calibrated DRQAT models for each building. Using the calibrated models, the demand response strategies were optimized to maximize the corresponding demand response savings.

PROJECT OBJECTIVES

The primary objective of this research is to develop pre-cooling and temperature reset strategies that are most effective for the eleven Tri-City Corporate Center buildings and to support the long term strategic goal of evaluation and deployment of control strategies to reduce peak demand in California. The demand response strategy determined to be most effective in this study will be programmed into the control systems of these buildings so the building owner can utilize them in future DR events.

REPORT ORGANIZATION

Chapter 1, Development of Optimal Pre-Cooling Strategies, provides an introduction with descriptions of previous studies, the theory and the objectives of this research. Chapter 2, Optimization of Pre-Cooling Strategies, covers the use of DRQAT to develop optimal pre-cooling strategies. Chapter 3, Pre-Cooling Field Test Analysis, provides field test results and procedures that were followed to refine the DRQAT models with the test data of the eleven office buildings. Chapter 4, Comparison of DRQAT with eQUEST and BEST, compares DRQAT with two building energy simulation tools. Chapter 5, Conclusions and Recommendations, completes the report and discusses future work. The Appendices include building descriptions, calibration results and field results.

DEVELOPMENT OF OPTIMAL PRE-COOLING STRATEGIES

INTRODUCTION

This section describes data collection, initial DRQAT model development, and model calibration of eleven buildings. Based on the calibrated simulation models, simulation analyses were conducted to determine how to discharge thermal mass efficiently and smoothly with no rebound.

DATA COLLECTION OF TRI-CITY CORPORATE CENTER

Data collection for simulation of the buildings was coordinated with Global Energy Partners' (GEP) technical audit process. The technical person visiting the site was provided with a site survey that was used to collect data from facilities and was then used for the simulations. Due to lack of time, forms were not completed. The feedback suggested that most of the information related to schedules and demand intensities was not available for these facilities anyway. The approach was then modified to use default values because the buildings were "typical" office buildings. Additional information on the DR strategies was collected by LBNL through a half hour interview with the facility engineer.

SIMULATION MODEL DEVELOPMENT

The simulation models were developed after available building information was collected. The sufficiency and precision of the collected data, such as building envelope, building load data, HVAC system characteristics, building operation had direct impact on the accuracy of the simulation results. The more sufficient and precise the collected data, the more accurate the models' predictions.

INPUTS FOR THE INITIAL SIMULATION MODEL

BUILDING DESCRIPTION

Table 1 presents a summary of the building description and the internal loads of eleven Tri-City Corporate Center buildings. The building audits provided general building information, such as number of stories, gross area, and other relevant information. The axis, length and width of each building were measured by using Google Earth, which provides maps and satellite images of the buildings.

TABLE 1: INITIAL SIMULATION MODEL INPUTS

BUILDING BASIC INPUT – INITIAL VALUES

SITE NAME	GROSS AREA (SQ FT)	LENGTH (FT)	WIDTH (FT)	FLOOR HEIGHT (FT)	WWR_SN	WWR_EW	BUILDING ORIENTATION
Two Carnegie Plaza	68,955	300	115	12	0.50	0.50	45
One Carnegie Plaza	62,800	300	105	12	0.50	0.50	315
One Carnegie Plaza (smaller building)	38,808	270	70	12	0.50	0.50	45
One Vanderbilt	73,730	205	90	12	0.25	0.25	315
One Parkside	70,069	175	100	12	0.60	0.60	0
Lakeside Tower	112,717	210	90	12	0.60	0.60	0
Two Parkside	80,750	250	110	12	0.40	0.40	0
Three Carnegie Plaza	83,698	420	100	12	0.40	0.40	45
Brier Corporate Center	104,501	350	100	12	0.40	0.40	45
Vanderbilt Plaza	119,035	200	150	12	0.40	0.40	0
Inland Regional Center	81,079	350	115	12	0.30	0.30	45

Notes:

WWR_SN: window to wall ratio for south and north sides of the building;

WWR_EW: window to wall ratio for east and west sides of the building;

Floor Height: height of a single floor;

Building Orientation: building north axis is specified relative to true north and the value is specified in degrees from “true north” (clockwise is positive).

INTERNAL LOADS

Internal loads such as occupants, lighting, and plug load constitute the majority of cooling loads in office buildings. Table 2 presents the building internal load inputs for the initial simulation models. Based on building type and year of built, lighting power intensities were estimated using the corresponding vintage of California’s Energy Efficiency Standards for Residential and Non Residential Buildings (Title 24, CEC 1987-2005). The plug intensity was estimated to be 0.75 W/ft^2, and occupancy intensity was estimated to be 390 ft^2 per person. The lighting, equipment and occupancy schedules (Figures 1 ad 2) were the same as specified in the typical operation of commercial buildings benchmark models developed by DOE’s Commercial Building Team, (Torcellini, Deru et al2008).

TABLE 2: BUILDING INTERNAL LOADS FOR INITIAL SIMULATION MODELS

		BUILDING INTERNAL LOAD		
SITE NAME	YEAR CONSTRUCTED	LIGHTING DENSITY (W / SQ FT)	PLUG DENSITY (W / SQ FT)	OCCUPANCY (SQ FT / PER PERSON)
Two Carnegie Plaza	1990	1.60	0.75	390
One Carnegie Plaza	1988	1.60	0.75	390
One Carnegie Plaza	1988	1.60	0.75	390
One Vanderbilt	1988	1.60	0.75	390
One Parkside	1993	1.60	0.75	390
Lakeside Tower	1990	1.60	0.75	390
Two Parkside	2001	1.20	0.75	390
Three Carnegie Plaza	2003	1.20	0.75	390
Brier Corporate Center	2005	1.10	0.75	390
Vanderbilt Plaza	2002	1.20	0.75	390
Inland Regional Center	1994	1.60	0.75	390

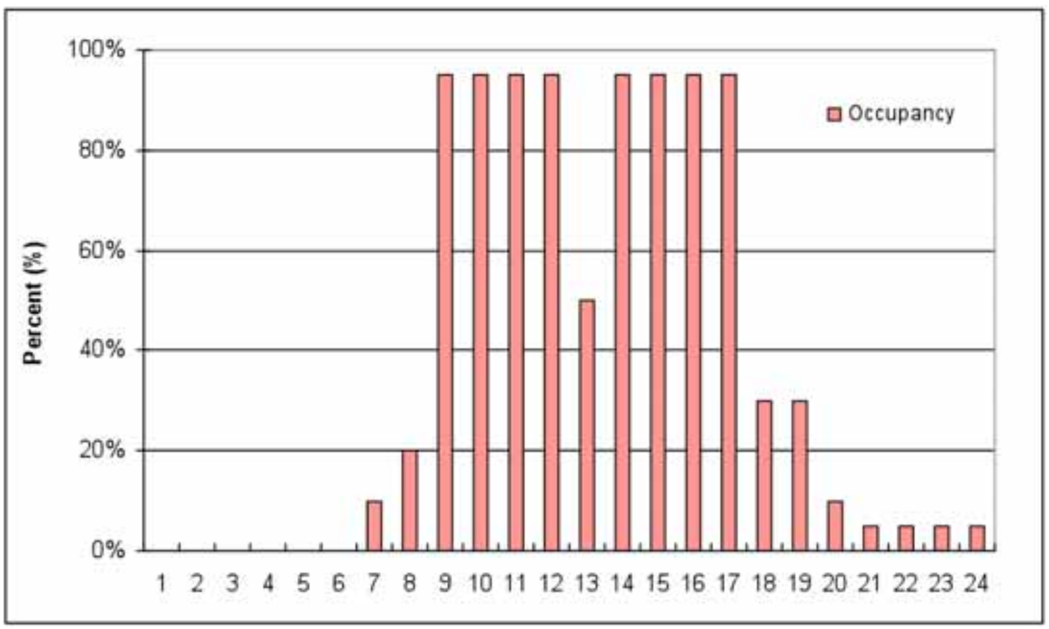

FIGURE 1: SCHEDULE OF OCCUPANCY ON WEEKDAYS

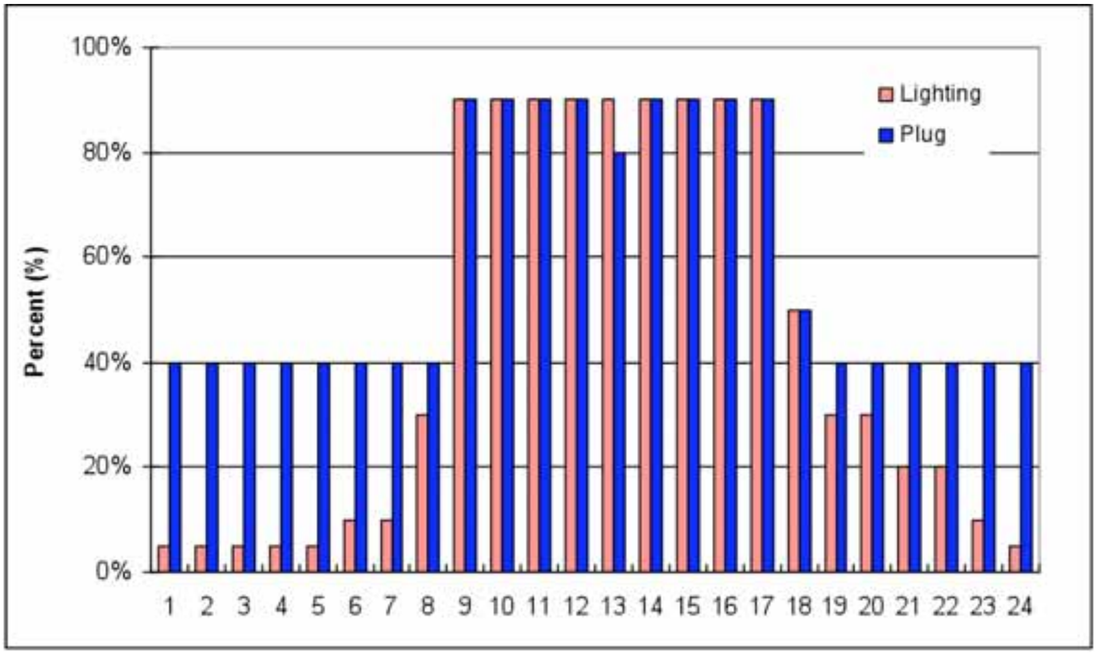

FIGURE 2: SCHEDULES OF LIGHTING AND PLUG POWER DENSITIES ON WEEKDAYS

HVAC SYSTEM

Table 3 summarizes each building's HVAC system type and capacity as well as zone temperature setpoints for each building. Most of the cooling systems are rooftop package DX units with VAV systems. The HVAC systems start between 6 am and 8 am, and turn off around 6 pm on weekdays. The zone temperature for each building is monitored and controlled by a fully equipped digital direct control (DDC) system which enable various global zone temperature reset strategies for demand response analysis. The normal zone temperature set points are about 77 °F in the summer period.

SIMULATION RESULTS

Using all the information mentioned above, initial simulation models were developed for each building using DRQAT. Because of the many input assumptions made, the initial simulated models were then calibrated with measured data. For each initial simulation model, the absolute and the relative difference between the simulation results and the measured data were calculated. The electric consumption predicted by the simulation models were compared to the building's monthly utility bills and to some spot measurements. The simulation results and measured data from the summer of 2007 for each building were compared on a monthly and hourly basis.

As shown in Table 4, only two simulation models had results within ±10% of the measured data. The simulated electricity consumption of the other nine buildings was much lower than the measured data and some monthly differences were larger than 20%.

TABLE 3: BUILDING INTERNAL LOADS FOR INITIAL SIMULATION MODEL

SITE NAME	BUILDING INTERNAL LOADS: COOLING PLANT TYPE	COOLING PLANT CAPACITY	AIR DISTRIBUTION TYPE	ZONE TEMP SET POINTS (COOLING °F)
Two Carnegie Plaza	Packaged DX Units	2 @ 55 Ton 2 @ 50 Ton	VAV	77
One Carnegie Plaza	Packaged DX Units	2 @ 55 Ton 2 @ 50 Ton	VAV	77
One Carnegie Plaza	Packaged DX Units	1 @ 50 Ton 1 @ 60 Ton	VAV	77
One Vanderbilt	Packaged DX Units	3 @ 55 Ton 1 @ 60 Ton	VAV	77
One Parkside	Packaged DX Units	4 @ 55 Ton	VAV	77
Lakeside Tower	Central Chiller (reciprocating)	2 @ 175 Ton	VAV	77
Two Parkside	Packaged DX Units	2 @ 90 Ton	VAV	77
Three Carnegie Plaza	Packaged DX Units	2 @ 50 Ton	VAV	77
Brier Corporate Center	Packaged DX Units	1 @ 80 Ton 2 @ 75 Ton	VAV	77
Vanderbilt Plaza	Packaged DX Units	2 @ 55 Ton 2 @ 50 Ton	VAV	77
Inland Regional Center	Packaged DX Units	2 @ 105 Ton 2 @ 90 Ton	VAV	77

TABLE 4: COMPARISON BETWEEN SIMULATION RESULTS AND ACTUAL DATA IN SUMMER 2007

SITE NAME	INDEX	MONTH (KWH) 6	7	8	9	AVERAGE (KWH)
Two Carnegie Plaza	Actual Data	80,257	90,791	94,380	72,318	337,746
	Simulation	62,173	72,467	73,364	63,207	271,212
	Difference	-18,084	-18,324	-21,016	-9,111	-66,534
		-23%	**-20%**	**-22%**	**-13%**	**-20%**
One Carnegie Plaza	Actual Data	86,551	108,140	110,590	86,803	392,084
	Simulation	57,388	67,155	67,973	58,429	250,944
	Difference	-29,163	-40,985	-42,617	-28,374	-141,140
		-34%	**-38%**	**-39%**	**-33%**	**-36%**
One Carnegie Plaza	Actual Data	61,972	75,944	82,813	60,954	281,682
	Simulation	34,743	41,128	41,530	35,408	152,808
	Difference	-27,230	-34,816	-41,283	-25,546	-128,874
		-44%	**-46%**	**-50%**	**-42%**	**-46%**
One Vanderbilt	Actual Data	146,649	165,824	178,890	140,342	631,705
	Simulation	70,957	83,133	84,290	72,161	310,541
	Difference	-75,692	-82,691	-94,601	-68,180	-321,165
		-52%	**-50%**	**-53%**	**-49%**	**-51%**
One Parkside	Actual Data	100,114	115,745	121,942	94,950	432,751

	Simulation	66,596	77,666	79,672	69,114	293,048
	Difference	-33,518	-38,079	-42,270	-25,836	-139,703
		-33%	**-33%**	**-35%**	**-27%**	**-32%**
Lakeside Tower	Actual Data	141,811	168,731	179,926	140,137	630,606
	Simulation	136,240	156,353	160,384	139,776	592,754
	Difference	-5,571	-12,377	-19,542	-361	-37,852
		-4%	**-7%**	**-11%**	**0%**	**-6%**
Two Parkside	Actual Data	103,487	117,825	124,713	98,815	444,840
	Simulation	63,266	72,744	74,712	65,006	275,728
	Difference	-40,221	-45,081	-50,001	-33,809	-169,112
		-39%	**-38%**	**-40%**	**-34%**	**-38%**
Three Carnegie Plaza	Actual Data	67,019	80,051	86,552	67,728	301,350
	Simulation	66,147	77,643	78,657	67,455	289,901
	Difference	-872	-2,408	-7,895	-273	-11,449
		-1%	**-3%**	**-9%**	**0%**	**-4%**
Brier Corporate Center	Actual Data	159,325	178,754	187,255	164,857	690,191
	Simulation	87,988	104,465	106,174	90,453	389,080
	Difference	-71,337	-74,289	-81,081	-74,404	-301,111
		-45%	**-42%**	**-43%**	**-45%**	**-44%**
Vanderbilt Plaza	Actual Data	127,048	152,719	165,028	125,764	570,559
	Simulation	93,818	108,881	111,544	96,429	410,672
	Difference	-33,230	-43,838	-53,484	-29,335	-159,887
		-26%	**-29%**	**-32%**	**-23%**	**-28%**
Inland Regional Center	Actual Data	95,139	109,179	115,479	89,562	409,359
	Simulation	75,484	87,581	88,892	76,719	328,677
	Difference	-19,655	-21,598	-26,587	-12,843	-80,682
		-21%	**-20%**	**-23%**	**-14%**	**-20%**

SIMULATION MODEL CALIBRATION

One office building "Three Carnegie Plaza" in Tri-City Corporate Center is used as the example to illustrate the initial simulation model calibration procedure. "Three Carnegie Plaza" is a typical office building: two stories with a large portion of the floor area covered with carpets. It has large single pane with low-e glazing areas on every sides of the building. The detailed building descriptions, inputs and simulation results are presented in the appendices of this report.

SIMULATION MODEL CALIBRATION CRITERIA

The calibration criteria used in this report is from the 2002 ASHRAE Guideline 14 - Measurement of Energy and Demand Saving. The standard was developed for energy use and demand saving measurement and verification based on monthly, daily and hourly comparison. The more accurate the initial simulation models are, the more accurate DR sheds the models predict.

The main focus of this study was to evaluate and verify the effect of pre-cooling strategies for decreasing electrical demand of the HVAC system during the peak period. The initial models were adjusted through a series of simulations until the monthly acceptable tolerances were achieved. The models were then calibrated to hourly data to achieve a higher level of accuracy. The following criteria (Equation 1) were used to assess the difference between the simulation results and measured data to determine whether the calibrated models sufficiently reflected the performance of the building: Mean Bias Error (MBE) (how well the energy consumption is predicted by the model as compared to the measured data) and CV(RSME) (how well a model matches the measured data due to the cancellation of errors). Table 5 includes the acceptable tolerance limits used in this analysis.

EQUATION 1: CRITERIA FOR ASSESSING THE DIFFERENCE BETWEEN SIMULATION MODEL AND MEASURED DATA

$$MBE_{month}(\%) = \left[\frac{(M-S)_{month}}{M_{month}}\right] \times 100\%$$

$$CV(RMSE_{month})(\%) = \left[\frac{RMSE_{month}}{\overline{M}_{month}}\right] \times 100\%$$

$$RMSE_{month} = \left\{\frac{\left[\sum_{month}(M-S)^2_{month}\right]}{N_{month}}\right\}^{1/2}$$

$$\overline{M}_{month} = \frac{\sum(M_{month})}{N_{month}}$$

Where M is the measured electric consumption (kWh) in one month, S is the simulated electric consumption (kWh) during the same month, N is the number of months in the field test period.

TABLE 5: ACCEPTABLE TOLERANCE FOR MONTHLY, DAILY AND HOURLY CALIBRATION

INDEX	MONTHLY	DAILY	HOURLY
MBE	±5%	±10%	±20%
CV(RMSE)	±15%	-	-

REAL WEATHER DATA

The initial models were run using TMY2 (Typical Meteorological Year) weather files available within DRQAT. For the calibration process, the measured weather data for 2007 and 2008 was downloaded from the EnergyPlus website according to the climate zone where these eleven buildings were located. Note that some modelers have reported using typical year weather data for model calibration before. This approach was not recommended since the utility data used for the comparison was incurred under actual weather conditions.

INTERNAL LOADS ADJUSTMENTS

After comparing the initial simulation model results to the measured data, it appeared that the plug loads assumed for most of the buildings might be too low. The occupancy, lighting and plug schedules on different weekdays were assumed to be similar to each other throughout the year. To fine tune these schedules, the densities and schedules for lighting and plug loads were estimated based on the whole building electricity data for the heating period from November 1st, 2007 to February 28th, 2008. During this time period, the maximum outside temperature was 55 °F or lower and the cooling plants were completed locked out. The whole building power during this period thus only included lighting, plug and fan power. The internal loads were separated out by analyzing the daily energy use of the buildings under extreme cold weather conditions. This method is applied to buildings where the heating sources are gas, steam, or hot water from other facilities.

Table 6 lists the inputs of the building internal loads for the calibrated simulation models. The lighting and occupancy schedules were similar to the initial simulation models, but the plug loads were increased.

Using “Three Carnegie Plaza” as an example, Figure 3 and Figure 4 show the lighting and plug load schedules on weekdays and weekend & holiday after the calibration. The electricity usage was constant during the unoccupied period. The occupancy schedule of the calibrated model was the same as that used for the initial simulation model.

Table 6: Building Internal Loads for Calibrated Simulation Model

		Building Internal Load		
Site Name	Year Constructed	Lighting Density (W / sq ft)	Plug Density (W / sq ft)	Occupancy (sq ft / per person)
Two Carnegie Plaza	1990	1.60	**0.75**	390
One Carnegie Plaza	1988	1.60	**1.50**	390
One Carnegie Plaza	1988	1.60	**1.50**	390
One Vanderbilt	1988	1.60	**1.80**	390
One Parkside	1993	1.60	**1.40**	390
Lakeside Tower	1990	1.60	**0.90**	390
Two Parkside	2001	1.20	**1.50**	390
Three Carnegie Plaza	2003	1.20	**0.60**	390
Brier Corporate Center	2005	1.10	**1.40**	390
Vanderbilt Plaza	2002	1.20	**1.00**	390
Inland Regional Center	1994	1.60	**1.00**	390

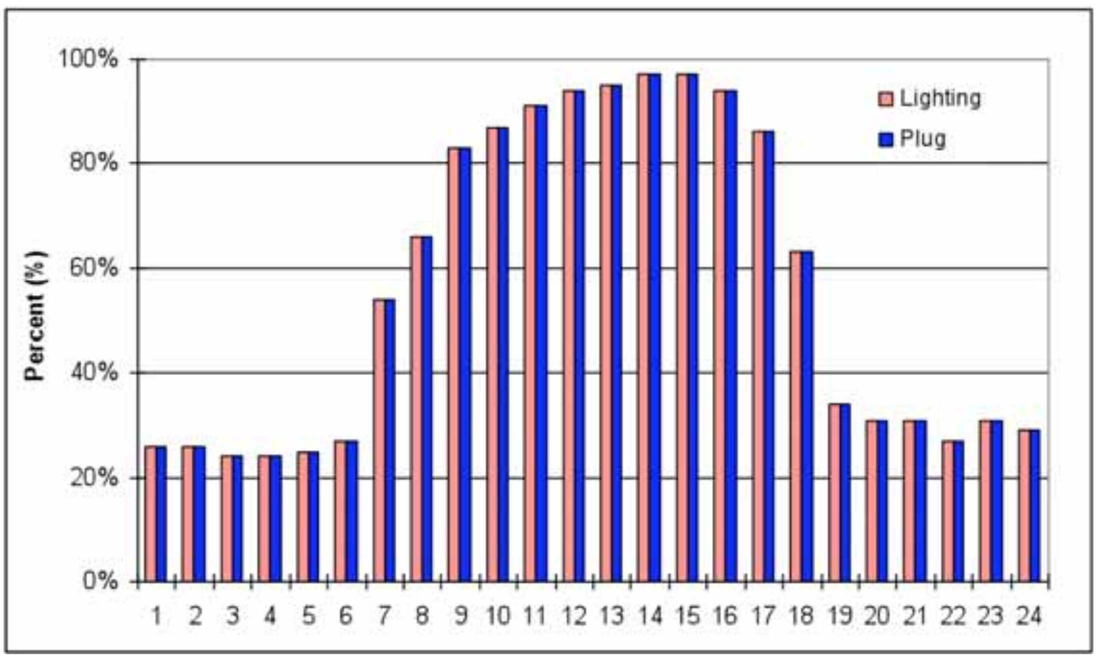

Figure 3: Calibrated Schedules of Lighting and Plug Power Densities on Weekdays

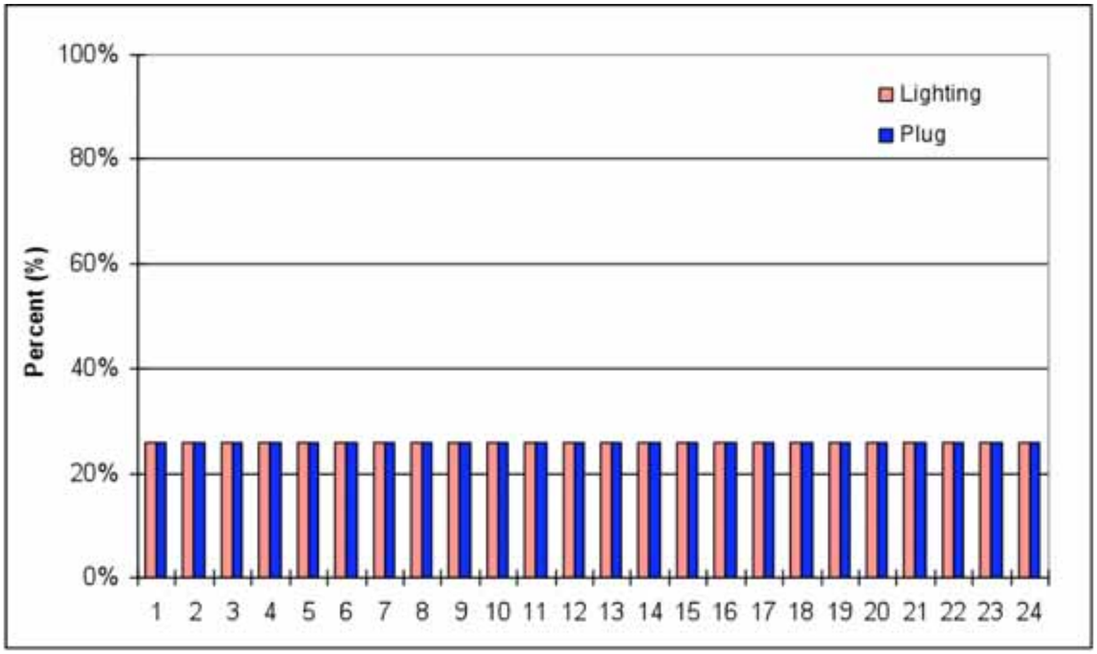

FIGURE 4: CALIBRATED SCHEDULES OF LIGHTING AND PLUG POWER DENSITIES ON WEEKEND AND HOLIDAYS

CALIBRATED INITIAL SIMULATION MODELS

COMPARISON OF MONTHLY MEASURED DATA

The simulation results of the calibrated models were compared with the measured monthly data. Table 7 indicates that the monthly simulation results were within ±5% of the measured data. Some monthly percent errors were higher than the others, but still within ±10%. The densities and schedules for lighting and plug loads used in the models were constant throughout the year. In reality, they may vary slightly between individual days.

TABLE 7: COMPARISON BETWEEN CALIBRATED SIMULATION RESULTS AND ACTUAL DATA IN SUMMER 2007

SITE NAME	INDEX	MONTH (KWH)				AVERAGE (KWH)
		6	7	8	9	
Two Carnegie Plaza	Measured	80,257	90,791	94,380	72,318	337,746
	Simulation	80,981	95,495	95,472	72,618	344,566
	Difference	724	4,704	1,092	300	6,820
		1%	**5%**	**1%**	**0%**	**2%**
One Carnegie Plaza	Measured	86,551	108,140	110,590	86,803	392,084
	Simulation	91,053	105,713	105,737	82,250	384,753
	Difference	4,502	-2,427	-4,853	-4,553	-7,331
		5%	**-2%**	**-4%**	**-5%**	**-2%**
One Carnegie Plaza	Measured	61,972	75,944	82,813	60,954	281,682
	Simulation	65,157	75,965	75,447	58,440	275,009

	Difference	3,185	21	-7,366	-2,514	-6,674
		5%	**0%**	**-9%**	**-4%**	**-2%**
One Vanderbilt	Measured	146,649	165,824	178,890	140,342	631,705
	Simulation	148,845	169,345	168,898	135,664	622,752
	Difference	2,196	3,520	-9,993	-4,677	-8,954
		1%	**2%**	**-6%**	**-3%**	**-1%**
One Parkside	Measured	100,114	115,745	121,942	94,950	432,751
	Simulation	104,489	122,594	123,318	96,093	446,493
	Difference	4,375	6,849	1,376	1,143	13,742
		4%	**6%**	**1%**	**1%**	**3%**
Lakeside Tower	Measured	141,811	168,731	179,926	140,137	630,606
	Simulation	149,166	170,884	174,826	141,030	635,906
	Difference	7,354	2,153	-5,100	893	5,301
		5%	**1%**	**-3%**	**1%**	**1%**
Two Parkside	Measured	103,487	117,825	124,713	98,815	444,840
	Simulation	103,362	120,951	122,953	94,977	442,242
	Difference	-125	3,126	-1,760	-3,838	-2,598
		0%	**3%**	**-1%**	**-4%**	**-1%**
Three Carnegie Plaza	Measured	67,019	80,051	86,552	67,728	301,350
	Simulation	69,931	84,550	84,571	61,304	300,356
	Difference	2,912	4,499	-1,981	-6,424	-994
		4%	**6%**	**-2%**	**-9%**	**0%**
Brier Corporate Center	Measured	159,325	178,754	187,255	164,857	690,191
	Simulation	161,828	186,986	187,524	148,086	684,424
	Difference	2,503	8,232	269	-16,771	-5,767
		2%	**5%**	**0%**	**-10%**	**-1%**
Vanderbilt Plaza	Measured	R127,048	152,719	165,028	125,764	570,559
	Simulation	136,118	159,638	161,984	124,334	582,074
	Difference	9,070	6,919	-3,044	-1,430	11,515
		7%	**5%**	**-2%**	**-1%**	**2%**
Inland Regional Center	Measured	95,139	109,179	115,479	89,562	409,359
	Simulation	99,944	115,992	116,928	90,549	423,413
	Difference	4,805	6,813	1,449	987	14,054
		5%	**6%**	**1%**	**1%**	**3%**

COMPARISON OF DAILY MEASURED DATA

The same building (Three Carnegie Plaza) was used to illustrate the results of the calibrated model. Figure 3 shows the standard lighting and plug load schedules for this building.

Figure 5 and Figure 6 show the comparison of the simulated and measured daily electrical usage for the whole building in July and August. The simulated electrical demand of the calibrated model was very close to the actual data. However, differences still existed in the electrical demand values on 7/16/2007. Perhaps it was because of high internal loads in the building on that day, or the weather data provided by EnergyPlus did not match the actual local weather condition for that day. However, the calibrated simulation results still predicted the actual electric usage throughout the summer period very well.

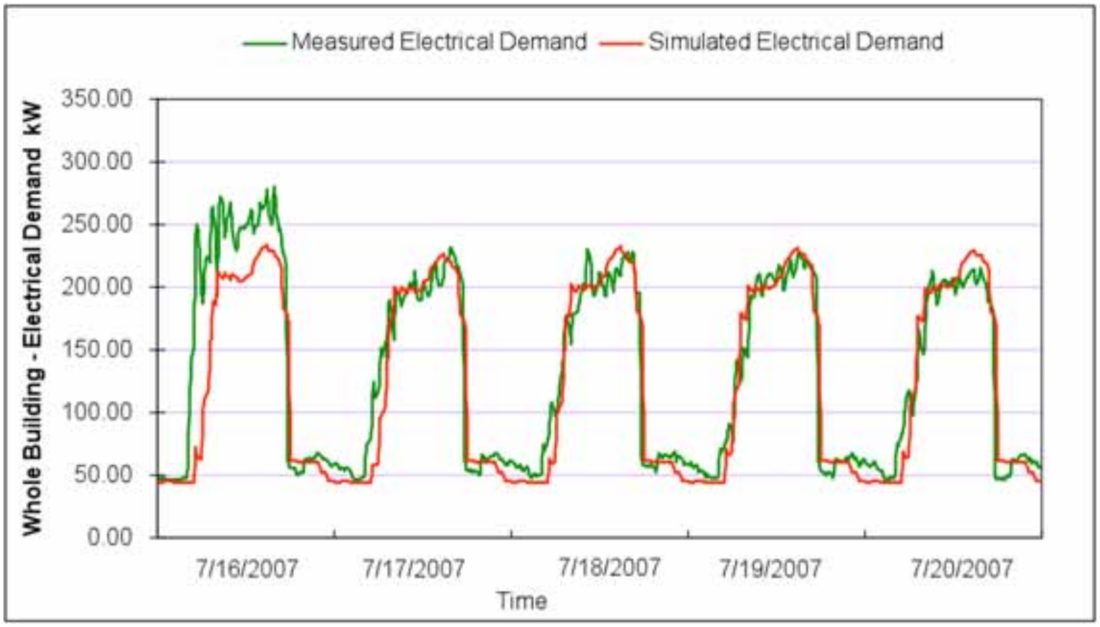

FIGURE 5: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY

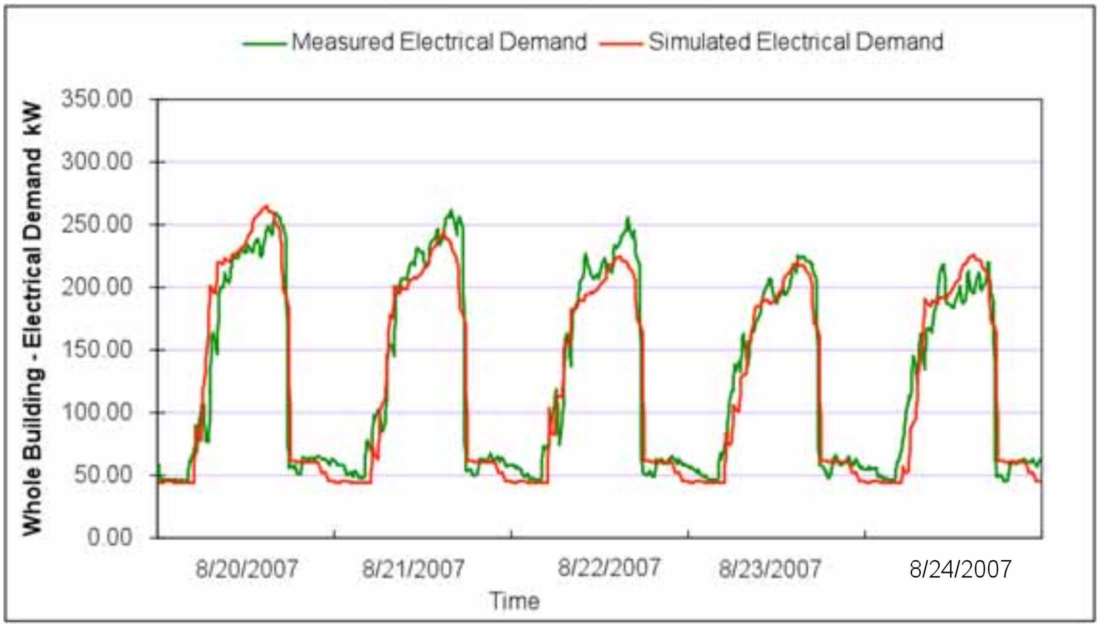

FIGURE 6: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN AUGUST

COMPARISON OF HOURLY MEASURED DATA

Because the internal loads such as lighting and plug loads could be slightly higher or lower compared to the normal operation on any given days, the data of two typical days in summer was selected to illustrate the accuracy of the simulation model. Figure 7 and Figure 8 show the comparison of the hourly whole building electrical demand between the calibrated simulation and the measured data. The calibration met the requirements of the ASHRAE standard - within ±20% for a minimum of 20 hours out of 24 hours for each day. Figure 7 and Figure 8 indicate that the simulation results matched well to the measured data within ±15%.

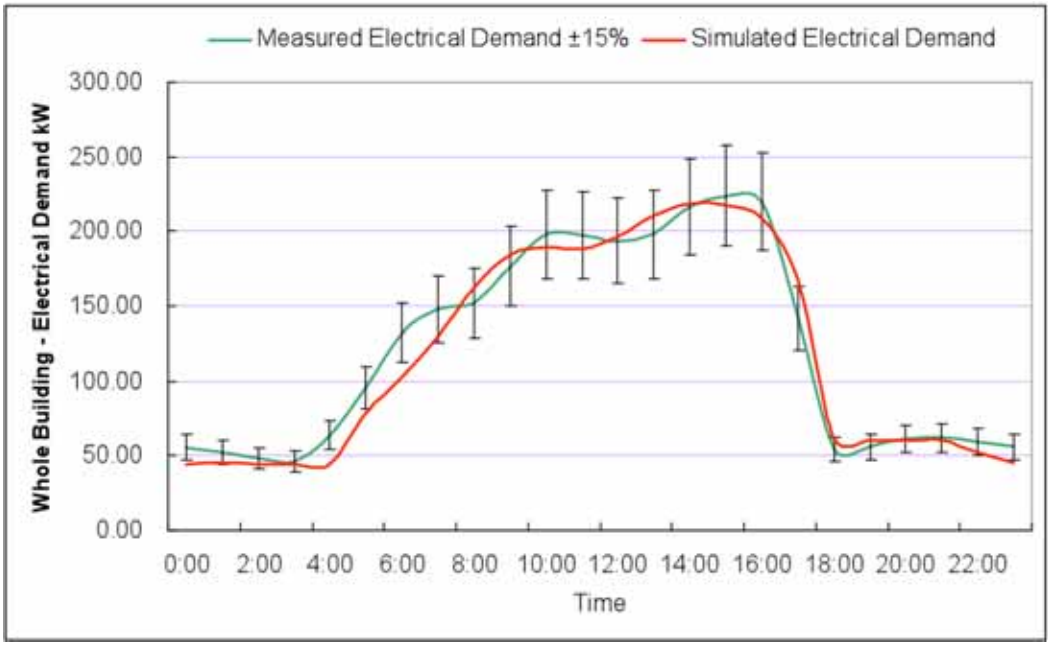

FIGURE 7: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY IN AUGUST

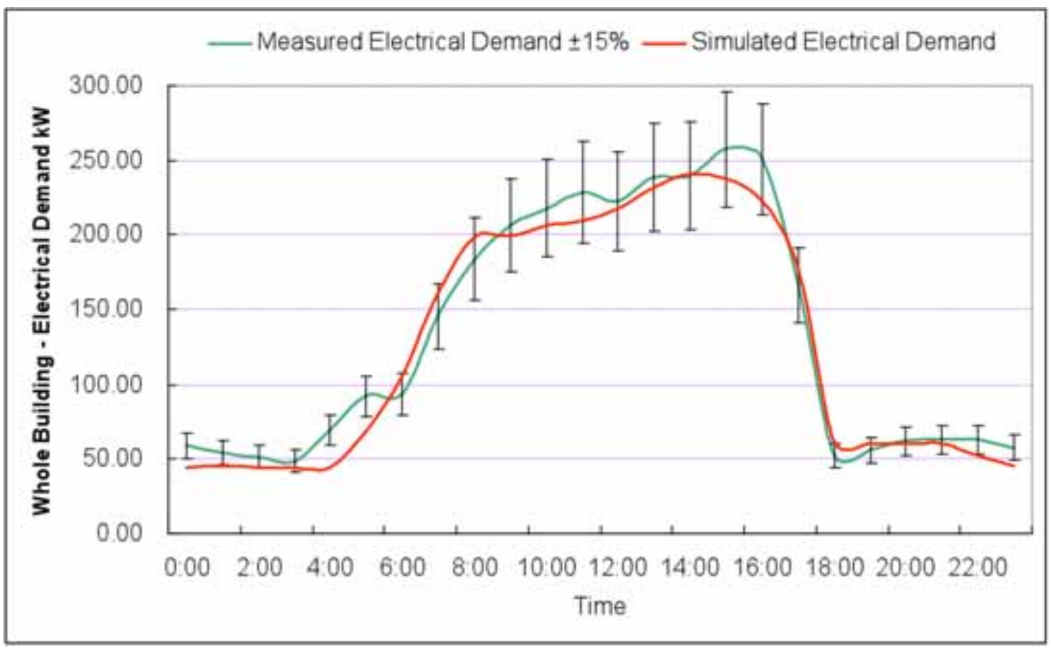

FIGURE 8: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY IN AUGUST

SUMMARY

The initial simulation models for the buildings generated from the basic building information were not able to predict the load profiles of the buildings within a reasonable range of accuracy. However, the refined models after adjusting the internal load schedules predicted the load profiles of the buildings within ±5% range. A standard procedure of model development and calibration was developed. The procedure takes the following steps:

- Generate a DRQAT initial model with basic building information
- Replace the TMY weather file in DRQAT and regenerate a .epw EnergyPlus file with real weather data collected from the site or the nearby weather stations
- Use whole building power under the extreme cold weather conditions to estimate the actual internal load schedule. The method will not work when electricity or heat pumps were used as heating sources
- Conduct simulation and compare the simulated result with the measure ones
- Readjust the internal loads until the measured electricity data match the simulated ones

The internal load had the largest impact on the accuracy of the building simulations when the basic building descriptions were accurate. However, it was hard to get the actual energy usage of the lighting and plug loads without historical data. For more accurate modeling, users should sub-meter end uses in the building for one or two weeks (weekdays) to separate out the internal and lighting electricity use from the HVAC electricity usage. Models generated from this procedure will be able to predict building electricity demand profile very accurately.

OPTIMIZATION OF PRE-COOLING STRATEGIES

OPTIMAL PRE-COOLING STRATEGIES

WHEN TO PRE-COOL: CPP VERSUS NON-CPP?

CPP (Critical Peak Pricing) days are called by the utility and tend be the 12 hottest days throughout the summer period. Normally, peak demand occurs on CPP days due to the high outside air temperature. Utility analyses were conducted to determine the strategy that could offer the highest economic savings to the building owner. From previous experience with similar buildings in this region, often the CPP incentives were not large enough to obtain enough demand charge savings and thus the owners may want to just use the pre-cooling strategies to reduce the peak demand in the summer months.

The utility charge includes energy charge, demand charge, customer charge and other charges. The energy and demand charges account for the majority of the total utility charge. The demand charge is the time-related demand charge per month, which is proportional to the monthly maximum demand. Customers can achieve economic savings by decreasing the monthly maximum demand. Therefore, it is recommended that the customers run the demand response strategies for a number of hot weather days.

The distribution of daily maximum demand throughout the summer period was different for each building in Tri-City Corporate Center. One goal of this analysis was to figure out whether to operate pre-cooling strategy throughout the summer period or only on hot days and determine how much demand charge could be reduced on test days under reasonable zone temperature reset strategy.

Figure 9 shows the distribution of daily peak demand on weekdays of the building tested in summer 2007. The peak demand was 339 kW, and the peak outside air temperature was 108 °F. In order to reduce the demand charge, operators need to run the pre-cooling strategy on hot days throughout the summer period, but not on cool days. The data points in the left rectangle in Figure 9 indicate that the peak demand were lower than 250 kW when the peak outside temperature was below 90 °F. Data in the right rectangle illustrate higher peak demand on the hot days. Since the goal of the optimization was to reduce the peak demand of the summer months and the difference between the peak demand on hot days and warm days was about 50~70 kW, operators should run pre-cooling only in these right rectangular days.

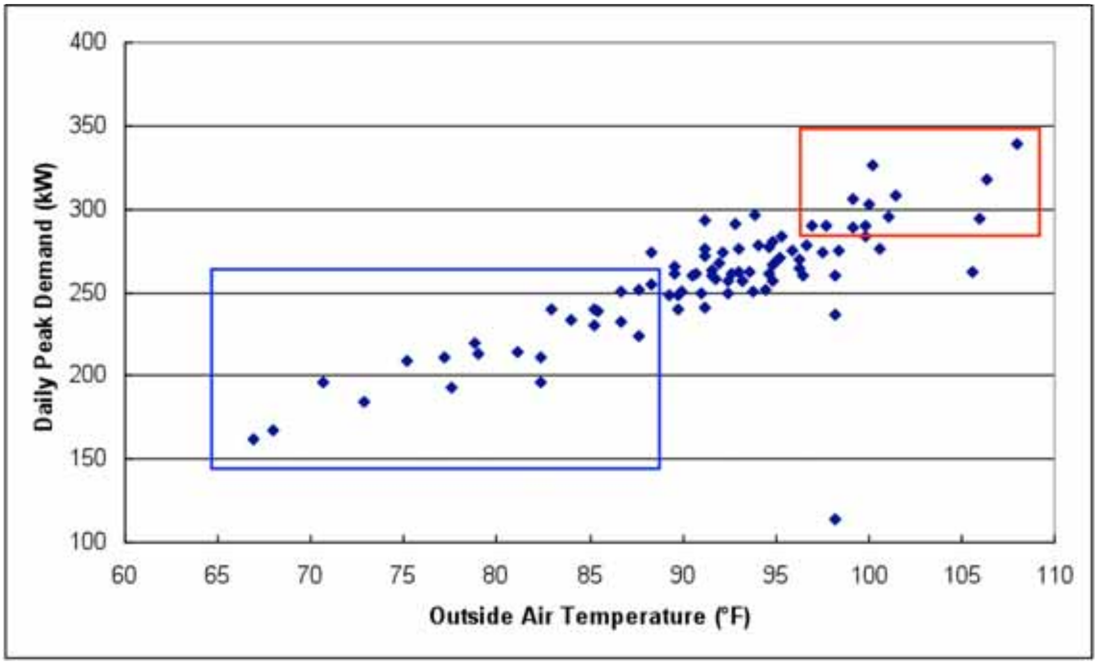

FIGURE 9: DISTRIBUTION OF DAILY MAX DEMAND THROUGHOUT SUMMER PERIOD-THREE CARNEGIE PLAZA

Figure 10 shows the distribution of daily maximum demand for "One Vanderbilt" office building. No large difference in daily maximum demand was observed when the outside temperature exceeded 90 °F. If customers apply the demand response strategies in the building on the twelve hottest days only, the monthly utility charge would not be reduced much because the monthly maximum demand was still very high on Non-CPP days. Therefore, in order to achieve maximum energy and demand charge savings, the operator should run the demand response strategy every day when the weather was hot.

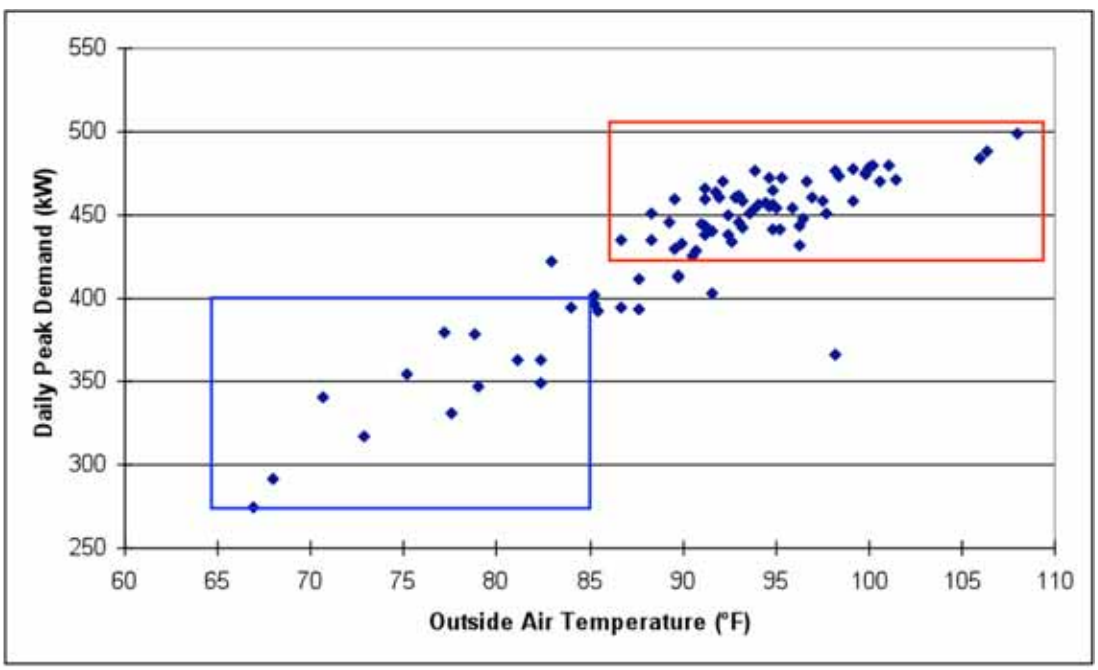

FIGURE 10: DISTRIBUTION OF DAILY MAX DEMAND THROUGHOUT SUMMER PERIOD-ONE VANDERBILT

PRE-COOLING STRATEGIES

The pre-cooling and zone temperature reset strategies evaluated in this study are shown in Figure 11. According to the trended operational data, all of these buildings were normally operated at constant temperature set points near 77 °F throughout the warm-up and occupied hours. The set points in individual zones ranged from 75 to 80 °F, with an average value of about 77 °F. After 6 pm, the system was shut off and zone temperatures started to float.

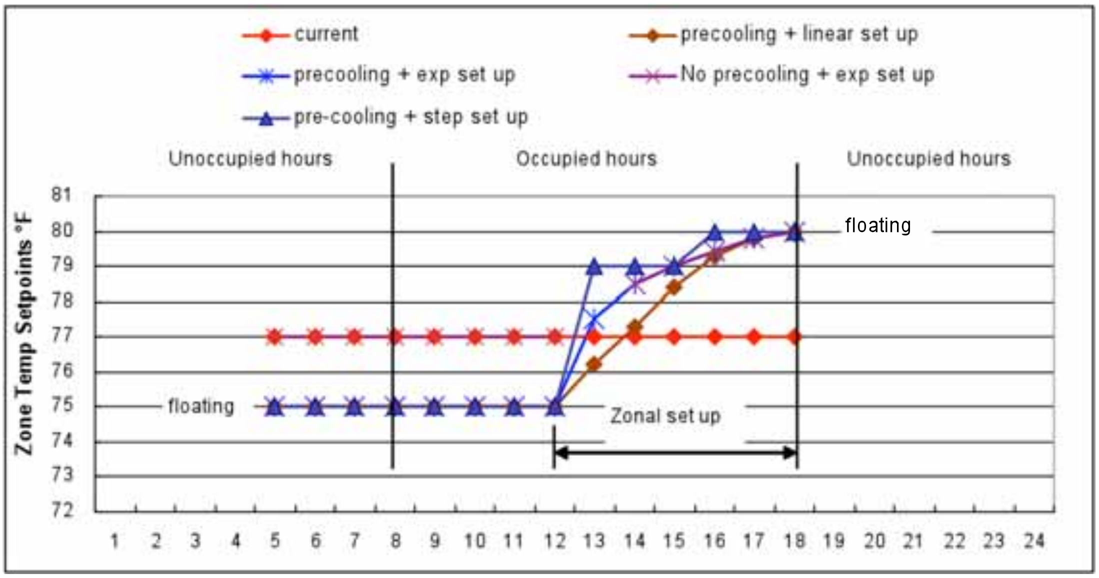

FIGURE 11: PRE-COOLING AND ZONE TEMPERATURE RESET STRATEGIES

The “pre-cooling + linear set up” strategy was the first strategy evaluated. From 5 am to 12 pm, mostly during the occupied hours, all of the zone temperature set points were reduced to 75 °F. From 12 pm to 6 pm (the high price period) the set points were raised linearly to 80 °F. After 6 pm, before the system was shut off, the set points were rolled back to 77 °F.

The second strategy was the “pre-cooling + exponential set up” strategy. While the pre-cooling period was same as for the first strategy, the temperatures were raised exponentially rather than linearly during the afternoon high price period.

The third strategy was the “no pre-cooling + exponential set up” strategy. The zone temperatures were raised exponentially in the afternoon in the same way as in the ”pre-cooling + exponential set up” strategy, but without pre-cooling from 5 am to 12 am. One aim of the tests was to determine the effect of pre-cooling on peak demand shedding.

The fourth strategy was the “pre-cooling + step set up” strategy. The zone temperature set points were reduced to 75 °F. From 12 pm to 3 pm, the set points were raised to 79 °F. After 3 pm, the zone temperature set points were kept at 80 °F.

SIMULATION RESULTS OF PRE-COOLING STRATEGIES

Simulations were conducted for the four different pre-cooling strategies. Figure 12 shows the simulation results of the different pre-cooling strategies for one office building. The plot illustrates the demand shed during the high price period. The "Pre-cooling with step temp set up" strategy load profile was much flatter than the others. Of the other three strategies, the "Pre-cooling with exponential temp set up" strategy load profile was better than those of the "No pre-cooling with exponential temp set up" and "Pre-cooling with linear temp set up" strategies. The "Pre-cooling with linear temp set up" strategy load profile fluctuated throughout the zonal temp reset period and the shed was smaller than that of "exponential set up" strategy.

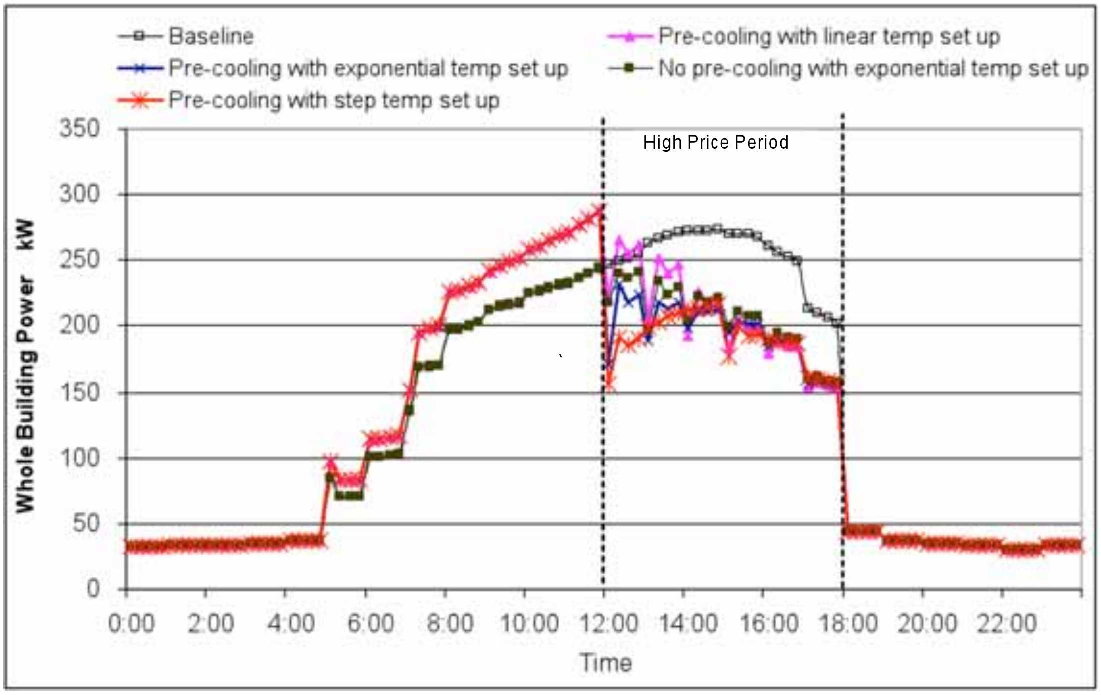

FIGURE 12: SIMULATION RESULTS OF PRE-COOLING STRATEGIES

OPTIMAL PRE-COOLING STRATEGIES

A series of simulations were conducted. The calibrated simulation models were used to find the optimal pre-cooling strategies for the eleven buildings. The optimal strategies were later tested in the buildings.

Due to the relative stability of their load profiles, the "Pre-cooling with exponential temp set up" and "Pre-cooling with step temp set up" strategies were determined to be the optimal strategies for the Tri-City Corporate Center buildings. The 'pre-cooling with step temp set up" strategy was implemented during the field tests as this strategy is easier to implement and results in a flat load profile at the beginning of the on-peak period. Figure 13 shows the simulation results of pre-cooling strategies "Pre-cooling with exponential temp set up" and "Pre-cooling with step temp set up". From 12 pm to 3 pm, zone temperature set points were raised to 79 °F. From 3 pm to 6 pm, zone temperatures were kept at 80 °F.

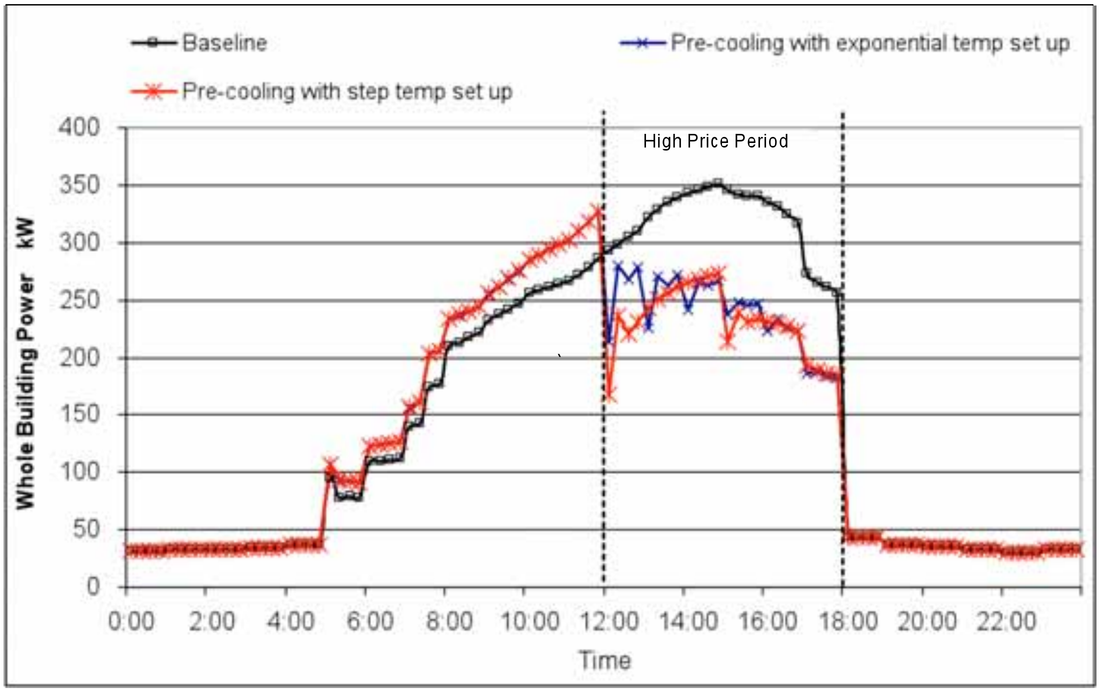

FIGURE 9: SIMULATION RESULTS OF OPTIMAL PRE-COOLING STRATEGIES

Table 8 presents the comparison of the simulation results for two types of pre-cooling strategies. The results indicate that the demand shed for these two pre-cooling strategies were similar during the high price period. The peak demand shedding for "Pre-cooling with exponential temp set up" was higher than that of "Pre-cooling with step temp set up" by 15 kW due to the exponential temperature reset. However, the average demand shedding of "Pre-cooling with step temp set up" strategy was larger than that of the "Pre-cooling with exponential temp set up" strategy. The simulation results of "Pre-cooling with step temp set up" strategy seems to have a flatter load profile at the beginning of demand response period. Therefore, "Pre-cooling with step temp set up" strategy is recommended to be the more optimal pre-cooling strategy. As a rule of thumb, the operators should run the strategy whenever the peak outdoor temperatures are higher than 90°F.

TABLE 8: SIMULATION RESULTS OF DIFFERENT PRE-COOLING STRATEGIES

STRATEGY	KW		W / FT^2		WBP %	
	MAX	AVE	MAX	AVE	MAX	AVE
Pre-cooling with exponential temp set up	122.05	65.96	1.46	0.79	37%	20%
Pre-cooling with step temp set up	107.30	68.88	1.28	0.82	36%	23%

SUMMARY OF SIMULATION RESULTS

Table 9 presents a summary of the simulation results for "pre-cooling with step temp set up" strategy in one office building (Three Carnegie Plaza). The average demand shed throughout the on-peak period was 44 kW and the peak demand shed ranged from 31 kW to 136 kW. The average demand saving was over 15% with this pre-cooling strategy.

TABLE 9: SIMULATION RESULTS OF OPTIMAL "STEP TEMPERATURE SET UP" PRE-COOLING STRATEGY (THREE CARNEGIE PLAZA)

EVENT	PERIOD	KW		W / FT²		WBP%	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	76.4	50.3	0.91	0.60	27%	18%
	High Price (3 pm-6 pm)	33.6	27.0	0.40	0.32	12%	10%
CPP-2	Moderate Price (12 pm-3 pm)	65.3	43.3	0.78	0.52	26%	17%
	High Price (3 pm-6 pm)	31.5	24.1	0.38	0.29	13%	10%
CPP-3	Moderate Price (12 pm-3 pm)	91.8	54.7	1.10	0.65	31%	19%
	High Price (3 pm-6 pm)	38.8	33.4	0.46	0.40	13%	11%
CPP-4	Moderate Price (12 pm-3 pm)	95.2	57.1	1.14	0.68	31%	19%
	High Price (3 pm-6 pm)	43.2	34.4	0.52	0.41	14%	11%
CPP-5	Moderate Price (12 pm-3 pm)	135.9	73.6	1.62	0.88	40%	22%
	High Price (3 pm-6 pm)	46.7	35.1	0.56	0.42	14%	10%
CPP-6	Moderate Price (12 pm-3 pm)	133.7	68.1	1.60	0.81	41%	21%
	High Price (3 pm-6 pm)	38.8	30.3	0.46	0.36	12%	9%
CPP-7	Moderate Price (12 pm-3 pm)	133.2	65.8	1.59	0.79	40%	20%
	High Price (3 pm-6 pm)	44.7	34.8	0.53	0.42	14%	11%
CPP-8	Moderate Price (12 pm-3 pm)	121.6	63.4	1.45	0.76	38%	20%
	High Price (3 pm-6 pm)	43.1	33.7	0.51	0.40	14%	11%
CPP-9	Moderate Price (12 pm-3 pm)	91.7	51.5	1.10	0.62	33%	19%
	High Price (3 pm-6 pm)	38.3	29.9	0.46	0.36	14%	11%
CPP-10	Moderate Price (12 pm-3 pm)	96.5	56.5	1.15	0.68	34%	20%
	High Price (3 pm-6 pm)	38.9	29.6	0.46	0.35	14%	10%
CPP-11	Moderate Price (12 pm-3 pm)	91.6	55.2	1.09	0.66	31%	19%
	High Price (3 pm-6 pm)	37.5	29.2	0.45	0.35	13%	10%
CPP-12	Moderate Price (12 pm-3 pm)	88.7	53.4	1.06	0.64	31%	19%
	High Price (3 pm-6 pm)	33.6	25.5	0.40	0.30	12%	9%

PRE-COOLING FIELD TEST ANALYSIS

PRE-COOLING AND DR EVENT FIELD TEST RESULTS

PRE-COOLING STRATEGY FIELD TEST

During Summer 2008, Global Energy Partner (GEP) implemented the “Pre-cooling with step temperature set up” strategy at each of the field sites, and conducted Auto-DR tests on the 12 DR events from July through September. Figure 14 shows the pre-cooling strategy used on the Auto-DR events days for the buildings.

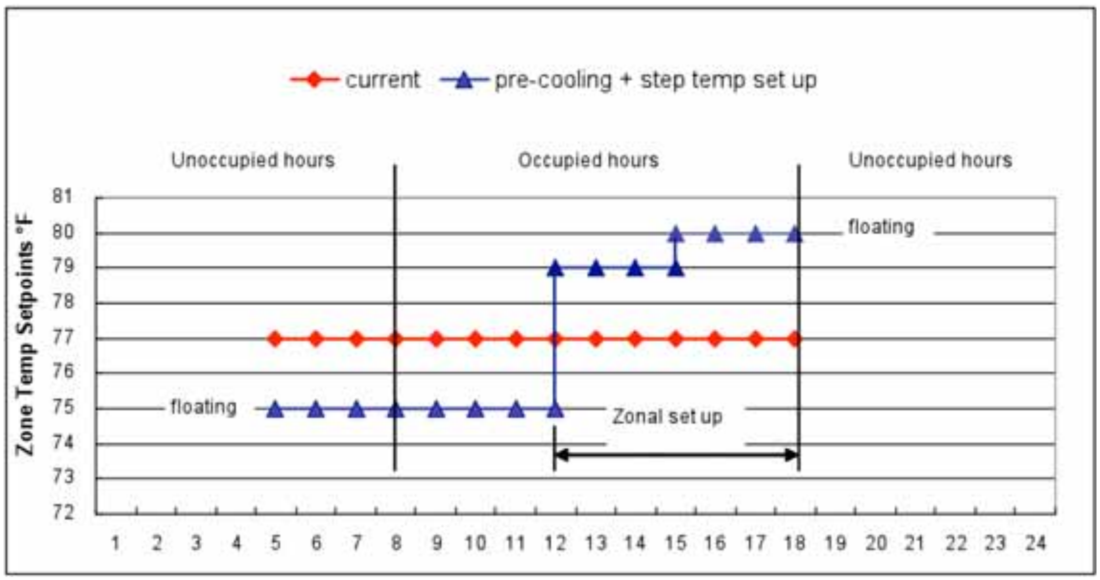

FIGURE 10: PRE-COOLING STRATEGIES – AUTO-DR

DR EVENT FIELD TEST

CONFIRMATION OF THE SIMULATION MODEL

In the 2003 and 2004 studies, a strong correlation was observed between maximum outside air temperature and whole building peak power (Xu et al. 2004). In order to minimize the weather difference between simulations and test days, baseline days for each test day were selected based on the similarity in peak outside air temperatures and outside air temperatures profiles.

Simply comparing maximum outside air temperature is not a reliable method to select baselines. The average variance of hourly outside air temperatures (AVHOAT) between the baseline days and test days provide an additional metric that is calculated as:

Equation 2: Average Variance of Hourly Outside Air Temperature

$$AVHOAT = \frac{1}{24}\sum_{i=1}^{24}(B_i - T_i)^2$$

Bi = the hourly outside air temperature for baseline days

Ti = the hourly outside air temperature for test days

Table 10 shows five potential baseline days that had similar maximum outside air temperatures to that of the 9/3/2008 test day. By only comparing the Peak OA Temperature, any of these five baseline days could be considered to be the best baseline day. The AVHOAT method, however, shows that 9/4/2008 had the smallest AVHOAT and thus would be the best match to use for the baseline day. As shown in Figure 15, the hourly outside air temperature on 9/4/2008 (the baseline day) were almost the same as on 9/3/2008 (Auto-DR day). This same method was used to select baseline days for the other CPP test event days.

Table 10: Temperature Comparison between Baseline Days and Auto-DR Days

	Test Day	Baseline Days				
Date	9/3/08	9/2/08	9/4/08	9/5/08	9/15/08	9/25/08
Peak OA temperature (°F)	98.06	98.96	96.98	100.04	98.96	98.06
AVHOAT	-	5.36	1.71	1.78	7.85	4.87

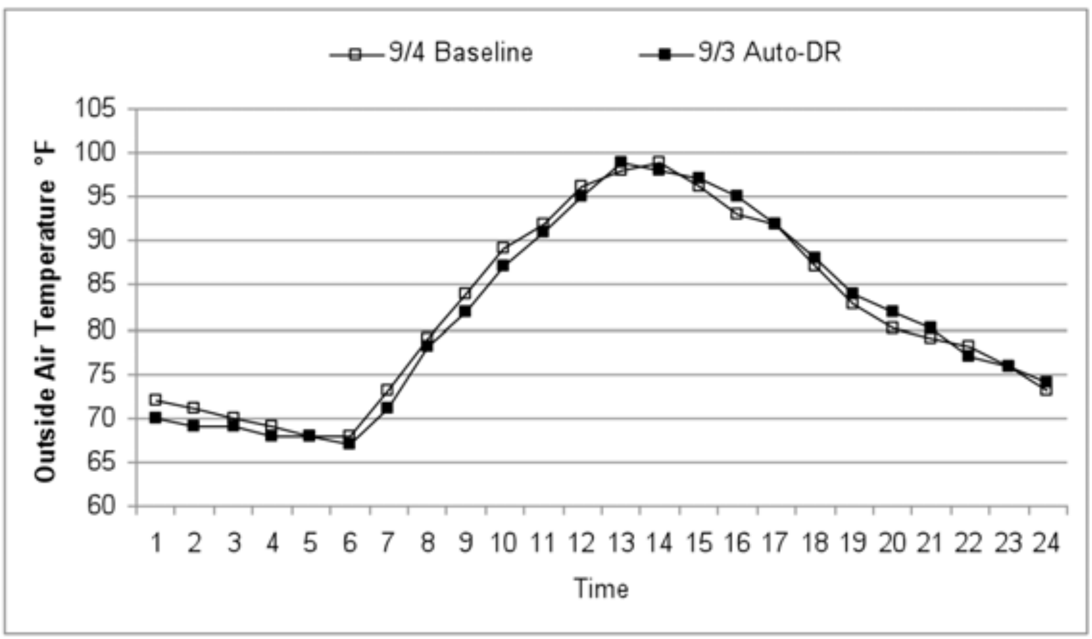

Figure 11: Outside Air Temperature Comparison Between Baseline Day and Auto-DR Day

Table 11 presents a summary of the eleven critical peak pricing (CPP) event days their corresponding baseline days (note that pre-cooling field tests were conducted on eleven of the twelve possible CPP days). Results are provided for these eleven test days. The maximum outside air temperatures for the August CPP days were similar to each other.

TABLE 11: SUMMARY OF AUTO-DR DAYS AND CORRESPONDING BASELINE DAYS

NUMBER	DATE	MAX OA TEMP	BASELINE
CPP-1	7/9/2008	92 °F	7/14/2008
CPP-2	7/10/2008	93 °F	7/14/2008
CPP-3	7/21/2008	93 °F	7/14/2008
CPP-4	8/1/2008	98 °F	7/31/2008
CPP-5	8/5/2008	96 °F	8/7/2008
CPP-6	8/6/2008	96 °F	8/7/2008
CPP-7	8/11/2008	97 °F	8/15/2008
CPP-8	8/12/2008	97 °F	8/15/2008
CPP-9	8/27/2008	92 °F	8/19/2008
CPP-10	8/28/2008	91 °F	8/19/2008
CPP-11	9/3/2008	99 °F	9/4/2008

LBNL BASELINE MODEL

LBNL developed a baseline model to estimate the demand saving from implementing the DR strategies. Previous research recommended a weather sensitive baseline model with adjustments for morning load variations. With respect to the LBNL baseline model, the whole building power baseline is estimated using a regression model that assumes that whole building power is linearly correlated with outside air temperature (OAT) (Coughlin, Piette et al, 2008).

EQUATION 3: COMPUTED BASELINE MODEL

$$L_i = a_i + b_i T_i$$

Where L_i is predicted 15-minute interval electric demand for time i from the previous non-CPP work days, a_i and b_i are estimated parameters generated from a linear regression of the input data for time i. T_i is the hourly or 15-minute interval outside air temperature of time i.

Ten non-DR days were selected to develop the baseline electric loads for the demand savings, and these 10 baseline days were non-weekend, non-holiday Monday through Friday workdays.

The morning power load was used to adjust the regression model. The regression model is multiplied by the average ratio between the actual demand and the predicted demand from 9 am to noon, as shown in Equation 4.

EQUATION 4: REGRESSION MODEL WITH MORNING LOAD ADJUSTMENT

$$L'_i = PL_i$$

$$P = Average(M_i / L_i)$$

Where L'_i is the adjusted load for time i, P is the calibration ratio, and M_i is the actual demand for time i.

Based on the analysis of multiple baselines using the 2004 Auto-DR tests, the OAT regression model with morning load shape adjustment provided a better estimate than the OAT regression model without the morning load shape adjustment. The demand savings on Auto-DR days between the baseline model (AVHOAT) and the LBNL baseline model were compared. The results are listed in Appendix D (Figures D1-11). There was no significant difference between these two baseline models due to the similarity between the selected baseline days and the Auto-DR days.

DR EVENT FIELD TEST RESULTS

" Three Carnegie Plaza" was again selected as the example to illustrate the pre-cooling strategy field test results. This building participated in the 2008 critical peak pricing program. Figure 16 shows the whole building power measurement for the "LBNL baseline", the "9/4 Baseline" and the 9/3/2008 CPP event day with the "pre-cooling with step temp set up" strategy. During the pre-cooling period (6 am to 12 pm) on the CPP day, the electricity demand was higher than on the baseline days. The electricity demand was reduced by as much as 64 kW from 12 pm to 6 pm. No rebound was observed before 6 pm. Notwithstanding the slight difference due to the adjustment of the LBNL baseline between 2 and 4 am, Figure 16 shows that the 9/4 baseline model load profile was similar to that of the LBNL baseline model. See Appendix D for results for the other buildings.

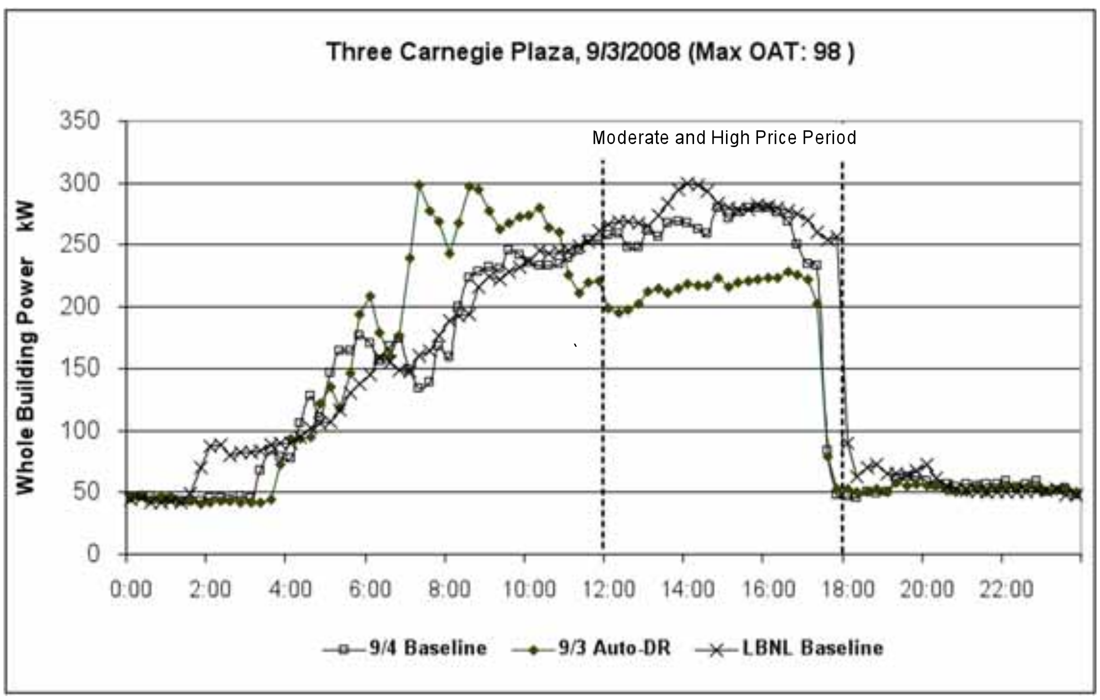

FIGURE 12: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY

The field test results in Table 12 show significant peak demand savings for "Pre-cooling with step set up" strategy throughout CPP days in the office building (Three Carnegie Plaza). Prior to the beginning of the CPP events, GEP conducted a short pre-cooling field test, however, the peak demand reduction was small. After they implemented the optimal "pre-cooling with step temp set up" strategy, the average of the peak demand savings on CPP days was about 59 kW, and the peak demand was reduced by as much as 36%.

TABLE 12: SUMMARY OF AUTO-DR FIELD TEST RESULTS – THREE CARNEGIE PLAZA

DATE	PERIOD	KW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	56.6	24.6	0.68	0.29	24%	10%
	High Price (3 pm-6 pm)	31.7	-37.6	0.38	-0.45	13%	-16%
CPP-2	Moderate Price (12 pm-3 pm)	43.2	4.3	0.52	0.05	18%	2%
	High Price (3 pm-6 pm)	48.0	-23.2	0.57	-0.28	20%	-10%
CPP-3	Moderate Price (12 pm-3 pm)	2.9	-11.4	0.03	-0.14	1%	-5%
	High Price (3 pm-6 pm)	20.2	-20.9	0.24	-0.25	8%	-9%
CPP-4	Moderate Price (12 pm-3 pm)	63.4	50.6	0.76	0.60	27%	21%
	High Price (3 pm-6 pm)	68.2	51.6	0.81	0.62	29%	22%
CPP-5	Moderate Price (12 pm-3 pm)	69.1	54.5	0.83	0.65	27%	21%
	High Price (3 pm-6 pm)	86.4	54.2	1.03	0.65	34%	21%
CPP-6	Moderate Price (12 pm-3 pm)	71.0	50.5	0.85	0.60	28%	20%
	High Price (3 pm-6 pm)	64.3	45.0	0.77	0.54	25%	18%
CPP-7	Moderate Price (12 pm-3 pm)	111.4	101.1	1.33	1.21	36%	33%
	High Price (3 pm-6 pm)	84.5	50.6	1.01	0.61	27%	16%
CPP-8	Moderate Price (12 pm-3 pm)	90.2	77.5	1.08	0.93	29%	25%
	High Price (3 pm-6 pm)	66.2	32.8	0.79	0.39	21%	11%
CPP-9	Moderate Price (12 pm-3 pm)	82.6	66.1	0.99	0.79	28%	22%
	High Price (3 pm-6 pm)	72.0	56.4	0.86	0.67	25%	19%
CPP-10	Moderate Price (12 pm-3 pm)	74.9	59.2	0.89	0.71	25%	20%
	High Price (3 pm-6 pm)	63.4	43.2	0.76	0.52	22%	15%
CPP-11	Moderate Price (12 pm-3 pm)	64.3	51.3	0.77	0.61	23%	18%
	High Price (3 pm-6 pm)	58.6	37.2	0.70	0.44	21%	13%

COMPARISON OF ACTUAL DATA AND SIMULATION PREDICTION

The measured data in Table 12 was compared to the simulation results in Table 9. The average demand shed of the simulation models was slightly lower than the measured data. Among the DRQAT inputs, level of thermal mass had the largest impact on peak demand reductions. The building thermal mass level was set to "Medium" in the first calibrated models, which was confirmed according to the characteristics of typical office buildings. The comparison results illustrated that the thermal mass level of the actual building was higher than that in the simulation models . Therefore, the thermal mass level was reset to "High" in the adjusted models in some buildings.

TABLE 13: SUMMARY OF OPTIMAL PRE-COOLING STRATEGY – RECALIBRATED MODEL

DATE	PERIOD	KW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	79.3	48.9	0.95	0.58	28%	17%
	High Price (3 pm-6 pm)	48.2	36.5	0.58	0.44	17%	13%
CPP-2	Moderate Price (12 pm-3 pm)	69.0	42.5	0.82	0.51	27%	17%
	High Price (3 pm-6 pm)	45.9	32.9	0.55	0.39	18%	13%
CPP-3	Moderate Price (12 pm-3 pm)	95.5	53.4	1.14	0.64	32%	18%
	High Price (3 pm-6 pm)	55.7	45.0	0.66	0.54	19%	15%
CPP-4	Moderate Price (12 pm-3 pm)	99.2	56.1	1.19	0.67	32%	18%
	High Price (3 pm-6 pm)	62.8	47.3	0.75	0.57	20%	15%
CPP-5	Moderate Price (12 pm-3 pm)	138.1	71.4	1.65	0.85	39%	20%
	High Price (3 pm-6 pm)	68.3	48.6	0.82	0.58	19%	14%
CPP-6	Moderate Price (12 pm-3 pm)	136.9	65.9	1.64	0.79	41%	20%
	High Price (3 pm-6 pm)	57.3	42.2	0.69	0.50	17%	13%
CPP-7	Moderate Price (12 pm-3 pm)	132.2	62.0	1.58	0.74	39%	18%
	High Price (3 pm-6 pm)	62.9	45.3	0.75	0.54	18%	13%
CPP-8	Moderate Price (12 pm-3 pm)	125.3	60.5	1.50	0.72	38%	18%
	High Price (3 pm-6 pm)	61.8	44.5	0.74	0.53	19%	14%
CPP-9	Moderate Price (12 pm-3 pm)	96.1	50.9	1.15	0.61	34%	18%
	High Price (3 pm-6 pm)	55.3	40.9	0.66	0.49	19%	14%
CPP-10	Moderate Price (12 pm-3 pm)	101.3	55.5	1.21	0.66	35%	19%
	High Price (3 pm-6 pm)	55.7	40.3	0.66	0.48	19%	14%
CPP-11	Moderate Price (12 pm-3 pm)	95.3	54.2	1.14	0.65	31%	18%
	High Price (3 pm-6 pm)	54.8	40.4	0.66	0.48	18%	13%
CPP-12	Moderate Price (12 pm-3 pm)	92.3	52.2	1.10	0.62	32%	18%

DATE	PERIOD	kW		W / FT^2		WBP%	
		MAX	AVE	MAX	AVE	MAX	AVE
	High Price (3 pm-6 pm)	48.7	35.2	0.58	0.42	17%	12%

Appendix D (Tables D1-D11) present the calculated results of demand savings on Auto-DR days for all of the buildings, and Appendix E (Tables E1-E11) present the DRQAT simulated results of demand savings for each building. The field test results indicate that some buildings show little demand reduction on Auto-DR days, while the simulated results show the effectiveness of the demand response strategies on CPP days. One reason for the low amount of demand shed was the operation of the demand response strategy; the operators didn't adjust the temperature properly. Another reason was the selection of the baseline for each Auto-DR day. Two baseline models were calculated for each Auto-DR day: the first baseline model was selected based on the similarity of the outside air temperature between baseline days and Auto-DR days, and the second baseline model was calculated using a weather sensitive baseline model with adjustments for morning load variations (LBNL baseline model). By comparing these two baseline models to electricity loads on Auto-DR days, the LBNL baseline model was almost the same as the first baseline model.

For some buildings, the difference in energy usage for the lighting, plug and miscellaneous loads between the baseline days and Auto-DR days could lead to the inaccurate calculation of demand savings for the demand response strategy. More attention needs to be paid to these buildings, including sub-metering the electric usage of lighting, plug, and HVAC system, to find reasons for the little demand shed on Auto-DR days.

SUMMARY

The pre-cooling and CPP field tests results were analyzed, the energy and economic analyses were conducted, and the DRQAT models were readjusted with the test data. Baseline days for the CPP test days were selected based on the similarity of the outside air temperature between the baseline days and the test days. In selecting baseline days, effort was taken to match the maximum outside air temperature and also to minimize the hourly temperature difference between the baseline days and CPP test days.

The optimal pre-cooling strategy worked very well in the office buildings and was able to reduce the demand significantly (15~30% throughout the summer period). The whole building power profiles on the CPP days indicated no rebound in the afternoon. The refined models can be used to predict the demand saving from other demand response strategies.

COMPARISON OF DRQAT WITH EQUEST AND BEST

Many building energy simulation tools have been developed to simulate building performance. These building energy simulation tools were used to simulate performance of building envelopes and HVAC systems to improve building design and operation. Building simulation models have also been used to establish DR baselines and calculate the energy and demand savings of DR strategies.

Features and capabilities of three building energy simulation tools were compared: Quick Energy Simulation Tool (eQUEST), Building Energy Simulation Tool (BEST), and Demand Response Quick Assessment Tool (DRQAT). All three tools are capable of simulating energy usage and predicting hourly building electric demand. However, because each software tool uses different calculation engines, they have different levels of accuracy and not all of them are suitable for simulating thermal mass effects.

INTRODUCTION TO ENERGY SIMULATION TOOLS

eQUEST is a sophisticated, yet easy to use, freeware building energy use analysis tool that provides professional-level results with an affordable level of effort. It was designed to allow users to perform detailed comparative analysis of building designs and technologies by applying sophisticated building energy simulation techniques but without requiring extensive experiences in the “art” of building performance modeling. It is accomplished by combining a building creation wizard, an energy efficiency measure (EEM) wizard and a graphic results display module with a complete DOE2.2 building energy use simulation program.

BEST is a building energy simulation tool linking DOE2.2 with custom building models. The tool is licensed to Global Energy Partners, LLC. Projects in BEST include CEC Demand Control, Iowa Utilities and DEEM Project. The project “CEC Demand Control” implements Demand-Control measures for a range of commercial building types. Each building type has default values for 4 vintages (Very Old, Old, Recent and New) that vary with climate zones. The 16 Standard CEC weather files are installed in BEST.

DRQAT is a tool for simulating large commercial buildings DR strategies, developed by LBNL’s Demand Response Research Center with funding from the California Energy Commission’s PIER Program. This tool is based on EnergyPlus simulations of prototypical buildings and HVAC equipment. It incorporates prototypical buildings and equipment and requires the user to specify only a relatively small number of important parameters in order to run a quick assessment of DR strategies. DRQAT predicts energy and peak electrical demand savings, economic savings, and thermal comfort impacts of various demand response strategies.

FUNCTIONALITY

GENERAL FEATURES

The general capabilities of eQUEST, BEST and DRQAT were compared (Table 14). eQUEST is the most sophisticated tool among all three. It can develop both simple and detailed building models integrated with many types of HVAC systems. Compared to eQUEST, BEST and DRQAT are developed only for predicting demand response savings. Both BEST and DRQAT are integrated with different demand response strategies, and can predict demand and energy savings quickly.

TABLE 14: GENERAL FEATURES OF BUILDING ENERGY SIMULATION TOOL

INDEX	CAPABILITY	EQUEST	BEST	DRQAT
Simulation Solution	Sequential loads, system, plant calculations	X	X	
	Simultaneous loads, system, plant calculations			X
	Floating room temperature	X	X	X
Time Step in Hour	Hourly	X	X	X
	1~60 in Hour			X
Building Geometry	Detailed and Flexible	X		
	Quick Modeling	X	X	X
Zone Load	Internal load	X	X	X
	Schedule flexibility	X		X
	Internal Thermal Mass	X	X	X
	Human Thermal Comfort			X
	Design Day Sizing	X	X	X
HVAC System	Types of HVAC System	X		
	System Sizing	X	X	X
Energy Cost	Complex energy tariffs	X		X
	Detailed economic analysis	X		X
	Graphic output			X
Results Reporting	User defined report	X		
	Interface of report			X
	Energy end-use	X	X	X
	Peak demand	X	X	X
	Quickly	X	X	X

DIFFERENCE IN BUILDING DYNAMICS PREDICTION

Figure 17 and Figure 18 show the load calculation procedures of DOE2 and EnergyPlus. DOE2 has one subprogram for translating input (BDL Processor), and four simulation subprograms (Loads, Systems, Plant and Economic). Loads, Systems and Plant are executed in sequence, with the output of Loads becoming the input to Economics. In contrast, EnergyPlus handles loads calculated (by a heat balance engine) and system simulation simultaneously at each time step, calculating heating and cooling system and plant and electrical system balance. This integrated solution provides more accurate space temperature prediction, which is crucial for system and plant sizing, occupant comfort and occupant health calculations. Therefore, Loads calculation in EnergyPlus fully accounts for thermal mass compared to DOE2. DOE2 does not fully capture the effect of the wall thermal mass in the load adjustment module.

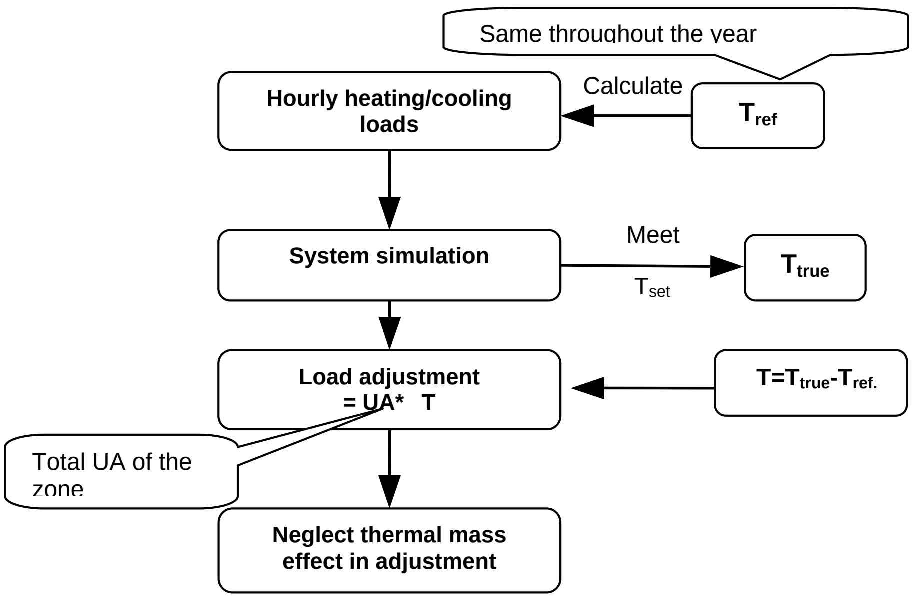

FIGURE 13: DOE-2 LOADS CALCULATION PROCEDURE

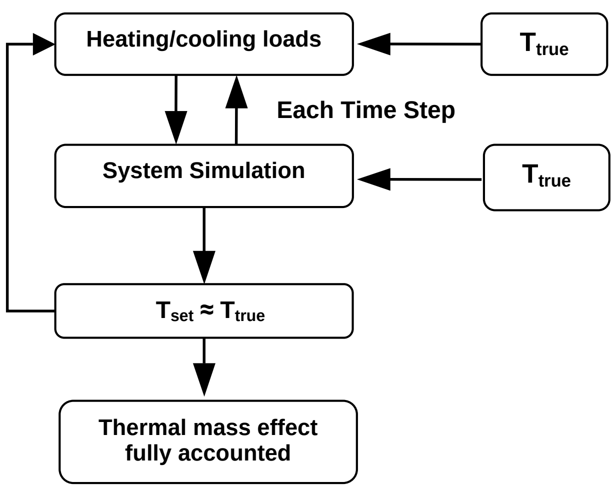

FIGURE 14: ENERGYPLUS LOADS CALCULATION PROCEDURE

Comparison of Simulations with Real Building Data

Three office buildings ("Three Carnegie Plaza", "Three Carnegie Plaza" and "Brier Corporate Center") were selected to compare these simulation tool's results for different DR strategies, pre-cooling, and thermal mass levels. The three simulation tools used the same building inputs for their simulation models.

Pre-cooling Strategy

BEST has three DR strategies that implement zone temperature reset, while eQUEST and DRQAT can run different zone temperature reset strategies. Because of BEST's limitation on the types of zone temperature reset strategies it could model and the fact that this strategy was implemented during the field tests in the buildings modeled, the "Pre-cooling step temp set up" DR strategy was simulated with eQUEST, BEST and DRQAT. Comparing the results between the simulation model and the measured data helped predict which simulation tools could better predict the energy usage and demand shed of real buildings.

Pre-cooling with exponential temperature set up. The zone temperatures were decreased in the morning as was done with the "pre-cooling with exponential temperature set up" strategy. In the afternoon, the zone temperature set points are raised exponentially to maximum of 4 °F.

Table 15 presents the simulation results of different simulation tools under the same pre-cooling strategy. For "Two Parkside" and "Three Carnegie Plaza", the demand sheds that eQUEST and BEST predicted were lower than the actual data by as much as 40%. The relative difference between the simulation results of DRQAT and the actual data was about 10 to 20%. "Brier Corporate Center"'s eQUEST and BEST simulations under-predicted while DRQAT over-predicted the savings.

Table 15: Simulation Results of Demand Shed for DR Strategy (kW)

Test Building	eQUEST		BEST		DRQAT		Actual Data	
	Max	Ave	Max	Ave	Max	Ave	Max	Ave
Two Parkside	42.9	35.6	59.7	43.5	99.4	53.4	119.8	66.0
Three Carnegie Plaza	39.3	32.7	42.1	29.2	80.7	49.0	74.5	55.1
Brier Corporate Center	55.0	42.4	64.0	47.3	125.0	68.0	91.2	56.9

Thermal Mass Level

Both eQUEST and DRQAT provide the capability to adjust building thermal mass, while BEST does not. In eQUEST and BEST, the type and coverage of the furniture can be specified for better calculation of the actual building thermal mass. Therefore, the simulation results of two types of thermal mass level were compared in this report. Figure 19 shows the comparison of different thermal mass level for eQUEST and DRQAT. The results indicated that, with DRQAT, the level of thermal mass affected the simulated demand shed much more than it did with eQUEST. The average demand difference between the "High" and "Medium" was about 10 kW. The demand was raised by as much as 20% when compared with the average demand shed of "Medium" in the thermal mass models.

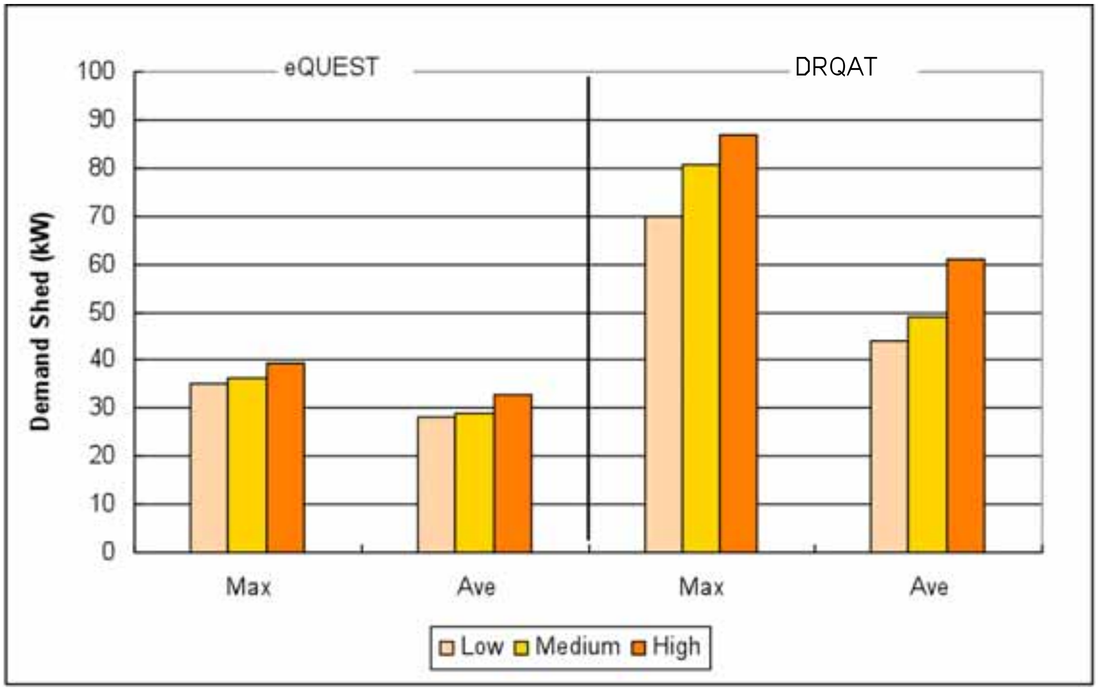

FIGURE 15: SIMULATION RESULTS OF DIFFERENT THERMAL MASS LEVEL FOR eQUEST AND DRQAT

SUMMARY

With simple inputs, friendly interface, powerful calculation core, and flexibility in reporting outputs, DRQAT has many advantages against the two other tools in predicting DR sheds. Comparison of the simulation results to the field test data indicated that the simulation model developed by DRQAT could well match the actual energy usage of buildings in the Tri-City Corporate Center. Other building energy simulation tools such as eQUEST and BEST were able to simulate the effects of demand response strategies and generate some reasonable results as well. However, when the simulation results were compared to the measured data, the predicted demand reductions by eQUEST and BEST were lower than that for the measured data. This is because DOE2 does not handle thermal mass in walls properly in the load adjusting module. DRQAT seems to be more accurate than the other two tools in estimating demand reductions due to demand response strategies.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This project studied how to optimize pre-cooling strategies for the buildings in the Tri-City Corporate Center, San Bernardino, California, with the assistance of Demand Response Quick Assessment Tool (DRQAT) - a building energy simulation tool.

Eleven DRQAT models were built for the buildings in the Tri-City Corporation Center. The simulation results from calibrated simulation models matched well with the measured monthly, daily and hourly data. Using the calibrated simulation models, a series of simulations were conducted to determine the optimal pre-cooling strategies for the eleven buildings. The “Pre-cooling with step temp set up” and “Pre-cooling with exponential temp set up” strategies turned out to be the optimal strategies. The ”Pre-cooling with step temp set up” was used in the field tests as it was easier to implement and had a flatter load shape at the beginning of the peak demand period.

The resulting simulation-based DR optimization is summarized into a procedure to develop and calibrate DRQAT building models with the following steps:

- Generate a DRQAT initial simulation model with basic building information.
- Replace TMY weather file in DRQAT and regenerate a .epw EnergyPlus file with real weather data collected from the site or nearby weather stations.
- Use whole building power under extreme cold weather conditions to estimate the actual internal load schedules. The method will not work if electricity or heat pumps were used as heating sources.
- Run simulations and compare the simulated results with the measure data.
- Readjust the internal load schedule until the simulated daily and monthly demand data match with the measured data.

The field test results indicated that the pre-cooling strategies were able to reduce the peak demand as expected on CPP event days. The demand reductions for each building were different and pre-cooling strategies to each building should be matched based on demand reductions.

If a building owner decides not to sign up for the CPP program, but wants to use the pre-cooling strategies to reduce their monthly demand charge, the buildings should operate the pre-cooling strategies on days when the weather forecast predicts outside air temperature above 90^{o}F. From the thermal comfort point of view, it will be better to operate the pre-cooling strategies throughout summer periods because the occupants can predict the temperature variation in advance and dress accordingly.

The demand shed predicted by DRQAT matched well with the measured data on CPP event days. The study showed that after refining and calibrating the initial simulation models with measured data, the accuracy of the models are greatly improved and the models can be used to predict load reductions in these buildings on DR event days within ±10% of accuracy.

The simulation results of eQUEST, BEST, the two simulation tools built on different versions of DOE2, indicate that these tools did not work as well as the DRQAT in predicting demand reduction. The predicted demand sheds from these two tools seemed to be lower than the actual data. DRQAT can better simulate the DR effects because both eQUEST and BEST underestimate the effect of thermal mass of walls.

RECOMMENDATIONS

Although the carefully calibrated baseline model can match the measured interval meter data within the requirements of the ASHRAE Guide, we believe the efforts in the following areas can further improve the accuracy of the simulations and usefulness of the DRQAT tool.

- **Real weather data**. The real weather file that we use to calibrate the simulation model may be different than the actual weather data for the building. An outside air sensor or weather station should be installed in the building to measure the outside air temperature on site. This measured data can be converted into a weather file and used in the DRQAT simulation. This will greatly improve the accuracy of the model prediction.
- **Sub-metered HVAC and whole building power**. It was hard to estimate the internal loads without sub-metering. The winter data can be used to estimate the internal load schedules in summer. However, the internal load estimate could be improved by sub-metering key HVAC equipment. Direct measurement or short term spot measurements could provide strong evidence in backing up the models and predicting savings.
- **Determine internal mass level.** It is difficult to estimate the mass level in different buildings. The default value in DRQAT was inherited from EnergyPlus prototypical models and those values may not be representative of real buildings in California.
- **Adding utility baselines to the DRQAT.** Utilities use different baseline methodologies for their various DR programs. A simulated baseline day was used in the simulation analysis which, except for the zone temperature setpoints for the pre-cooling strategies, have the same operating conditions as the DR event day. In estimating the DR savings from the field, baselines with similar outdoor temperature profiles were used. However, in reality, no baseline day exists with same weather condition, internal loads and other electrical usage for an actual DR event day. Adding specific utility baselines to DRQAT will improve usability and predicting economic savings.
- **Refining accuracy requirements for DR simulations.** While the calibration met the requirement in the ASHRAE standard, within ±20% for a minimum of 20 hours out of 24 hours for each day, this standard was established for energy simulations. DR reductions are usually within 10% to 15% of the peak load and may be within the error margin between the simulated and measured data. Accuracy requirements for DR simulations have to be developed.

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APPENDIX A - BUILDING AUDITS

An audit template was developed to collect the input information for DRQAT. The audit information includes general building description, building internal load and HVAC system.

TWO CARNEGIE PLAZA

TABLE A 1: BUILDING AUDIT-TWO CARNEGIE PLAZA

GENERAL INFORMATION	
Building name	Two Carnegie Plaza
Total square footage	68,955
Numbers of floors	2
Location	685 Carnegie Drive, San Bernardino, CA 92408
Year constructed	1990
Function	Office 60~70%
BUILDING ENVELOPE	
Construction Material	Masonry
Windows	Single-pane, low-e
Window to wall ratio	50% on all sides
INTERNAL MASS	
Uncarpeted slab	2%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 4 units, 2*50 TOU, 2*55 TOU
Air Handing Unit Fan Control	Variable speed drive

ONE CARNEGIE PLAZA

TABLE A 2: BUILDING AUDIT-ONE CARNEGIE PLAZA

GENERAL INFORMATION	
Building name	One Carnegie Plaza
Total square footage	62,800
Numbers of floors	2
Location	625 Carnegie Drive, San Bernardino, CA 92408
Year constructed	1988
Function	Office 100%
BUILDING ENVELOPE	
Construction Material	Masonry
Windows	Single-pane, low-e
Window to wall ratio	50% on all sides
INTERNAL MASS	
Uncarpeted slab	2%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 4 units, 2*50 TOU, 2*55 TOU
Air Handing Unit Fan Control	Variable speed drive

ONE CARNEGIE PLAZA (SMALLER BUILDING)

TABLE A 3: BUILDING AUDIT-ONE CARNEGIE PLAZA (SMALLER BUILDING)

GENERAL INFORMATION	
Building name	One Carnegie Plaza (smaller building)
Total square footage	38,808
Numbers of floors	2
Location	621 Carnegie Drive, San Bernardino, CA 92408
Year constructed	1988
Function	Office 100%
BUILDING ENVELOPE	
Construction Material	Masonry
Windows	Single-pane, low-e
Window to wall ratio	50% on all sides
INTERNAL MASS	
Uncarpeted slab	2%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 2 units, 1*50 TOU, 1*60 TOU
Air Handing Unit Fan Control	Variable speed drive

ONE VANDERBILT

TABLE A 4: BUILDING AUDIT-ONE VANDERBILT

GENERAL INFORMATION	
Building name	One Vanderbilt
Total square footage	73,730
Numbers of floors	3
Location	301 E. Vanderbilt Way, San Bernardino, CA 92408
Year constructed	1988
Function	Office 55%, bank 50%
BUILDING ENVELOPE	
Construction Material	Curtain wall
Windows	Single-pane, low-e
Window to wall ratio	25% on all sides
INTERNAL MASS	
Uncarpeted slab	2%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 4 units, 3*55 TOU, 1*60 TOU
Air Handing Unit Fan Control	Variable speed drive

ONE PARKSIDE

TABLE A 5: BUILDING AUDIT-ONE PARKSIDE

GENERAL INFORMATION	
Building name	One Parkside
Total square footage	70,069
Numbers of floors	4
Location	560 E. Hospitality Lane, San Bernardino, CA 92408
Year constructed	1993
Function	Office 100%
BUILDING ENVELOPE	
Construction Material	Curtain wall
Windows	Single-pane, low-e
Window to wall ratio	60% on all sides
INTERNAL MASS	
Uncarpeted slab	2%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 4 units, 4*55 TOU
Air Handing Unit Fan Control	Variable speed drive

LAKESIDE TOWER

TABLE A 6: BUILDING AUDIT-LAKESIDE TOWER

GENERAL INFORMATION	
Building name	Lakeside Tower
Total square footage	112,717
Numbers of floors	6
Location	650 E. Hospitality Lane, San Bernardino, CA 92408
Year constructed	1990
Function	Office 100%
BUILDING ENVELOPE	
Construction Material	Frame
Windows	Single-pane, low-e
Window to wall ratio	60% on all sides
INTERNAL MASS	
Uncarpeted slab	2%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Central chiller, 2*175 reciprocating chiller
Air Handing Unit Fan Control	Variable speed drive

TWO PARKSIDE

TABLE A 7: BUILDING AUDIT-TWO PARKSIDE

GENERAL INFORMATION	
Building name	Two Parkside
Total square footage	80,750
Numbers of floors	3
Location	550 E. Hospitality Lane, San Bernardino, CA 92408
Year constructed	2001
Function	Office 90%, classroom 10%
BUILDING ENVELOPE	
Construction Material	Frame
Windows	Single-pane, low-e
Window to wall ratio	40% on all sides
INTERNAL MASS	
Uncarpeted slab	2%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 2 units, 2*90 TOU
Air Handing Unit Fan Control	Variable speed drive

THREE CARNEGIE PLAZA

TABLE A 8:	BUILDING AUDIT-THREE CARNEGIE PLAZA
GENERAL INFORMATION	
Building name	Three Carnegie Plaza
Total square footage	83,698
Numbers of floors	2
Location	735 Carnegie Drive, San Bernardino, CA 92408
Year constructed	2003
Function	Office 100%
BUILDING ENVELOPE	
Construction Material	masonry
Windows	Single-pane, low-e
Window to wall ratio	40% on all sides
INTERNAL MASS	
Uncarpeted slab	25%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 2 units, 2*50 TOU
Air Handing Unit Fan Control	Variable speed drive

Brier Corporate Center

Table A 9: Building Audit-Brier Corporate Center

General Information

Building name	Brier Corporate Center
Total square footage	104,501
Numbers of floors	3
Location	862 E. Hospitality Lane, San Bernardino, CA 92408
Year constructed	2005
Function	Office, conference rooms, data center

Building Envelope

Construction Material	Frame
Windows	Single-pane, low-e
Window to wall ratio	40% on all sides

Internal Mass

Uncarpeted slab	50%
Slab thickness (inch)	4

Internal Load

Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office

Schedule

Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm

HVAC System

Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 3 units, 1*80 TOU, 2*75 TOU
Air Handing Unit Fan Control	Variable speed drive

VANDERBILT PLAZA

TABLE A 10: BUILDING AUDIT-VANDERBILT PLAZA

GENERAL INFORMATION	
Building name	Vanderbilt Plaza
Total square footage	119,305
Numbers of floors	4
Location	451 E. Vanderbilt Way, San Bernardino, CA 92408
Year constructed	2002
Function	Office 75%, classroom 25%
BUILDING ENVELOPE	
Construction Material	Frame
Windows	Single-pane, low-e
Window to wall ratio	40% on all sides
INTERNAL MASS	
Uncarpeted slab	20%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 4 units, 2*50 TOU, 2*55 TOU
Air Handing Unit Fan Control	Variable speed drive

INLAND REGIONAL CENTER

TABLE A 11: BUILDING AUDIT-INLAND REGIONAL CENTER

GENERAL INFORMATION	
Building name	Inland Regional Center
Total square footage	81,079
Numbers of floors	2
Location	674 E. Brier Drive, San Bernardino, CA 92408
Year constructed	1994
Function	Office 75%, auditorium 25%
BUILDING ENVELOPE	
Construction Material	Masonry
Windows	Single-pane, low-e
Window to wall ratio	30% on all sides
INTERNAL MASS	
Uncarpeted slab	2%
Slab thickness (inch)	4
INTERNAL LOAD	
Occupant	Unavailable, Regular office
Lighting	Unavailable, Regular office
Equipment	Unavailable, Regular office
SCHEDULE	
Occupant schedule	Unavailable
HVAC operating schedule	5 am – 6 pm
HVAC SYSTEM	
Air Distribution Type	Variable air volume
Zone temperature set points	77 (Cooling)
Cooling Plant	Packaged DX, 4 units, 2*105 TOU, 2*90 TOU
Air Handing Unit Fan Control	Variable speed drive

APPENDIX B - BUILDING INTERNAL LOADS AND SCHEDULES

TABLE B 1: BUILDING INTERNAL LOADS – CALIBRATED BASELINE MODEL

	BUILDING INTERNAL LOAD			
SITE NAME	YEAR CONSTRUCTED	LIGHTING DENSITY (W / SQ FT)	PLUG DENSITY (W / SQ FT)	OCCUPANCY (SQ FT / PER PERSON)
Two Carnegie Plaza	1990	1.60	**0.75**	390
One Carnegie Plaza	1988	1.60	**1.50**	390
One Carnegie Plaza	1988	1.60	**1.50**	390
One Vanderbilt	1988	1.60	**1.80**	390
One Parkside	1993	1.60	**1.40**	390
Lakeside Tower	1990	1.60	**0.90**	390
Two Parkside	2001	1.20	**1.50**	390
Three Carnegie Plaza	2003	1.20	**0.60**	390
Brier Corporate Center	2005	1.10	**1.40**	390
Vanderbilt Plaza	2002	1.20	**1.00**	390
Inland Regional Center	1994	1.60	**1.00**	390

LIGHTING AND PLUG SCHEDULES

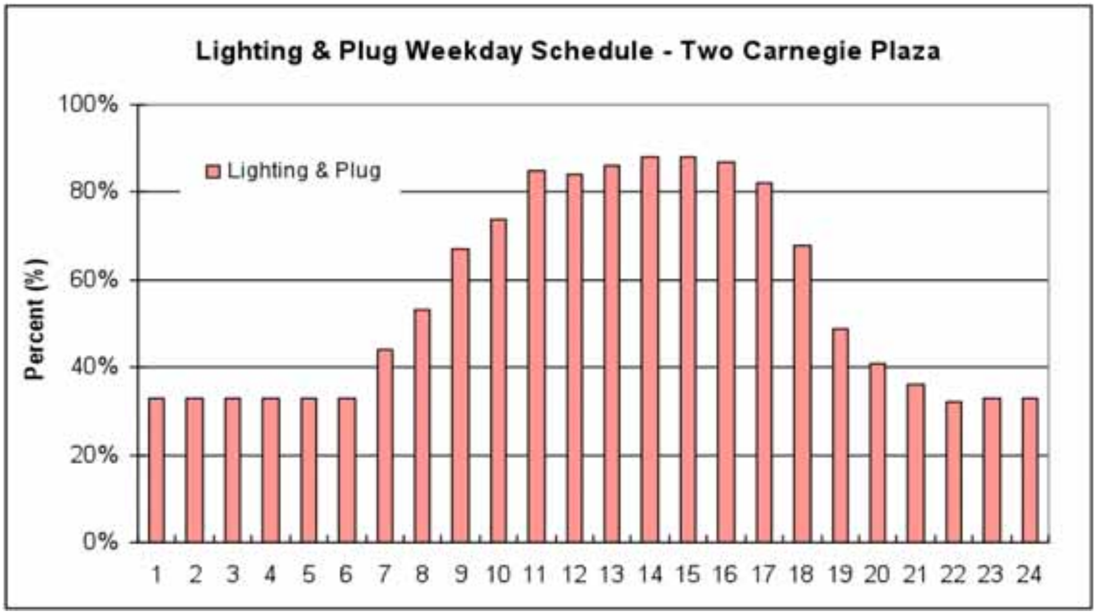

FIGURE B 1: LIGHTING AND PLUG SCHEDULES – TWO CARNEGIE PLAZA

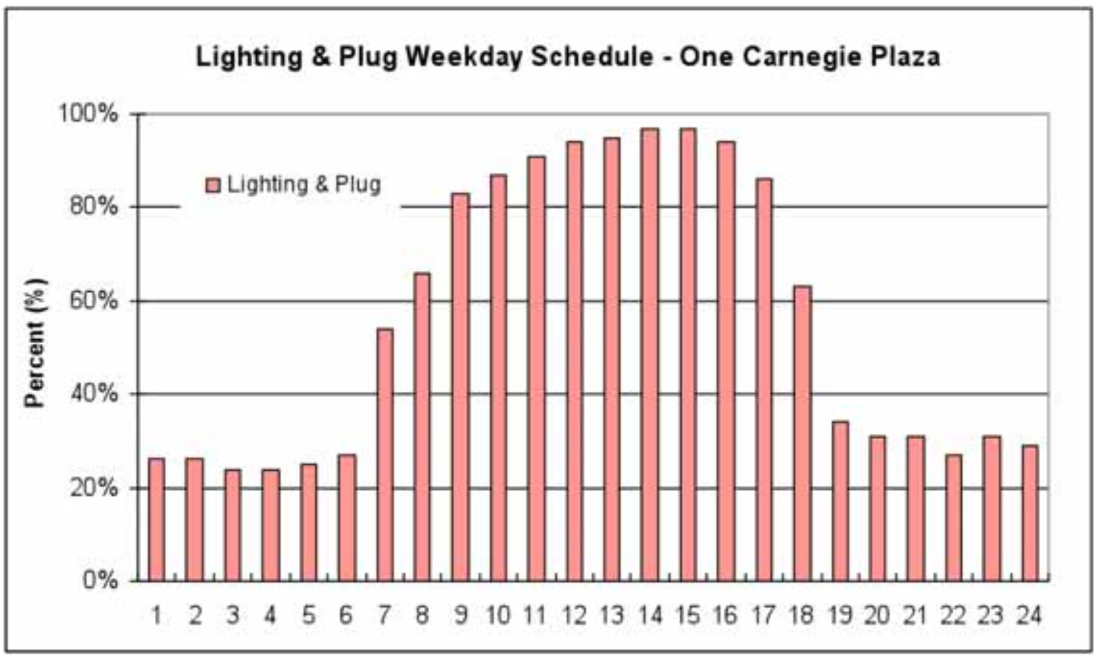

FIGURE B 2: LIGHTING AND PLUG SCHEDULES – ONE CARNEGIE PLAZA

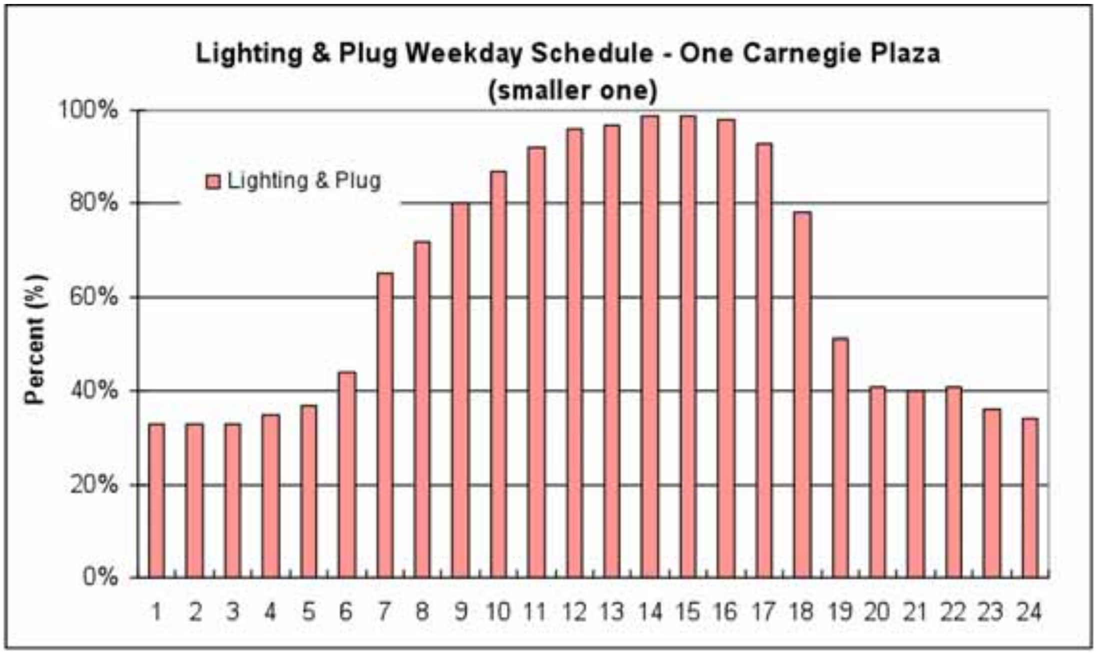

FIGURE B 3: LIGHTING AND PLUG SCHEDULES – ONE CARNEGIE PLAZA (SMALLER BUILDING)

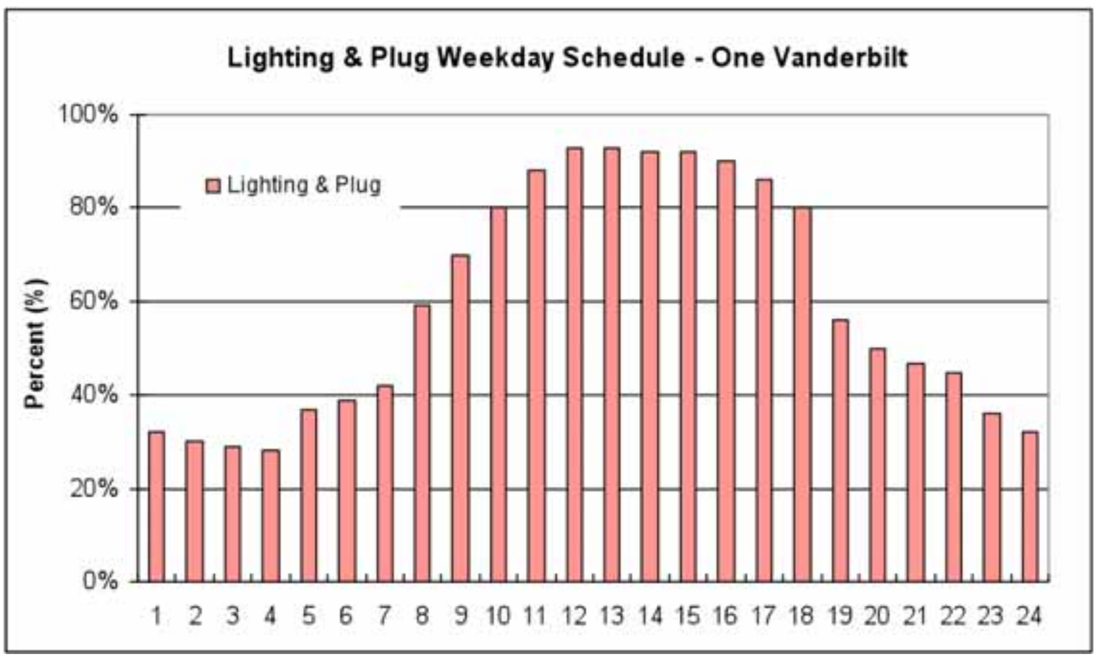

FIGURE B 4: LIGHTING AND PLUG SCHEDULES – ONE VANDERBILT

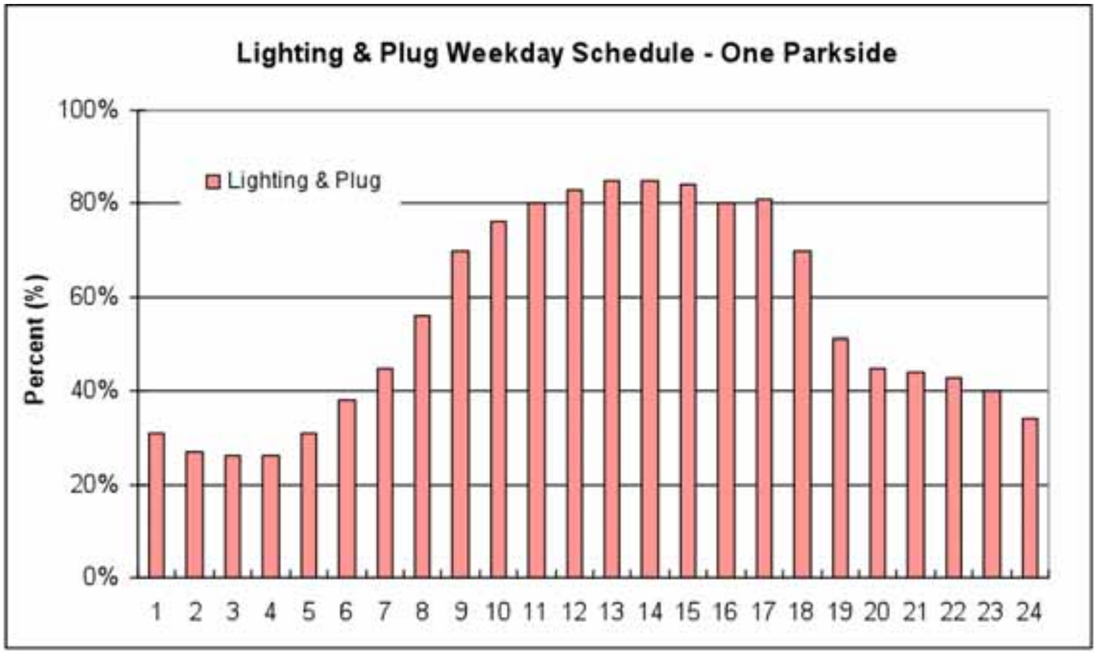

FIGURE B 5: LIGHTING AND PLUG SCHEDULES – ONE PARKSIDE

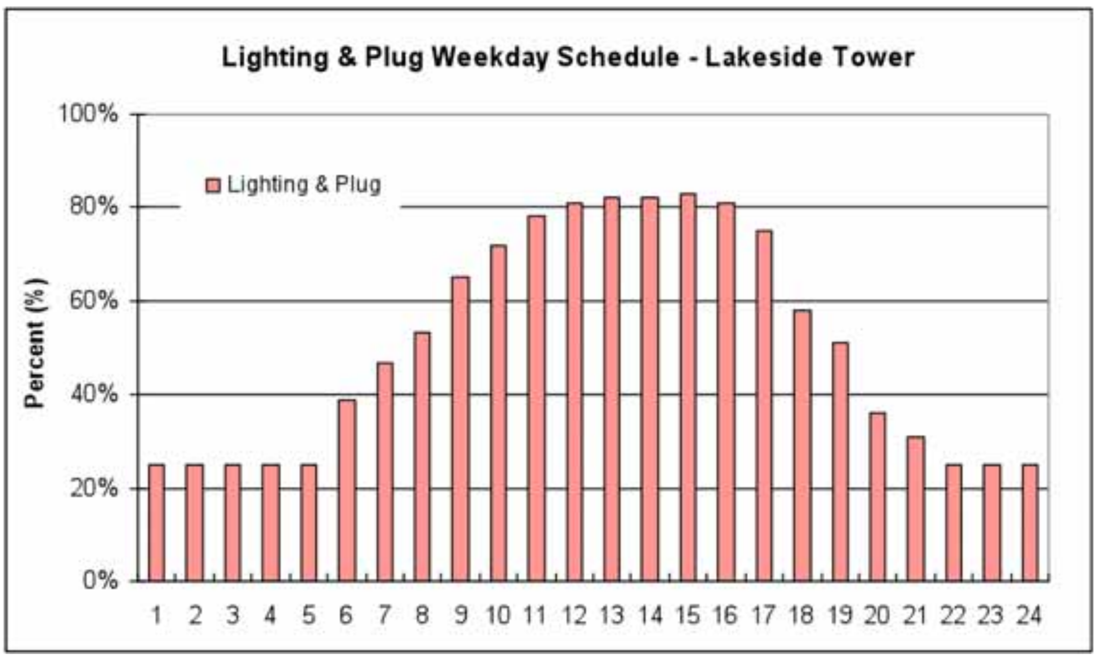

FIGURE B 6: LIGHTING AND PLUG SCHEDULES – LAKESIDE TOWER

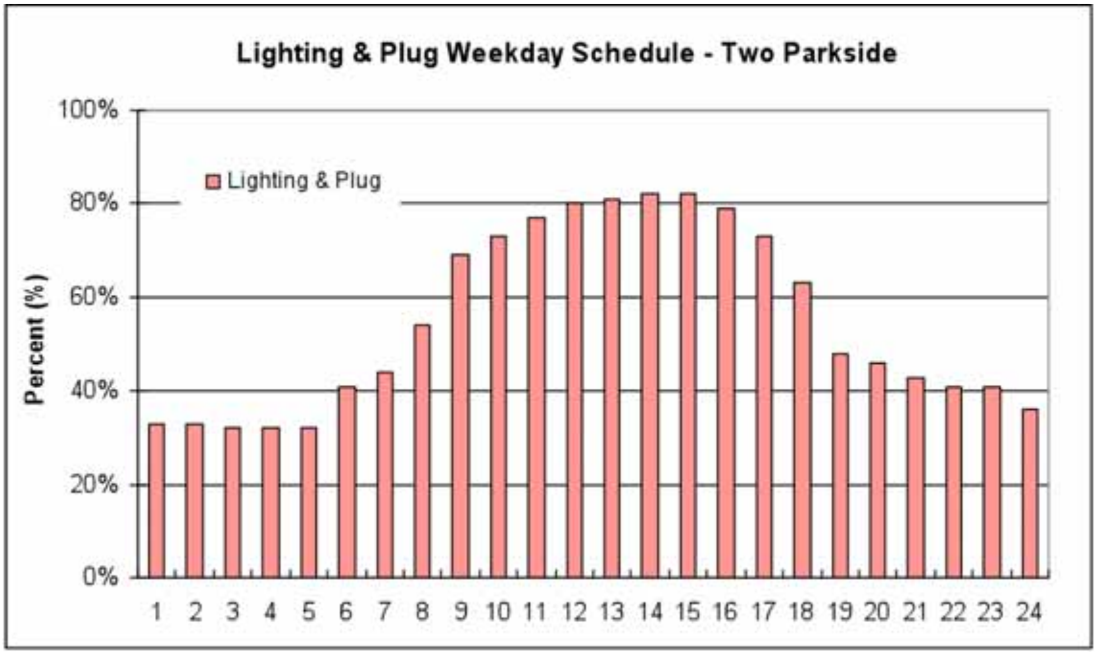

FIGURE B 7: LIGHTING AND PLUG SCHEDULES – TWO PARKSIDE

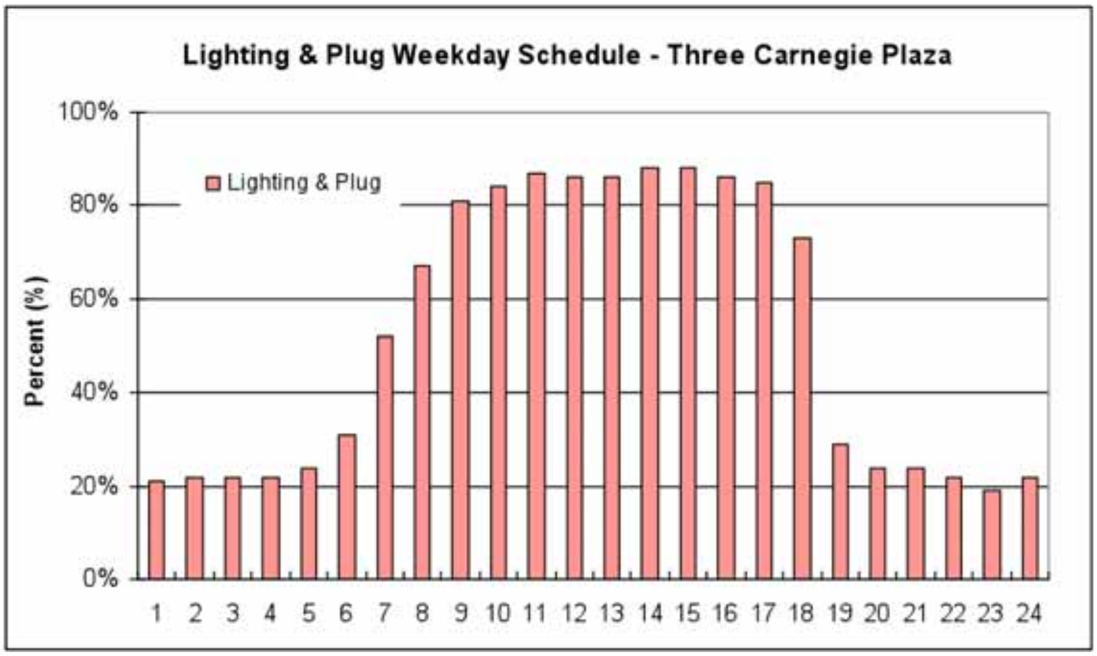

FIGURE B 8: LIGHTING AND PLUG SCHEDULES – THREE CARNEGIE PLAZA

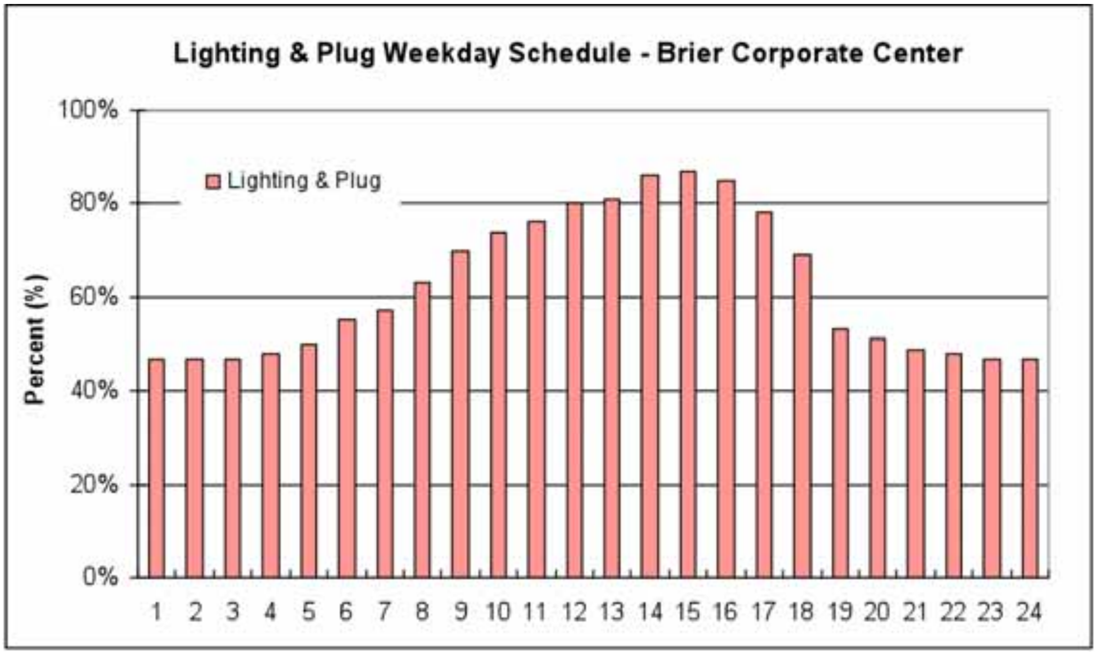

FIGURE B 9: LIGHTING AND PLUG SCHEDULES – BRIER CORPORATE CENTER

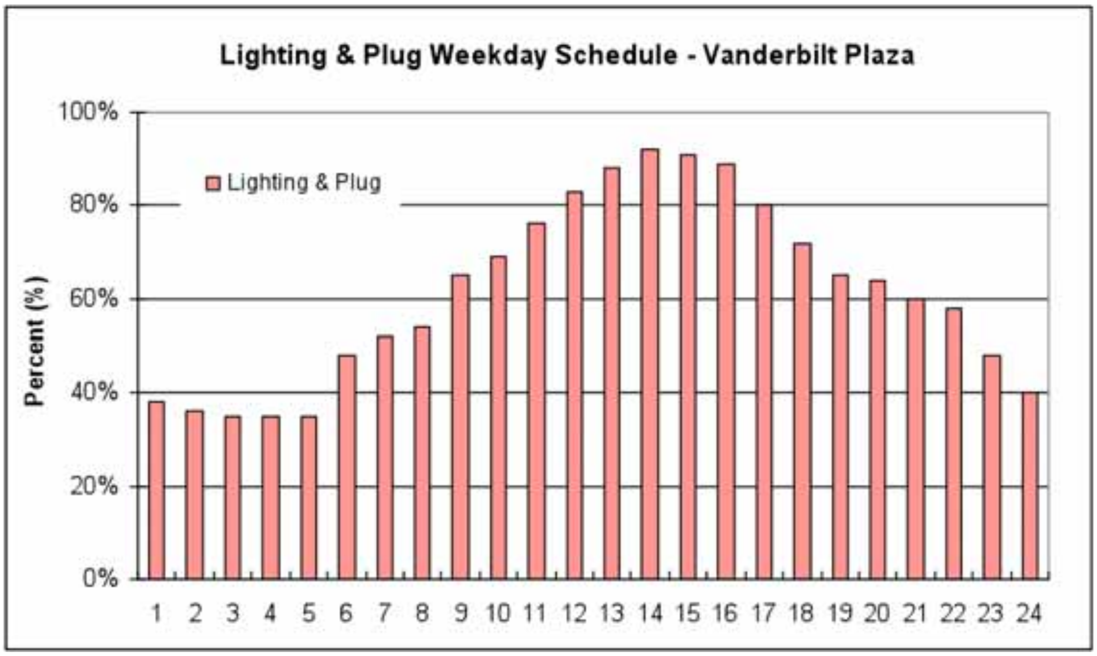

FIGURE B 10: LIGHTING AND PLUG SCHEDULES – VANDERBILT PLAZA

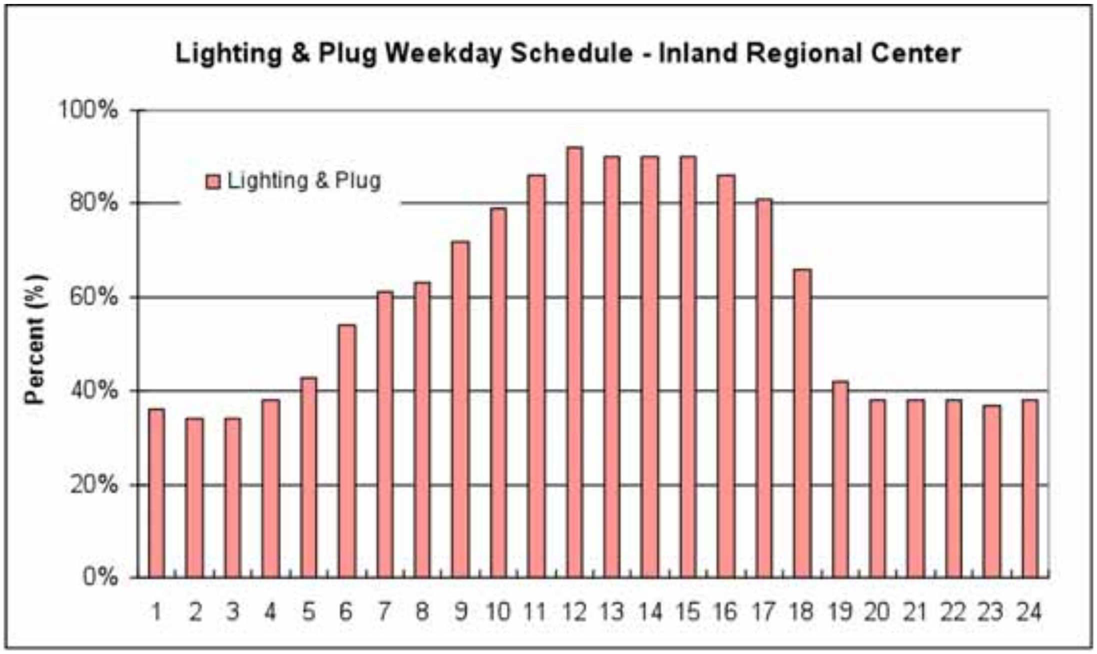

FIGURE B 11: LIGHTING AND PLUG SCHEDULES – INLAND REGIONAL CENTER

APPENDIX C – CALIBRATION RESULTS

MONTHLY CALIBRATION RESULTS

TABLE C 1: COMPARISON BETWEEN CALIBRATED SIMULATION RESULTS AND ACTUAL DATA IN SUMMER 2007

SITE NAME	INDEX	MONTH (KWH)				AVERAGE (KWH)
		6	7	8	9	
Two Carnegie Plaza	Measured	80,257	90,791	94,380	72,318	337,746
	Simulation	80,981	95,495	95,472	72,618	344,566
	Difference	724	4,704	1,092	300	6,820
		1 %	**5 %**	**1 %**	**0 %**	**2 %**
One Carnegie Plaza	Measured	86,551	108,140	110,590	86,803	392,084
	Simulation	91,053	105,713	105,737	82,250	384,753
	Difference	4,502	-2,427	-4,853	-4,553	-7,331
		5 %	**-2 %**	**-4 %**	**-5 %**	**-2 %**
One Carnegie Plaza	Measured	61,972	75,944	82,813	60,954	281,682
	Simulation	65,157	75,965	75,447	58,440	275,009
	Difference	3,185	21	-7,366	-2,514	-6,674
		5 %	**0 %**	**-9 %**	**-4 %**	**-2 %**
One Vanderbilt	Measured	146,649	165,824	178,890	140,342	631,705
	Simulation	148,845	169,345	168,898	135,664	622,752
	Difference	2,196	3,520	-9,993	-4,677	-8,954
		1 %	**2 %**	**-6 %**	**-3 %**	**-1 %**
One Parkside	Measured	100,114	115,745	121,942	94,950	432,751
	Simulation	104,489	122,594	123,318	96,093	446,493
	Difference	4,375	6,849	1,376	1,143	13,742
		4 %	**6 %**	**1 %**	**1 %**	**3 %**
Lakeside Tower	Measured	141,811	168,731	179,926	140,137	630,606
	Simulation	149,166	170,884	174,826	141,030	635,906
	Difference	7,354	2,153	-5,100	893	5,301
		5 %	**1 %**	**-3 %**	**1 %**	**1 %**
Two Parkside	Measured	103,487	117,825	124,713	98,815	444,840
	Simulation	103,362	120,951	122,953	94,977	442,242
	Difference	-125	3,126	-1,760	-3,838	-2,598
		0 %	**3 %**	**-1 %**	**-4 %**	**-1 %**
Three Carnegie Plaza	Measured	67,019	80,051	86,552	67,728	301,350
	Simulation	69,931	84,550	84,571	61,304	300,356
	Difference	2,912	4,499	-1,981	-6,424	-994

		4%	**6%**	**-2%**	**-9%**	**0%**
Brier Corporate Center	Measured	159,325	178,754	187,255	164,857	690,191
	Simulation	161,828	186,986	187,524	148,086	684,424
	Difference	2,503	8,232	269	-16,771	-5,767
		2%	**5%**	**0%**	**-10%**	**-1%**
Vanderbilt Plaza	Measured	127,048	152,719	165,028	125,764	570,559
	Simulation	136,118	159,638	161,984	124,334	582,074
	Difference	9,070	6,919	-3,044	-1,430	11,515
		7%	**5%**	**-2%**	**-1%**	**2%**
Inland Regional Center	Measured	95,139	109,179	115,479	89,562	409,359
	Simulation	99,944	115,992	116,928	90,549	423,413
	Difference	4,805	6,813	1,449	987	14,054
		5%	**6%**	**1%**	**1%**	**3%**

WEEKLY AND DAILY CALIBRATION RESULTS

TWO CARNEGIE PLAZA

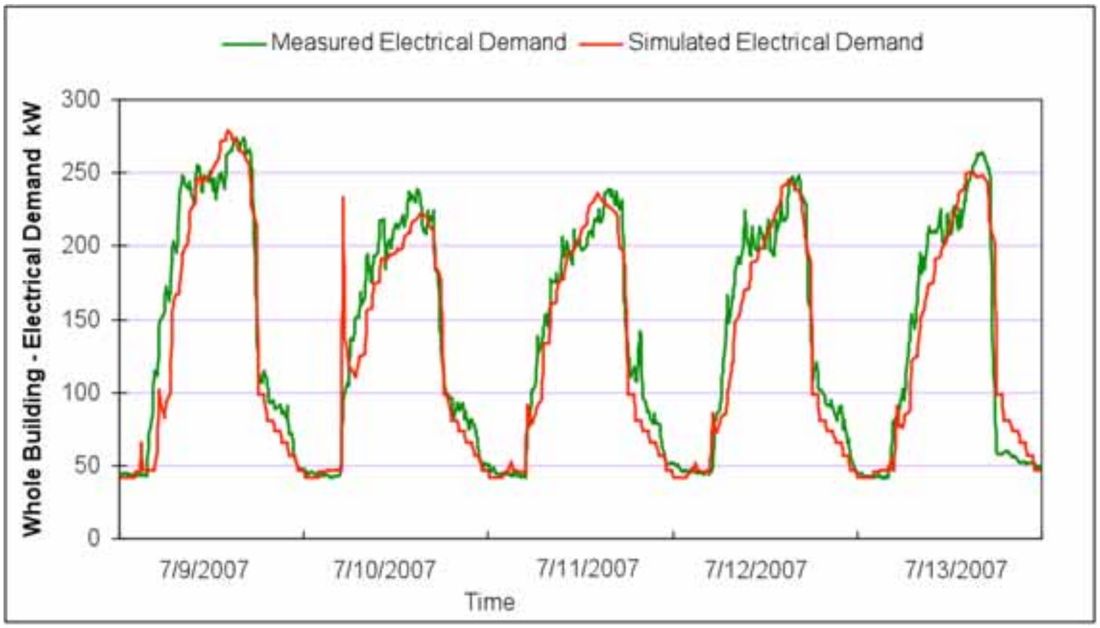

FIGURE C 1: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO CARNEGIE PLAZA

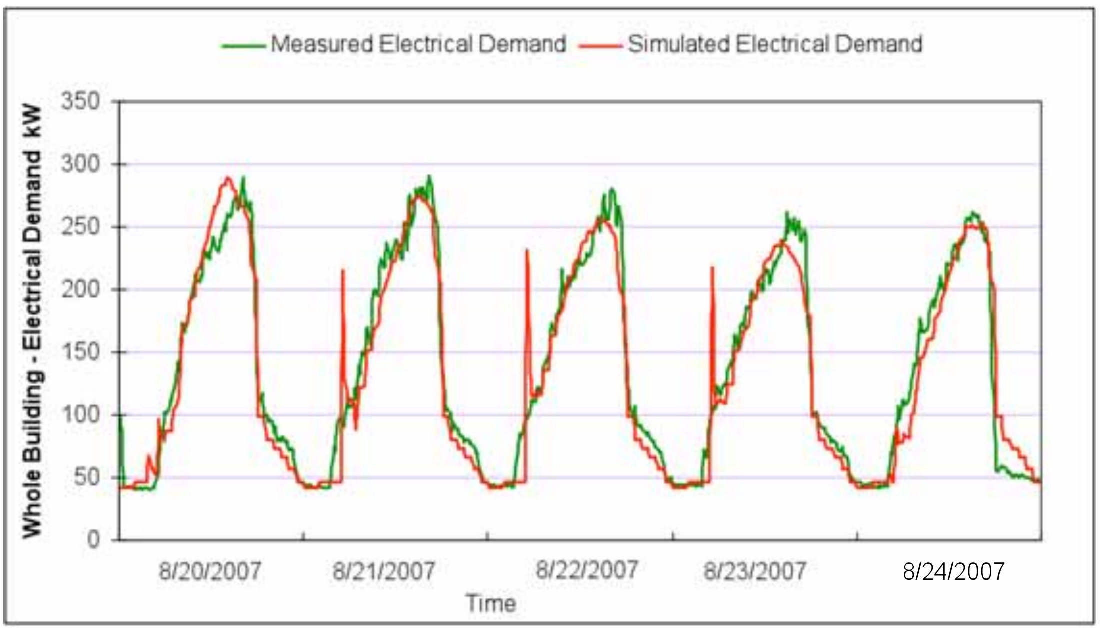

FIGURE C 2: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN AUGUST – TWO CARNEGIE PLAZA

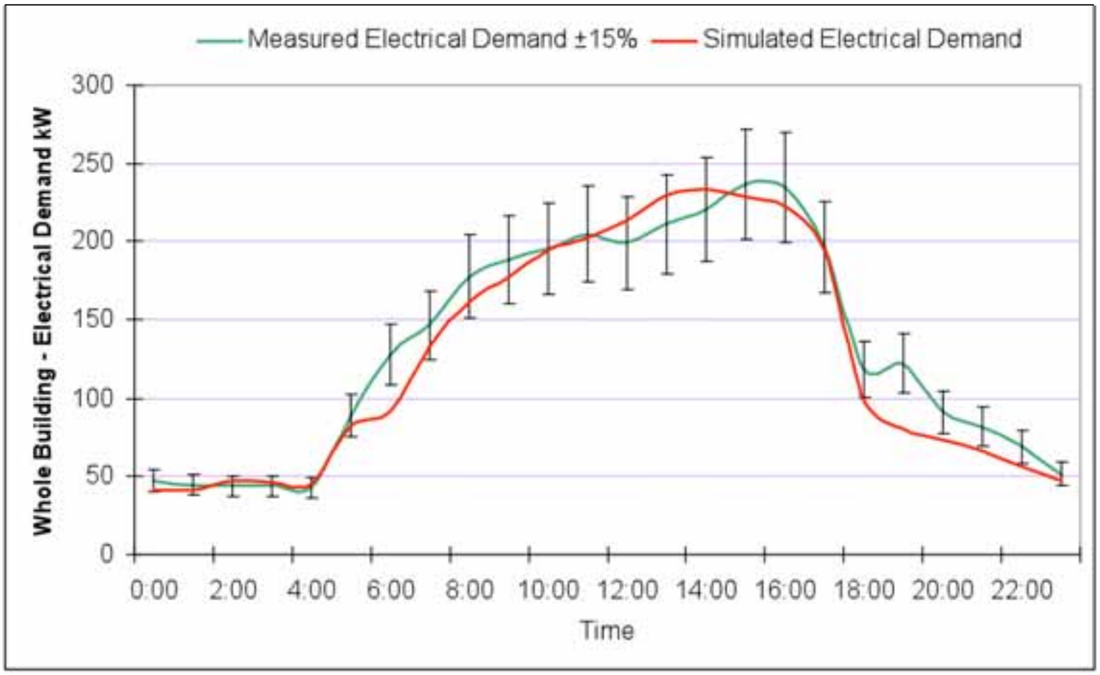

FIGURE C 3: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO CARNEGIE PLAZA

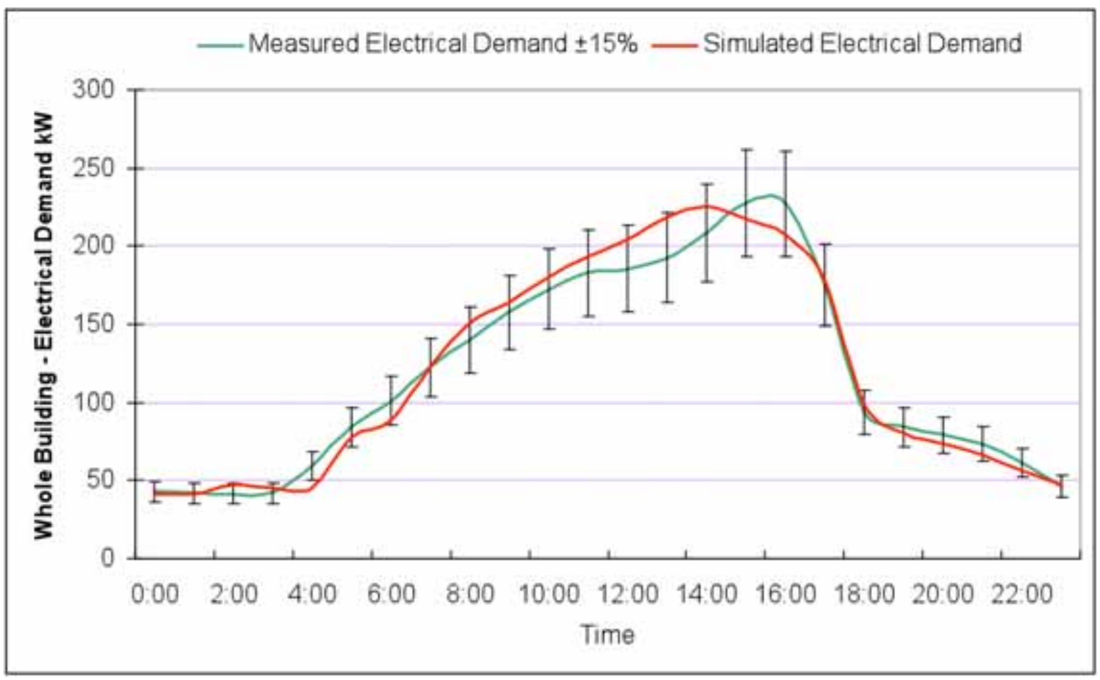

FIGURE C 4: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO CARNEGIE PLAZA

ONE CARNEGIE PLAZA

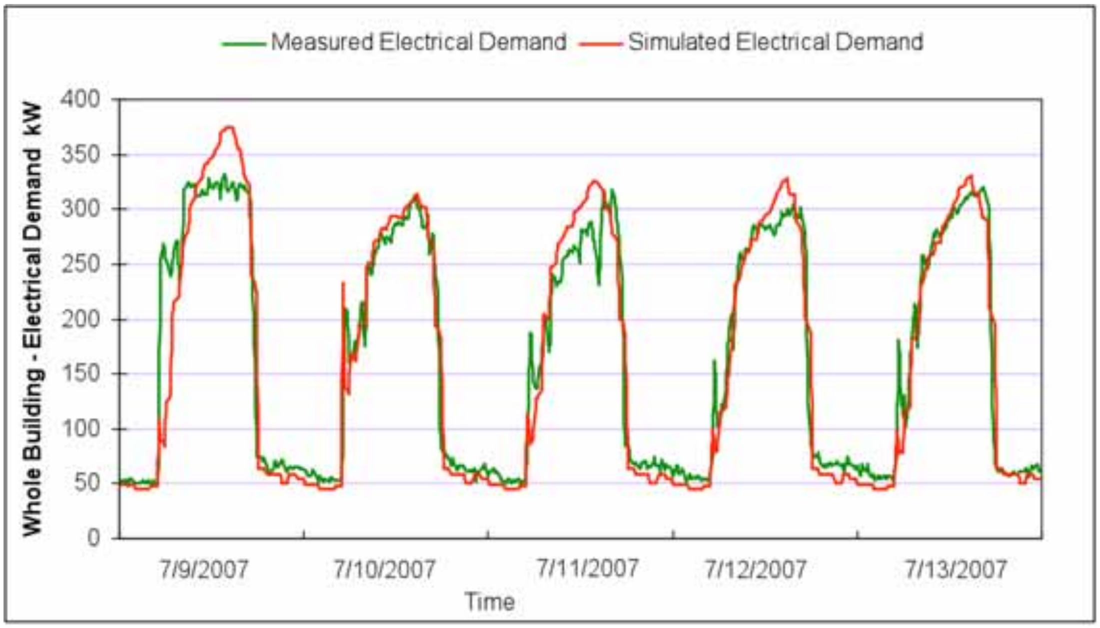

FIGURE C 5: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – ONE CARNEGIE PLAZA

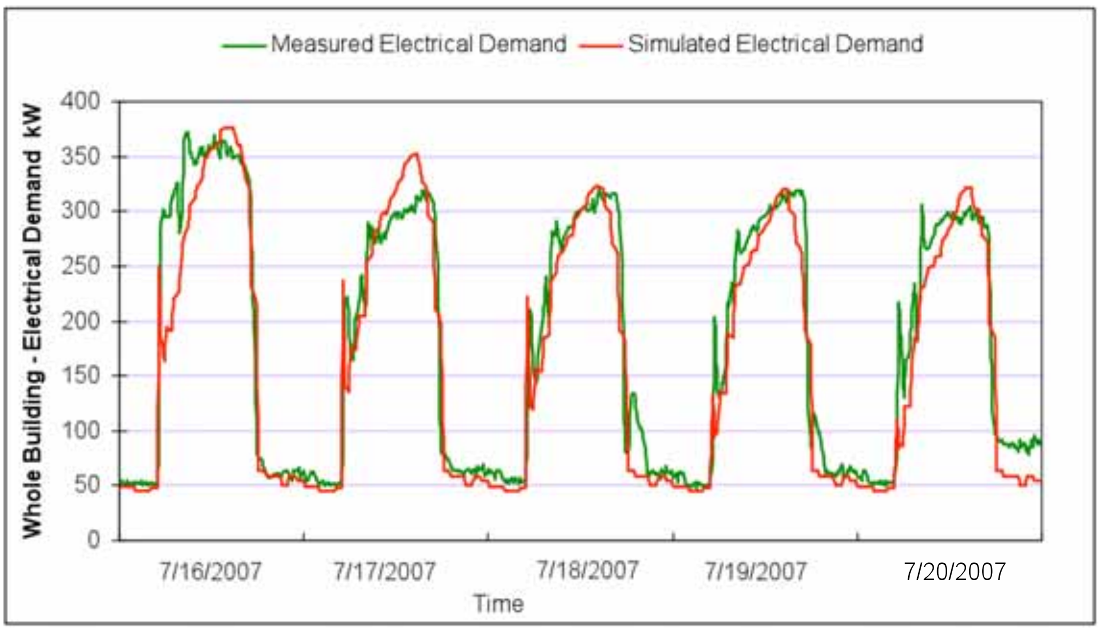

FIGURE C 6: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – ONE CARNEGIE PLAZA

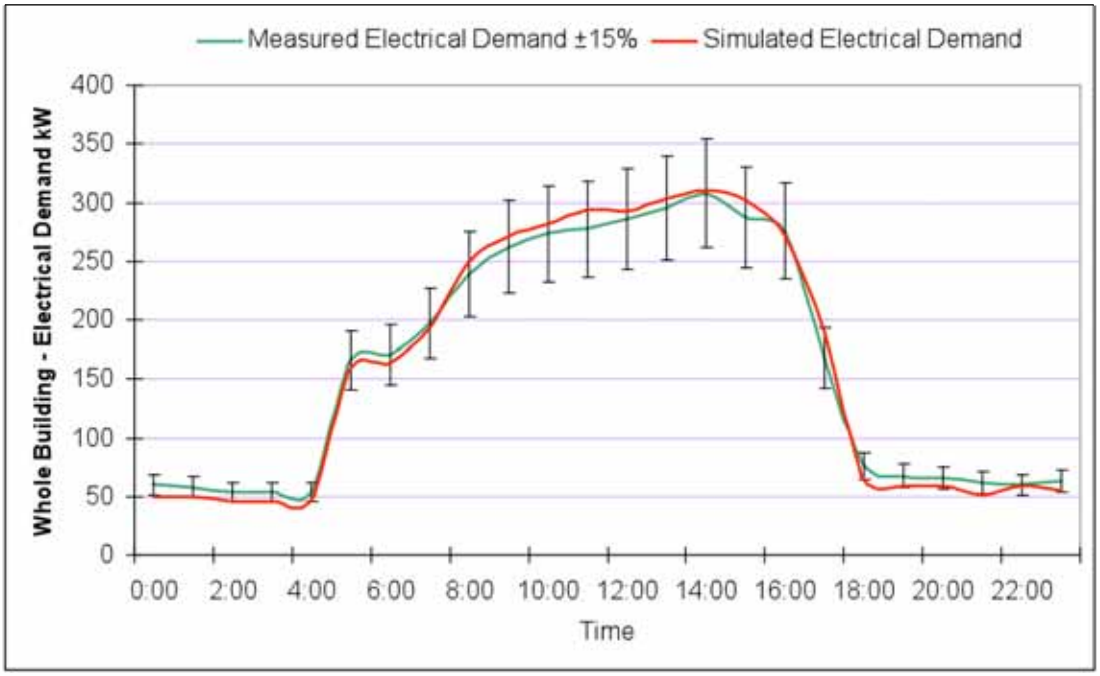

FIGURE C 7: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – ONE CARNEGIE PLAZA

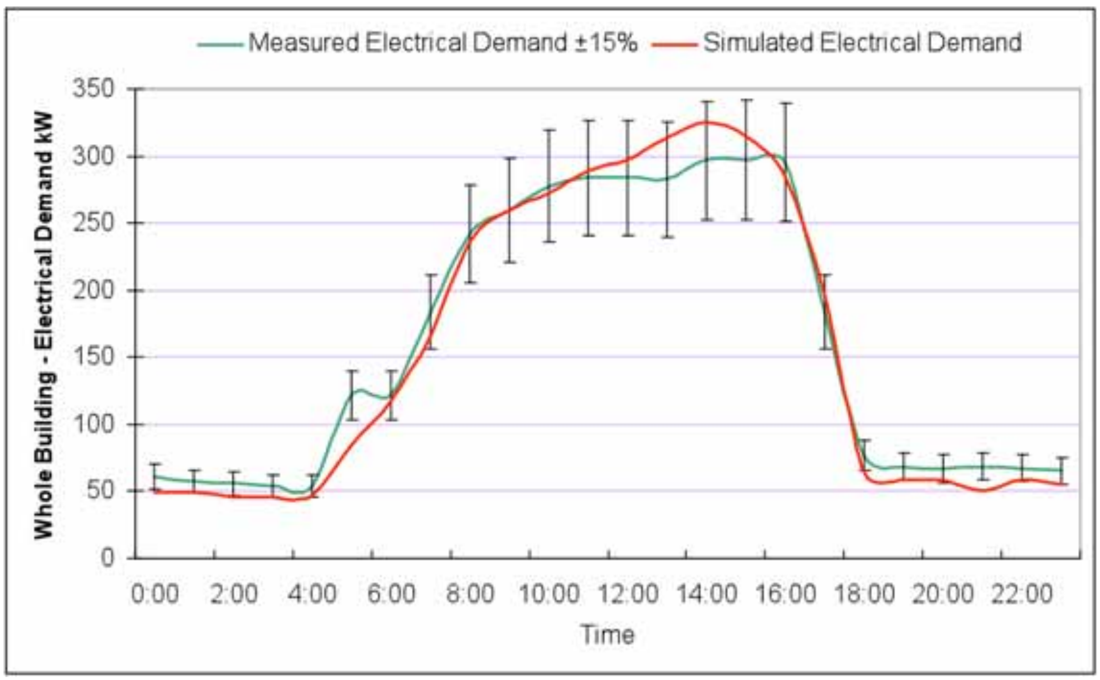

FIGURE C 8: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – ONE CARNEGIE PLAZA

One Carnegie Plaza (smaller building)

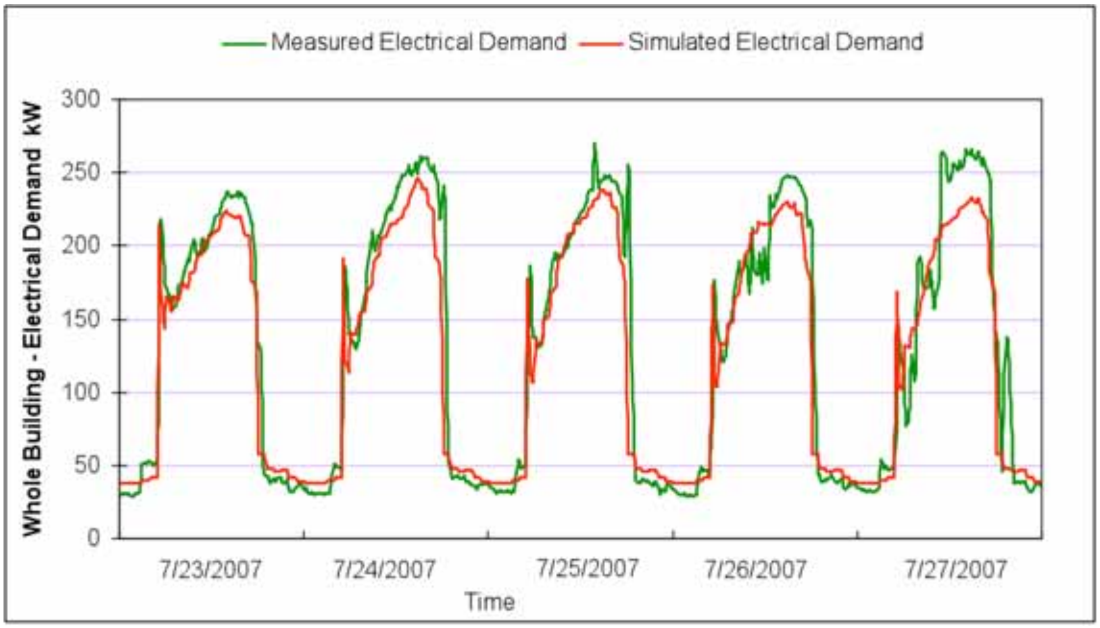

Figure C 9: Daily Electrical Consumption of Simulation Model vs. Actual Electrical Consumption in July – One Carnegie Plaza (smaller building)

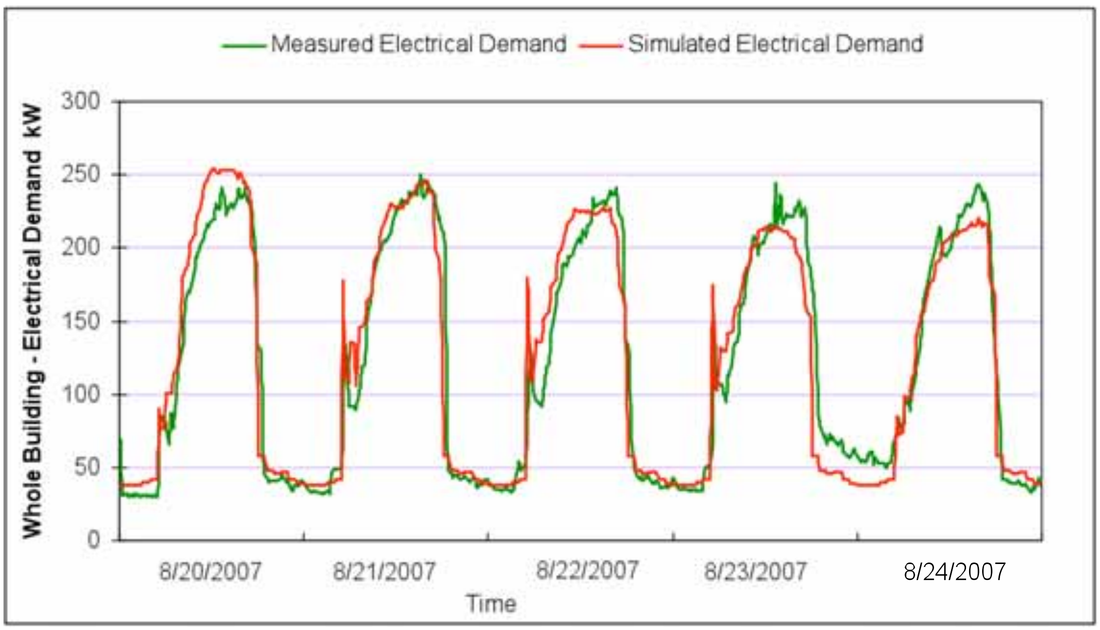

Figure C 10: Daily Electrical Consumption of Simulation Model vs. Actual Electrical Consumption in July – One Carnegie Plaza (smaller building)

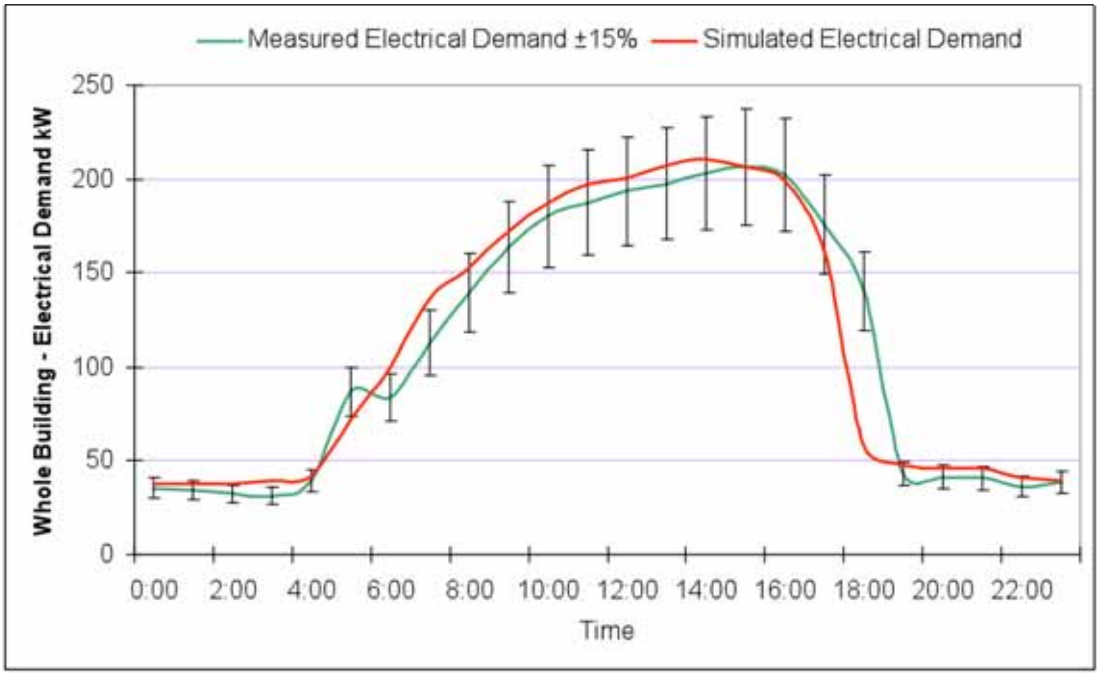

FIGURE C 11: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – ONE CARNEGIE PLAZA (SMALLER BUILDING)

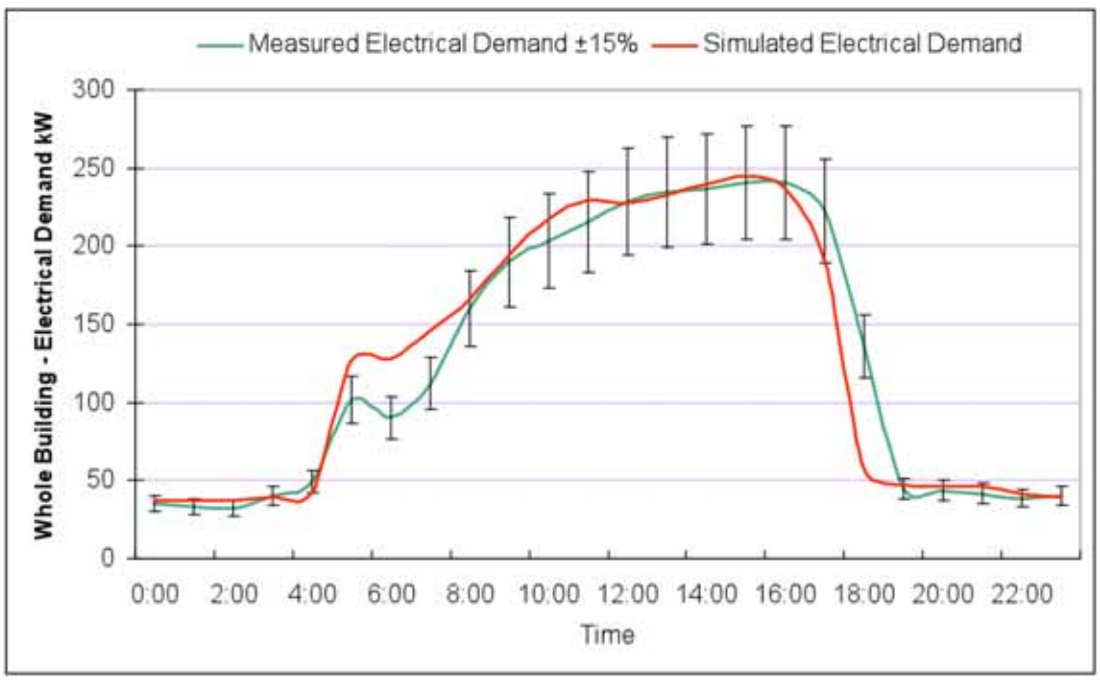

FIGURE C 12: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – ONE CARNEGIE PLAZA (SMALLER BUILDING)

ONE VANDERBILT

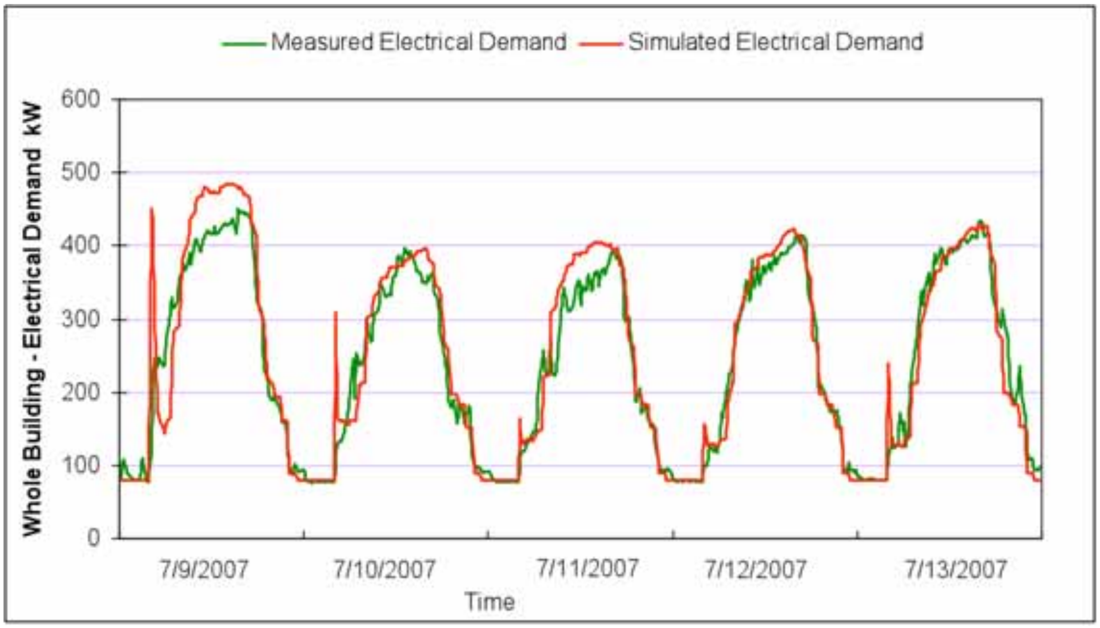

FIGURE C 13: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – ONE VANDERBILT

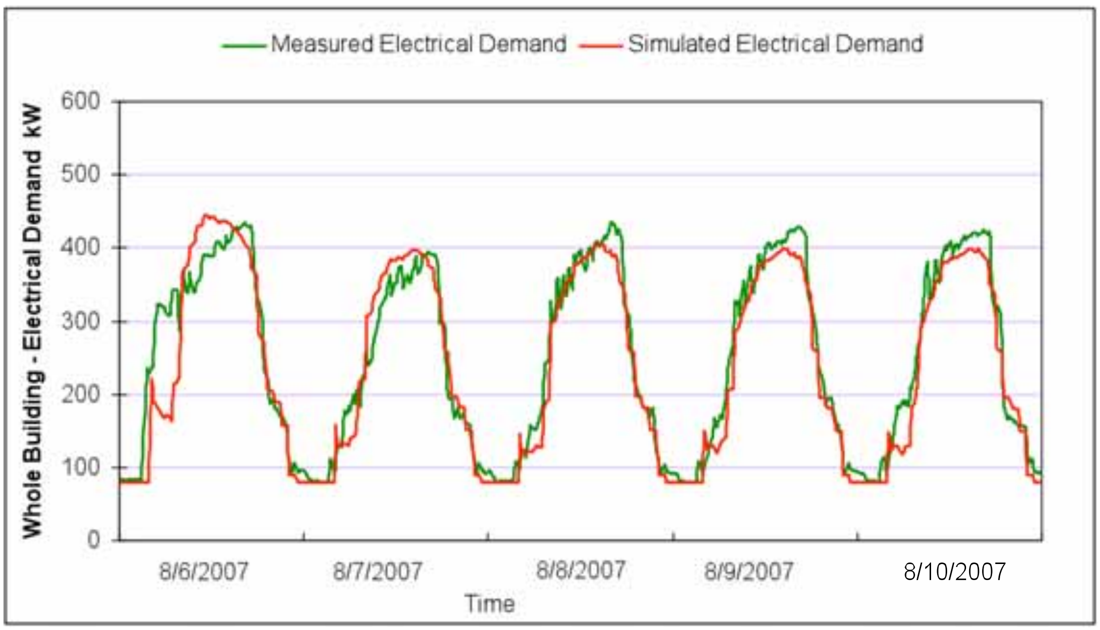

FIGURE C 14: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – ONE VANDERBILT

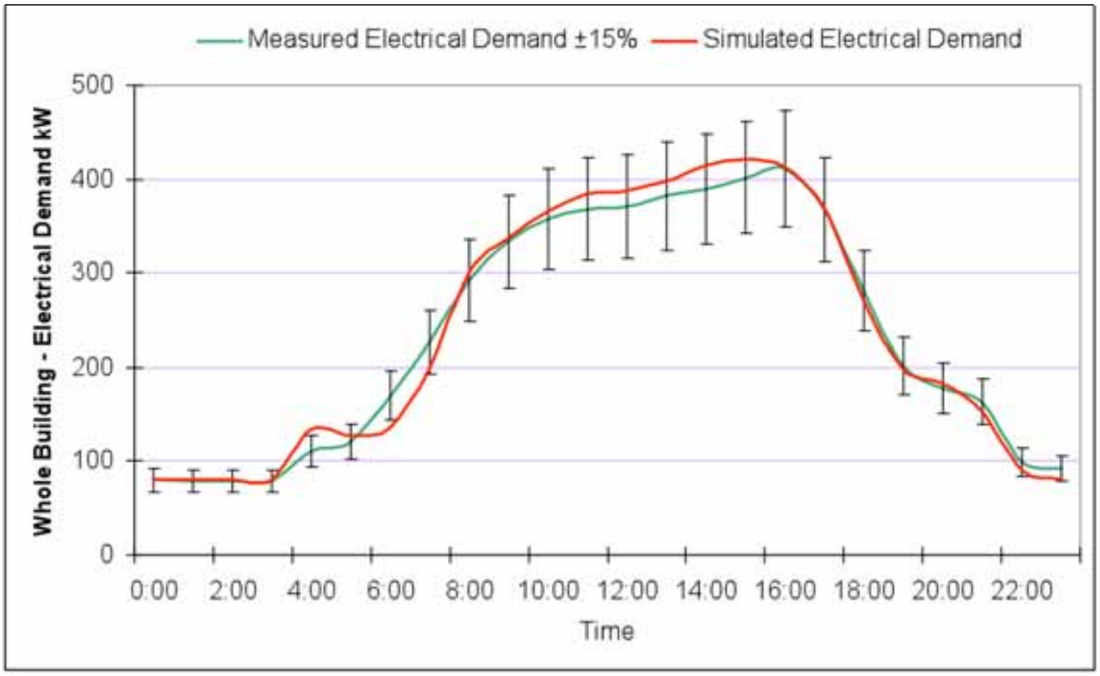

FIGURE C 15: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – ONE VANDERBILT

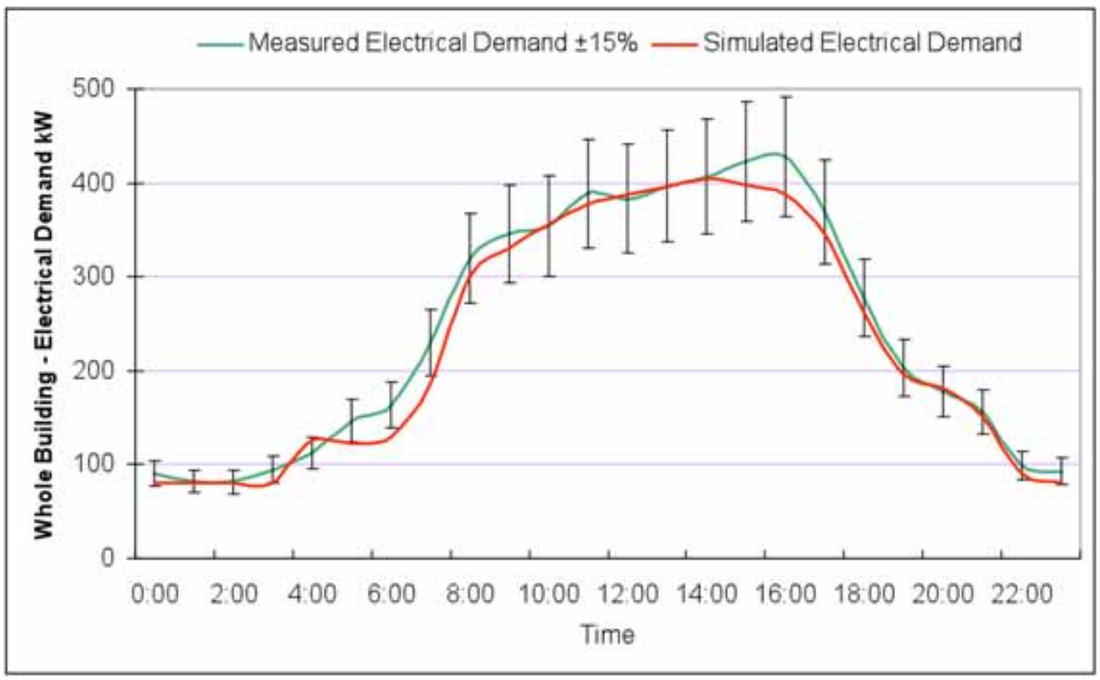

FIGURE C 16: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – ONE VANDERBILT

ONE PARKSIDE

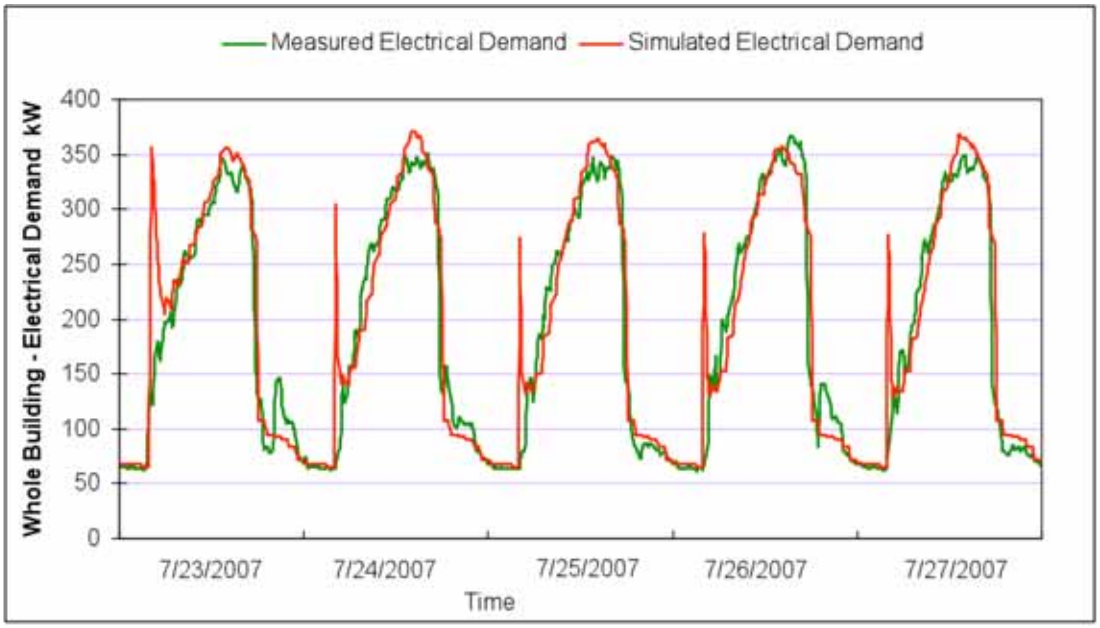

FIGURE C 17: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – ONE PARKSIDE

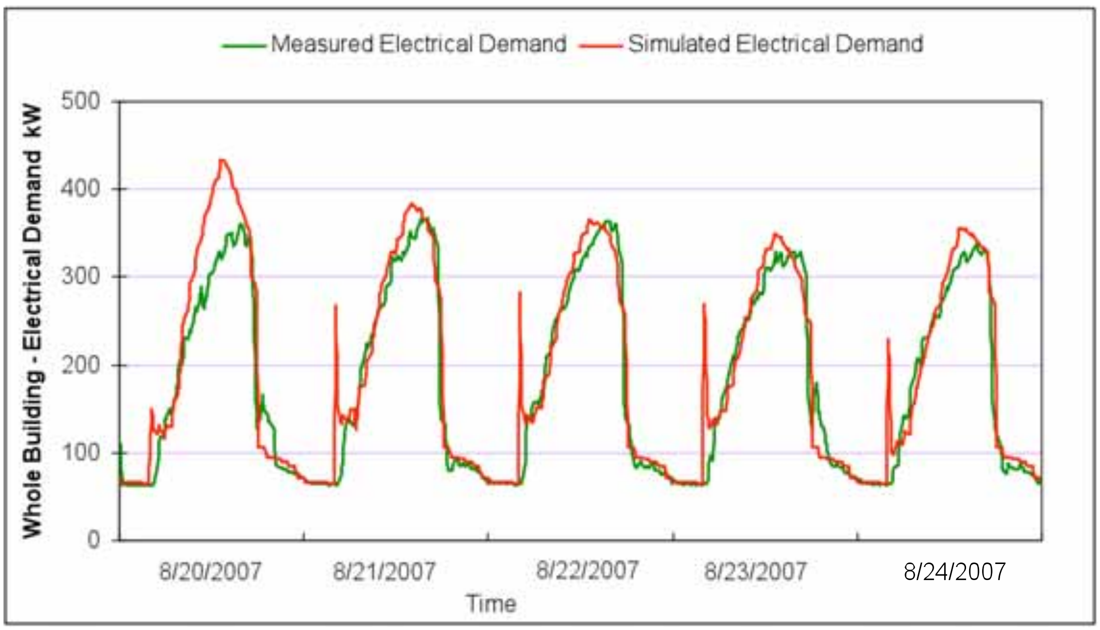

FIGURE C 18: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – ONE PARKSIDE

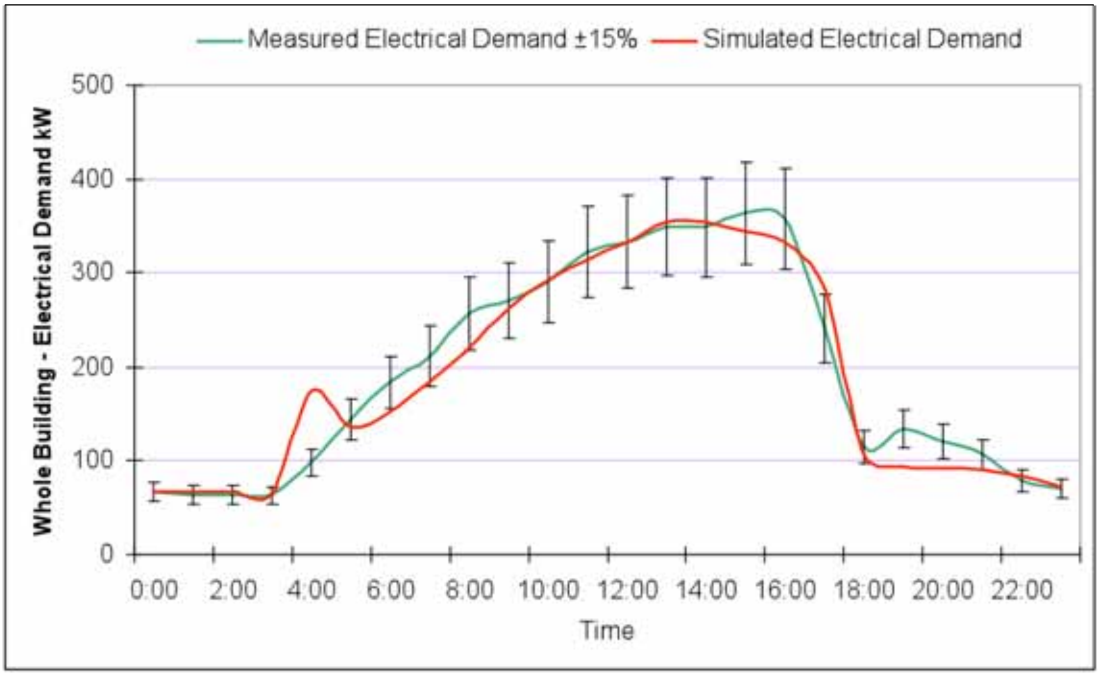

Figure C 19: Hourly Electrical Consumption of Simulation Model vs. Actual Electrical Consumption One day – One Parkside

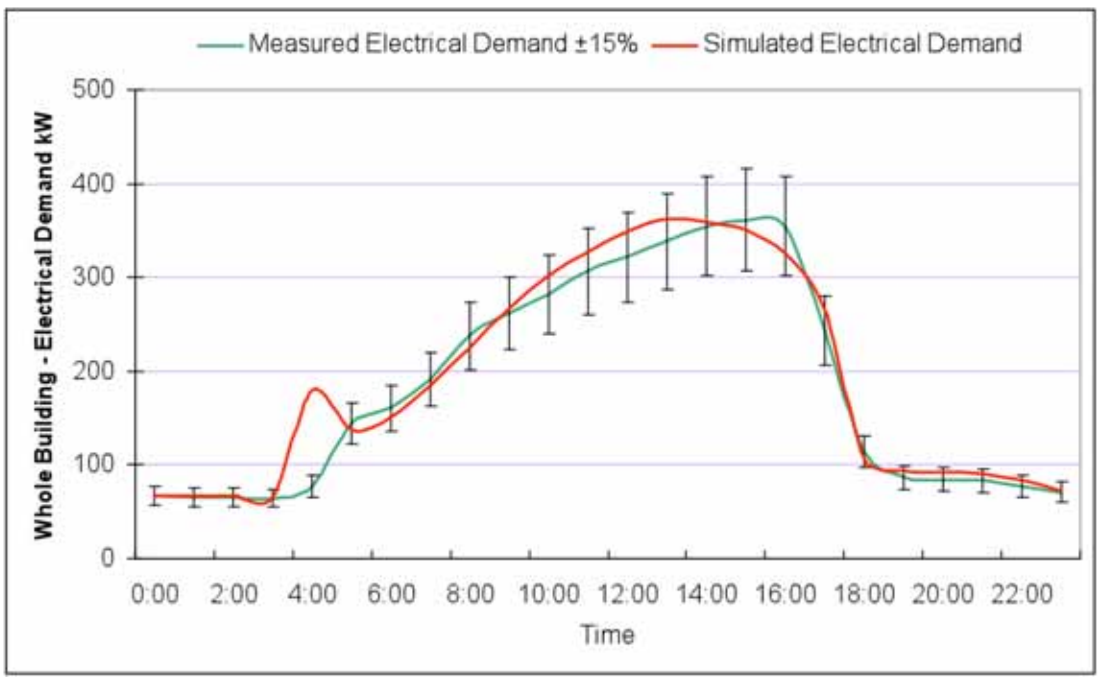

Figure C 20: Hourly Electrical Consumption of Simulation Model vs. Actual Electrical Consumption One day – One Parkside

LAKESIDE TOWER

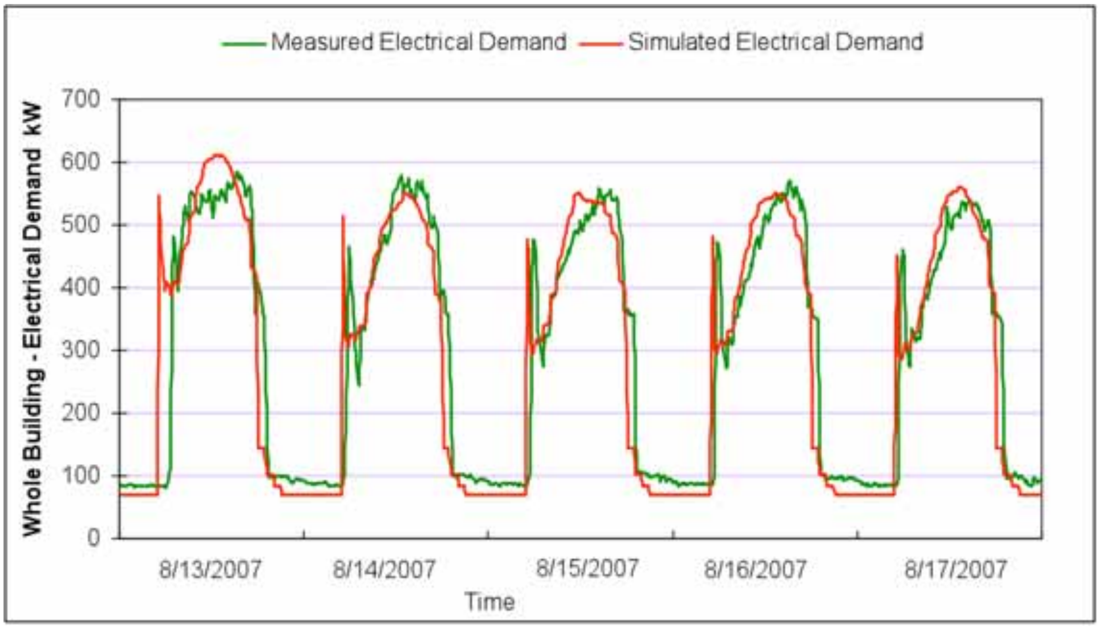

FIGURE C 21: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – LAKESIDE TOWER

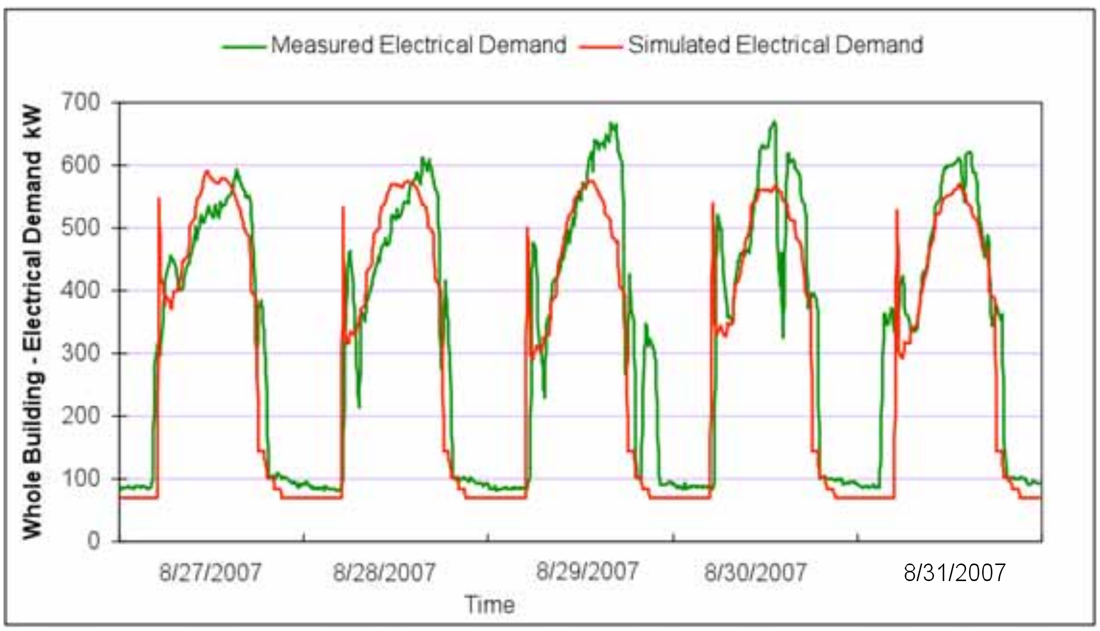

FIGURE C 22: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – LAKESIDE TOWER

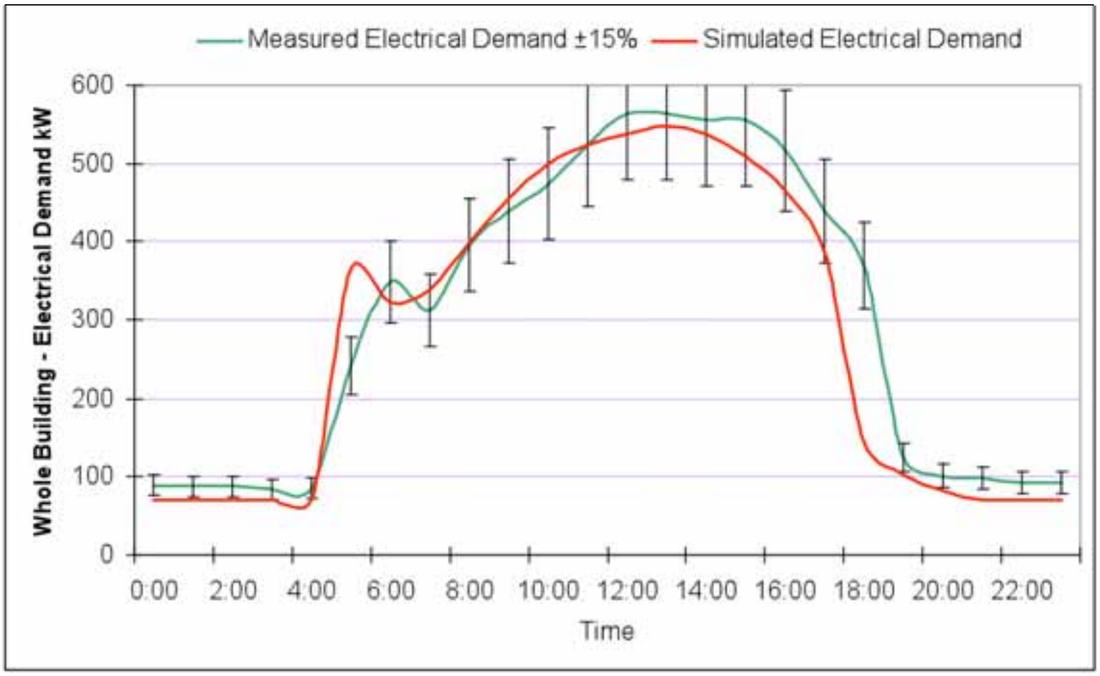

FIGURE C 23: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – LAKESIDE TOWER

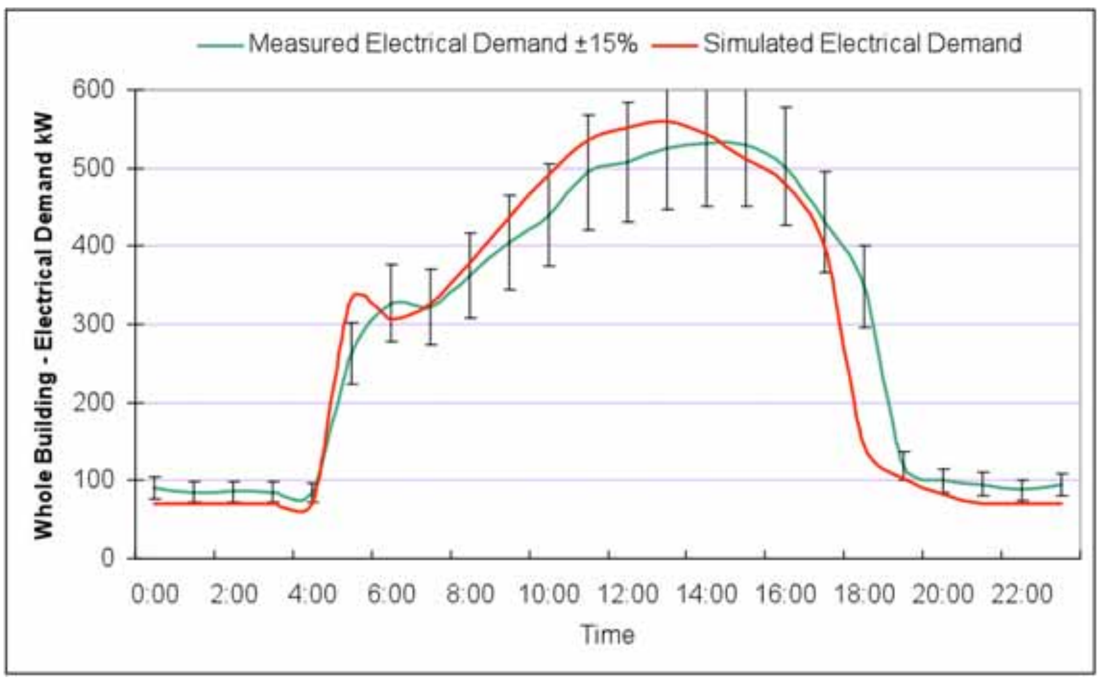

FIGURE C 24: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – LAKESIDE TOWER

TWO PARKSIDE

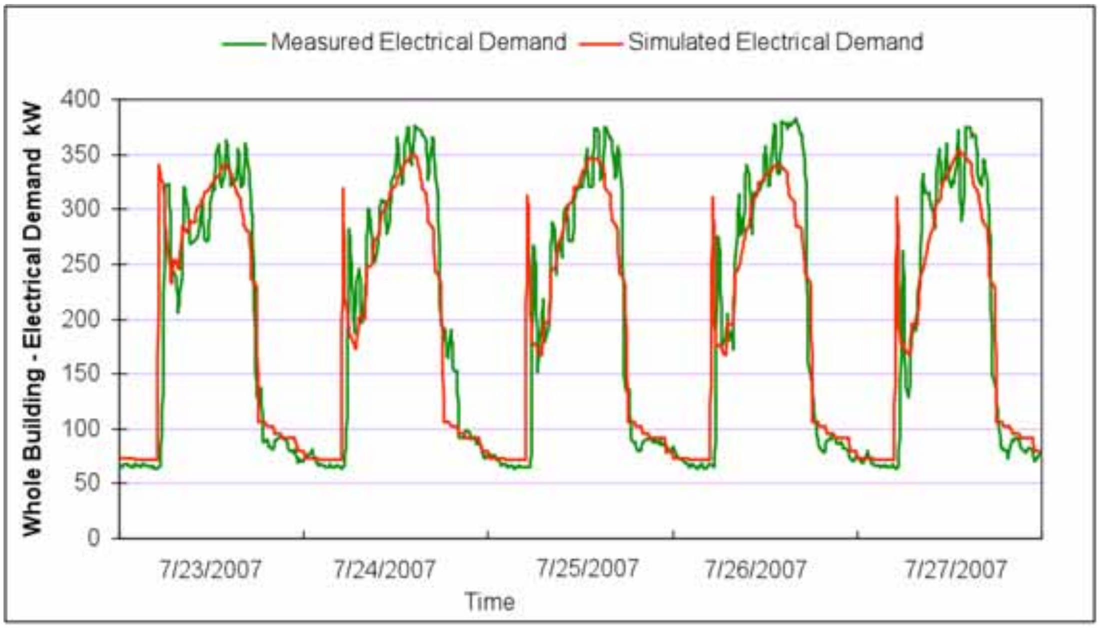

FIGURE C 25: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

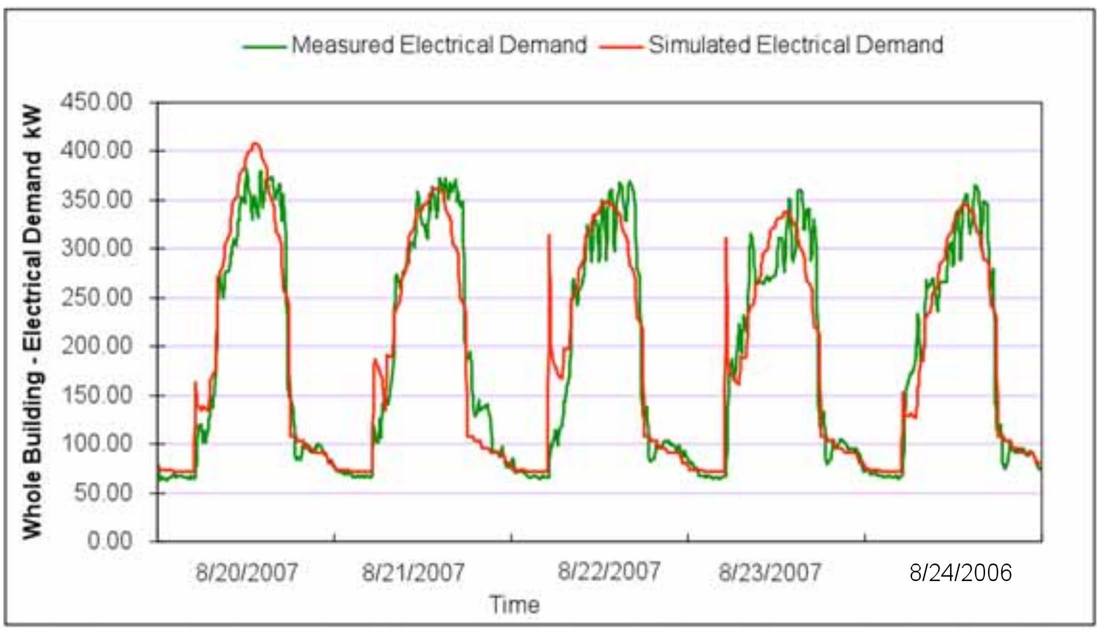

FIGURE C 26: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

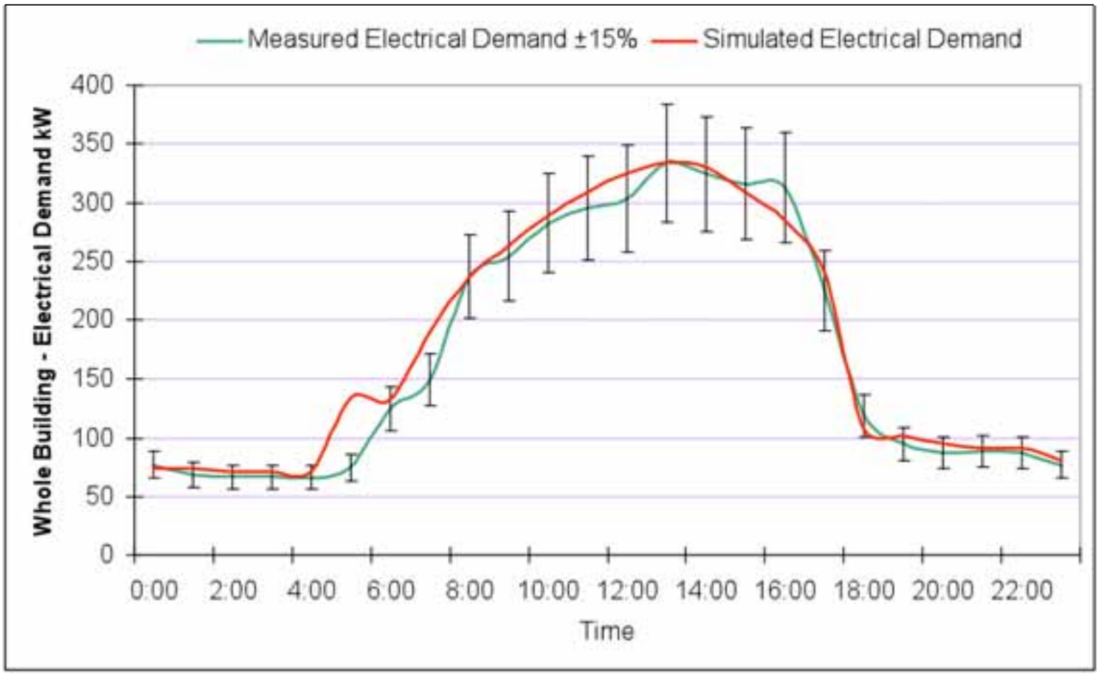

FIGURE C 27: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

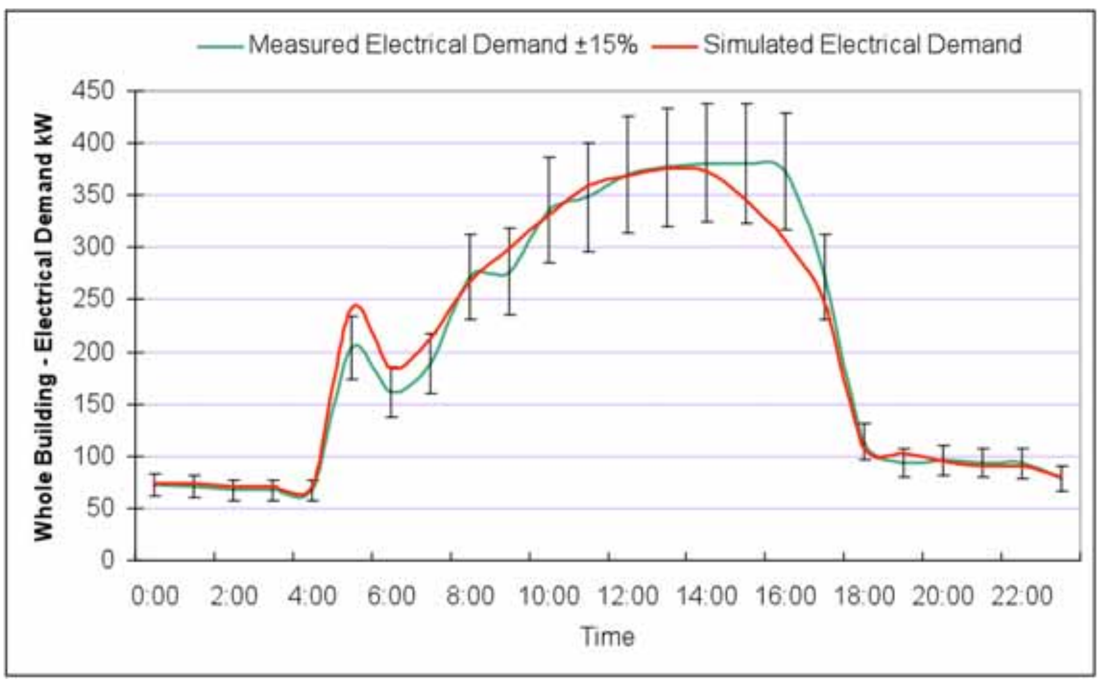

FIGURE C 28: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

THREE CARNEGIE PLAZA

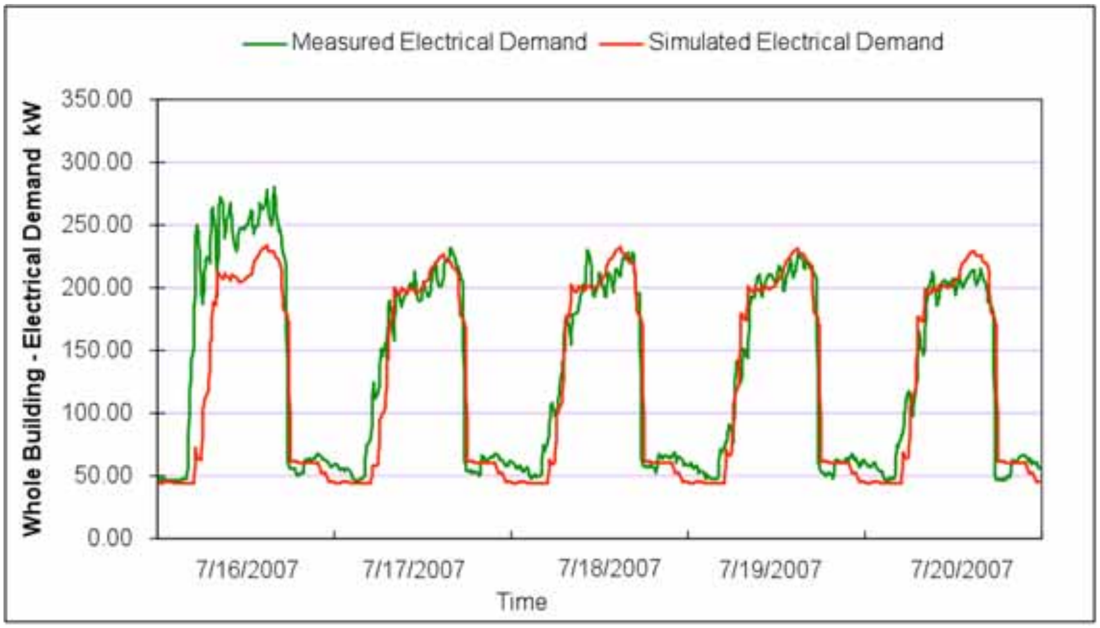

FIGURE C 29: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

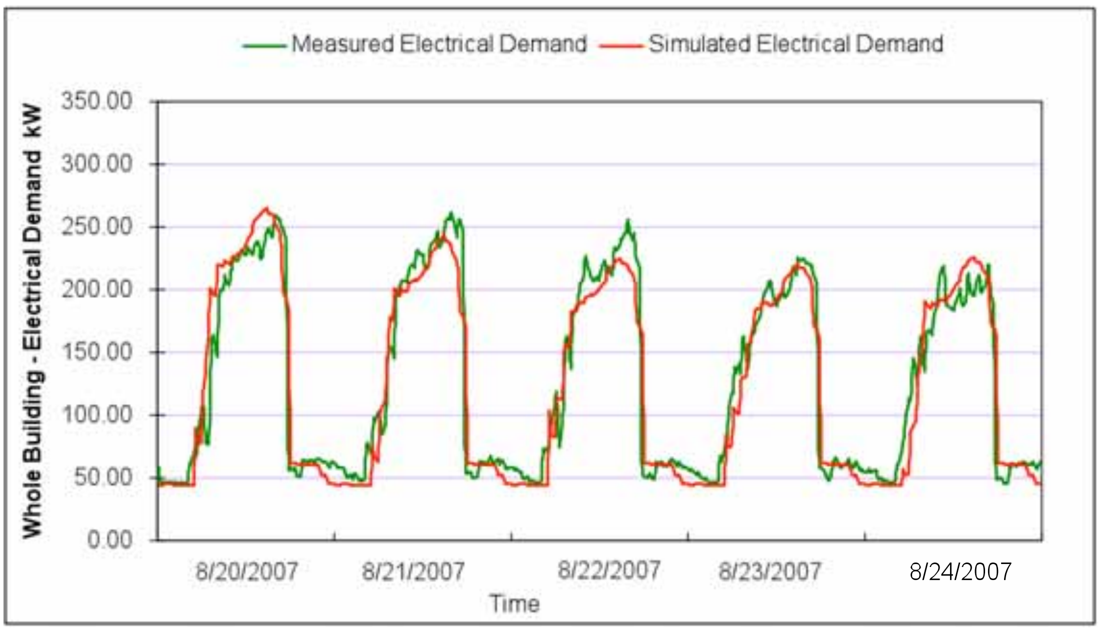

FIGURE C 30: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

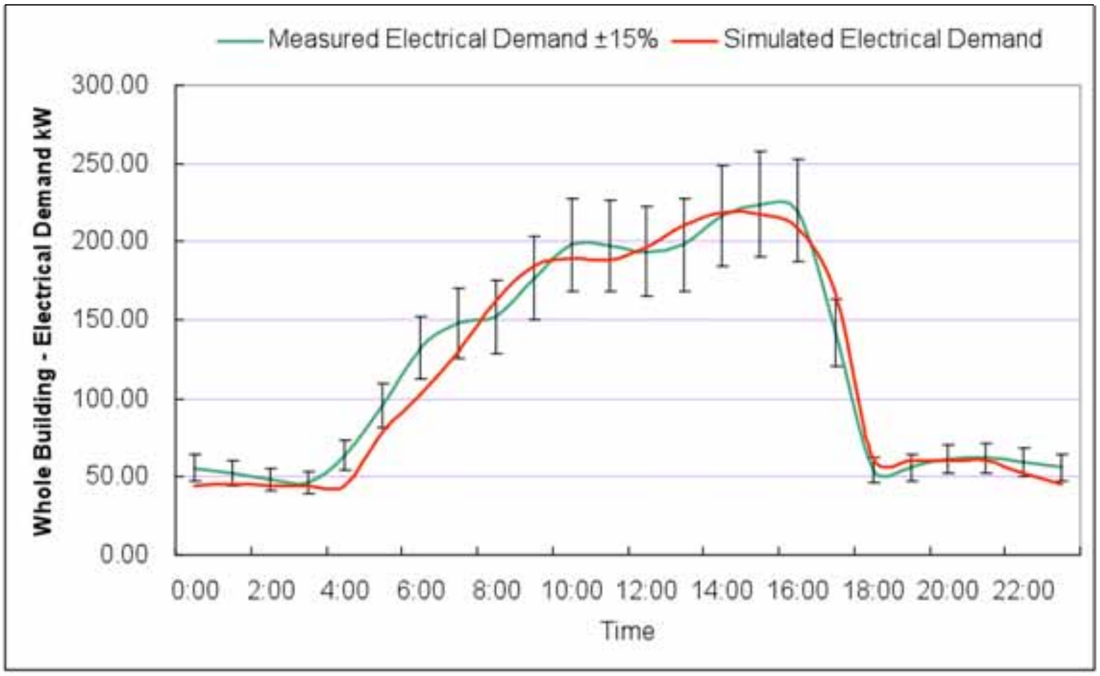

FIGURE C 31: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

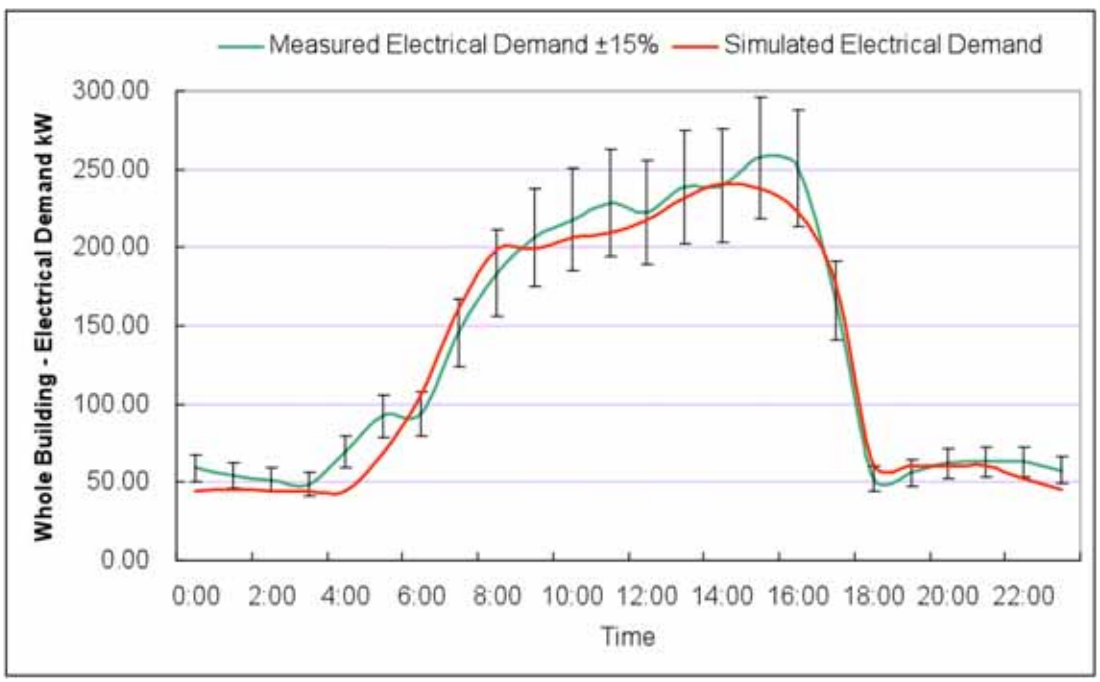

FIGURE C 32: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

BRIER CORPORATE CENTER

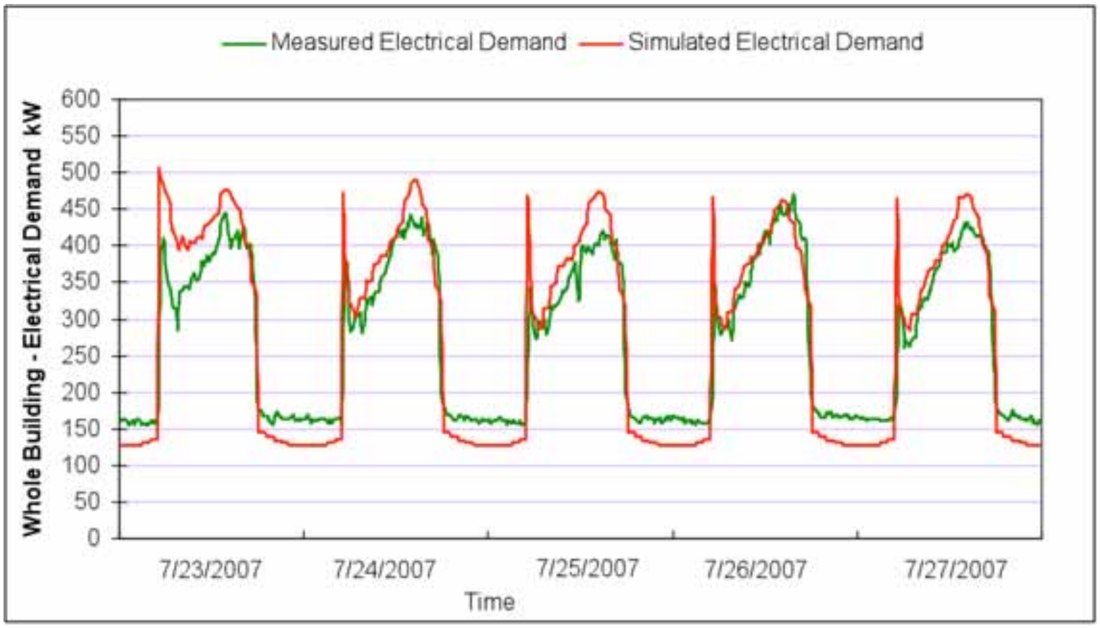

FIGURE C 33: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

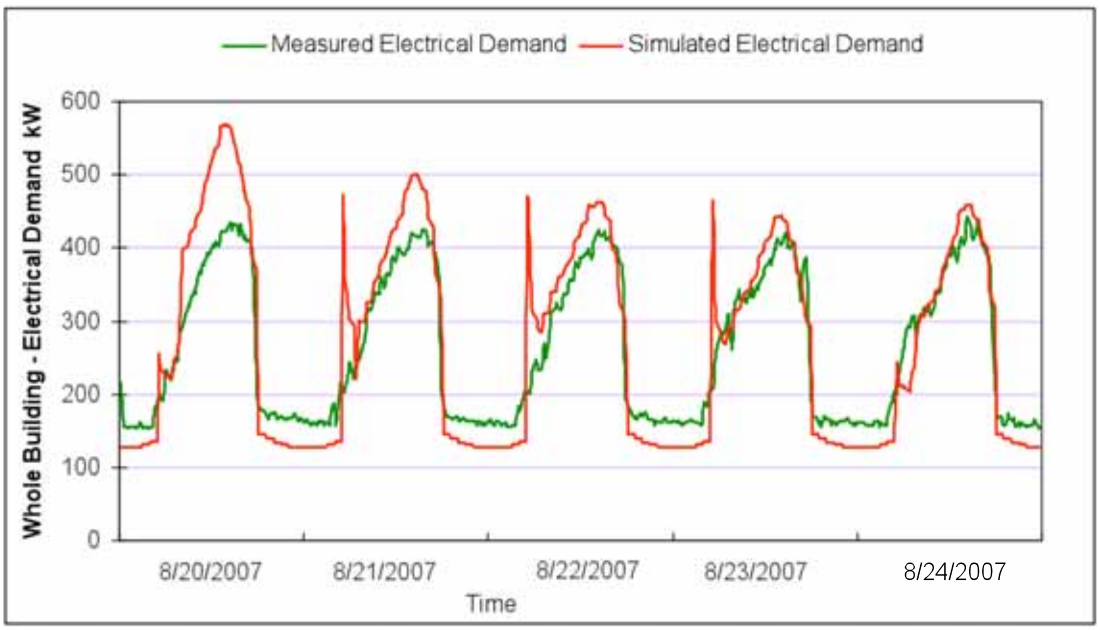

FIGURE C 34: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

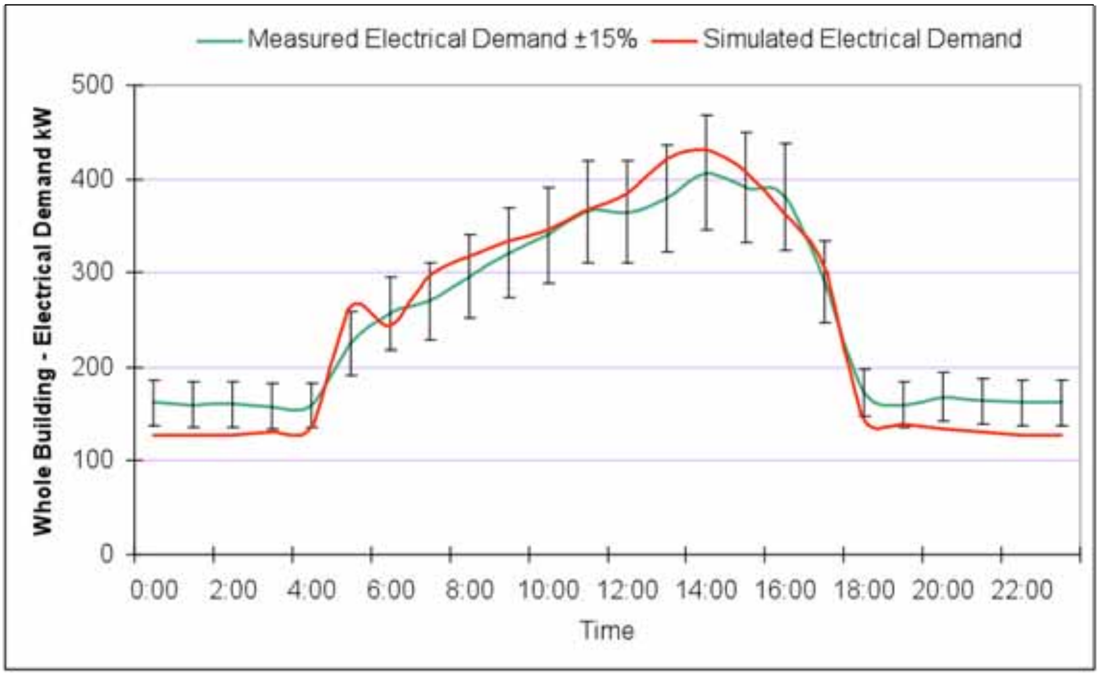

FIGURE C 35: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

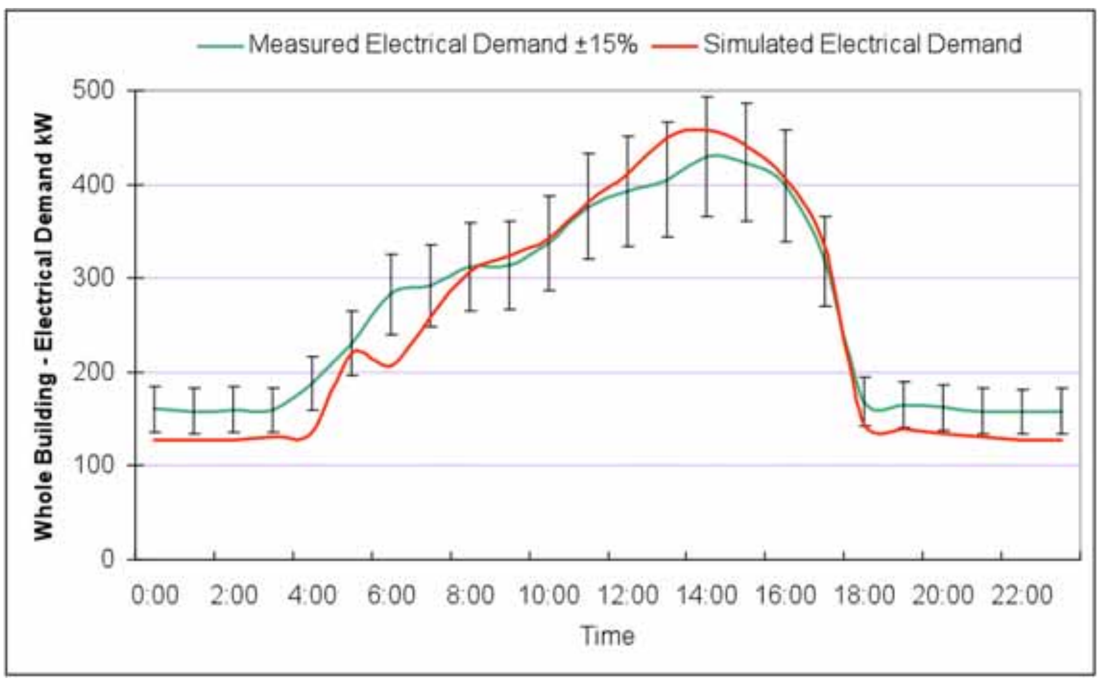

FIGURE C 36: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

VANDERBILT PLAZA

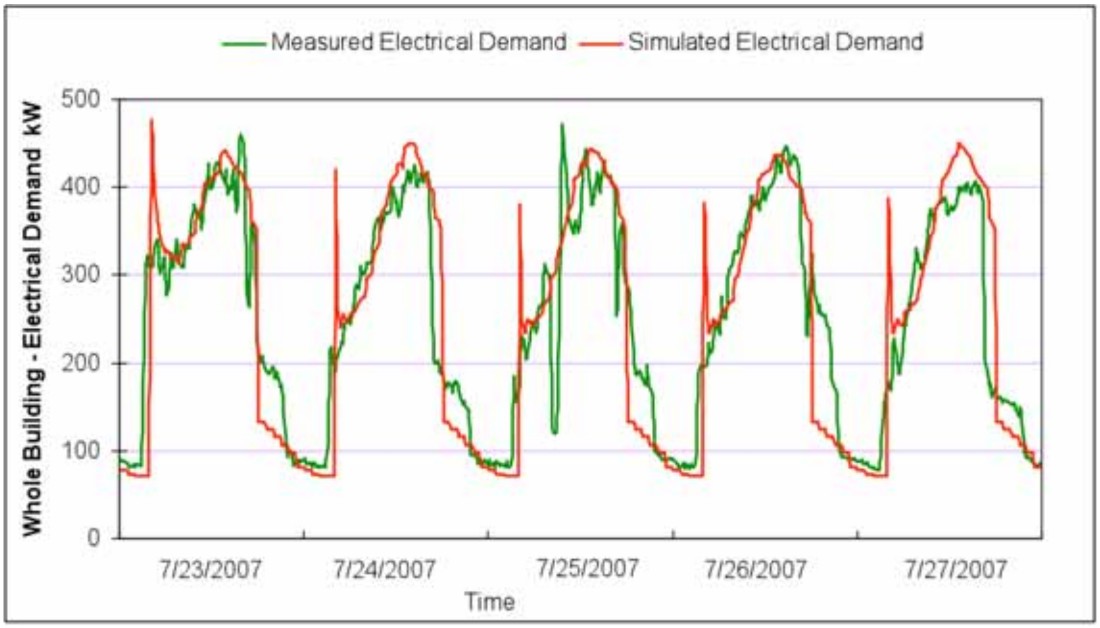

FIGURE C 37: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

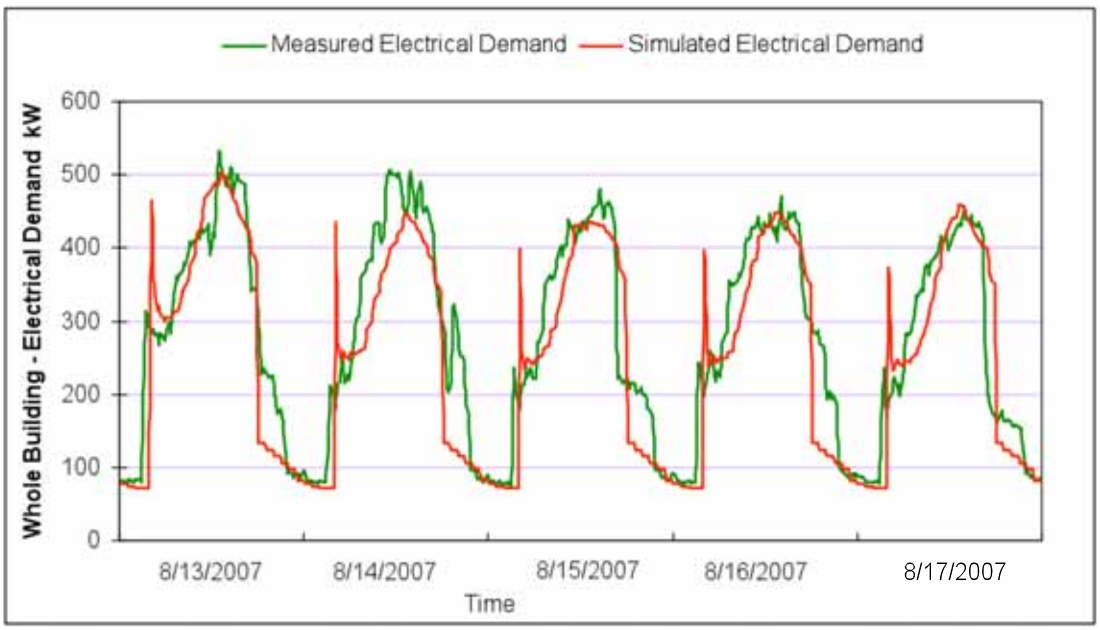

FIGURE C 38: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

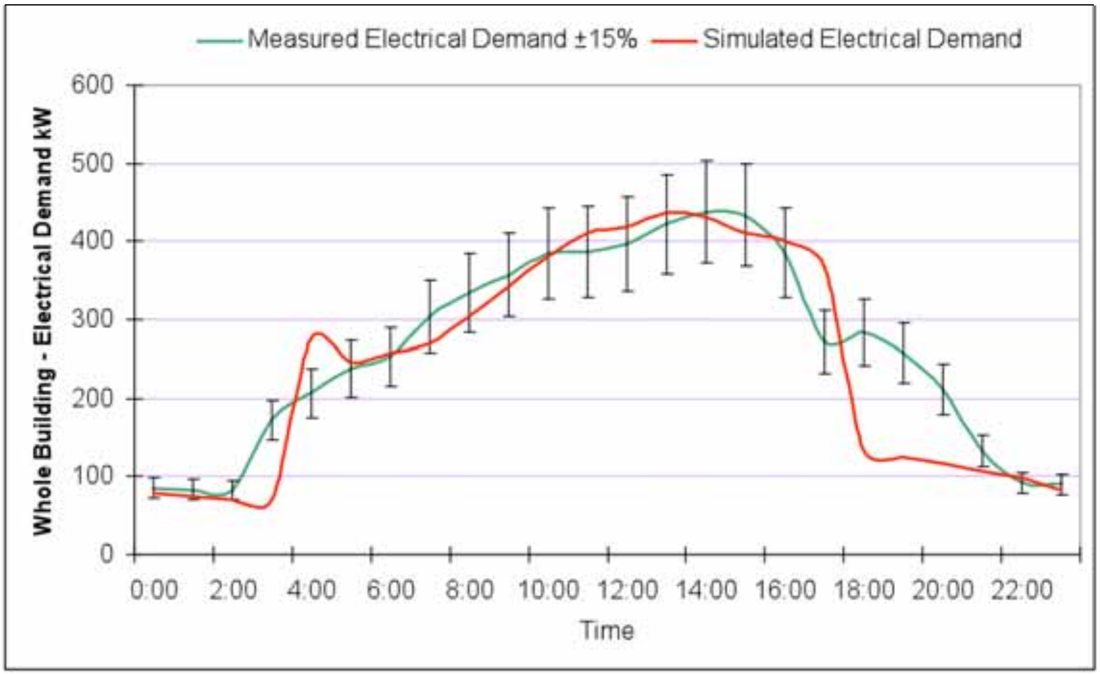

FIGURE C 39: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

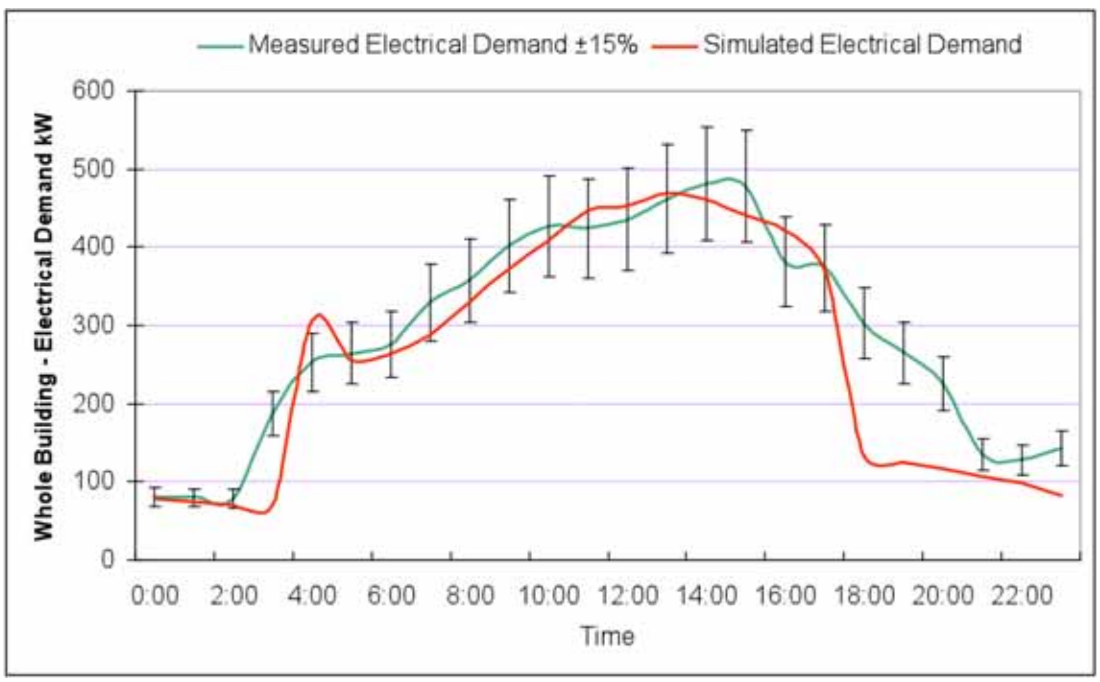

FIGURE C 40: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

INLAND REGIONAL CENTER

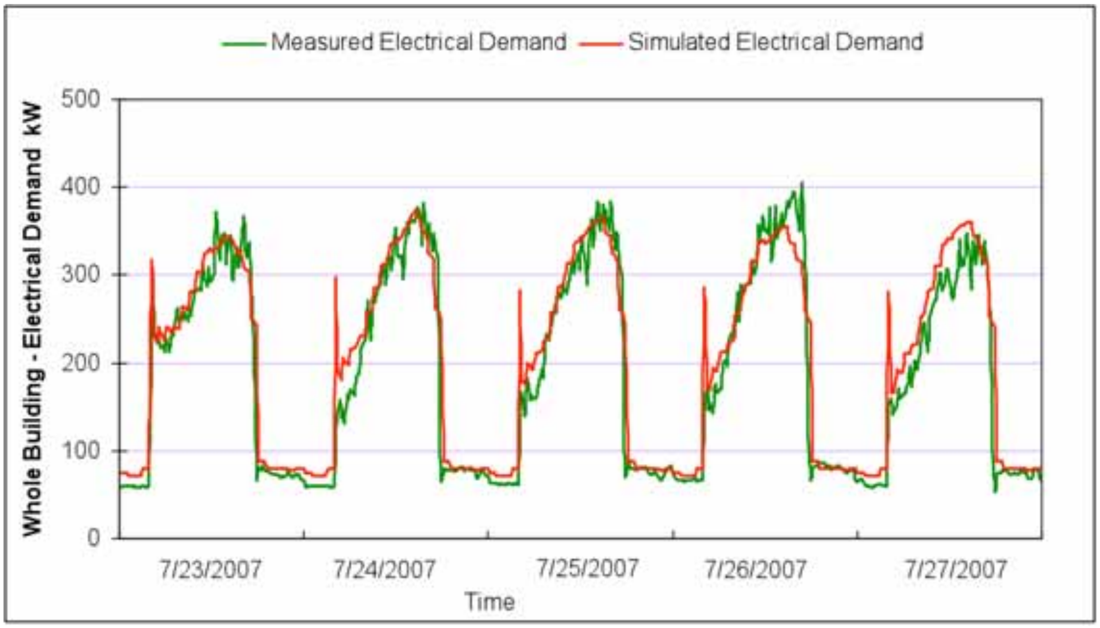

FIGURE C 41: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

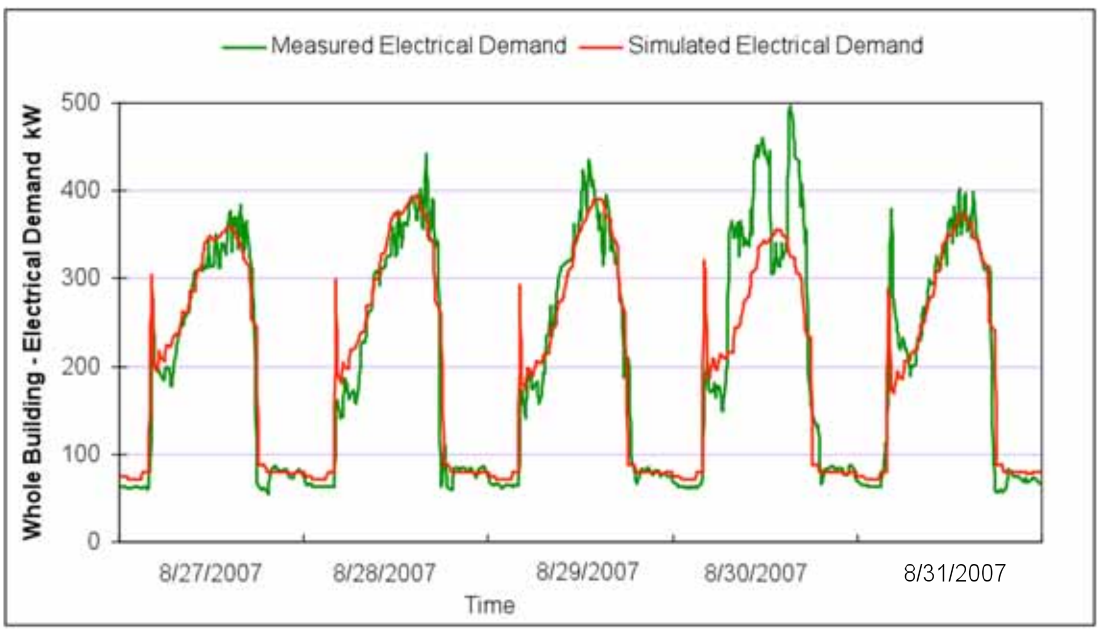

FIGURE C 42: DAILY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION IN JULY – TWO PARKSIDE

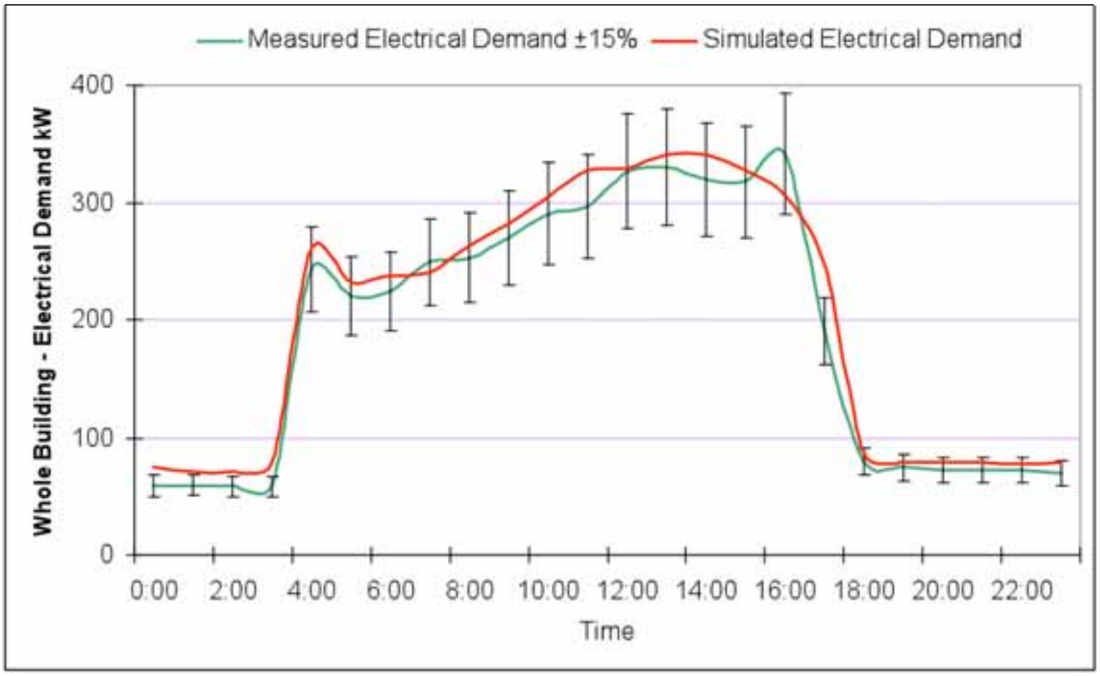

FIGURE C 43: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

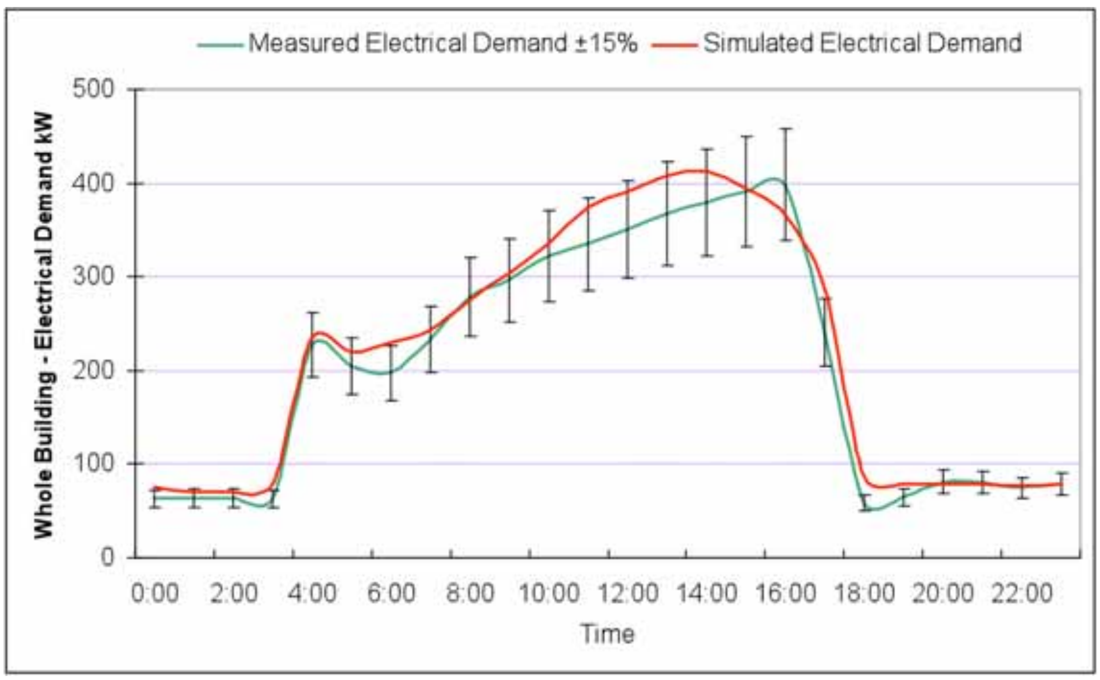

FIGURE C 44: HOURLY ELECTRICAL CONSUMPTION OF SIMULATION MODEL VS. ACTUAL ELECTRICAL CONSUMPTION ONE DAY – TWO PARKSIDE

APPENDIX D – FIELD RESULTS

ENERGY ANALYSIS ON AUTO-DR EVENT DAYS

TABLE D 1: DEMAND SHED ON AUTO-DR DAYS – TWO CARNEGIE PLAZA

DATE	PERIOD	KW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	45.1	18.2	0.54	0.22	15%	6%
	High Price (3 pm-6 pm)	57.6	-8.2	0.69	-0.10	20%	-3%
CPP-2	Moderate Price (12 pm-3 pm)	42.7	12.9	0.51	0.15	15%	4%
	High Price (3 pm-6 pm)	55.2	0.8	0.66	0.01	19%	0%
CPP-3	Moderate Price (12 pm-3 pm)	19.7	9.0	0.24	0.11	7%	3%
	High Price (3 pm-6 pm)	18.7	-12.4	0.22	-0.15	6%	-4%
CPP-4	Moderate Price (12 pm-3 pm)	30.2	19.1	0.36	0.23	12%	8%
	High Price (3 pm-6 pm)	30.7	17.4	0.37	0.21	13%	7%
CPP-5	Moderate Price (12 pm-3 pm)	43.7	21.9	0.52	0.26	17%	8%
	High Price (3 pm-6 pm)	47.5	22.6	0.57	0.27	18%	9%
CPP-6	Moderate Price (12 pm-3 pm)	32.6	14.7	0.39	0.18	12%	6%
	High Price (3 pm-6 pm)	46.1	16.0	0.55	0.19	17%	6%
CPP-7	Moderate Price (12 pm-3 pm)	39.8	16.0	0.48	0.19	16%	7%
	High Price (3 pm-6 pm)	41.3	9.3	0.49	0.11	17%	4%
CPP-8	Moderate Price (12 pm-3 pm)	43.2	21.6	0.52	0.26	18%	9%
	High Price (3 pm-6 pm)	29.3	6.6	0.35	0.08	12%	3%
CPP-9	Moderate Price (12 pm-3 pm)	26.9	6.9	0.32	0.08	11%	3%
	High Price (3 pm-6 pm)	31.7	7.8	0.38	0.09	13%	3%
CPP-10	Moderate Price (12 pm-3 pm)	25.4	6.1	0.30	0.07	10%	2%
	High Price (3 pm-6 pm)	20.2	6.0	0.24	0.07	8%	2%
CPP-11	Moderate Price (12 pm-3 pm)	22.6	9.7	0.27	0.12	8%	4%
	High Price (3 pm-6 pm)	22.1	7.2	0.26	0.09	8%	3%
Average	**Peak Period (12 pm-3 pm)**	**33.3**	**13.1**	**0.40**	**0.16**	**13%**	**5%**

TABLE D 2: DEMAND SHED ON AUTO-DR DAYS – ONE CARNEGIE PLAZA

DATE	PERIOD	KW		W / FT²		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	26.9	-4.3	0.32	-0.05	8%	-1%
	High Price (3 pm-6 pm)	12.5	-20.1	0.15	-0.24	4%	-6%
CPP-2	Moderate Price (12 pm-3 pm)	-12.5	-20.9	-0.15	-0.25	-4%	-6%
	High Price (3 pm-6 pm)	9.6	-13.2	0.11	-0.16	3%	-4%
CPP-3	Moderate Price (12 pm-3 pm)	19.2	-5.3	0.23	-0.06	6%	-2%
	High Price (3 pm-6 pm)	35.5	7.5	0.42	0.09	10%	2%
CPP-4	Moderate Price (12 pm-3 pm)	107.5	33.1	1.28	0.40	31%	10%
	High Price (3 pm-6 pm)	34.6	14.5	0.41	0.17	10%	4%
CPP-5	Moderate Price (12 pm-3 pm)	71.0	17.0	0.85	0.20	19%	5%
	High Price (3 pm-6 pm)	49.0	11.1	0.58	0.13	13%	3%
CPP-6	Moderate Price (12 pm-3 pm)	60.5	16.7	0.72	0.20	16%	5%
	High Price (3 pm-6 pm)	43.2	2.2	0.52	0.03	12%	1%
CPP-7	Moderate Price (12 pm-3 pm)	90.2	41.8	1.08	0.50	25%	11%
	High Price (3 pm-6 pm)	75.8	32.8	0.91	0.39	21%	9%
CPP-8	Moderate Price (12 pm-3 pm)	65.3	29.3	0.78	0.35	18%	8%
	High Price (3 pm-6 pm)	43.2	18.9	0.52	0.23	12%	5%
CPP-9	Moderate Price (12 pm-3 pm)	46.1	22.3	0.55	0.27	13%	6%
	High Price (3 pm-6 pm)	73.9	14.0	0.88	0.17	20%	4%
CPP-10	Moderate Price (12 pm-3 pm)	68.2	13.4	0.81	0.16	19%	4%
	High Price (3 pm-6 pm)	71.0	7.6	0.85	0.09	19%	2%
CPP-11	Moderate Price (12 pm-3 pm)	67.2	25.4	0.80	0.30	18%	7%
	High Price (3 pm-6 pm)	51.8	13.0	0.62	0.16	14%	4%
Average	**Peak Period (12 pm-3 pm)**	**63.7**	**19.6**	**0.76**	**0.23**	**17%**	**5%**

Table D 3: Demand Shed on Auto-DR Days – One Carnegie Plaza (smaller building)

Date	Period	kW		W / ft^2		WBP %	
		Max	Ave	Max	Ave	Max	Ave
CPP-1	Moderate Price (12 pm-3 pm)	34.6	3.5	0.41	0.04	18%	2%
	High Price (3 pm-6 pm)	33.6	1.6	0.40	0.02	18%	1%
CPP-2	Moderate Price (12 pm-3 pm)	35.5	-13.7	0.42	-0.16	19%	-7%
	High Price (3 pm-6 pm)	11.5	-1.5	0.14	-0.02	6%	-1%
CPP-3	Moderate Price (12 pm-3 pm)	32.6	-8.4	0.39	-0.10	17%	-4%
	High Price (3 pm-6 pm)	16.3	-2.6	0.19	-0.03	9%	-1%
CPP-4	Moderate Price (12 pm-3 pm)	123.8	50.6	1.48	0.60	59%	24%
	High Price (3 pm-6 pm)	99.8	26.6	1.19	0.32	47%	13%
CPP-5	Moderate Price (12 pm-3 pm)	34.6	18.1	0.41	0.22	16%	8%
	High Price (3 pm-6 pm)	107.5	26.2	1.28	0.31	49%	12%
CPP-6	Moderate Price (12 pm-3 pm)	42.2	11.8	0.50	0.14	19%	5%
	High Price (3 pm-6 pm)	67.2	24.6	0.80	0.29	30%	11%
CPP-7	Moderate Price (12 pm-3 pm)	50.9	28.4	0.61	0.34	26%	14%
	High Price (3 pm-6 pm)	48.0	20.3	0.57	0.24	24%	10%
CPP-8	Moderate Price (12 pm-3 pm)	77.8	39.6	0.93	0.47	40%	20%
	High Price (3 pm-6 pm)	36.5	15.8	0.44	0.19	19%	8%
CPP-9	Moderate Price (12 pm-3 pm)	36.5	1.3	0.44	0.02	20%	1%
	High Price (3 pm-6 pm)	16.3	-10.1	0.19	-0.12	9%	-6%
CPP-10	Moderate Price (12 pm-3 pm)	16.3	-9.1	0.19	-0.11	9%	-5%
	High Price (3 pm-6 pm)	35.5	-0.4	0.42	0.00	20%	0%
CPP-11	Moderate Price (12 pm-3 pm)	39.4	10.1	0.47	0.12	20%	5%
	High Price (3 pm-6 pm)	24.0	-1.7	0.29	-0.02	12%	-1%
Average	**Peak Period (12 pm-3 pm)**	**53.5**	**15.8**	**0.64**	**0.19**	**26%**	**8%**

TABLE D 4: DEMAND SHED ON AUTO-DR DAYS – ONE VANDERBILT

DATE	PERIOD	kW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	19.2	5.8	0.23	0.07	5%	1%
	High Price (3 pm-6 pm)	4.8	-17.1	0.06	-0.20	1%	-4%
CPP-2	Moderate Price (12 pm-3 pm)	16.3	2.8	0.19	0.03	4%	1%
	High Price (3 pm-6 pm)	10.6	-14.9	0.13	-0.18	3%	-4%
CPP-3	Moderate Price (12 pm-3 pm)	7.7	-0.5	0.09	-0.01	2%	0%
	High Price (3 pm-6 pm)	2.9	-3.8	0.03	-0.05	1%	-1%
CPP-4	Moderate Price (12 pm-3 pm)	84.5	45.1	1.01	0.54	19%	10%
	High Price (3 pm-6 pm)	34.6	12.8	0.41	0.15	8%	3%
CPP-5	Moderate Price (12 pm-3 pm)	18.2	7.0	0.22	0.08	4%	2%
	High Price (3 pm-6 pm)	27.8	20.6	0.33	0.25	6%	5%
CPP-6	Moderate Price (12 pm-3 pm)	11.5	7.3	0.14	0.09	3%	2%
	High Price (3 pm-6 pm)	22.1	13.5	0.26	0.16	5%	3%
CPP-7	Moderate Price (12 pm-3 pm)	14.4	0.1	0.17	0.00	3%	0%
	High Price (3 pm-6 pm)	65.3	15.1	0.78	0.18	15%	4%
CPP-8	Moderate Price (12 pm-3 pm)	23.0	13.5	0.28	0.16	5%	3%
	High Price (3 pm-6 pm)	10.6	2.1	0.13	0.02	2%	0%
CPP-9	Moderate Price (12 pm-3 pm)	28.8	22.2	0.34	0.27	7%	5%
	High Price (3 pm-6 pm)	80.6	53.9	0.96	0.64	19%	13%
CPP-10	Moderate Price (12 pm-3 pm)	34.6	27.0	0.41	0.32	8%	6%
	High Price (3 pm-6 pm)	28.8	20.3	0.34	0.24	7%	5%
CPP-11	Moderate Price (12 pm-3 pm)	8.6	1.7	0.10	0.02	2%	0%
	High Price (3 pm-6 pm)	2.9	-0.7	0.03	-0.01	1%	0%
Average	**Peak Period (12 pm-3 pm)**	**31.0**	**16.4**	**0.37**	**0.20**	**7%**	**4%**

Table D 5: Demand Shed on Auto-DR Days – One Parkside

Date	Period	kW Max	kW Ave	W / ft^2 Max	W / ft^2 Ave	WBP% Max	WBP% Ave
CPP-1	Moderate Price (12 pm-3 pm)	16.3	-2.8	0.19	-0.03	5%	-1%
	High Price (3 pm-6 pm)	4.8	-10.6	0.06	-0.13	2%	-3%
CPP-2	Moderate Price (12 pm-3 pm)	1.0	-17.4	0.01	-0.21	0%	-5%
	High Price (3 pm-6 pm)	19.2	-8.1	0.23	-0.10	6%	-3%
CPP-3	Moderate Price (12 pm-3 pm)	19.2	-5.8	0.23	-0.07	6%	-2%
	High Price (3 pm-6 pm)	7.7	-4.1	0.09	-0.05	2%	-1%
CPP-4	Moderate Price (12 pm-3 pm)	30.7	-0.1	0.37	0.00	10%	0%
	High Price (3 pm-6 pm)	19.2	0.4	0.23	0.00	6%	0%
CPP-5	Moderate Price (12 pm-3 pm)	29.8	17.0	0.36	0.20	9%	5%
	High Price (3 pm-6 pm)	75.8	25.2	0.91	0.30	22%	7%
CPP-6	Moderate Price (12 pm-3 pm)	54.7	27.4	0.65	0.33	16%	8%
	High Price (3 pm-6 pm)	52.8	12.3	0.63	0.15	15%	4%
CPP-7	Moderate Price (12 pm-3 pm)	77.8	39.9	0.93	0.48	24%	12%
	High Price (3 pm-6 pm)	54.7	23.9	0.65	0.29	17%	7%
CPP-8	Moderate Price (12 pm-3 pm)	52.8	34.2	0.63	0.41	16%	11%
	High Price (3 pm-6 pm)	61.4	20.7	0.73	0.25	19%	6%
CPP-9	Moderate Price (12 pm-3 pm)	92.2	35.3	1.10	0.42	28%	11%
	High Price (3 pm-6 pm)	60.5	29.6	0.72	0.35	18%	9%
CPP-10	Moderate Price (12 pm-3 pm)	51.8	32.9	0.62	0.39	16%	10%
	High Price (3 pm-6 pm)	41.3	15.7	0.49	0.19	12%	5%
CPP-11	Moderate Price (12 pm-3 pm)	41.3	22.6	0.49	0.27	12%	7%
	High Price (3 pm-6 pm)	45.1	19.8	0.54	0.24	13%	6%
Average	**Peak Period (12 pm-3 pm)**	**52.6**	**22.3**	**0.63**	**0.27**	**16%**	**7%**

TABLE D 6: DEMAND SHED ON AUTO-DR DAYS – LAKESIDE TOWER

DATE	PERIOD	KW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	65.3	1.4	0.78	0.02	14%	0%
	High Price (3 pm-6 pm)	134.4	16.3	1.61	0.19	28%	3%
CPP-2	Moderate Price (12 pm-3 pm)	58.6	-11.4	0.70	-0.14	12%	-2%
	High Price (3 pm-6 pm)	168.0	24.6	2.01	0.29	35%	5%
CPP-3	Moderate Price (12 pm-3 pm)	24.0	-6.1	0.29	-0.07	5%	-1%
	High Price (3 pm-6 pm)	27.8	3.0	0.33	0.04	6%	1%
CPP-4	Moderate Price (12 pm-3 pm)	79.7	22.6	0.95	0.27	18%	5%
	High Price (3 pm-6 pm)	197.8	54.4	2.36	0.65	44%	12%
CPP-5	Moderate Price (12 pm-3 pm)	253.4	78.4	3.03	0.94	49%	15%
	High Price (3 pm-6 pm)	321.6	145.3	3.84	1.74	62%	28%
CPP-6	Moderate Price (12 pm-3 pm)	208.3	71.4	2.49	0.85	40%	14%
	High Price (3 pm-6 pm)	333.1	132.1	3.98	1.58	64%	26%
CPP-7	Moderate Price (12 pm-3 pm)	247.7	117.9	2.96	1.41	50%	24%
	High Price (3 pm-6 pm)	273.6	106.9	3.27	1.28	55%	22%
CPP-8	Moderate Price (12 pm-3 pm)	289.9	147.7	3.46	1.76	59%	30%
	High Price (3 pm-6 pm)	190.1	50.9	2.27	0.61	38%	10%
CPP-9	Moderate Price (12 pm-3 pm)	320.6	150.7	3.83	1.80	62%	29%
	High Price (3 pm-6 pm)	282.2	120.2	3.37	1.44	55%	23%
CPP-10	Moderate Price (12 pm-3 pm)	273.6	116.1	3.27	1.39	53%	22%
	High Price (3 pm-6 pm)	268.8	64.7	3.21	0.77	52%	13%
CPP-11	Moderate Price (12 pm-3 pm)	94.1	60.2	1.12	0.72	17%	11%
	High Price (3 pm-6 pm)	112.3	67.6	1.34	0.81	20%	12%
Average	**Peak Period (12 pm-3 pm)**	234.2	94.2	2.80	1.13	46%	18%

TABLE D 7: DEMAND SHED ON AUTO-DR DAYS – TWO PARKSIDE

DATE	PERIOD	KW		W / FT²		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	84.5	51.4	1.01	0.61	21%	13%
	High Price (3 pm-6 pm)	44.2	12.1	0.53	0.14	11%	3%
CPP-2	Moderate Price (12 pm-3 pm)	87.8	43.2	1.05	0.52	22%	11%
	High Price (3 pm-6 pm)	136.3	9.3	1.63	0.11	34%	2%
CPP-3	Moderate Price (12 pm-3 pm)	88.8	54.5	1.06	0.65	22%	14%
	High Price (3 pm-6 pm)	55.7	-18.0	0.67	-0.22	14%	-5%
CPP-4	Moderate Price (12 pm-3 pm)	52.8	2.5	0.63	0.03	15%	1%
	High Price (3 pm-6 pm)	66.7	34.3	0.80	0.41	19%	10%
CPP-5	Moderate Price (12 pm-3 pm)	132.5	86.5	1.58	1.03	32%	21%
	High Price (3 pm-6 pm)	158.9	82.2	1.90	0.98	39%	20%
CPP-6	Moderate Price (12 pm-3 pm)	104.2	60.1	1.24	0.72	25%	15%
	High Price (3 pm-6 pm)	162.2	103.6	1.94	1.24	39%	25%
CPP-7	Moderate Price (12 pm-3 pm)	70.1	30.1	0.84	0.36	18%	8%
	High Price (3 pm-6 pm)	104.6	33.1	1.25	0.40	27%	8%
CPP-8	Moderate Price (12 pm-3 pm)	73.9	27.8	0.88	0.33	19%	7%
	High Price (3 pm-6 pm)	76.3	26.9	0.91	0.32	19%	7%
CPP-9	Moderate Price (12 pm-3 pm)	37.9	-1.7	0.45	-0.02	13%	-1%
	High Price (3 pm-6 pm)	32.2	-13.1	0.38	-0.16	11%	-4%
CPP-10	Moderate Price (12 pm-3 pm)	39.8	22.3	0.48	0.27	13%	7%
	High Price (3 pm-6 pm)	37.0	-12.1	0.44	-0.14	12%	-4%
CPP-11	Moderate Price (12 pm-3 pm)	127.2	34.4	1.52	0.41	33%	9%
	High Price (3 pm-6 pm)	73.0	8.4	0.87	0.10	19%	2%
Average	**Peak Period (12 pm-3 pm)**	84.3	32.8	1.01	0.39	22%	8%

Table D 8: Demand Shed on Auto-DR Days – Three Carnegie Plaza

Date	Period	kW		W / ft^2		WBP %	
		Max	Ave	Max	Ave	Max	Ave
CPP-1	Moderate Price (12 pm-3 pm)	56.6	24.6	0.68	0.29	24%	10%
	High Price (3 pm-6 pm)	31.7	-37.6	0.38	-0.45	13%	-16%
CPP-2	Moderate Price (12 pm-3 pm)	43.2	4.3	0.52	0.05	18%	2%
	High Price (3 pm-6 pm)	48.0	-23.2	0.57	-0.28	20%	-10%
CPP-3	Moderate Price (12 pm-3 pm)	2.9	-11.4	0.03	-0.14	1%	-5%
	High Price (3 pm-6 pm)	20.2	-20.9	0.24	-0.25	8%	-9%
CPP-4	Moderate Price (12 pm-3 pm)	63.4	50.6	0.76	0.60	27%	21%
	High Price (3 pm-6 pm)	68.2	51.6	0.81	0.62	29%	22%
CPP-5	Moderate Price (12 pm-3 pm)	69.1	54.5	0.83	0.65	27%	21%
	High Price (3 pm-6 pm)	86.4	54.2	1.03	0.65	34%	21%
CPP-6	Moderate Price (12 pm-3 pm)	71.0	50.5	0.85	0.60	28%	20%
	High Price (3 pm-6 pm)	64.3	45.0	0.77	0.54	25%	18%
CPP-7	Moderate Price (12 pm-3 pm)	111.4	101.1	1.33	1.21	36%	33%
	High Price (3 pm-6 pm)	84.5	50.6	1.01	0.61	27%	16%
CPP-8	Moderate Price (12 pm-3 pm)	90.2	77.5	1.08	0.93	29%	25%
	High Price (3 pm-6 pm)	66.2	32.8	0.79	0.39	21%	11%
CPP-9	Moderate Price (12 pm-3 pm)	82.6	66.1	0.99	0.79	28%	22%
	High Price (3 pm-6 pm)	72.0	56.4	0.86	0.67	25%	19%
CPP-10	Moderate Price (12 pm-3 pm)	74.9	59.2	0.89	0.71	25%	20%
	High Price (3 pm-6 pm)	63.4	43.2	0.76	0.52	22%	15%
CPP-11	Moderate Price (12 pm-3 pm)	64.3	51.3	0.77	0.61	23%	18%
	High Price (3 pm-6 pm)	58.6	37.2	0.70	0.44	21%	13%
Average	**Peak Period (12 pm-3 pm)**	74.4	55.1	0.89	0.66	27%	20%

TABLE D 9: DEMAND SHED ON AUTO-DR DAYS – BRIER CORPORATE CENTER

DATE	PERIOD	KW		W / FT²		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	45.6	25.6	0.54	0.31	11%	6%
	High Price (3 pm-6 pm)	24.0	-68.8	0.29	-0.82	6%	-16%
CPP-2	Moderate Price (12 pm-3 pm)	21.6	12.0	0.26	0.14	5%	3%
	High Price (3 pm-6 pm)	16.8	-51.8	0.20	-0.62	4%	-12%
CPP-3	Moderate Price (12 pm-3 pm)	12.0	0.8	0.14	0.01	3%	0%
	High Price (3 pm-6 pm)	26.4	-36.0	0.32	-0.43	6%	-8%
CPP-4	Moderate Price (12 pm-3 pm)	28.8	16.2	0.34	0.19	7%	4%
	High Price (3 pm-6 pm)	28.8	13.2	0.34	0.16	7%	3%
CPP-5	Moderate Price (12 pm-3 pm)	72.0	55.8	0.86	0.67	15%	12%
	High Price (3 pm-6 pm)	84.0	71.2	1.00	0.85	18%	15%
CPP-6	Moderate Price (12 pm-3 pm)	74.4	52.8	0.89	0.63	16%	11%
	High Price (3 pm-6 pm)	69.6	55.6	0.83	0.66	15%	12%
CPP-7	Moderate Price (12 pm-3 pm)	67.2	47.2	0.80	0.56	15%	10%
	High Price (3 pm-6 pm)	52.8	26.2	0.63	0.31	12%	6%
CPP-8	Moderate Price (12 pm-3 pm)	69.6	47.0	0.83	0.56	15%	10%
	High Price (3 pm-6 pm)	38.4	14.8	0.46	0.18	9%	3%
CPP-9	Moderate Price (12 pm-3 pm)	21.6	6.0	0.26	0.07	5%	1%
	High Price (3 pm-6 pm)	24.0	5.6	0.29	0.07	6%	1%
CPP-10	Moderate Price (12 pm-3 pm)	12.0	0.8	0.14	0.01	3%	0%
	High Price (3 pm-6 pm)	21.6	-2.4	0.26	-0.03	5%	-1%
CPP-11	Moderate Price (12 pm-3 pm)	57.6	39.8	0.69	0.48	12%	8%
	High Price (3 pm-6 pm)	38.4	25.6	0.46	0.31	8%	5%
Average	**Peak Period (12 pm-3 pm)**	47.6	29.7	0.57	0.35	10%	6%

TABLE D 10: DEMAND SHED ON AUTO-DR DAYS – VANDERBILT PLAZA

DATE	PERIOD	KW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	87.8	59.5	1.05	0.71	16%	11%
	High Price (3 pm-6 pm)	90.7	25.8	1.08	0.31	16%	5%
CPP-2	Moderate Price (12 pm-3 pm)	126.7	85.6	1.51	1.02	23%	15%
	High Price (3 pm-6 pm)	157.0	49.2	1.88	0.59	28%	9%
CPP-3	Moderate Price (12 pm-3 pm)	37.4	23.4	0.45	0.28	7%	4%
	High Price (3 pm-6 pm)	106.6	24.0	1.27	0.29	19%	4%
CPP-4	Moderate Price (12 pm-3 pm)	97.9	70.8	1.17	0.85	22%	16%
	High Price (3 pm-6 pm)	89.3	49.3	1.07	0.59	20%	11%
CPP-5	Moderate Price (12 pm-3 pm)	178.6	131.6	2.13	1.57	34%	25%
	High Price (3 pm-6 pm)	161.3	121.3	1.93	1.45	31%	23%
CPP-6	Moderate Price (12 pm-3 pm)	169.9	144.6	2.03	1.73	32%	28%
	High Price (3 pm-6 pm)	139.7	94.8	1.67	1.13	27%	18%
CPP-7	Moderate Price (12 pm-3 pm)	93.6	61.6	1.12	0.74	21%	14%
	High Price (3 pm-6 pm)	54.7	12.8	0.65	0.15	13%	3%
CPP-8	Moderate Price (12 pm-3 pm)	105.1	68.0	1.26	0.81	24%	16%
	High Price (3 pm-6 pm)	106.6	34.4	1.27	0.41	24%	8%
CPP-9	Moderate Price (12 pm-3 pm)	76.3	54.5	0.91	0.65	18%	13%
	High Price (3 pm-6 pm)	70.6	28.3	0.84	0.34	16%	7%
CPP-10	Moderate Price (12 pm-3 pm)	80.6	56.6	0.96	0.68	19%	13%
	High Price (3 pm-6 pm)	79.2	14.6	0.95	0.17	18%	3%
CPP-11	Moderate Price (12 pm-3 pm)	72.0	46.9	0.86	0.56	16%	10%
	High Price (3 pm-6 pm)	83.5	46.3	1.00	0.55	18%	10%
Average	**Peak Period (12 pm-3 pm)**	103.7	64.8	1.24	0.77	22%	14%

TABLE D 11: DEMAND SHED ON AUTO-DR DAYS – INLAND REGIONAL CENTER

DATE	PERIOD	kW		W / FT²		WBP%	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	30.7	0.2	0.37	0.00	7%	0%
	High Price (3 pm-6 pm)	31.2	-33.9	0.37	-0.41	7%	-8%
CPP-2	Moderate Price (12 pm-3 pm)	25.9	-8.8	0.31	-0.11	6%	-2%
	High Price (3 pm-6 pm)	42.7	-24.2	0.51	-0.29	10%	-6%
CPP-3	Moderate Price (12 pm-3 pm)	23.0	-9.7	0.28	-0.12	5%	-2%
	High Price (3 pm-6 pm)	33.6	-6.8	0.40	-0.08	8%	-2%
CPP-4	Moderate Price (12 pm-3 pm)	104.2	67.0	1.24	0.80	26%	17%
	High Price (3 pm-6 pm)	109.9	81.5	1.31	0.97	28%	20%
CPP-5	Moderate Price (12 pm-3 pm)	107.0	61.1	1.28	0.73	23%	13%
	High Price (3 pm-6 pm)	185.3	117.1	2.21	1.40	39%	25%
CPP-6	Moderate Price (12 pm-3 pm)	104.6	49.6	1.25	0.59	22%	11%
	High Price (3 pm-6 pm)	133.9	67.6	1.60	0.81	28%	14%
CPP-7	Moderate Price (12 pm-3 pm)	-9.6	-27.3	-0.11	-0.33	-3%	-7%
	High Price (3 pm-6 pm)	-1.9	-23.8	-0.02	-0.28	-1%	-6%
CPP-8	Moderate Price (12 pm-3 pm)	-9.6	-28.1	-0.11	-0.34	-3%	-7%
	High Price (3 pm-6 pm)	37.0	-27.7	0.44	-0.33	10%	-7%
CPP-9	Moderate Price (12 pm-3 pm)	49.4	7.9	0.59	0.09	13%	2%
	High Price (3 pm-6 pm)	82.1	32.1	0.98	0.38	22%	9%
CPP-10	Moderate Price (12 pm-3 pm)	55.7	12.0	0.67	0.14	15%	3%
	High Price (3 pm-6 pm)	58.6	20.3	0.70	0.24	16%	5%
CPP-11	Moderate Price (12 pm-3 pm)	103.2	72.2	1.23	0.86	21%	14%
	High Price (3 pm-6 pm)	139.2	86.1	1.66	1.03	28%	17%
Average	**Peak Period (12 pm-3 pm)**	78.1	35.5	0.93	0.42	18%	8%

DEMAND PLOT ON AUTO-DR EVENTS DAYS

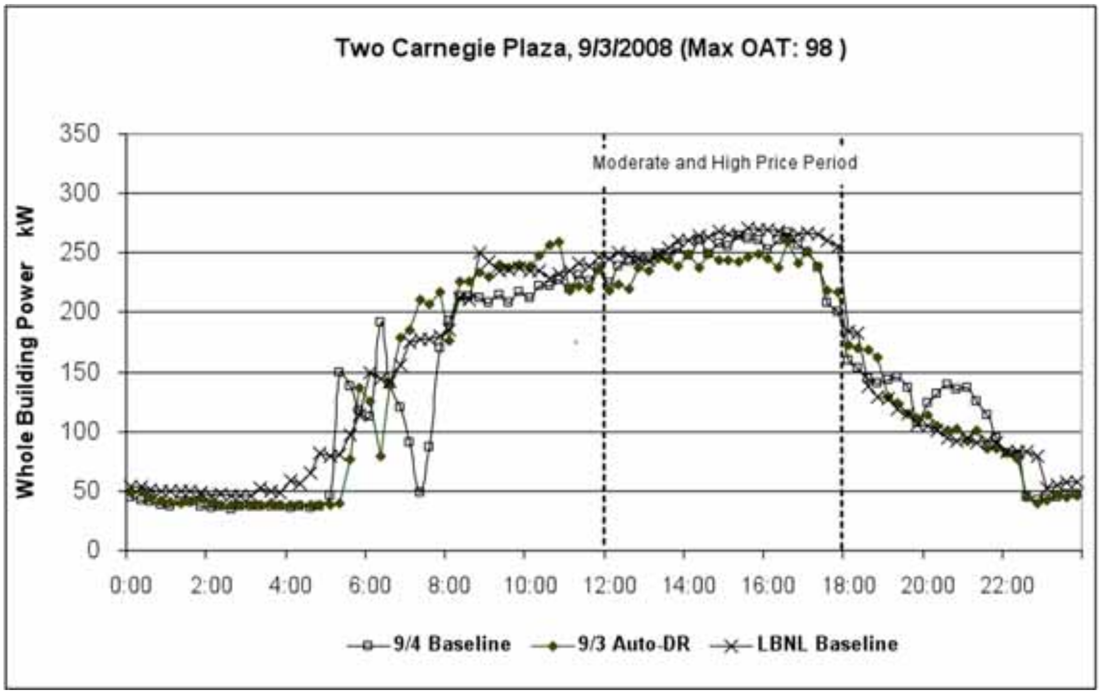

FIGURE D 1: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – TWO CARNEGIE PLAZA

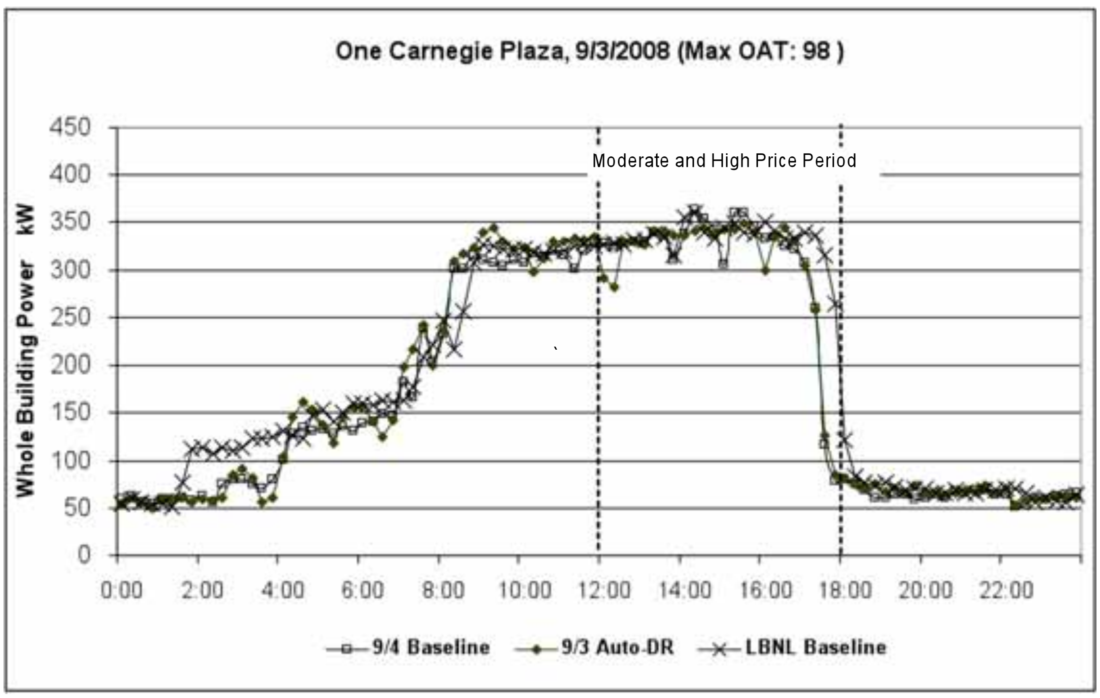

FIGURE D 2: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – ONE CARNEGIE PLAZA

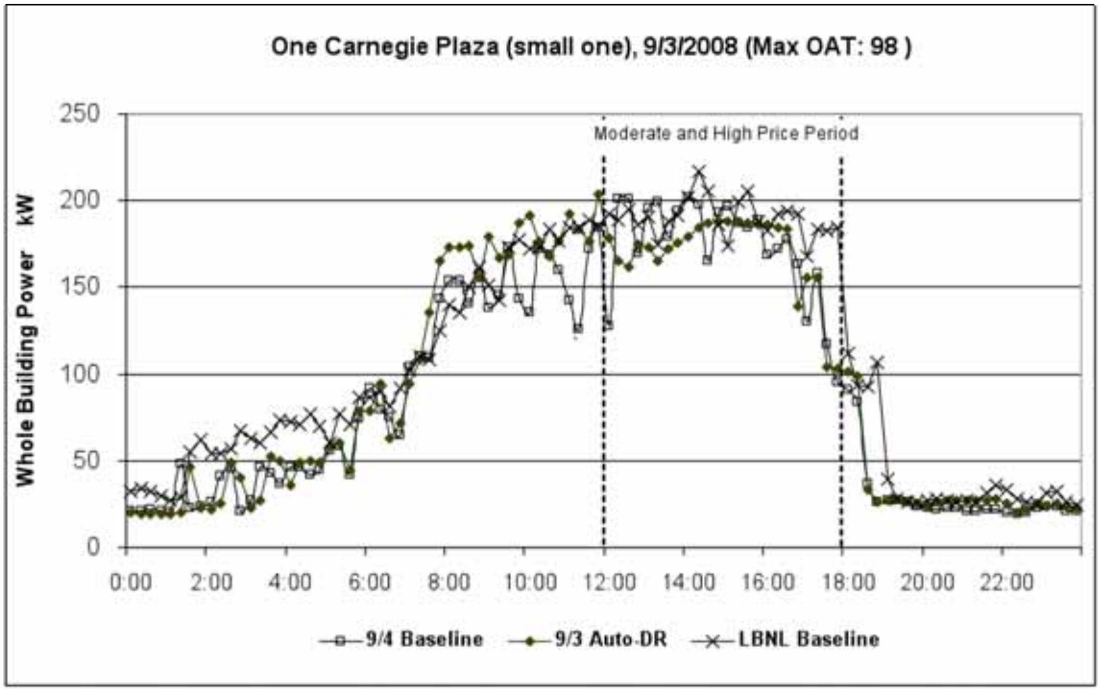

FIGURE D 3: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – ONE CARNEGIE PLAZA (SMALL ONE)

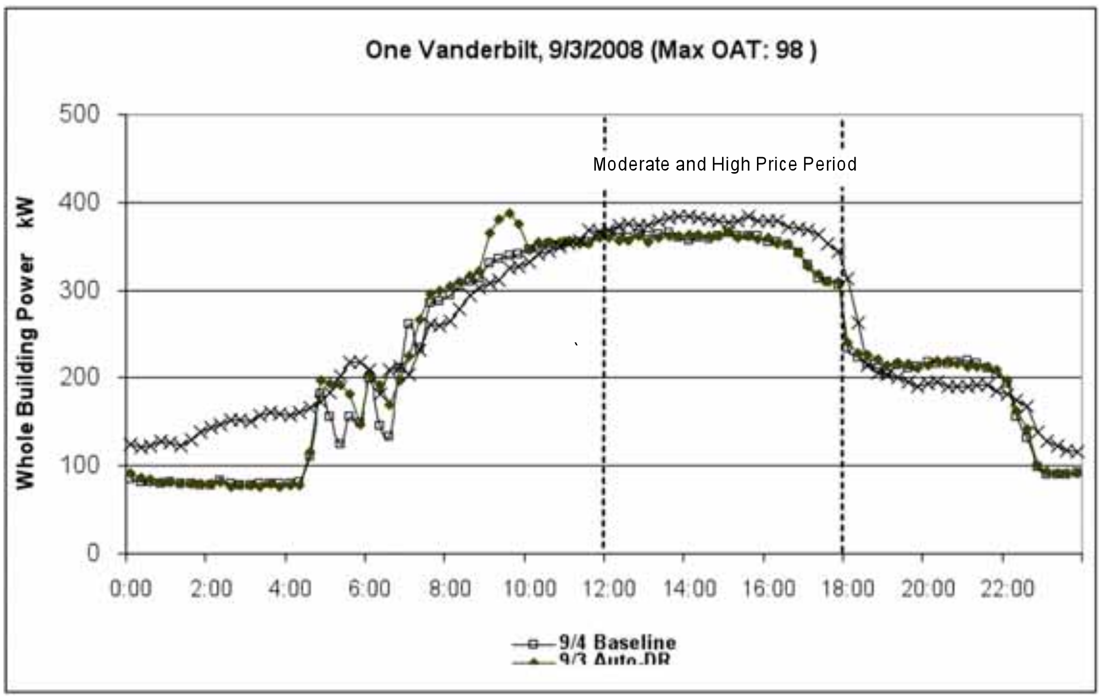

FIGURE D 4: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – ONE VANDERBILT

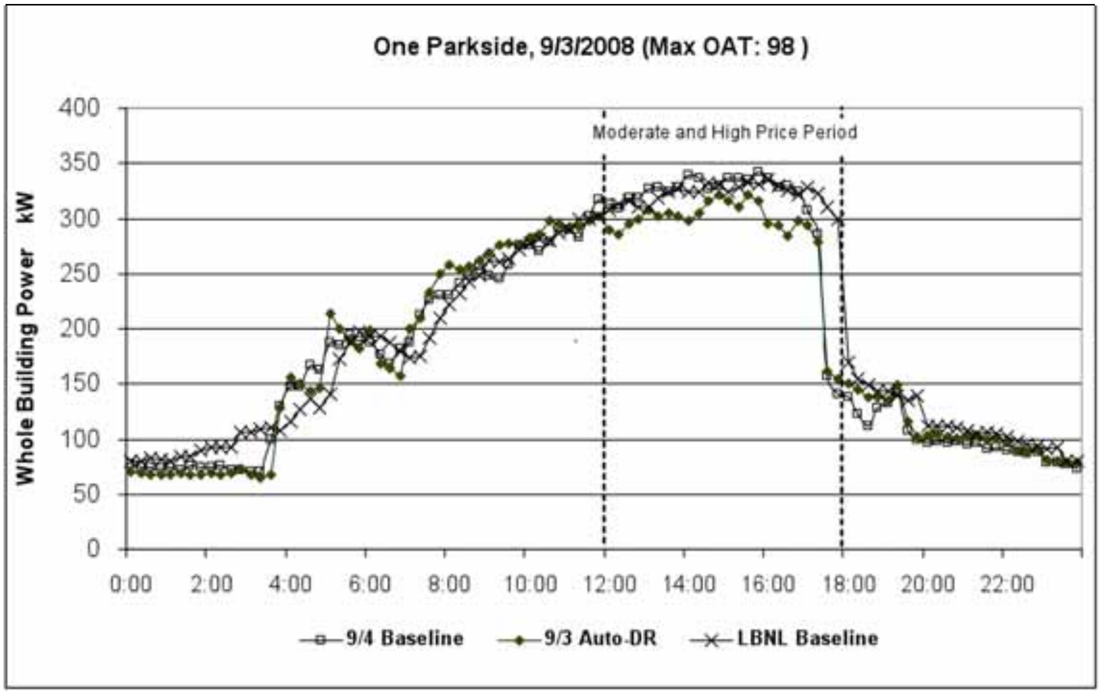

FIGURE D 5: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – ONE PARKSIDE

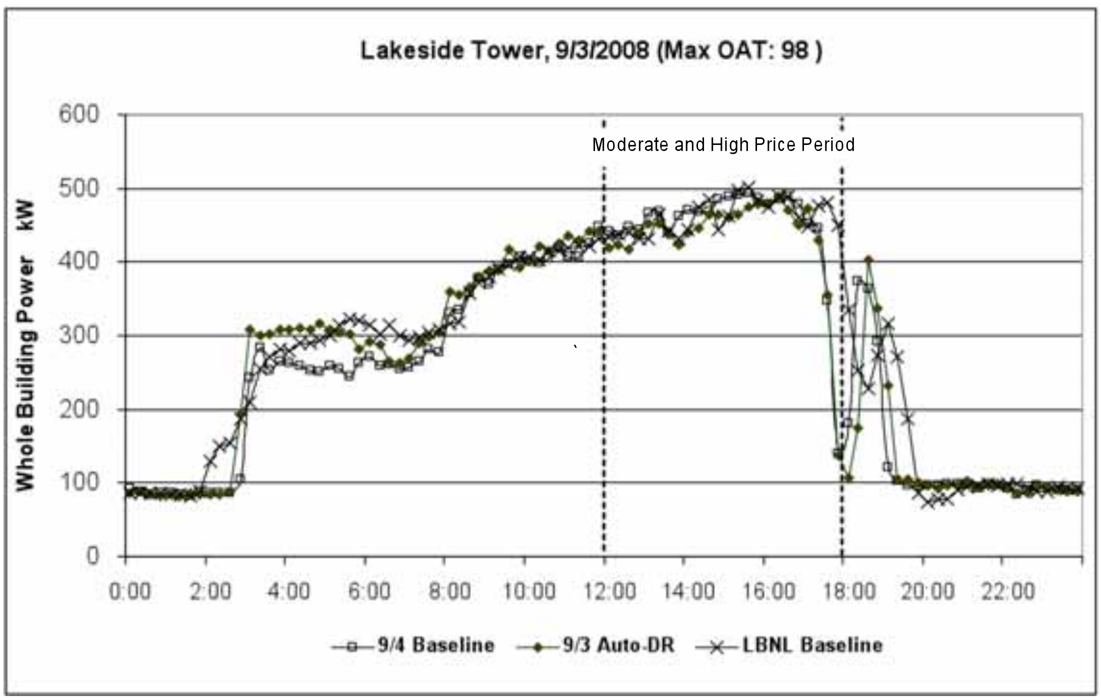

FIGURE D 6: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – LAKESIDE TOWER

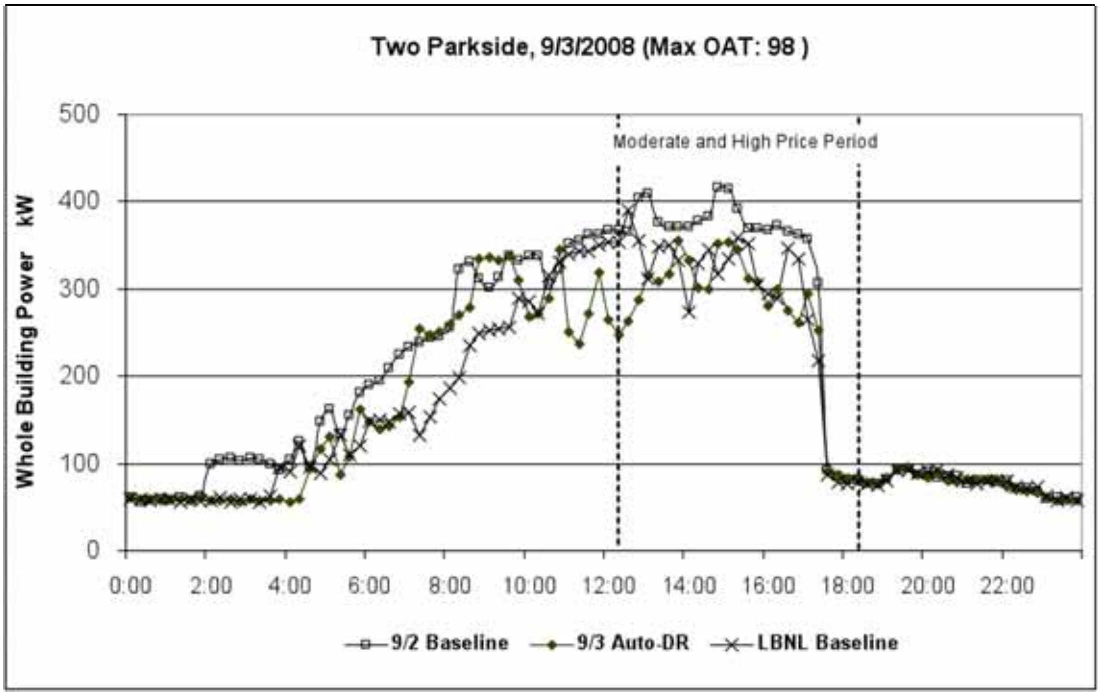

FIGURE D 7: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – TWO PARKSIDE

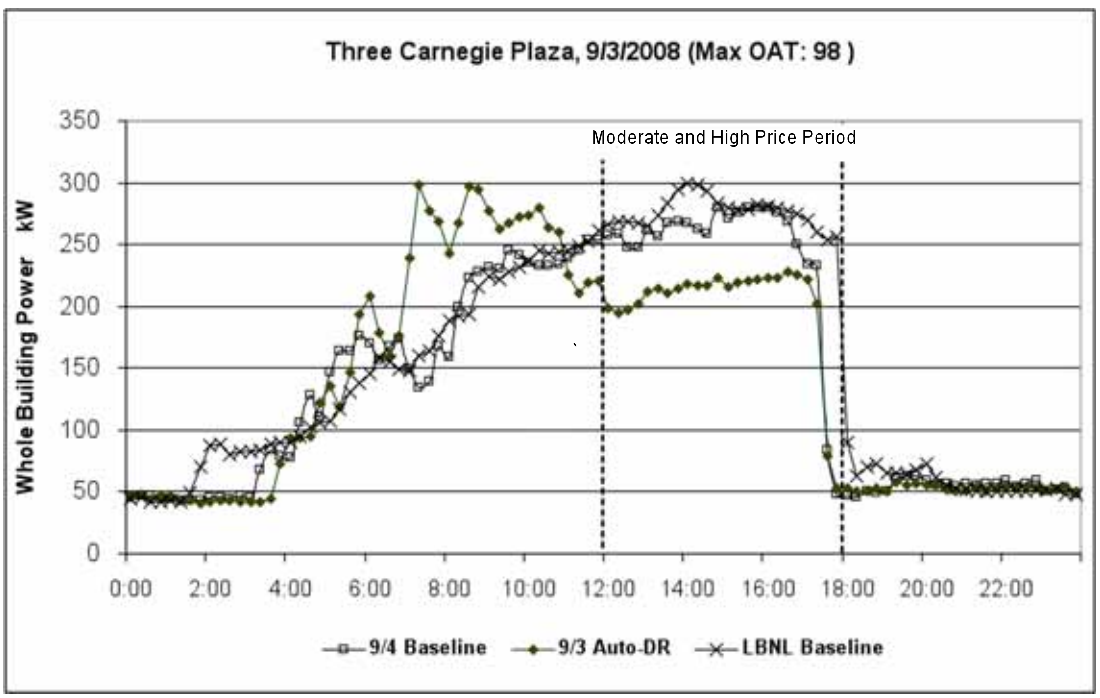

FIGURE D 8: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – THREE CARNEGIE PLAZA

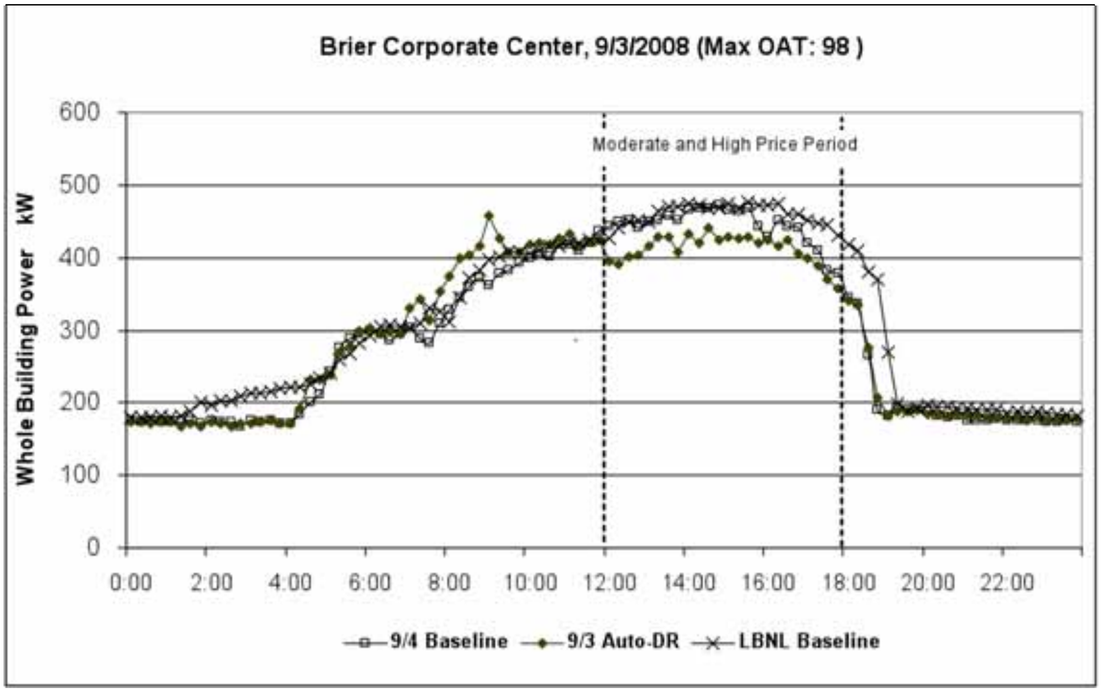

FIGURE D 9: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – BRIER CORPORATE CENTER

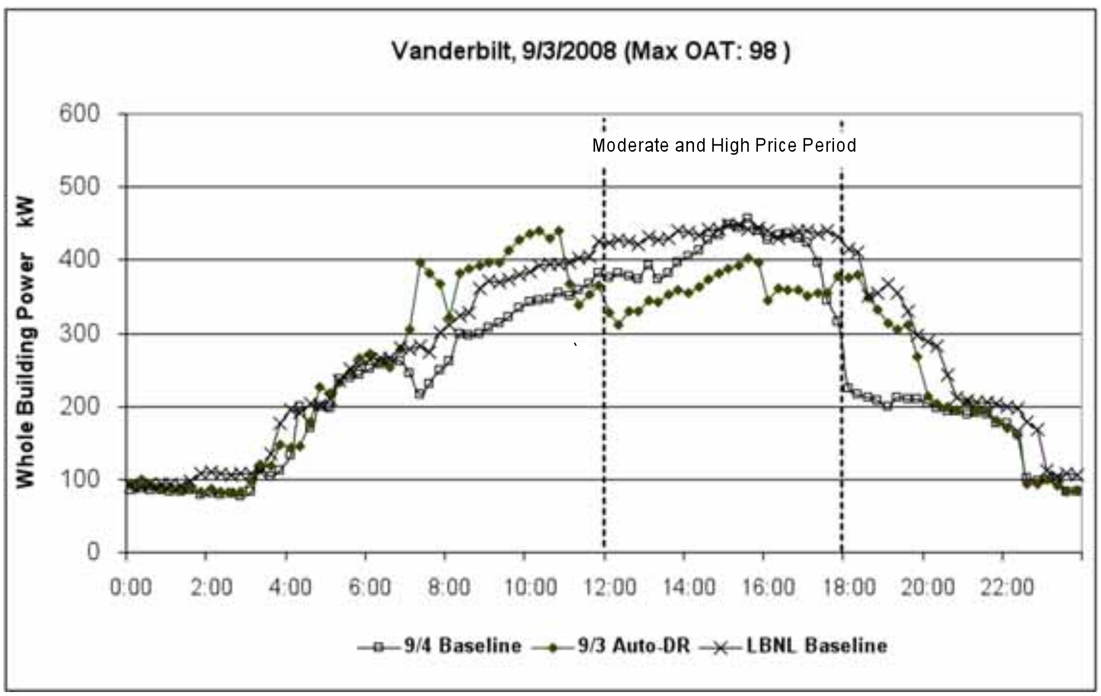

FIGURE D 10: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – VANDERBILT

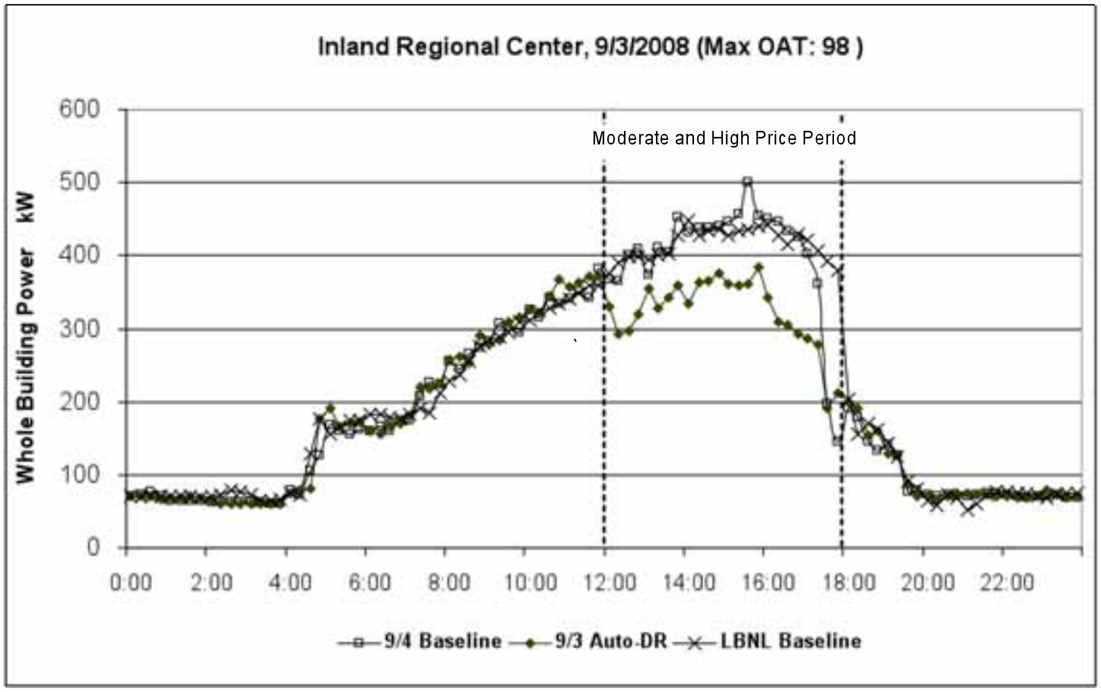

FIGURE D 11: FIELD TEST RESULTS OF PRE-COOLING STRATEGIES ON AUTO-DR DAY – INLAND REGIONAL CENTER

ECONOMIC ANALYSIS ON AUTO-DR EVENTS DAYS

TABLE D 12: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – TWO CARNEGIE PLAZA

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	3,715	1,352	293	4,667
	Actual Auto-DR Event	3,535	1,234	301	4,795
	Savings	180	118	-8	-127
CPP-2	Baseline	3,715	1,352	293	4,667
	Actual Auto-DR Event	3,678	1,311	276	4,397
	Savings	37	41	17	271
CPP-3	Baseline	3,715	1,352	293	4,667
	Actual Auto-DR Event	3,768	1,375	281	4,476
	Savings	-53	-23	12	191
CPP-4	Baseline	3,225	1,201	244	3,887
	Actual Auto-DR Event	3,127	1,128	224	3,568
	Savings	98	73	20	319
CPP-5	Baseline	3,374	1,288	264	4,206
	Actual Auto-DR Event	3,329	1,213	244	3,887
	Savings	45	75	20	319
CPP-6	Baseline	3,374	1,288	264	4,206
	Actual Auto-DR Event	3,398	1,243	240	3,823
	Savings	-24	45	24	382
CPP-7	Baseline	3,068	1,156	249	3,967
	Actual Auto-DR Event	3,413	1,191	219	3,489
	Savings	-345	-35	30	478
CPP-8	Baseline	3,068	1,156	249	3,967
	Actual Auto-DR Event	3,156	1,153	223	3,552
	Savings	-88	3	26	414
CPP-9	Baseline	3,064	1,184	243	3,871
	Actual Auto-DR Event	3,289	1,193	235	3,744
	Savings	-225	-9	8	127

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
CPP-10	Baseline	3,064	1,184	243	3,871
	Actual Auto-DR Event	3,335	1,207	237	3,775
	Savings	-271	-23	6	96
CPP-11	Baseline	3,537	1,348	267	4,253
	Actual Auto-DR Event	3,563	1,326	260	4,142
	Savings	-26	22	7	112
Average Savings		**293**	**-105**	**19**	**281**

TABLE D 13: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – ONE CARNEGIE PLAZA

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	4,726	1,657	344	5,480
	Actual Auto-DR Event	4,383	1,660	377	6,006
	Savings	343	-3	-33	-526
CPP-2	Baseline	4,726	1,657	344	5,480
	Actual Auto-DR Event	4,484	1,663	363	5,783
	Savings	242	-6	-19	-303
CPP-3	Baseline	4,726	1,657	344	5,480
	Actual Auto-DR Event	4,683	1,635	345	5,496
	Savings	43	22	-1	-16
CPP-4	Baseline	5,480	1,317	345	5,496
	Actual Auto-DR Event	4,235	1,184	356	5,671
	Savings	1,245	133	-11	-175
CPP-5	Baseline	4,474	1,682	368	5,862
	Actual Auto-DR Event	4,537	1,653	354	5,639
	Savings	-63	29	14	223
CPP-6	Baseline	4,474	1,682	368	5,862
	Actual Auto-DR Event	4,400	1,651	368	5,862
	Savings	74	31	0	0
CPP-7	Baseline	4,474	1,682	368	5,862
	Actual Auto-DR Event	4,501	1,570	331	5,273
	Savings	-27	112	37	589
CPP-8	Baseline	4,474	1,682	368	5,862
	Actual Auto-DR Event	4,112	1,557	355	5,655
	Savings	362	125	13	207
CPP-9	Baseline	4,474	1,682	368	5,862
	Actual Auto-DR Event	4,278	1,603	365	5,814
	Savings	196	79	3	48
CPP-10	Baseline	4,474	1,682	368	5,862
	Actual Auto-DR Event	4,404	1,644	364	5,799

Date	Index	Energy: Consumption (kWh)	Energy: Charge ($)	Demand: Max Demand On Peak (kW)	Demand: Demand Savings ($)
	Savings	70	38	4	64
CPP-11	Baseline	4,932	1,777	362	5,767
	Actual Auto-DR Event	4,416	1,646	349	5,560
	Savings	516	131	13	207
Average Savings		**293**	**206**	**62**	**992**

TABLE D 14: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – ONE CARNEGIE PLAZA (SMALL ONE)

Date	Index	Energy: Consumption (kWh)	Energy: Charge ($)	Demand: Max Demand On Peak (kW)	Demand: Demand Savings ($)
CPP-1	Baseline	2,396	881	192	3,059
	Actual Auto-DR Event	2,037	822	194	3,090
	Savings	359	59	-2	-32
CPP-2	Baseline	2,396	881	192	3,059
	Actual Auto-DR Event	2,181	875	218	3,473
	Savings	215	6	-26	-414
CPP-3	Baseline	2,396	881	192	3,059
	Actual Auto-DR Event	2,248	877	186	2,963
	Savings	148	4	6	96
CPP-4	Baseline	2,997	1,026	210	3,345
	Actual Auto-DR Event	2,074	783	196	3,122
	Savings	923	243	14	223
CPP-5	Baseline	2,454	974	221	3,521
	Actual Auto-DR Event	2,343	883	199	3,170
	Savings	111	91	22	350
CPP-6	Baseline	2,454	974	221	3,521
	Actual Auto-DR Event	2,324	890	199	3,170
	Savings	130	84	22	350
CPP-7	Baseline	2,273	872	197	3,138
	Actual Auto-DR Event	2,329	807	166	2,644
	Savings	-56	65	31	494
CPP-8	Baseline	2,273	872	197	3,138
	Actual Auto-DR Event	1,932	748	162	2,581
	Savings	341	124	35	558
CPP-9	Baseline	1,999	772	179	2,851
	Actual Auto-DR Event	2,177	823	195	3,106
	Savings	-178	-51	-16	-255
CPP-10	Baseline	1,999	772	179	2,851
	Actual Auto-DR Event	2,198	813	180	2,867

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
	Savings	-199	-41	-1	-16
CPP-11	Baseline	2,249	887	202	3,218
	Actual Auto-DR Event	2,347	899	188	2,995
	Savings	-98	-12	14	223
Average Savings		**122**	**63**	**15**	**315**

TABLE D 15: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – ONE VANDERBILT

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	6,849	2,287	419	6,675
	Actual Auto-DR Event	6,404	2,256	417	6,643
	Savings	445	31	2	32
CPP-2	Baseline	6,849	2,287	419	6,675
	Actual Auto-DR Event	6,380	2,247	420	6,691
	Savings	469	40	-1	-16
CPP-3	Baseline	6,849	2,287	419	6,675
	Actual Auto-DR Event	6,756	2,290	416	6,627
	Savings	93	-3	3	48
CPP-4	Baseline	7,550	2,464	435	6,930
	Actual Auto-DR Event	6,109	2,175	404	6,436
	Savings	1,441	289	31	494
CPP-5	Baseline	6,730	2,400	445	7,089
	Actual Auto-DR Event	6,623	2,331	432	6,882
	Savings	107	69	13	207
CPP-6	Baseline	6,730	2,400	445	7,089
	Actual Auto-DR Event	6,525	2,332	431	6,866
	Savings	205	68	14	223
CPP-7	Baseline	6,473	2,280	425	6,770
	Actual Auto-DR Event	6,688	2,277	416	6,627
	Savings	-215	3	9	143
CPP-8	Baseline	6,473	2,280	425	6,770
	Actual Auto-DR Event	6,055	2,200	415	6,611
	Savings	418	80	10	159
CPP-9	Baseline	6,817	2,356	429	6,834
	Actual Auto-DR Event	6,248	2,126	407	6,484
	Savings	569	230	22	350
CPP-10	Baseline	6,817	2,356	429	6,834
	Actual Auto-DR Event	6,191	2,187	408	6,499

Date	Index	Energy: Consumption (kWh)	Energy: Charge ($)	Demand: Max Demand On Peak (kW)	Demand: Demand Savings ($)
	Savings	626	169	21	335
CPP-11	Baseline	5,575	1,992	365	5,814
	Actual Auto-DR Event	5,704	2,013	367	5,846
	Savings	-129	-21	-2	-32
Average Savings		**378**	**111**	**15**	**315**

TABLE D 16: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – ONE PARKSIDE

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	4,457	1,561	317	5,050
	Actual Auto-DR Event	4,204	1,551	324	5,161
	Savings	253	10	-7	-112
CPP-2	Baseline	4,457	1,561	317	5,050
	Actual Auto-DR Event	4,250	1,562	327	5,209
	Savings	207	-1	-10	-159
CPP-3	Baseline	4,457	1,561	317	5,050
	Actual Auto-DR Event	4,412	1,570	325	5,177
	Savings	45	-9	-8	-127
CPP-4	Baseline	4,044	1,485	303	4,827
	Actual Auto-DR Event	4,247	1,516	308	4,906
	Savings	-203	-31	-5	-80
CPP-5	Baseline	4,418	1,629	341	5,432
	Actual Auto-DR Event	4,314	1,542	311	4,954
	Savings	104	87	30	478
CPP-6	Baseline	4,418	1,629	341	5,432
	Actual Auto-DR Event	4,240	1,548	324	5,161
	Savings	178	81	17	271
CPP-7	Baseline	4,316	1,566	325	5,177
	Actual Auto-DR Event	4,262	1,466	294	4,683
	Savings	54	100	31	494
CPP-8	Baseline	4,316	1,566	325	5,177
	Actual Auto-DR Event	4,001	1,441	293	4,667
	Savings	315	125	32	510
CPP-9	Baseline	4,470	1,610	332	5,289
	Actual Auto-DR Event	4,297	1,487	293	4,667
	Savings	173	123	39	621
CPP-10	Baseline	4,470	1,610	332	5,289
	Actual Auto-DR Event	4,201	1,502	293	4,667

Date	Index	Energy: Consumption (kWh)	Energy: Charge ($)	Demand: Max Demand On Peak (kW)	Demand: Demand Savings ($)
	Savings	269	108	39	621
CPP-11	Baseline	4,598	1,688	342	5,448
	Actual Auto-DR Event	4,529	1,615	322	5,129
	Savings	69	73	20	319
Average Savings		**120**	**83**	**25**	**404**

TABLE D 17: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – LAKESIDE TOWER

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	6,775	2,303	474	7,285
	Actual Auto-DR Event	6,562	2,240	560	8,607
	Savings	213	63	-86	-1,322
CPP-2	Baseline	6,775	2,303	474	7,285
	Actual Auto-DR Event	6,552	2,217	526	8,085
	Savings	223	86	-52	-799
CPP-3	Baseline	6,775	2,303	474	7,285
	Actual Auto-DR Event	7,005	2,337	483	7,424
	Savings	-230	-34	-9	-138
CPP-4	Baseline	5,958	2,069	444	6,824
	Actual Auto-DR Event	5,768	1,907	427	6,563
	Savings	190	162	17	261
CPP-5	Baseline	7,452	2,540	517	7,946
	Actual Auto-DR Event	6,367	2,005	506	7,777
	Savings	1,085	535	11	169
CPP-6	Baseline	7,452	2,540	517	7,946
	Actual Auto-DR Event	6,308	2,030	506	7,777
	Savings	1,144	510	11	169
CPP-7	Baseline	6,860	2,318	495	7,608
	Actual Auto-DR Event	5,964	1,859	520	7,992
	Savings	896	459	-25	-384
CPP-8	Baseline	6,860	2,318	495	7,608
	Actual Auto-DR Event	5,716	1,912	536	8,238
	Savings	1,144	406	-41	-630
CPP-9	Baseline	7,452	2,540	517	7,946
	Actual Auto-DR Event	6,086	1,957	531	8,161
	Savings	1,366	583	-14	-215
CPP-10	Baseline	7,452	2,540	517	7,946
	Actual Auto-DR Event	6,500	2,161	552	8,484

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
	Savings	952	379	-35	-538
CPP-11	Baseline	7,704	2,623	558	8,576
	Actual Auto-DR Event	6,751	2,290	490	7,531
	Savings	953	333	68	1,045
Average Savings		**966**	**421**	**-1**	**-15**

TABLE D 18: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – TWO PARKSIDE

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	4,730	1,765	399	6,356
	Actual Auto-DR Event	4,218	1,616	360	5,735
	Savings	512	149	39	621
CPP-2	Baseline	4,730	1,765	399	6,356
	Actual Auto-DR Event	4,324	1,653	390	6,213
	Savings	406	112	9	143
CPP-3	Baseline	4,730	1,765	399	6,356
	Actual Auto-DR Event	4,731	1,762	402	6,404
	Savings	-1	3	-3	-48
CPP-4	Baseline	3,585	1,422	344	5,480
	Actual Auto-DR Event	3,704	1,364	312	4,970
	Savings	-119	58	32	510
CPP-5	Baseline	4,518	1,829	412	6,563
	Actual Auto-DR Event	4,190	1,520	347	5,528
	Savings	328	309	65	1,035
CPP-6	Baseline	4,518	1,829	412	6,563
	Actual Auto-DR Event	3,924	1,452	339	5,400
	Savings	594	377	73	1,163
CPP-7	Baseline	4,229	1,630	392	6,245
	Actual Auto-DR Event	4,232	1,524	339	5,400
	Savings	-3	106	53	844
CPP-8	Baseline	4,229	1,630	392	6,245
	Actual Auto-DR Event	3,912	1,495	340	5,416
	Savings	317	135	52	828
CPP-9	Baseline	3,637	1,396	299	4,763
	Actual Auto-DR Event	4,238	1,531	337	5,368
	Savings	-601	-135	-38	-605
CPP-10	Baseline	3,637	1,396	299	4,763
	Actual Auto-DR Event	4,004	1,464	298	4,747

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
	Savings	-367	-68	1	16
CPP-11	Baseline	4,930	1,849	417	6,643
	Actual Auto-DR Event	4,164	1,531	356	5,671
	Savings	766	318	61	972
Average Savings		**114**	**138**	**37**	**595**

TABLE D 19: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – THREE CARNEGIE PLAZA

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	3,228	1,113	239	3,807
	Actual Auto-DR Event	3,003	1,139	348	5,544
	Savings	225	-26	-109	-1,736
CPP-2	Baseline	3,228	1,113	239	3,807
	Actual Auto-DR Event	2,997	1,094	276	4,397
	Savings	231	19	-37	-589
CPP-3	Baseline	3,228	1,113	239	3,807
	Actual Auto-DR Event	3,468	1,208	252	4,014
	Savings	-240	-95	-13	-207
CPP-4	Baseline	2,909	1,096	239	3,807
	Actual Auto-DR Event	2,715	905	172	2,740
	Savings	194	191	67	1,067
CPP-5	Baseline	3,250	1,199	254	4,046
	Actual Auto-DR Event	3,009	994	189	3,011
	Savings	241	205	65	1,035
CPP-6	Baseline	3,250	1,199	254	4,046
	Actual Auto-DR Event	3,030	1,020	192	3,059
	Savings	220	179	62	988
CPP-7	Baseline	3,822	1,417	311	4,954
	Actual Auto-DR Event	3,343	1,136	228	3,632
	Savings	479	281	83	1,322
CPP-8	Baseline	3,822	1,417	311	4,954
	Actual Auto-DR Event	3,280	1,190	254	4,046
	Savings	542	227	57	908
CPP-9	Baseline	3,643	1,386	294	4,683
	Actual Auto-DR Event	3,272	1,142	228	3,632
	Savings	371	244	66	1,051
CPP-10	Baseline	3,643	1,386	294	4,683
	Actual Auto-DR Event	3,415	1,199	248	3,951

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
	Savings	228	187	46	733
CPP-11	Baseline	3,515	1,312	280	4,460
	Actual Auto-DR Event	3,450	1,175	228	3,632
	Savings	65	137	52	828
Average Savings		**293**	**206**	**62**	**992**

TABLE D 20: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – BRIER CORPORATE CENTER

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	6,626	2,238	430	6,850
	Actual Auto-DR Event	6,803	2,386	494	7,869
	Savings	-177	-148	-64	-1,020
CPP-2	Baseline	6,626	2,238	430	6,850
	Actual Auto-DR Event	6,786	2,322	418	6,659
	Savings	-160	-84	12	191
CPP-3	Baseline	6,626	2,238	430	6,850
	Actual Auto-DR Event	6,742	2,326	422	6,722
	Savings	-116	-88	8	127
CPP-4	Baseline	6,497	2,241	406	6,468
	Actual Auto-DR Event	6,473	2,192	391	6,229
	Savings	24	49	15	239
CPP-5	Baseline	7,226	2,549	470	7,487
	Actual Auto-DR Event	6,817	2,278	413	6,579
	Savings	409	271	57	908
CPP-6	Baseline	7,226	2,549	470	7,487
	Actual Auto-DR Event	6,907	2,327	422	6,722
	Savings	319	222	48	765
CPP-7	Baseline	6,949	2,373	451	7,184
	Actual Auto-DR Event	6,704	2,232	401	6,388
	Savings	245	141	50	797
CPP-8	Baseline	6,949	2,373	451	7,184
	Actual Auto-DR Event	6,682	2,258	413	6,579
	Savings	267	115	38	605
CPP-9	Baseline	6,673	2,292	425	6,770
	Actual Auto-DR Event	6,894	2,310	418	6,659
	Savings	-221	-18	7	112
CPP-10	Baseline	6,673	2,292	425	6,770
	Actual Auto-DR Event	7,027	2,351	427	6,802

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
	Savings	-354	-59	-2	-32
CPP-11	Baseline	7,154	2,519	473	7,535
	Actual Auto-DR Event	7,131	2,425	442	7,041
	Savings	23	94	31	494
Average Savings		**89**	**102**	**31**	**486**

TABLE D 21: SUMMARY OF ENERGY AND DEMAND SAVINGS FOR AUTO-DR EVENTS – VANDERBILT PLAZA

DATE	INDEX	ENERGY		DEMAND	
		CONSUMPTION (KWH)	CHARGE ($)	MAX DEMAND ON PEAK (KW)	DEMAND SAVINGS ($)
CPP-1	Baseline	8,160	2,818	563	8,969
	Actual Auto-DR Event	6,583	2,459	492	7,838
	Savings	1,577	359	71	1,131
CPP-2	Baseline	8,160	2,818	563	8,969
	Actual Auto-DR Event	6,324	2,292	442	7,041
	Savings	1,836	526	121	1,928
CPP-3	Baseline	8,160	2,818	563	8,969
	Actual Auto-DR Event	7,611	2,657	495	7,885
	Savings	549	161	68	1,083
CPP-4	Baseline	5,882	2,213	439	6,993
	Actual Auto-DR Event	5,675	2,006	399	6,356
	Savings	207	207	40	637
CPP-5	Baseline	6,891	2,614	524	8,347
	Actual Auto-DR Event	6,402	2,154	433	6,898
	Savings	489	460	91	1,450
CPP-6	Baseline	6,891	2,614	524	8,347
	Actual Auto-DR Event	6,346	2,187	431	6,866
	Savings	545	427	93	1,481
CPP-7	Baseline	5,925	2,182	438	6,977
	Actual Auto-DR Event	6,925	2,264	436	6,945
	Savings	-1,000	-82	2	32
CPP-8	Baseline	5,925	2,182	438	6,977
	Actual Auto-DR Event	6,286	2,111	521	8,300
	Savings	-361	71	-83	-1,322
CPP-9	Baseline	6,055	2,188	433	6,898
	Actual Auto-DR Event	6,353	2,127	400	6,372
	Savings	-298	61	33	526
CPP-10	Baseline	6,055	2,188	433	6,898
	Actual Auto-DR Event	6,289	2,144	508	8,092

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
	Savings	-234	44	-75	-1,195
CPP-11	Baseline	6,033	2,251	456	7,264
	Actual Auto-DR Event	6,427	2,177	402	6,404
	Savings	-394	74	54	860
Average Savings		**-131**	**158**	**19**	**309**

Table D 22: Summary of Energy and Demand Savings for Auto-DR events – Inland Regional Center

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
CPP-1	Baseline	5,121	1,918	420	6,691
	Actual Auto-DR Event	4,566	1,903	492	7,838
	Savings	555	15	-72	-1,147
CPP-2	Baseline	5,121	1,918	420	6,691
	Actual Auto-DR Event	4,607	1,877	509	8,108
	Savings	514	41	-89	-1,418
CPP-3	Baseline	5,121	1,918	420	6,691
	Actual Auto-DR Event	4,962	1,914	440	7,009
	Savings	159	4	-20	-319
CPP-4	Baseline	4,656	1,832	399	6,356
	Actual Auto-DR Event	4,027	1,492	322	5,129
	Savings	629	340	77	1,227
CPP-5	Baseline	5,137	2,061	471	7,503
	Actual Auto-DR Event	4,608	1,655	351	5,591
	Savings	529	406	120	1,912
CPP-6	Baseline	6,891	2,614	524	8,347
	Actual Auto-DR Event	4,703	1,799	387	6,165
	Savings	2,188	815	137	2,182
CPP-7	Baseline	4,492	1,747	377	6,006
	Actual Auto-DR Event	4,859	1,882	403	6,420
	Savings	-367	-135	-26	-414
CPP-8	Baseline	4,492	1,747	377	6,006
	Actual Auto-DR Event	4,581	1,849	418	6,659
	Savings	-89	-102	-41	-653
CPP-9	Baseline	4,318	1,702	372	5,926
	Actual Auto-DR Event	4,454	1,649	357	5,687
	Savings	-136	53	15	239
CPP-10	Baseline	4,318	1,702	372	5,926
	Actual Auto-DR Event	4,565	1,687	355	5,655

Date	Index	Energy		Demand	
		Consumption (kWh)	Charge ($)	Max Demand On Peak (kW)	Demand Savings ($)
	Savings	-247	15	17	271
CPP-11	Baseline	5,097	2,061	501	7,981
	Actual Auto-DR Event	4,683	1,742	385	6,133
	Savings	414	319	116	1,848
Average Savings		**365**	**214**	**52**	**826**

APPENDIX E – SIMULATION RESULTS OF RECALIBRATED MODEL

TABLE E 1: SIMULATION RESULTS OF RECALIBRATED MODEL ON CPP DAYS – TWO CARNEGIE PLAZA

DATE	PERIOD	KW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	66.2	37.0	0.96	0.54	25%	14%
	High Price (3 pm-6 pm)	62.9	33.0	0.91	0.48	24%	13%
CPP-2	Moderate Price (12 pm-3 pm)	55.5	31.2	0.81	0.45	24%	13%
	High Price (3 pm-6 pm)	55.8	30.3	0.81	0.44	24%	13%
CPP-3	Moderate Price (12 pm-3 pm)	82.6	41.3	1.20	0.60	30%	15%
	High Price (3 pm-6 pm)	71.6	41.0	1.04	0.59	26%	15%
CPP-4	Moderate Price (12 pm-3 pm)	82.7	42.5	1.20	0.62	29%	15%
	High Price (3 pm-6 pm)	78.2	42.9	1.13	0.62	27%	15%
CPP-5	Moderate Price (12 pm-3 pm)	113.1	54.2	1.64	0.79	36%	17%
	High Price (3 pm-6 pm)	89.7	44.5	1.30	0.65	28%	14%
CPP-6	Moderate Price (12 pm-3 pm)	111.9	50.8	1.62	0.74	38%	17%
	High Price (3 pm-6 pm)	76.2	38.8	1.10	0.56	26%	13%
CPP-7	Moderate Price (12 pm-3 pm)	113.2	47.1	1.64	0.68	36%	15%
	High Price (3 pm-6 pm)	82.0	42.5	1.19	0.62	26%	14%
CPP-8	Moderate Price (12 pm-3 pm)	111.5	47.0	1.62	0.68	37%	16%
	High Price (3 pm-6 pm)	79.9	42.0	1.16	0.61	27%	14%
CPP-9	Moderate Price (12 pm-3 pm)	81.2	38.7	1.18	0.56	31%	15%
	High Price (3 pm-6 pm)	79.9	37.0	1.16	0.54	30%	14%
CPP-10	Moderate Price (12 pm-3 pm)	85.2	42.0	1.24	0.61	32%	16%
	High Price (3 pm-6 pm)	70.5	35.9	1.02	0.52	27%	14%
CPP-11	Moderate Price (12 pm-3 pm)	80.4	41.0	1.17	0.59	30%	15%
	High Price (3 pm-6 pm)	69.9	36.1	1.01	0.52	26%	13%
CPP-12	Moderate Price (12 pm-3 pm)	76.5	39.4	1.11	0.57	30%	15%
	High Price (3 pm-6 pm)	61.2	31.3	0.89	0.45	24%	12%
Average	**Peak Period (12 pm-3 pm)**	**80.7**	**40.3**	**1.17**	**0.58**	**29%**	**14%**

TABLE E 2: SIMULATION RESULTS OF RECALIBRATED MODEL ON CPP DAYS – ONE CARNEGIE PLAZA

DATE	PERIOD	KW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	78.6	37.2	1.25	0.59	25%	12%
	High Price (3 pm-6 pm)	59.9	30.1	0.95	0.48	19%	10%
CPP-2	Moderate Price (12 pm-3 pm)	69.5	32.7	1.11	0.52	24%	11%
	High Price (3 pm-6 pm)	54.3	27.5	0.86	0.44	19%	10%
CPP-3	Moderate Price (12 pm-3 pm)	93.8	40.9	1.49	0.65	29%	12%
	High Price (3 pm-6 pm)	67.3	36.6	1.07	0.58	21%	11%
CPP-4	Moderate Price (12 pm-3 pm)	95.8	42.4	1.52	0.68	28%	13%
	High Price (3 pm-6 pm)	74.4	38.8	1.19	0.62	22%	11%
CPP-5	Moderate Price (12 pm-3 pm)	125.8	53.7	2.00	0.85	34%	15%
	High Price (3 pm-6 pm)	84.2	40.1	1.34	0.64	23%	11%
CPP-6	Moderate Price (12 pm-3 pm)	124.7	50.5	1.99	0.80	35%	14%
	High Price (3 pm-6 pm)	71.8	35.1	1.14	0.56	20%	10%
CPP-7	Moderate Price (12 pm-3 pm)	120.2	47.9	1.91	0.76	33%	13%
	High Price (3 pm-6 pm)	77.0	38.9	1.23	0.62	21%	11%
CPP-8	Moderate Price (12 pm-3 pm)	116.6	46.9	1.86	0.75	33%	13%
	High Price (3 pm-6 pm)	75.2	38.2	1.20	0.61	21%	11%
CPP-9	Moderate Price (12 pm-3 pm)	93.1	38.7	1.48	0.62	30%	12%
	High Price (3 pm-6 pm)	75.2	33.6	1.20	0.54	24%	11%
CPP-10	Moderate Price (12 pm-3 pm)	98.7	42.2	1.57	0.67	31%	13%
	High Price (3 pm-6 pm)	68.1	33.3	1.09	0.53	21%	10%
CPP-11	Moderate Price (12 pm-3 pm)	92.4	41.0	1.47	0.65	28%	13%
	High Price (3 pm-6 pm)	67.0	32.9	1.07	0.52	20%	10%
CPP-12	Moderate Price (12 pm-3 pm)	88.5	39.5	1.41	0.63	28%	13%
	High Price (3 pm-6 pm)	58.5	28.8	0.93	0.46	19%	9%
Average	**Peak Period (12 pm-3 pm)**	**84.6**	**38.7**	**1.35**	**0.62**	**25%**	**12%**

Table E 3: Simulation Results of Recalibrated Model on CPP Days – One Carnegie Plaza (building)

Date	Period	kW		W / ft²		WBP %	
		Max	Ave	Max	Ave	Max	Ave
CPP-1	Moderate Price (12 pm-3 pm)	51.6	22.8	1.33	0.59	24%	11%
	High Price (3 pm-6 pm)	38.9	21.0	1.00	0.54	18%	10%
CPP-2	Moderate Price (12 pm-3 pm)	45.6	20.0	1.18	0.52	23%	10%
	High Price (3 pm-6 pm)	35.5	18.8	0.91	0.48	18%	9%
CPP-3	Moderate Price (12 pm-3 pm)	62.5	25.2	1.61	0.65	27%	11%
	High Price (3 pm-6 pm)	42.9	26.6	1.10	0.69	19%	12%
CPP-4	Moderate Price (12 pm-3 pm)	63.9	26.1	1.65	0.67	27%	11%
	High Price (3 pm-6 pm)	46.8	26.7	1.21	0.69	20%	11%
CPP-5	Moderate Price (12 pm-3 pm)	81.8	32.9	2.11	0.85	33%	13%
	High Price (3 pm-6 pm)	52.6	27.6	1.36	0.71	21%	11%
CPP-6	Moderate Price (12 pm-3 pm)	81.2	30.8	2.09	0.79	34%	13%
	High Price (3 pm-6 pm)	45.3	25.1	1.17	0.65	19%	11%
CPP-7	Moderate Price (12 pm-3 pm)	76.0	28.9	1.96	0.74	31%	12%
	High Price (3 pm-6 pm)	47.5	26.3	1.22	0.68	19%	11%
CPP-8	Moderate Price (12 pm-3 pm)	75.8	28.0	1.95	0.72	32%	12%
	High Price (3 pm-6 pm)	45.2	25.4	1.16	0.65	19%	11%
CPP-9	Moderate Price (12 pm-3 pm)	63.0	23.5	1.62	0.61	29%	11%
	High Price (3 pm-6 pm)	45.2	22.7	1.16	0.59	21%	10%
CPP-10	Moderate Price (12 pm-3 pm)	65.2	24.7	1.68	0.64	31%	12%
	High Price (3 pm-6 pm)	39.1	20.6	1.01	0.53	19%	10%
CPP-11	Moderate Price (12 pm-3 pm)	62.0	23.7	1.60	0.61	30%	11%
	High Price (3 pm-6 pm)	38.2	20.8	0.98	0.54	18%	10%
CPP-12	Moderate Price (12 pm-3 pm)	58.7	23.2	1.51	0.60	29%	11%
	High Price (3 pm-6 pm)	35.0	17.9	0.90	0.46	17%	9%
Average	**Peak Period (12 pm-3 pm)**	**54.1**	**24.6**	**1.40**	**0.63**	**24%**	**11%**

TABLE E 4: SIMULATION RESULTS OF RECALIBRATED MODEL ON CPP DAYS – ONE VANDERBILT

DATE	PERIOD	KW		W / FT²		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	92.3	43.1	1.25	0.58	21%	10%
	High Price (3 pm-6 pm)	72.2	40.9	0.98	0.56	17%	9%
CPP-2	Moderate Price (12 pm-3 pm)	82.3	38.2	1.12	0.52	20%	9%
	High Price (3 pm-6 pm)	66.5	37.5	0.90	0.51	16%	9%
CPP-3	Moderate Price (12 pm-3 pm)	113.3	48.0	1.54	0.65	25%	10%
	High Price (3 pm-6 pm)	80.5	51.1	1.09	0.69	17%	11%
CPP-4	Moderate Price (12 pm-3 pm)	111.3	48.9	1.51	0.66	24%	11%
	High Price (3 pm-6 pm)	86.8	50.8	1.18	0.69	19%	11%
CPP-5	Moderate Price (12 pm-3 pm)	143.5	61.3	1.95	0.83	29%	12%
	High Price (3 pm-6 pm)	97.4	53.4	1.32	0.72	20%	11%
CPP-6	Moderate Price (12 pm-3 pm)	142.6	58.3	1.93	0.79	31%	12%
	High Price (3 pm-6 pm)	84.9	48.9	1.15	0.66	18%	10%
CPP-7	Moderate Price (12 pm-3 pm)	148.3	59.2	2.01	0.80	28%	11%
	High Price (3 pm-6 pm)	95.6	54.6	1.30	0.74	18%	10%
CPP-8	Moderate Price (12 pm-3 pm)	142.7	56.3	1.93	0.76	29%	11%
	High Price (3 pm-6 pm)	91.1	52.6	1.24	0.71	18%	11%
CPP-9	Moderate Price (12 pm-3 pm)	111.3	44.7	1.51	0.61	25%	10%
	High Price (3 pm-6 pm)	91.1	44.7	1.24	0.61	21%	10%
CPP-10	Moderate Price (12 pm-3 pm)	120.1	48.2	1.63	0.65	28%	11%
	High Price (3 pm-6 pm)	77.1	42.7	1.05	0.58	18%	10%
CPP-11	Moderate Price (12 pm-3 pm)	110.3	45.9	1.50	0.62	26%	11%
	High Price (3 pm-6 pm)	74.4	42.1	1.01	0.57	17%	10%
CPP-12	Moderate Price (12 pm-3 pm)	104.3	44.5	1.42	0.60	25%	11%
	High Price (3 pm-6 pm)	67.3	36.8	0.91	0.50	16%	9%
Average	**Peak Period (12 pm-3 pm)**	**100.3**	**48.0**	**1.36**	**0.65**	**22%**	**10%**

TABLE E 5: SIMULATION RESULTS OF RECALIBRATED MODEL ON CPP DAYS – ONE PARKSIDE

DATE	PERIOD	KW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	92.8	45.0	1.33	0.64	26%	13%
	High Price (3 pm-6 pm)	70.3	38.2	1.00	0.54	20%	11%
CPP-2	Moderate Price (12 pm-3 pm)	82.2	39.8	1.17	0.57	25%	12%
	High Price (3 pm-6 pm)	64.7	35.5	0.92	0.51	19%	11%
CPP-3	Moderate Price (12 pm-3 pm)	115.9	50.3	1.65	0.72	31%	13%
	High Price (3 pm-6 pm)	77.6	46.5	1.11	0.66	21%	12%
CPP-4	Moderate Price (12 pm-3 pm)	115.9	51.7	1.65	0.74	30%	13%
	High Price (3 pm-6 pm)	85.5	48.4	1.22	0.69	22%	13%
CPP-5	Moderate Price (12 pm-3 pm)	147.6	65.8	2.11	0.94	34%	15%
	High Price (3 pm-6 pm)	98.6	52.0	1.41	0.74	23%	12%
CPP-6	Moderate Price (12 pm-3 pm)	147.0	62.3	2.10	0.89	35%	15%
	High Price (3 pm-6 pm)	84.2	45.6	1.20	0.65	20%	11%
CPP-7	Moderate Price (12 pm-3 pm)	140.7	59.6	2.01	0.85	32%	13%
	High Price (3 pm-6 pm)	91.3	49.4	1.30	0.70	21%	11%
CPP-8	Moderate Price (12 pm-3 pm)	136.9	57.4	1.95	0.82	32%	13%
	High Price (3 pm-6 pm)	88.7	47.8	1.27	0.68	21%	11%
CPP-9	Moderate Price (12 pm-3 pm)	114.5	48.0	1.63	0.69	31%	13%
	High Price (3 pm-6 pm)	88.7	42.1	1.27	0.60	24%	12%
CPP-10	Moderate Price (12 pm-3 pm)	123.6	53.2	1.76	0.76	33%	14%
	High Price (3 pm-6 pm)	81.5	43.2	1.16	0.62	22%	11%
CPP-11	Moderate Price (12 pm-3 pm)	114.9	51.6	1.64	0.74	30%	13%
	High Price (3 pm-6 pm)	78.6	41.6	1.12	0.59	20%	11%
CPP-12	Moderate Price (12 pm-3 pm)	109.9	50.0	1.57	0.71	29%	13%
	High Price (3 pm-6 pm)	72.6	38.0	1.04	0.54	19%	10%
Average	**Peak Period (12 pm-3 pm)**	**101.0**	**48.4**	**1.44**	**0.69**	**26%**	**12%**

TABLE E 6: SIMULATION RESULTS OF RECALIBRATED MODEL ON CPP DAYS – LAKESIDE TOWER

DATE	PERIOD	kW MAX	kW AVE	W / FT^2 MAX	W / FT^2 AVE	WBP% MAX	WBP% AVE
CPP-1	Moderate Price (12 pm-3 pm)	80.5	35.5	0.71	0.31	15%	7%
	High Price (3 pm-6 pm)	45.6	25.3	0.40	0.22	8%	5%
CPP-2	Moderate Price (12 pm-3 pm)	79.7	33.6	0.71	0.30	16%	7%
	High Price (3 pm-6 pm)	42.2	22.8	0.37	0.20	8%	4%
CPP-3	Moderate Price (12 pm-3 pm)	97.1	47.7	0.86	0.42	17%	8%
	High Price (3 pm-6 pm)	51.9	30.2	0.46	0.27	9%	5%
CPP-4	Moderate Price (12 pm-3 pm)	93.3	43.6	0.83	0.39	16%	8%
	High Price (3 pm-6 pm)	50.3	28.6	0.45	0.25	9%	5%
CPP-5	Moderate Price (12 pm-3 pm)	100.5	44.6	0.89	0.40	17%	8%
	High Price (3 pm-6 pm)	52.2	29.3	0.46	0.26	9%	5%
CPP-6	Moderate Price (12 pm-3 pm)	99.0	43.7	0.88	0.39	17%	7%
	High Price (3 pm-6 pm)	50.4	28.7	0.45	0.25	9%	5%
CPP-7	Moderate Price (12 pm-3 pm)	119.7	65.8	1.06	0.58	19%	10%
	High Price (3 pm-6 pm)	77.4	39.9	0.69	0.35	12%	6%
CPP-8	Moderate Price (12 pm-3 pm)	129.0	54.9	1.14	0.49	21%	9%
	High Price (3 pm-6 pm)	67.0	37.6	0.59	0.33	11%	6%
CPP-9	Moderate Price (12 pm-3 pm)	91.3	39.5	0.81	0.35	17%	7%
	High Price (3 pm-6 pm)	67.0	27.0	0.59	0.24	12%	5%
CPP-10	Moderate Price (12 pm-3 pm)	113.2	47.4	1.00	0.42	20%	8%
	High Price (3 pm-6 pm)	53.4	26.3	0.47	0.23	9%	5%
CPP-11	Moderate Price (12 pm-3 pm)	99.9	46.0	0.89	0.41	17%	8%
	High Price (3 pm-6 pm)	47.4	25.7	0.42	0.23	8%	4%
CPP-12	Moderate Price (12 pm-3 pm)	99.5	42.7	0.88	0.38	17%	7%
	High Price (3 pm-6 pm)	51.3	23.1	0.46	0.20	9%	4%
Average	**Peak Period (12 pm-3 pm)**	**77.5**	**37.1**	**0.69**	**0.33**	**13%**	**6%**

Table E 7: Simulation Results of Recalibrated Model on CPP Days – Two Parkside

Date	Period	kW		W / ft²		WBP%	
		Max	Ave	Max	Ave	Max	Ave
CPP-1	Moderate Price (12 pm-3 pm)	109.4	52.3	1.35	0.65	31%	15%
	High Price (3 pm-6 pm)	80.1	42.5	0.99	0.53	23%	12%
CPP-2	Moderate Price (12 pm-3 pm)	99.1	46.8	1.23	0.58	30%	14%
	High Price (3 pm-6 pm)	73.4	39.6	0.91	0.49	22%	12%
CPP-3	Moderate Price (12 pm-3 pm)	131.2	57.5	1.62	0.71	36%	16%
	High Price (3 pm-6 pm)	86.8	49.9	1.07	0.62	23%	14%
CPP-4	Moderate Price (12 pm-3 pm)	134.3	59.5	1.66	0.74	35%	16%
	High Price (3 pm-6 pm)	96.7	53.7	1.20	0.66	25%	14%
CPP-5	Moderate Price (12 pm-3 pm)	175.2	75.7	2.17	0.94	41%	18%
	High Price (3 pm-6 pm)	111.4	57.2	1.38	0.71	26%	13%
CPP-6	Moderate Price (12 pm-3 pm)	173.9	71.2	2.15	0.88	42%	17%
	High Price (3 pm-6 pm)	94.0	48.9	1.16	0.61	23%	12%
CPP-7	Moderate Price (12 pm-3 pm)	139.3	62.9	1.72	0.78	32%	14%
	High Price (3 pm-6 pm)	103.8	53.8	1.29	0.67	24%	12%
CPP-8	Moderate Price (12 pm-3 pm)	149.5	64.4	1.85	0.80	35%	15%
	High Price (3 pm-6 pm)	99.7	51.4	1.23	0.64	24%	12%
CPP-9	Moderate Price (12 pm-3 pm)	134.1	56.3	1.66	0.70	38%	16%
	High Price (3 pm-6 pm)	99.7	46.1	1.23	0.57	28%	13%
CPP-10	Moderate Price (12 pm-3 pm)	146.0	62.4	1.81	0.77	39%	16%
	High Price (3 pm-6 pm)	93.3	48.7	1.15	0.60	25%	13%
CPP-11	Moderate Price (12 pm-3 pm)	135.5	59.7	1.68	0.74	35%	16%
	High Price (3 pm-6 pm)	89.6	46.4	1.11	0.57	23%	12%
CPP-12	Moderate Price (12 pm-3 pm)	130.4	58.7	1.61	0.73	35%	16%
	High Price (3 pm-6 pm)	84.0	43.6	1.04	0.54	22%	12%
Average	**Peak Period (12 pm-3 pm)**	**115.4**	**54.5**	**1.43**	**0.68**	**30%**	**15%**

Table E 8: Simulation Results of Recalibrated Model on CPP Days – Three Carnegie Plaza

Date	Period	kW Max	kW Ave	W / ft² Max	W / ft² Ave	WBP % Max	WBP % Ave
CPP-1	Moderate Price (12 pm-3 pm)	79.3	48.9	0.95	0.58	28%	17%
	High Price (3 pm-6 pm)	48.2	36.5	0.58	0.44	17%	13%
CPP-2	Moderate Price (12 pm-3 pm)	69.0	42.5	0.82	0.51	27%	17%
	High Price (3 pm-6 pm)	45.9	32.9	0.55	0.39	18%	13%
CPP-3	Moderate Price (12 pm-3 pm)	95.5	53.4	1.14	0.64	32%	18%
	High Price (3 pm-6 pm)	55.7	45.0	0.66	0.54	19%	15%
CPP-4	Moderate Price (12 pm-3 pm)	99.2	56.1	1.19	0.67	32%	18%
	High Price (3 pm-6 pm)	62.8	47.3	0.75	0.57	20%	15%
CPP-5	Moderate Price (12 pm-3 pm)	138.1	71.4	1.65	0.85	39%	20%
	High Price (3 pm-6 pm)	68.3	48.6	0.82	0.58	19%	14%
CPP-6	Moderate Price (12 pm-3 pm)	136.9	65.9	1.64	0.79	41%	20%
	High Price (3 pm-6 pm)	57.3	42.2	0.69	0.50	17%	13%
CPP-7	Moderate Price (12 pm-3 pm)	132.2	62.0	1.58	0.74	39%	18%
	High Price (3 pm-6 pm)	62.9	45.3	0.75	0.54	18%	13%
CPP-8	Moderate Price (12 pm-3 pm)	125.3	60.5	1.50	0.72	38%	18%
	High Price (3 pm-6 pm)	61.8	44.5	0.74	0.53	19%	14%
CPP-9	Moderate Price (12 pm-3 pm)	96.1	50.9	1.15	0.61	34%	18%
	High Price (3 pm-6 pm)	55.3	40.9	0.66	0.49	19%	14%
CPP-10	Moderate Price (12 pm-3 pm)	101.3	55.5	1.21	0.66	35%	19%
	High Price (3 pm-6 pm)	55.7	40.3	0.66	0.48	19%	14%
CPP-11	Moderate Price (12 pm-3 pm)	95.3	54.2	1.14	0.65	31%	18%
	High Price (3 pm-6 pm)	54.8	40.4	0.66	0.48	18%	13%
CPP-12	Moderate Price (12 pm-3 pm)	92.3	52.2	1.10	0.62	32%	18%
	High Price (3 pm-6 pm)	48.7	35.2	0.58	0.42	17%	12%
Average	**Peak Period (12 pm-3 pm)**	**80.7**	**48.9**	**0.97**	**0.58**	**26%**	**16%**

TABLE E 9: SIMULATION RESULTS OF RECALIBRATED MODEL ON CPP DAYS – BRIER CORPORATE CENTER

DATE	PERIOD	KW		W / FT²		WBP%	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	98.3	59.9	0.94	0.57	23%	14%
	High Price (3 pm-6 pm)	83.8	47.7	0.80	0.46	20%	11%
CPP-2	Moderate Price (12 pm-3 pm)	85.5	51.3	0.82	0.49	22%	13%
	High Price (3 pm-6 pm)	75.4	44.8	0.72	0.43	19%	11%
CPP-3	Moderate Price (12 pm-3 pm)	109.1	63.2	1.04	0.61	24%	14%
	High Price (3 pm-6 pm)	92.3	59.1	0.88	0.57	21%	13%
CPP-4	Moderate Price (12 pm-3 pm)	109.9	65.9	1.05	0.63	23%	14%
	High Price (3 pm-6 pm)	102.9	63.1	0.98	0.60	22%	13%
CPP-5	Moderate Price (12 pm-3 pm)	147.1	84.3	1.41	0.81	28%	16%
	High Price (3 pm-6 pm)	115.5	64.4	1.11	0.62	22%	12%
CPP-6	Moderate Price (12 pm-3 pm)	149.9	81.7	1.43	0.78	30%	17%
	High Price (3 pm-6 pm)	99.2	55.1	0.95	0.53	20%	11%
CPP-7	Moderate Price (12 pm-3 pm)	106.5	51.2	1.02	0.49	19%	9%
	High Price (3 pm-6 pm)	106.5	71.0	1.02	0.68	19%	13%
CPP-8	Moderate Price (12 pm-3 pm)	110.6	63.0	1.06	0.60	20%	12%
	High Price (3 pm-6 pm)	117.3	68.2	1.12	0.65	21%	12%
CPP-9	Moderate Price (12 pm-3 pm)	110.4	60.8	1.06	0.58	26%	15%
	High Price (3 pm-6 pm)	117.3	51.3	1.12	0.49	28%	12%
CPP-10	Moderate Price (12 pm-3 pm)	118.3	65.5	1.13	0.63	28%	15%
	High Price (3 pm-6 pm)	89.6	50.5	0.86	0.48	21%	12%
CPP-11	Moderate Price (12 pm-3 pm)	108.5	63.1	1.04	0.60	25%	14%
	High Price (3 pm-6 pm)	88.8	50.3	0.85	0.48	20%	11%
CPP-12	Moderate Price (12 pm-3 pm)	109.2	63.3	1.05	0.61	26%	15%
	High Price (3 pm-6 pm)	81.1	45.8	0.78	0.44	19%	11%
Average	**Peak Period (12 pm-3 pm)**	**105.5**	**60.2**	**1.01**	**0.58**	**23%**	**13%**

TABLE E 10: SIMULATION RESULTS OF RECALIBRATED MODEL ON CPP DAYS – VANDERBILT PLAZA

DATE	PERIOD	KW MAX	KW AVE	W / FT² MAX	W / FT² AVE	WBP% MAX	WBP% AVE
CPP-1	Moderate Price (12 pm-3 pm)	72.4	32.5	0.61	0.27	17%	7%
	High Price (3 pm-6 pm)	44.7	25.8	0.38	0.22	10%	6%
CPP-2	Moderate Price (12 pm-3 pm)	71.3	30.0	0.60	0.25	17%	7%
	High Price (3 pm-6 pm)	40.9	22.9	0.34	0.19	10%	6%
CPP-3	Moderate Price (12 pm-3 pm)	87.7	42.6	0.74	0.36	19%	9%
	High Price (3 pm-6 pm)	50.5	31.6	0.42	0.27	11%	7%
CPP-4	Moderate Price (12 pm-3 pm)	85.0	40.4	0.71	0.34	18%	9%
	High Price (3 pm-6 pm)	49.3	29.6	0.41	0.25	11%	6%
CPP-5	Moderate Price (12 pm-3 pm)	94.0	42.4	0.79	0.36	19%	9%
	High Price (3 pm-6 pm)	51.7	30.6	0.43	0.26	11%	6%
CPP-6	Moderate Price (12 pm-3 pm)	93.2	41.7	0.78	0.35	19%	9%
	High Price (3 pm-6 pm)	50.1	30.0	0.42	0.25	10%	6%
CPP-7	Moderate Price (12 pm-3 pm)	112.3	61.2	0.94	0.51	21%	12%
	High Price (3 pm-6 pm)	77.9	42.3	0.65	0.36	15%	8%
CPP-8	Moderate Price (12 pm-3 pm)	114.2	51.7	0.96	0.43	23%	10%
	High Price (3 pm-6 pm)	62.2	37.9	0.52	0.32	12%	8%
CPP-9	Moderate Price (12 pm-3 pm)	83.0	36.3	0.70	0.30	19%	8%
	High Price (3 pm-6 pm)	62.2	27.7	0.52	0.23	14%	6%
CPP-10	Moderate Price (12 pm-3 pm)	104.1	43.8	0.87	0.37	22%	9%
	High Price (3 pm-6 pm)	52.2	27.1	0.44	0.23	11%	6%
CPP-11	Moderate Price (12 pm-3 pm)	91.2	42.6	0.77	0.36	19%	9%
	High Price (3 pm-6 pm)	46.3	26.3	0.39	0.22	10%	6%
CPP-12	Moderate Price (12 pm-3 pm)	91.4	39.7	0.77	0.33	20%	8%
	High Price (3 pm-6 pm)	50.5	23.6	0.42	0.20	11%	5%
Average	**Peak Period (12 pm-3 pm)**	**72.4**	**35.8**	**0.61**	**0.30**	**15%**	**8%**

TABLE E 11: SIMULATION RESULTS OF RECALIBRATED MODEL ON CPP DAYS – INLAND REGIONAL CENTER

DATE	PERIOD	kW		W / FT^2		WBP %	
		MAX	AVE	MAX	AVE	MAX	AVE
CPP-1	Moderate Price (12 pm-3 pm)	76.5	56.5	0.94	0.70	23%	17%
	High Price (3 pm-6 pm)	76.1	48.2	0.94	0.59	23%	14%
CPP-2	Moderate Price (12 pm-3 pm)	65.4	49.2	0.81	0.61	21%	16%
	High Price (3 pm-6 pm)	68.6	45.1	0.85	0.56	22%	14%
CPP-3	Moderate Price (12 pm-3 pm)	84.9	59.8	1.05	0.74	24%	17%
	High Price (3 pm-6 pm)	84.0	58.8	1.04	0.72	24%	17%
CPP-4	Moderate Price (12 pm-3 pm)	88.5	62.1	1.09	0.77	24%	17%
	High Price (3 pm-6 pm)	94.5	63.5	1.17	0.78	25%	17%
CPP-5	Moderate Price (12 pm-3 pm)	120.6	79.5	1.49	0.98	30%	20%
	High Price (3 pm-6 pm)	105.8	64.5	1.30	0.80	27%	16%
CPP-6	Moderate Price (12 pm-3 pm)	120.8	75.8	1.49	0.94	32%	20%
	High Price (3 pm-6 pm)	90.2	54.7	1.11	0.67	24%	14%
CPP-7	Moderate Price (12 pm-3 pm)	107.4	69.1	1.32	0.85	26%	17%
	High Price (3 pm-6 pm)	102.2	62.1	1.26	0.77	25%	15%
CPP-8	Moderate Price (12 pm-3 pm)	109.8	70.1	1.35	0.86	28%	18%
	High Price (3 pm-6 pm)	96.1	57.8	1.18	0.71	24%	15%
CPP-9	Moderate Price (12 pm-3 pm)	84.8	57.3	1.05	0.71	25%	17%
	High Price (3 pm-6 pm)	96.1	50.7	1.18	0.63	29%	15%
CPP-10	Moderate Price (12 pm-3 pm)	88.4	60.7	1.09	0.75	26%	18%
	High Price (3 pm-6 pm)	79.9	50.3	0.99	0.62	24%	15%
CPP-11	Moderate Price (12 pm-3 pm)	83.1	58.6	1.02	0.72	24%	17%
	High Price (3 pm-6 pm)	80.4	50.3	0.99	0.62	23%	15%
CPP-12	Moderate Price (12 pm-3 pm)	82.6	59.1	1.02	0.73	25%	18%
	High Price (3 pm-6 pm)	74.6	46.9	0.92	0.58	22%	14%
Average	**Peak Period (12 pm-3 pm)**	**90.1**	**58.8**	**1.11**	**0.73**	**25%**	**16%**