FILED
June 30, 2016
INDIANA UTILITY
REGULATORY COMMISSION

STATE OF INDIANA

INDIANA UTILITY REGULATORY COMMISSION

IN THE MATTER OF THE VERIFIED PETITION OF INDIANA MICHIGAN POWER COMPANY FOR APPROVAL OF ALTERNATIVE REGULATORY PLAN FOR DEMAND SIDE MANAGEMENT (DSM) AND ENERGY EFFICIENCY (EE) PROGRAMS FOR 2015 AND ASSOCIATED ACCOUNTING AND RATEMAKING MECHANISMS, INCLUDING TIMELY RECOVERY THROUGH I&M'S DSM/EE PROGRAM COST RIDER OF ASSOCIATED COSTS, INCLUDING ALL PROGRAM COSTS, NET LOST REVENUE, SHAREHOLDER INCENTIVES AND CARRYING CHARGES, DEPRECIATION AND OPERATIONS AND MAINTENANCE EXPENSE ON CAPITAL EXPENDITURES.	)	**CAUSE NO. 44486**

SUBMISSION OF INDEPENDENT EVALUATION, VERIFICATION AND MEASUREMENT REPORTS-EECO

Indiana Michigan Power Company (I&M) respectfully submits its 2015 evaluation, verification and measurement (EM&V) reports for the Energy Consumption Optimization (EECO) program in accordance with the Commission's December 3, 2014 Order in this Cause.

Respectively submitted,

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Evaluation, Monitoring and Verification Report for I&M 2015 EECO Program

Final Version
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1 INTRODUCTION AND PROGRAM BACKGROUND

This report addresses the measuring, verifying and evaluating of energy savings and demand reductions that resulted from the implementation by Indiana Michigan Power Company (I&M) in 2015 of a program for Electric Energy Consumption Optimization (EECO). I&M implemented this program in conjunction with Utilidata, Inc.

1.1 DESCRIPTION OF PROGRAM

Under ANSI Standard C84.1 Electric Power Systems and Equipment, a utility system is to deliver electricity to end-users at a voltage within the range of 120 $\pm$ 5% volts (i.e., 114 – 126). With the usual system design, customers close to a substation receive voltages closer to 126 volts and customers farther from the substation receive lower voltages. Voltage regulating equipment is applied as necessary to ensure the required minimum voltages are provided.

The EECO program is based on implementing Conservation Voltage Reduction (CVR), which is a process by which the utility systematically reduces voltages in its distribution network, resulting in a proportional reduction of load on the network. Because most devices operated by electricity (especially motors) are designed to operate most efficiently at 115 volts, any "excess" voltage is typically wasted, usually in the form of heat. Tighter voltage regulation allows end-use devices to operate more efficiently without any action on the part of consumers. Consumers receive a lower but still acceptable voltage and use less energy to accomplish the same tasks.

I&M's EECO program was first implemented on 9 distribution circuits during 2014. Data on the characteristics of these first VVO circuits are shown in Table 1-1. For 2015, six more stations with 16 circuits were added to the EECO program. The stations and circuits in the 2015 program are identified in Table 1-2.

Table 1-1. Demographic Characteristics of Circuits in EECO Program

Circuit ID	*Station*	*Circuit*	*Customer Count (as of 10/9/12)*	*Primary Line Miles (as of 1/25/12)*	*Customers per Line Mile*	*Urban or Rural*
4933525	Hacienda	Hartford	1,922	31.7	61	Urban
4933526	Hacienda	Wheelock	2,106	49.9	42	Urban
4933527	Hacienda	Schwartz	747	27.1	28	Urban
4051821	Lincoln	Hartzell	1,651	31.2	53	Urban
4051822	Lincoln	Maysville	1,938	33.5	58	Urban
4051824	Lincoln	Parrott	247	10.8	23	Urban
4928721	State Street	Brentwood	1,999	21.2	94	Urban
4928722	State Street	Lahmeyer	1,437	19.4	74	Urban
4928723	State Street	Trier	1,030	13.6	76	Urban

Table 1-2. Customer Class Composition of Circuits in EECO Program

Station	Circuits on VVO	Account Class Description				Grand Total
		Commercial	Industrial	Public Authority	Residential	
Hacienda	Hartford	102		5	1,823	1,930
	Schwartz	205		6	540	751
	Wheelock	101		5	2,046	2,152
Lincoln	Hartzell	270	15	23	1,371	1,679
	Maysville	215	2	17	1,764	1,998
	Parrott	80	9	16	138	243
State Street	Brentwood	216	3	8	1,768	1,995
	Lahmeyer	165		8	1,270	1,443
	Trier	32		1	1,001	1,034
East Side 1 & 2	6 circuits	621	9		9,398	10,028
Elcona	3 circuits	250	102		1,814	2,166
Harper	2 circuits	366	21		3,078	3,465
South Bend	3 circuits	532	2		4,833	5,367
Spy Run	2 circuits	276	13		1,618	1,907

I&M implemented the 2015 EECO program using Utilidata's AdaptiVolt Volt/VAR Optimization (VVO) platform that had been installed at the three stations. AdaptiVolt uses secure digital communications to implement a closed-loop control system. Using AdaptiVolt allowed I&M to dispatch voltage-based demand control within seconds. The system measures end-of-line voltage and sends the voltage information back to the controller at the substation in real time. The AdaptiVolt™ system allows control of circuit voltage both at the substation level and for individual phases on the circuits served through that substation. For each station in the 2015 EECO program, voltage control was provided for the nine stations with three circuits each, with the three phases of each circuit being controlled independently.

2 DATA COLLECTION

The effects of voltage optimization for the on substations in the 2015 EECO program were analyzed using data on voltages and power demands.

I&M and Utilidata used an "On/Off" procedure for voltage reductions during various parts of the year.[1] This procedure provides data sets with measurements of voltages and energy use that include both regular voltages (measured on "Off" 'days) and reduced voltages (measured on "On" days).

For three of the stations (i.e., Hacienda, Lincoln, State), data were collected over the twelve-month period from January 1, 2015 through December 31, 2015. The voltage optimization did not become operational for the other six stations until later in the year. Table 2-1 shows the months when VVO was operational for the different stations during 2015.

Table 2-1. Months When VVO Was in Operation for Stations in EECO Program during 2015

Station	***Months VVO in Operation during 2015***
Hacienda	January 1 – December 31
Lincoln	January 1 – December 31
State	January 1 – December 31
Eastside 1	July 28 – December 31
Eastside 2	July 28 – December 31
Elcona	July 28 – December 1
Harper	August 5 – December 31
South Bend	August 4 – December 31
Spy Run	July 27 – December 31

Data for the following elements were collected and stored with the AdaptiVolt™ system during the year.

- Regulated source voltages by phase,
- Total feeder current by phase,
- kW by phase,
- kvar by phase,
- Primary voltages at or near the end of the distribution feeders by phase, and
- Temperature data.

The data collected during 2015 are of high time granularity. The Adaptivolt™ system can make continuous changes in voltage levels; voltage readings were made continuously, not dichotomously (i.e., off / on). The power and voltage elements were measured and the data

[1] For discussion of "on / off" testing, see, for example, Pacific Northwest Regional Technical Forum, *Standard Protocol #1 for Automated CVR,* November 2011.

collected and stored at 10-second intervals. Data were collected and stored six times per minute, 360 times per hour. Because of this frequency of recording, there could be over 3 million data points for each station / circuit / phase. (If no gaps in recording, there would be 3,153,600 data points, for 365 days at 24 hours per day and 360 data points per hour.)

The power demand and voltage data provided by Utilidata were examined to identify when and how much data might be missing and to identify pronounced changes in loads that would not necessarily be associated with reductions in voltage (e.g., operational changes shifting loads among circuits). Suspect data were flagged and excluded from the analysis.

Hourly temperature readings were available from the quality controlled local climatological data program of the National Climatic Data Center[2] for the Fort Wayne airport. These temperature data were obtained and used for the analysis.

[2] For information on the QCLCD data, see http://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/quality-controlled-local-climatological-data-qclcd

3 METHOD FOR DETERMINING ENERGY SAVINGS

This chapter discusses the method used for determining energy savings resulting from implementation of the EECO program during 2015.

3.1 PROTOCOLS FOR CVR ANALYSIS

Methods for using circuit-level data on voltages and power usage to measure and verify savings from voltage reductions are set out in several existing protocols. Because much of the early work on voltage reduction was performed in the Pacific Northwest, the Northwest Regional Technical Forum (RTF) managed a process to prepare a protocol for estimating savings from automated CVR. This protocol (Automated CVR Protocol No. 1) was approved by the RTF in 2004. The RTF approved a second protocol (Simplified Voltage Optimization Protocol) in 2010.

With the RTF protocols, savings resulting from voltage reduction are estimated by multiplying a change in voltage level by a CVR factor that reflects the estimated relationship between voltage reduction and energy reduction. For application of the protocols in the Pacific Northwest, load research data were used to develop a series of lookup tables with CVR values for participating utilities. However, these CVR values depend on load and weather conditions and end-use equipment saturations (e.g., air conditioning use) that are specific to the Pacific Northwest.

An enhanced version of the RTF protocols has been developed by a CVR working group in Pennsylvania. Using data collected for utility distribution circuits in Pennsylvania, the working group developed a Conservation Voltage Reduction (CVR) Custom Measurement Protocol for Demand Reduction. (Revised version was published September 21, 2011.)

3.2 METHOD FOR DETERMINING KWH SAVINGS

As shown by Equation 1, the kWh savings that result from voltage reduction can be quantified as the difference between a baseline energy use (when voltage is not reduced) and actual energy use when voltage is reduced.

$$kWh\ savings = kWh_{Baseline} - kWh_{Actual\ when\ VVO\ is\ \text{“On”}} \quad (1)$$

The energy use when VVO is “On” can be measured. However, baseline energy use is essentially “counterfactual”: what would the energy use have been during the given time period were VVO “Off”.

Because power use is a product of voltage and amps, baseline sets of values for voltages and amps are needed to determine baseline values for power demand and energy use that can be used to determine energy savings.

3.2.1 Determining Baseline Voltages

Baseline voltages for hours when VVO was “On” were imputed using mean values of voltages when VVO was “Off”. These mean values were calculated for each circuit phase for cells defined by season, type of day (i.e., weekday, weekend), and hour of day. For each hour that

VVO was "On", the baseline voltage for a phase was imputed to be the "Off" voltage from the cell similarly defined by season x type of day x hour of day. For example, the baseline voltage for Phase 1 for 1 PM on a weekday in November when VVO was "On" was imputed to be the mean voltage for Phase 1 calculated from the Phase 1 voltage readings for the 1 PM hour for weekdays in the heating season when VVO was "Off".

3.2.2 Determining Baseline Current (Amps)

Current for a circuit / phase is not completely independent from voltage changes because not all loads react in the same way to a voltage change. Various studies have shown that the energy savings that result from voltage reduction depend on the characteristics and loads of a feeder.

- Some loads are characterized by constant impedance, where power consumed is proportional to voltage squared. Examples of such loads include incandescent lighting, resistive water heaters, stovetop and oven cooking loads.
- Other loads are constant power, where demand is constant regardless of voltage. Examples of constant power loads include electric motors and regulated power supplies.
- A relatively small percentage of loads are constant current, where demand is proportional to voltage. Examples of constant current loads include welding units, smelting, and electroplating processes.

The overall load on a feeder will be a mix of the different load types. Rules of thumb for the split between constant power and constant impedance loads are as follows[3]:

- For summer peak loads, 60% constant power and 40% constant impedance
- For winter peak loads, 40% constant power and 60% constant impedance
- For industrial loads, 80% constant power and 20% constant impedance
- For summer peaking residential loads, 70% constant power and 30% constant impedance
- For winter peaking residential loads, 30% constant power and 70% constant impedance
- For commercial loads, the split between constant power and constant impedance is generally 50%/50% or 60%/40%

Regression analysis was used to relate circuit / phase amp data to month of year, voltage and ambient temperature. The regression model used is shown in Equation (2).

$$Amps_i = \beta_0 + \beta_1 Dummy_{Nov} + \beta_2 Dummy_{Dec} + \beta_3 V_i + \beta_4 T_i + e_i \quad (2)$$

A model of this form was estimated for each hour of the day. For each period *i* within an hour, $Amps_i$ is the current (in amps), V_i is the voltage, T_i is the ambient temperature (in degrees Celsius), $Dummy_{Nov}$ and $Dummy_{Dec}$ are indicator (0,1) variables for whether an observation is in

[3] Willis, H. Lee, *Power Distribution Planning Reference Book.*

that month, e_i is the error term, and β_0, β_1, β_2, β_3, β_4 are the regression coefficients being estimated.

Ambient temperature was included in the regression to account for variation in heating and/or cooling requirements across the period the pilot program was conducted.

For each circuit / phase, hourly regression models using the specification in Equation (2) were estimated. Separate models were estimated for weekdays and for weekend days. There were 3,600 regressions estimated for the analysis (i.e., 25 circuits x 3 phases per circuit x 2 types of day x 24 hours per day). STATA™ was used to perform the regressions. The results from the regressions are included in Excel files in Appendix A.

The value for β_3 estimated through the regression analysis shows how amps on a circuit change in response to a change in voltage (controlling for month of year and weather). Accordingly, β_3 was used to develop baseline values for amps for when VVO was "On", per the following equation.

$$PhaseX\_Base\_Amps = PhaseX\_Actual\_Amps + \beta_3 * (PhaseX\_Base\_Volts - PhaseX\_Actual\_Volts) \quad (2)$$

3.2.3 Determining Baseline and Actual MW

Given the calculated baseline values for voltages and amps, baseline power demand (MW) for a 5-minute interval when VVO is "On" is calculated as follows:

$$PhaseX\_Base\_MW = (PhaseX\_Base\_Volts * PhaseX\_Base\_Amps * 60)/1000000 \quad (3)$$

Actual power demand (MW) for a 5-minute interval when VVO is "On" is calculated from the measured readings for voltage and amps as shown in Equation (4).

$$PhaseX\_Actual\_MW = (PhaseX\_Actual\_Volts * PhaseX\_Actual\_Amps * 60)/1000000 \quad (4)$$

These calculations are performed by circuit / phase and by type of day (weekday, weekend).

3.2.4 Determining Energy Savings

The reduction in MW demand for each 5-minute interval for a circuit / phase when VVO was "On" was calculated as shown in Equation (5).

$$MW\ Reduction = PhaseX\_Base\_MW - PhaseX\_Actual\_MW \quad (5)$$

The values for *MW Reduction* within an hour were averaged. This average *MW Reduction* was applied to determine *PhaseX_kWh savings* in each hour.

The hourly values for *PhaseX_Base_Volts, PhaseX_Base_MW, PhaseX_Actual_Volts, PhaseX_Actual_MW,* and *PhaseX_kWh savings* were then averaged by type of day (weekday, weekend) and hour-of-the-day.

3.2.5 Determining CVR Factorsa

The results from studies of voltage reduction are often summarized in terms of a conservation voltage reduction factor (CVF_f). A CVR_f measures the relationship between changes in energy in response to changes in voltage effected under the CVR program. Mathematically, CVR_f is calculated as the ratio between the percentage change in energy and the percentage change in voltage, as shown in Equation (6).

$$CVR_f = \frac{\%\Delta\ in\ energy}{\%\Delta\ in\ voltage} \tag{6}$$

where $\%\Delta\ in\ energy$ = ΔkWh/kWh_{Base} and $\%\Delta\ in\ voltage$ = ΔVolts/$Volts_{Base}$. ΔkWh is kWh savings and ΔVolts is the voltage reduction.

3.2.3 Refinements for the Analysis

Rules of thumb and results from other studies indicate that responsiveness to voltage reductions (as evidence by CVR factors) is likely to differ between seasons of the year. Differences among seasons are evident both in measures of heating and cooling degree days and in patterns of circuit kW loads during the year.

Table 3-1 shows that there is variation across months in "normal" heating and cooling degree days for Fort Wayne.

Table 3-1. Normal Heating and Cooling Days for Fort Wayne, by Month

Month	***Normal Heating Degree Days***	***Normal Cooling Degree Days***
January	1,283	0
February	1,089	0
March	834	0
April	480	0
May	144	1
June	0	141
July	0	260
August	0	189
September	50	23
October	391	0
November	732	0
December	1,116	0

Studies of voltage reduction programs have generally considered three types of seasons: heating, "shoulder", and cooling. Shoulder seasons are the seasons that do not have much cooling or heating activity and generally include months in the spring and fall. However, preliminary analysis performed for this evaluation of the 2015 EECO program was performed to correlate power loads with ambient temperature. The correlations showed that months could be separated into two categories, based on whether the correlation between power demand and temperature was positive or negative. Months with positive correlation were categorized as cooling months, while months with negative correlations were categorized as heating months.

Table 3-2 shows how months of the year were divided between seasons for the analysis.

Table 3-2. Months of Year Categorized into Two Seasons

Month	Heating Season	Cooling Season
January	X	
February	X	
March	X	
April		X
May		X
June		X
July		X
August		X
September		X
October	X	
November	X	
December	X	

Using two seasons rather than three allowed more observations in the analysis for a season. This was of practical importance for the analysis of the six new stations that came into the EECO program in 2015. VVO operation for the circuits at these stations did not begin until the second half of 2015. Under a three-season categorization, the analysis for some of the stations would have had to use data for only one or two months to represent a season. Using a two-season categorization allowed data for more than a few months to be brought together for the analysis.

Besides considering heating and cooling in the analysis, observations were also divided between weekdays and weekends. This was done because inspection of the power demand data showed generally lower demands during weekend days.

Based on these considerations, the analysis for each circuit / phase was conducted for four scenarios:

- Heating season (January-March, October-December), weekdays
- Heating season (January-March, October-December), weekend days
- Cooling season (June-September), weekdays
- Cooling season (June-September), weekend days

For each scenario, the power demand for each hour of the day for each station / circuit / phase, was calculated using Equation (3), with the regression results providing values for the coefficients. Values for voltage and temperature were specified as follows.

- For each station / circuit, the temperature value used for each hour was the average temperature for that hour over the number of days in the seasonal period (i.e., either weekdays or weekend days).
- Power demand was calculated for two voltage conditions, either VVO "On" or VVO "Off". Average voltage values that were calculated from the recorded data according to the "On" or "Off" status of the VVO were used.

With these assumptions, two power demand values were calculated for each hour for each station / circuit / phase for each scenario that were normalized to the same temperature conditions. The CVR factor for an hour was then calculated as the ratio of the percentage savings value calculated from the two power demand values to the percentage voltage reduction. (The calculations for these hourly CVR factors are included in the Excel files in Appendix A.)

3.3 METHOD TO CALCULATE AGGREGATE ANNUAL KWH SAVINGS

The method described in Section 3.2 provides estimates by hour of the day of the average kWh savings that result from VVO voltage reduction. Multiplying an hour-of-the-day estimate of savings by the number of hours voltage was reduced during that hour of the day during the pilot program provides an aggregate estimate of kWh savings. Summing the hourly kWh savings across hours of the day and type of day provides kWh savings for the whole period of the pilot program. These savings are those that occurred on the days when VVO was "On".

VVO was not "On" for all hours during the year. An additional calculation is therefore made to determine what kWh savings would have been had VVO been "On" for all days during the period of the pilot program. This calculation is made by multiplying the hour-of-the-day estimates of savings by the total number of those hours of the day in the pilot program and then summing these kWh savings across hours of the day and type of day.

3.4 METHOD TO CALCULATE AGGREGATE ANNUAL KWH SAVINGS

The method described in Section 3.3 provides estimates of average hourly kWh savings that result from VVO voltage reduction. Multiplying an hourly estimate of savings by the number of times voltage was reduced during that hour provides an aggregate estimate of kWh savings. Summing the hourly kWh savings across hours, type of day and season provides kWh savings in 2014. These savings are those that occurred on the days when VVO was "On".

As shown in Table 2-1, VVO was not "On" for all hours during 2014. An additional calculation is therefore made to determine what annual kWh savings would have been had VVO been "On" for all days of the year. This calculation is made by multiplying the hourly estimates of savings by the total number of days in the year and then summing the hourly kWh savings across hours, type of day and season.

4 DAILY ENERGY SAVINGS AND CVR FACTORS BY STATION CIRCUITS / PHASES

This chapter presents and discusses the results from the analysis of data from the 2015 EECO program to determine energy savings and CVR factors associated with voltage reduction.

For each scenario for each station / circuit / phase, energy savings for a weekday or weekend day with typical temperatures was calculated. For each of the two voltage conditions, the 24 hourly power demand values were aggregated to give daily totals for power usage. The percentage savings from reducing voltage was calculated and divided by the percentage reduction in voltage to provide the estimate of the daily CVR factor for a day. These results are presented by station.

Table 4-1. Energy Savings for F3525 Hacienda Hartford Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	28,677	27,147	1,529	5.33%	3.46
			Volts	124.15	122.22	1.93	1.54%	
		Weekend	kWh	28,807	28,843	-36	-0.12%	-0.09
			Volts	124.15	122.41	1.75	1.39%	
	Cooling	Weekday	kWh	27,830	25,185	2,645	9.50%	6.78
			Volts	123.98	122.25	1.73	1.40%	
		Weekend	kWh	28,136	26,332	1,803	6.41%	4.61
			Volts	124.02	122.32	1.69	1.39%	
Phase B	Heating	Weekday	kWh	27,320	25,217	2,103	7.70%	3.46
			Volts	124.49	121.38	3.12	2.50%	
		Weekend	kWh	27,660	26,803	857	3.10%	1.27
			Volts	124.43	121.38	3.05	2.45%	
	Cooling	Weekday	kWh	27,784	25,001	2,783	10.02%	4.40
			Volts	124.45	121.59	2.86	2.28%	
		Weekend	kWh	28,229	26,481	1,748	6.19%	2.79
			Volts	124.41	121.66	2.74	2.22%	
Phase C	Heating	Weekday	kWh	27,698	25,705	1,993	7.19%	2.47
			Volts	124.76	121.13	3.63	2.91%	
		Weekend	kWh	28,329	27,210	1,119	3.95%	1.38
			Volts	124.70	121.12	3.58	2.87%	
	Cooling	Weekday	kWh	28,153	25,294	2,858	10.15%	3.83
			Volts	124.67	121.34	3.32	2.65%	
		Weekend	kWh	28,338	26,667	1,671	5.90%	2.16
			Volts	124.70	121.31	3.39	2.73%	

Table 4-2. Energy Savings for F3526 Hacienda Wheelock Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	24,923	24,382	541	2.17%	1.43
			Volts	124.13	122.23	1.91	1.52%	
		Weekend	kWh	26,555	25,814	741	2.79%	2.05
			Volts	124.12	122.41	1.71	1.36%	
	Cooling	Weekday	kWh	24,887	22,098	2,790	11.21%	8.00
			Volts	123.98	122.25	1.73	1.40%	
		Weekend	kWh	25,316	23,315	2,001	7.91%	5.69
			Volts	124.02	122.32	1.69	1.39%	
Phase B	Heating	Weekday	kWh	23,341	22,571	769	3.30%	1.43
			Volts	124.49	121.37	3.12	2.50%	
		Weekend	kWh	24,911	23,774	1,137	4.56%	1.86
			Volts	124.42	121.38	3.05	2.45%	
	Cooling	Weekday	kWh	26,765	24,254	2,510	9.38%	4.12
			Volts	124.45	121.59	2.85	2.28%	
		Weekend	kWh	28,041	26,219	1,822	6.50%	2.93
			Volts	124.41	121.66	2.74	2.22%	
Phase C	Heating	Weekday	kWh	22,208	21,432	777	3.50%	1.20
			Volts	124.76	121.12	3.63	2.91%	
		Weekend	kWh	24,153	22,620	1,533	6.35%	2.21
			Volts	124.70	121.12	3.58	2.87%	
	Cooling	Weekday	kWh	24,975	22,256	2,719	10.89%	4.11
			Volts	124.67	121.34	3.32	2.65%	
		Weekend	kWh	26,069	24,277	1,792	6.87%	2.52
			Volts	124.70	121.31	3.39	2.73%	

Table 4-3. Energy Savings for F3527 Hacienda Schwartz Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	29,747	29,634	113	0.38%	0.25
			Volts	124.15	122.22	1.93	1.54%	
		Weekend	kWh	29,509	29,162	346	1.17%	0.85
			Volts	124.15	122.41	1.75	1.39%	
	Cooling	Weekday	kWh	32,944	31,735	1,208	3.67%	2.61
			Volts	123.98	122.24	1.73	1.41%	
		Weekend	kWh	32,138	31,615	523	1.63%	1.19
			Volts	124.02	122.35	1.67	1.36%	
Phase B	Heating	Weekday	kWh	35,027	34,825	202	0.58%	0.25
			Volts	124.49	121.38	3.12	2.50%	
		Weekend	kWh	36,501	35,845	655	1.80%	0.73
			Volts	124.43	121.38	3.05	2.45%	
	Cooling	Weekday	kWh	34,760	33,406	1,354	3.89%	1.72
			Volts	124.44	121.60	2.84	2.27%	
		Weekend	kWh	34,568	33,631	937	2.71%	1.21
			Volts	124.42	121.65	2.77	2.24%	
Phase C	Heating	Weekday	kWh	27,464	27,201	263	0.96%	0.33
			Volts	124.76	121.13	3.63	2.91%	
		Weekend	kWh	28,192	27,701	491	1.74%	0.61
			Volts	124.70	121.12	3.58	2.87%	
	Cooling	Weekday	kWh	30,323	29,112	1,211	3.99%	1.50
			Volts	124.67	121.34	3.33	2.66%	
		Weekend	kWh	30,521	29,670	851	2.79%	1.03
			Volts	124.69	121.32	3.36	2.70%	

Table 4-4. Energy Savings for F1821 Lincoln Hartzell Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	33,034	31,428	1,606	4.86%	2.06
			Volts	124.38	121.45	2.93	2.35%	
		Weekend	kWh	29,248	27,624	1,624	5.55%	2.22
			Volts	124.41	121.30	3.11	2.50%	
	Cooling	Weekday	kWh	34,448	32,650	1,798	5.22%	2.62
			Volts	124.31	121.84	2.47	1.99%	
		Weekend	kWh	31,867	30,267	1,601	5.02%	2.48
			Volts	124.29	121.82	2.47	2.03%	
Phase B	Heating	Weekday	kWh	30,183	29,350	833	2.76%	2.06
			Volts	124.65	121.78	2.87	2.31%	
		Weekend	kWh	25,574	24,795	779	3.05%	1.23
			Volts	124.90	121.82	3.08	2.47%	
	Cooling	Weekday	kWh	29,908	29,465	443	1.48%	0.77
			Volts	124.50	122.14	2.36	1.94%	
		Weekend	kWh	25,806	25,605	201	0.78%	0.38
			Volts	124.77	122.29	2.48	2.04%	
Phase C	Heating	Weekday	kWh	31,250	29,926	1,323	4.23%	1.71
			Volts	125.29	122.19	3.10	2.47%	
		Weekend	kWh	27,116	25,856	1,260	4.64%	1.82
			Volts	125.41	122.21	3.20	2.55%	
	Cooling	Weekday	kWh	28,674	28,179	495	1.73%	0.82
			Volts	124.98	122.42	2.56	2.12%	
		Weekend	kWh	25,898	25,589	309	1.19%	0.60
			Volts	125.01	122.57	2.44	2.00%	

Table 4-5. Energy Savings for F1822 Lincoln Maysville Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	32,288	30,006	2,282	7.07%	3.00
			Volts	124.38	121.45	2.93	2.35%	
		Weekend	kWh	29,720	27,353	2,368	7.97%	3.18
			Volts	124.41	121.30	3.11	2.50%	
	Cooling	Weekday	kWh	30,377	29,858	518	1.71%	0.85
			Volts	124.31	121.82	2.48	2.00%	
		Weekend	kWh	29,139	28,806	333	1.14%	0.56
			Volts	124.29	121.82	2.47	2.03%	
Phase B	Heating	Weekday	kWh	32,432	30,232	2,200	6.78%	3.00
			Volts	124.65	121.78	2.87	2.31%	
		Weekend	kWh	30,129	27,832	2,297	7.62%	3.09
			Volts	124.90	121.82	3.08	2.47%	
	Cooling	Weekday	kWh	29,808	29,545	263	0.88%	0.45
			Volts	124.50	122.13	2.38	1.94%	
		Weekend	kWh	29,310	29,248	62	0.21%	0.10
			Volts	124.77	122.29	2.48	2.04%	
Phase C	Heating	Weekday	kWh	34,758	32,278	2,479	7.13%	2.89
			Volts	125.29	122.19	3.10	2.47%	
		Weekend	kWh	32,106	29,622	2,484	7.74%	3.03
			Volts	125.41	122.21	3.20	2.55%	
	Cooling	Weekday	kWh	27,374	27,404	-29	-0.11%	-0.05
			Volts	124.98	122.41	2.58	2.12%	
		Weekend	kWh	26,434	26,568	-134	-0.51%	-0.25
			Volts	125.01	122.57	2.44	2.00%	

Table 4-6. Energy Savings for F1824 Lincoln Parrott Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	20,537	20,506	31	0.15%	0.07
			Volts	124.35	121.57	2.78	2.23%	
		Weekend	kWh	17,208	17,229	-21	-0.12%	-0.05
			Volts	124.36	121.38	2.97	2.40%	
	Cooling	Weekday	kWh	18,248	18,510	-262	-1.44%	-0.72
			Volts	124.29	121.83	2.47	1.99%	
		Weekend	kWh	14,250	14,459	-209	-1.47%	-0.73
			Volts	124.28	121.82	2.46	2.02%	
Phase B	Heating	Weekday	kWh	21,783	21,832	-49	-0.23%	0.07
			Volts	124.63	121.87	2.76	2.21%	
		Weekend	kWh	18,304	18,276	28	0.15%	0.06
			Volts	124.91	121.94	2.97	2.39%	
	Cooling	Weekday	kWh	19,531	19,982	-451	-2.31%	-1.13
			Volts	124.63	122.12	2.51	2.04%	
		Weekend	kWh	15,298	15,361	-64	-0.42%	-0.20
			Volts	124.86	122.29	2.57	2.11%	
Phase C	Heating	Weekday	kWh	22,026	21,898	128	0.58%	0.25
			Volts	125.23	122.28	2.95	2.35%	
		Weekend	kWh	18,547	18,411	136	0.73%	0.30
			Volts	125.34	122.30	3.04	2.43%	
	Cooling	Weekday	kWh	18,984	19,206	-222	-1.17%	-0.53
			Volts	125.08	122.41	2.67	2.19%	
		Weekend	kWh	14,986	15,058	-72	-0.48%	-0.24
			Volts	125.06	122.57	2.49	2.03%	

Table 4-7. Energy Savings for F8721 State Brentwood Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	42,379	42,245	134	0.32%	0.11
			Volts	124.64	121.03	3.60	2.89%	
		Weekend	kWh	41,372	39,898	1,474	3.56%	1.22
			Volts	124.61	120.98	3.63	2.91%	
	Cooling	Weekday	kWh	36,214	35,003	1,211	3.34%	1.01
			Volts	124.57	120.43	4.14	3.32%	
		Weekend	kWh	35,899	34,249	1,650	4.60%	1.37
			Volts	124.55	120.36	4.19	3.36%	
Phase B	Heating	Weekday	kWh	37,137	36,891	246	0.66%	0.11
			Volts	124.99	121.32	3.67	2.94%	
		Weekend	kWh	35,959	34,792	1,168	3.25%	1.09
			Volts	125.11	121.40	3.71	2.97%	
	Cooling	Weekday	kWh	36,470	35,571	899	2.46%	0.74
			Volts	124.82	120.67	4.14	3.32%	
		Weekend	kWh	35,698	34,631	1,068	2.99%	0.87
			Volts	125.13	120.81	4.32	3.45%	
Phase C	Heating	Weekday	kWh	39,774	39,752	21	0.05%	0.02
			Volts	125.95	122.36	3.59	2.86%	
		Weekend	kWh	38,418	37,158	1,260	3.28%	1.13
			Volts	125.99	122.35	3.64	2.89%	
	Cooling	Weekday	kWh	36,244	35,065	1,178	3.25%	1.01
			Volts	125.59	121.54	4.05	3.22%	
		Weekend	kWh	35,190	33,822	1,368	3.89%	1.17
			Volts	125.71	121.56	4.15	3.31%	

Table 4-8. Energy Savings for F8722 State Lahmeyer Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	24,153	23,714	439	1.82%	0.63
			Volts	124.64	121.03	3.60	2.89%	
		Weekend	kWh	23,815	22,381	1,434	6.02%	2.07
			Volts	124.60	120.98	3.62	2.91%	
	Cooling	Weekday	kWh	26,305	23,805	2,500	9.50%	2.86
			Volts	124.57	120.43	4.14	3.32%	
		Weekend	kWh	26,299	23,008	3,291	12.51%	3.72
			Volts	124.55	120.36	4.19	3.36%	
Phase B	Heating	Weekday	kWh	23,331	22,673	658	2.82%	0.63
			Volts	124.98	121.32	3.66	2.93%	
		Weekend	kWh	23,015	21,525	1,490	6.47%	2.22
			Volts	125.05	121.40	3.65	2.92%	
	Cooling	Weekday	kWh	26,629	23,932	2,696	10.13%	3.05
			Volts	124.82	120.67	4.14	3.32%	
		Weekend	kWh	27,114	23,197	3,917	14.45%	4.18
			Volts	125.13	120.81	4.32	3.45%	
Phase C	Heating	Weekday	kWh	26,968	26,352	616	2.28%	0.80
			Volts	125.96	122.36	3.60	2.87%	
		Weekend	kWh	26,540	24,712	1,829	6.89%	2.38
			Volts	125.98	122.35	3.63	2.89%	
	Cooling	Weekday	kWh	27,613	24,751	2,862	10.37%	3.22
			Volts	125.59	121.54	4.05	3.22%	
		Weekend	kWh	28,169	23,671	4,498	15.97%	4.82
			Volts	125.71	121.56	4.15	3.31%	

Table 4-9. Energy Savings for F8723 State Trier Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	15,954	13,332	2,622	16.43%	5.68
			Volts	124.64	121.03	3.60	2.89%	
		Weekend	kWh	18,510	13,365	5,145	27.79%	9.56
			Volts	124.60	120.98	3.62	2.91%	
	Cooling	Weekday	kWh	13,363	10,610	2,753	20.60%	6.23
			Volts	124.56	120.44	4.12	3.30%	
		Weekend	kWh	15,186	11,044	4,142	27.28%	8.14
			Volts	124.55	120.38	4.17	3.35%	
Phase B	Heating	Weekday	kWh	16,109	12,908	3,201	19.87%	5.68
			Volts	124.98	121.32	3.66	2.93%	
		Weekend	kWh	19,264	12,858	6,406	33.25%	11.38
			Volts	125.05	121.40	3.65	2.92%	
	Cooling	Weekday	kWh	13,217	10,561	2,656	20.09%	6.15
			Volts	124.76	120.68	4.08	3.27%	
		Weekend	kWh	15,518	11,036	4,482	28.88%	8.44
			Volts	125.10	120.82	4.28	3.42%	
Phase C	Heating	Weekday	kWh	15,537	12,748	2,789	17.95%	6.26
			Volts	125.96	122.36	3.60	2.87%	
		Weekend	kWh	18,351	12,878	5,472	29.82%	10.32
			Volts	125.98	122.35	3.63	2.89%	
	Cooling	Weekday	kWh	13,529	10,887	2,641	19.52%	6.16
			Volts	125.52	121.54	3.98	3.17%	
		Weekend	kWh	15,541	11,410	4,132	26.58%	8.22
			Volts	125.63	121.57	4.05	3.24%	

Table 4-10. Energy Savings for F3124 Eastside (1) Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	18,766	18,642	125	0.66%	0.19
			Volts	125.22	120.86	4.36	3.48%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	26,102	24,328	1,774	6.80%	2.02
			Volts	125.23	121.02	4.21	3.36%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	18,954	18,746	208	1.10%	0.19
			Volts	125.30	120.63	4.68	3.73%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	25,565	24,121	1,443	5.65%	1.58
			Volts	125.18	120.70	4.49	3.58%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	19,072	18,675	397	2.08%	0.56
			Volts	125.34	120.67	4.67	3.73%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	26,625	24,817	1,808	6.79%	1.93
			Volts	125.24	120.84	4.40	3.52%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

Table 4-11. Energy Savings for F 3125 Eastside (1) Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	17,859	17,791	69	0.38%	0.11
			Volts	125.23	120.86	4.38	3.49%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	25,948	24,734	1,215	4.68%	1.39
			Volts	125.24	121.01	4.22	3.37%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	19,037	18,884	152	0.80%	0.11
			Volts	125.30	120.63	4.67	3.73%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	26,708	25,401	1,307	4.90%	1.35
			Volts	125.22	120.70	4.52	3.61%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	17,537	17,442	95	0.54%	0.15
			Volts	125.34	120.67	4.67	3.73%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	25,322	23,805	1,517	5.99%	1.69
			Volts	125.27	120.83	4.44	3.54%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-12. Energy Savings for F3126 Eastside (1) Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	13,697	13,548	149	1.09%	0.31
			Volts	125.31	120.93	4.38	3.49%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	20,407	19,698	709	3.48%	1.03
			Volts	125.30	121.08	4.22	3.37%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	14,835	14,464	372	2.50%	0.31
			Volts	125.34	120.67	4.67	3.73%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	21,681	20,654	1,027	4.74%	1.31
			Volts	125.25	120.74	4.51	3.60%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	15,955	15,518	437	2.74%	0.74
			Volts	125.41	120.74	4.67	3.73%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	22,773	21,892	882	3.87%	1.10
			Volts	125.33	120.90	4.43	3.53%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-13. Energy Savings for F3221 Eastside (2) Circuit, by Phase, Season and Day of Week

rr	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	8,561	8,551	10	0.12%	0.06
			Volts	124.66	122.08	2.57	2.05%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	9,318	8,472	845	9.07%	3.89
			Volts	124.67	121.72	2.95	2.33%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	8,765	8,936	-171	-1.95%	0.06
			Volts	125.14	121.89	3.25	2.60%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	10,421	9,486	936	8.98%	3.31
			Volts	124.94	121.58	3.35	2.71%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	7,776	7,701	74	0.95%	0.28
			Volts	125.35	121.01	4.34	3.46%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	8,997	8,099	898	9.99%	2.89
			Volts	125.26	120.96	4.30	3.45%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-14. Energy Savings for F3222 Eastside (2) Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	23,187	22,701	487	2.10%	0.95
			Volts	124.91	122.17	2.74	2.21%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	30,865	27,305	3,559	11.53%	4.31
			Volts	124.89	121.65	3.23	2.68%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	22,536	22,202	334	1.48%	0.95
			Volts	125.14	121.89	3.25	2.60%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	30,686	28,316	2,370	7.72%	2.84
			Volts	124.93	121.56	3.37	2.72%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	21,491	21,158	333	1.55%	0.45
			Volts	125.34	121.00	4.34	3.46%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	31,488	28,669	2,820	8.96%	2.63
			Volts	125.24	120.99	4.25	3.40%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-15. Energy Savings for F3223 Eastside (2) Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	25,529	25,219	310	1.21%	0.55
			Volts	124.90	122.16	2.74	2.21%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	34,416	31,300	3,116	9.05%	3.38
			Volts	124.88	121.65	3.23	2.68%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	24,849	24,435	415	1.67%	0.55
			Volts	125.14	121.87	3.27	2.61%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	34,469	32,080	2,390	6.93%	2.55
			Volts	124.93	121.56	3.37	2.72%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	25,042	24,478	564	2.25%	0.65
			Volts	125.34	121.00	4.34	3.46%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	34,384	31,760	2,623	7.63%	2.24
			Volts	125.24	120.99	4.25	3.40%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-16. Energy Savings for F8121 Elcona Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	28,275	25,349	2,926	10.35%	4.12
			Volts	125.27	122.10	3.17	2.51%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	29,450	29,686	-236	-0.80%	-0.40
			Volts	124.83	122.50	2.33	1.99%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	31,622	27,404	4,218	13.34%	4.12
			Volts	125.48	121.00	4.47	3.56%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	32,852	32,281	572	1.74%	0.55
			Volts	125.39	121.46	3.93	3.14%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	28,502	25,036	3,466	12.16%	3.49
			Volts	125.29	120.91	4.37	3.49%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	29,545	29,918	-373	-1.26%	-0.41
			Volts	125.13	121.31	3.82	3.05%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-17. Energy Savings for F8122 Elcona Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	20,091	19,269	822	4.09%	1.63
			Volts	125.29	122.12	3.17	2.51%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	25,145	22,301	2,844	11.31%	5.67
			Volts	124.85	122.52	2.33	2.00%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	21,358	19,786	1,572	7.36%	1.63
			Volts	125.51	121.03	4.47	3.55%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	26,607	23,582	3,026	11.37%	3.62
			Volts	125.42	121.49	3.92	3.14%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	22,892	21,757	1,135	4.96%	1.42
			Volts	125.29	120.92	4.37	3.49%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	30,234	26,385	3,850	12.73%	4.18
			Volts	125.14	121.32	3.82	3.05%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-18. Energy Savings for F8123 Elcona Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	45,604	44,057	1,547	3.39%	1.35
			Volts	125.27	122.10	3.17	2.51%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	51,823	52,693	-870	-1.68%	-0.83
			Volts	124.89	122.50	2.39	2.03%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	45,544	42,900	2,645	5.81%	1.35
			Volts	125.48	121.01	4.47	3.56%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	52,965	52,772	193	0.37%	0.12
			Volts	125.43	121.47	3.96	3.17%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	46,023	44,280	1,744	3.79%	1.09
			Volts	125.28	120.90	4.37	3.49%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	54,336	55,696	-1,360	-2.50%	-0.82
			Volts	125.14	121.31	3.83	3.06%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-19. Energy Savings for F8821 Harper Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	31,387	30,284	1,103	3.51%	2.11
			Volts	124.33	122.27	2.06	1.66%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	36,900	36,130	770	2.09%	1.37
			Volts	124.30	122.40	1.90	1.52%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	28,373	27,426	948	3.34%	2.11
			Volts	124.41	122.64	1.77	1.46%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	32,848	31,997	851	2.59%	1.83
			Volts	124.44	122.68	1.76	1.41%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	31,048	30,095	953	3.07%	1.72
			Volts	124.38	122.16	2.22	1.79%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	37,003	35,872	1,131	3.06%	1.79
			Volts	124.30	122.16	2.14	1.71%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-20. Energy Savings for F8822 Harper Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	28,495	27,757	738	2.59%	1.56
			Volts	124.31	122.25	2.06	1.66%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	27,067	26,881	186	0.69%	0.42
			Volts	124.30	122.19	2.11	1.66%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	36,794	35,792	1,002	2.72%	1.56
			Volts	124.39	122.62	1.76	1.46%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	43,014	40,882	2,133	4.96%	3.54
			Volts	124.41	122.67	1.73	1.40%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	31,108	30,434	675	2.17%	1.22
			Volts	124.37	122.15	2.22	1.78%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	36,086	34,605	1,480	4.10%	2.42
			Volts	124.29	122.16	2.13	1.70%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-21. Energy Savings for F0321 South Bend Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	35,062	34,723	339	0.97%	0.23
			Volts	125.57	120.21	5.36	4.28%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	42,081	41,394	687	1.63%	0.42
			Volts	125.47	120.57	4.91	3.90%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	35,186	34,287	898	2.55%	0.23
			Volts	125.38	119.99	5.39	4.30%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	41,741	42,138	-397	-0.95%	-0.24
			Volts	125.27	120.35	4.92	3.92%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	33,925	33,131	794	2.34%	0.55
			Volts	125.30	119.99	5.31	4.23%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	41,938	40,941	997	2.38%	0.60
			Volts	125.29	120.34	4.95	3.94%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-22. Energy Savings for F0322 South Bend Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	21,803	21,147	656	3.01%	0.73
			Volts	125.58	120.44	5.14	4.10%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	29,557	28,574	983	3.33%	0.85
			Volts	125.47	120.56	4.91	3.91%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	25,859	25,493	365	1.41%	0.73
			Volts	125.40	120.12	5.28	4.21%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	31,511	30,521	989	3.14%	0.80
			Volts	125.25	120.33	4.92	3.92%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	16,786	16,128	658	3.92%	0.96
			Volts	125.37	120.23	5.14	4.10%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	21,210	20,655	556	2.62%	0.67
			Volts	125.28	120.34	4.94	3.94%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-23. Energy Savings for F0323 South Bend Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	15,075	14,962	112	0.75%	0.17
			Volts	125.57	120.20	5.36	4.27%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	18,061	17,462	599	3.32%	0.85
			Volts	125.46	120.54	4.91	3.91%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase B	Heating	Weekday	kWh	17,234	16,901	333	1.93%	0.17
			Volts	125.35	119.97	5.39	4.30%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	20,499	19,642	857	4.18%	1.07
			Volts	125.22	120.30	4.92	3.92%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
Phase C	Heating	Weekday	kWh	13,684	13,321	363	2.65%	0.63
			Volts	125.31	120.00	5.31	4.24%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	17,412	16,712	700	4.02%	1.02
			Volts	125.27	120.33	4.94	3.94%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	

* Too few weekend days with VVO off to provide basis for imputation

Table 4-24. Energy Savings for F3321 Spy Run Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	16,774	16,392	383	2.28%	0.78
			Volts	125.15	121.48	3.67	2.94%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	**	**	**	**	**
			Volts	**	**	**	**	
		Weekend	kWh	**	**	**	**	**
			Volts	**	**	**	**	
Phase B	Heating	Weekday	kWh	22,343	21,711	632	2.83%	0.78
			Volts	125.41	121.03	4.38	3.49%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	**	**	**	**	**
			Volts	**	**	**	**	
		Weekend	kWh	**	**	**	**	**
			Volts	**	**	**	**	
Phase C	Heating	Weekday	kWh	18,554	17,974	580	3.13%	0.86
			Volts	125.33	120.77	4.56	3.64%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	**	**	**	**	**
			Volts	**	**	**	**	
		Weekend	kWh	**	**	**	**	**
			Volts	**	**	**	**	

* Too few weekend days with VVO off to provide basis for imputation

** VVO not on anytime during cool season

Table 4-25. Energy Savings for F3322 Spy Run Circuit, by Phase, Season and Day of Week

Circuit Name / ID / Phase	Season	Day of Week	Measure	Average Daily VVO Off	Average Daily VVO On	Difference (Off – On)	% Difference	Estimated Daily CVR Factor
Phase A	Heating	Weekday	kWh	50,353	48,248	2,105	4.18%	1.47
			Volts	125.14	121.59	3.55	2.84%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	**	**	**	**	**
			Volts	**	**	**	**	
		Weekend	kWh	**	**	**	**	**
			Volts	**	**	**	**	
Phase B	Heating	Weekday	kWh	51,038	48,343	2,696	5.28%	1.47
			Volts	125.41	121.17	4.24	3.39%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	**	**	**	**	**
			Volts	**	**	**	**	
		Weekend	kWh	**	**	**	**	**
			Volts	**	**	**	**	
Phase C	Heating	Weekday	kWh	51,755	49,477	2,278	4.40%	1.24
			Volts	125.34	120.91	4.43	3.54%	
		Weekend	kWh	*	*	*	*	*
			Volts	*	*	*	*	
	Cooling	Weekday	kWh	**	**	**	**	**
			Volts	**	**	**	**	
		Weekend	kWh	**	**	**	**	**
			Volts	**	**	**	**	

* Too few weekend days with VVO off to provide basis for imputation

** VVO not on anytime during cool season

4.1 DISCUSSION OF FACTORS AFFECTING ESTIMATED ENERGY SAVINGS AND CVR FACTORS

The estimated CVR factors in the tables in Chapter 4 show a range of values, which is consistent with evidence from previous studies of the voltage reduction strategy. Results reported from previous studies show the range of CVR factors that have been estimated.

- Kirshner and Giorsetto[4] analyzed trials of voltage reduction at several utilities in the early 1980s. Their analysis showed that most test circuits had energy savings of between 0.5 and 1% for each 1% voltage reduction, implying CVR factors of 0.5 to 1. Their regression analysis showed that each 1% reduction in voltage resulted in energy savings of 0.76% for residential loads, of 0.99% for commercial loads, and of 0.41% for industrial loads.
- More recently, a study conducted for the Northwest Energy Efficiency Alliance (NEEA) evaluated voltage reduction at several utilities in the Pacific Northwest.[5] Evaluation of voltage changes at the circuit level, using temperature adjusted regressions, gave an average CVR factor of 0.69 based on a voltage change of 2.5%. The range of CVR factors was -0.11 to 1.98.
- In EPRI's Green Circuits collaborative project, 42 distribution circuits across different utilities were modeled in detail using an open-source distribution system electrical simulation package (OpenDSS). This modeling was augmented with historical circuit-measurement data, allowing the hourly resolution simulation of circuit operation for actual load patterns for each hour in a calendar year (8760 hours). As part of the study, the effects of voltage reduction were modeled using a consistent approach to control an end-of-line primary bus to 118 V. The results showed a median reduction in energy consumption across all circuits of 2%, with upper and lower quartiles of 1.3% and 2.8%.

[4] Kirshner, D. and Giorsetto, P., "Statistical Tests of Energy Savings Due to Voltage Reduction," IEEE Transactions on Power Apparatus and Systems, vol. PAS-103, no. 6, pp. 1205-10, June 1984.

[5] NEEA 1207, Distribution Efficiency Initiative, Northwest Energy Efficiency Alliance, 2007.

5 KWH SAVINGS FROM VVO AT SYSTEM PEAK

This chapter provides results on kWh savings that can be attributed to implementing VVO during I&M's system peak hour in 2015.

I&M's system peak in 2015 occurred on September 3 from 2 PM to 3 PM. Of the 75 circuits / phases for which VVO was implemented during 2015, VVO was on during the system peak hour for 49 circuits / phases and off for 26. Accordingly, actual kWh savings attributable to VVO would be realized only for the 49 circuits / phases for which VVO was on during the system peak hour.

The estimated savings during system peak hour are summarized in Table 5-1. Having VVO on during system peak hour was estimated to have reduced loads by 1.9 percent for the all of the circuits / phases taken together.

Table 5-1. Summary of Estimated kWh Savings from VVO during I&M System Peak Hour in 2015, by Station, Circuit, Phase

Id	Station	Circuit Name	Phase	VVO Status	Imputed Base Usage	Actual kWh Usage	Savings	Percentage kWh Savings
F3525a	Hacienda	Hartford	A	OFF	2,060	2,060	-	-
F3525b	Hacienda	Hartford	B	ON	1,973	1,892	81.0	4.1%
F3525c	Hacienda	Hartford	C	ON	2,058	1,950	107.2	5.2%
F3526a	Hacienda	Wheelock	A	OFF	1,976	1,976	-	-
F3526b	Hacienda	Wheelock	B	ON	2,272	2,176	96.7	4.3%
F3526c	Hacienda	Wheelock	C	ON	2,067	1,937	130.5	6.3%
F3527a	Hacienda	Schwartz	A	OFF	1,787	1,787	-	-
F3527b	Hacienda	Schwartz	B	OFF	1,827	1,827	-	-
F3527c	Hacienda	Schwartz	C	OFF	1,564	1,564	-	-
F1821a	Lincoln	Hartzell	A	OFF	2,418	2,418	-	-
F1821b	Lincoln	Hartzell	B	OFF	2,176	2,176	-	-
F1821c	Lincoln	Hartzell	C	OFF	2,230	2,230	-	-
F1822a	Lincoln	Maysville	A	OFF	2,087	2,087	-	-
F1822b	Lincoln	Maysville	B	OFF	2,147	2,147	-	-
F1822c	Lincoln	Maysville	C	OFF	2,085	2,085	-	-
F1824a	Lincoln	Parrott	A	OFF	1,148	1,148	-	-
F1824b	Lincoln	Parrott	B	OFF	1,210	1,210	-	-
F1824c	Lincoln	Parrott	C	OFF	1,179	1,179	-	-
F8721a	State	Brentwood	A	ON	2,575	2,517	57.8	2.2%
F8721b	State	Brentwood	B	ON	2,747	2,704	42.9	1.6%
F8721c	State	Brentwood	C	ON	2,724	2,668	56.0	2.1%
F8722a	State	Lahmeyer	A	ON	1,990	1,911	79.5	4.0%
F8722b	State	Lahmeyer	B	ON	2,108	2,021	87.6	4.2%
F8722c	State	Lahmeyer	C	ON	2,068	1,981	86.9	4.2%
F8723a	State	Trier	A	ON	882	780	102.6	11.6%
F8723b	State	Trier	B	ON	929	823	106.5	11.5%
F8723c	State	Trier	C	ON	943	843	99.8	10.6%
F3124	Eastside 1		A	ON	1,410	1,351	58.6	4.2%
F3124	Eastside 1		B	ON	1,389	1,337	52.3	3.8%
F3124	Eastside 1		C	ON	1,446	1,382	63.8	4.4%
F3125	Eastside 1		A	ON	1,426	1,366	60.1	4.2%
F3125	Eastside 1		B	ON	1,418	1,355	63.6	4.5%
F3125	Eastside 1		C	ON	1,396	1,319	76.1	5.5%
F3126	Eastside 1		A	ON	1,083	1,067	16.2	1.5%
F3126	Eastside 1		B	ON	1,113	1,088	25.7	2.3%
F3126	Eastside 1		C	ON	1,192	1,168	23.7	2.0%
F3221	Eastside 2		A	ON	505	482	23.4	4.6%
F3221	Eastside 2		B	ON	549	521	28.2	5.1%
F3221	Eastside 2		C	ON	477	458	18.3	3.8%
F3222	Eastside 2		A	ON	1,621	1,571	50.4	3.1%
F3222	Eastside 2		B	ON	1,610	1,565	44.6	2.8%
F3222	Eastside 2		C	ON	1,606	1,551	55.3	3.4%
F3223	Eastside 2		A	ON	2,145	2,098	47.2	2.2%
F3223	Eastside 2		B	ON	2,041	2,003	37.4	1.8%
F3223	Eastside 2		C	ON	2,098	2,060	38.0	1.8%

Table 5-2, continued. Summary of Estimated kWh Savings from VVO during I&M System Peak Hour in 2015, by Station, Circuit, Phase

Id	Station	Circuit Name	Phase	VVO Status	Imputed Base Usage	Actual kWh Usage	Savings	Percentage kWh Savings
F8121	Elcona		A	ON	2,008	2,004	3.6	0.2%
F8121	Elcona		B	ON	2,212	2,143	68.8	3.1%
F8121	Elcona		C	ON	1,994	1,979	14.9	0.7%
F8122	Elcona		A	ON	1,348	1,272	75.1	5.6%
F8122	Elcona		B	ON	1,391	1,281	110.4	7.9%
F8122	Elcona		C	ON	1,559	1,444	114.4	7.3%
F8123	Elcona		A	ON	3,256	3,281	-24.9	-0.8%
F8123	Elcona		B	ON	3,182	3,146	35.8	1.1%
F8123	Elcona		C	ON	3,250	3,283	-33.2	-1.0%
F8121	Harper		A	OFF	2,059	2,059	-	-
F8121	Harper		B	OFF	1,852	1,852	-	-
F8121	Harper		C	OFF	2,045	2,045	-	-
F8122	Harper		A	OFF	2,198	2,198	-	-
F8122	Harper		B	OFF	2,571	2,571	-	-
F8122	Harper		C	OFF	2,149	2,149	-	-
F0321	South Bend		A	ON	2,355	2,314	41.2	1.7%
F0321	South Bend		B	ON	2,374	2,367	6.9	0.3%
F0321	South Bend		C	ON	2,229	2,180	49.1	2.2%
F0322	South Bend		A	ON	1,680	1,619	60.7	3.6%
F0322	South Bend		B	ON	1,783	1,728	55.0	3.1%
F0322	South Bend		C	ON	1,212	1,176	36.8	3.0%
F0323	South Bend		A	ON	997	961	36.0	3.6%
F0323	South Bend		B	ON	1,093	1,058	35.6	3.3%
F0323	South Bend		C	ON	925	900	24.7	2.7%
F3321	Spy Run		A	OFF	1,167	1,167	-	-
F3321	Spy Run		B	OFF	1,415	1,415	-	-
F3321	Spy Run		C	OFF	1,206	1,206	-	-
F3322	Spy Run		A	OFF	2,548	2,548	-	-
F3322	Spy Run		B	OFF	2,586	2,586	-	-
F3322	Spy Run		C	OFF	2,621	2,621	-	-
	Totals, All Circuits / Phases				135,018	132,390	2,628.5	1.9%

6 AGGREGATE KWH SAVINGS FOR 2015 EECO PROGRAM

Two sets of aggregate kWh savings were calculated for the 2015 EECO program.

- One set of aggregate savings applies to savings in 2015 calculated over those days when VVO was “On”. (As shown in Table 2-1, VVO was “Off” for some days in 2015 for the various stations.) These savings are reported in Section 6.1.
- A second set of aggregate savings was calculated to show the savings that would result if VVO could be continually “On” during the year. These savings are reported in Section 6.2.

6.1 KWH SAVINGS IN 2015 WHEN VVO WAS “ON”

The kWh savings in 2015 were first calculated for days when VVO was “On”. The results for the Hacienda circuits are reported in Table 6-1, for the Lincoln circuits in Table 6-2, and for the State circuits in Table 6-3. Also reported in these tables are the kWh savings in 2015 according to season and type of day. Table 6-4 provides a summary of kWh savings in 2015 by station and circuit for the three stations for which data for the full year were available.

Tables 6-5 and 6-6 provide estimates of savings from VVO on weekdays for the six stations that came into the EECO program in 2015. Results are provided for these stations only for weekdays because the regression results for the stations could not provide adequate values for adjusting amps in response to voltage changes for weekends. This occurred because most of the stations were on VVO for most weekend days, and there were few observations for weekends when VVO was off.

6.2 PROJECTED ANNUAL KWH SAVINGS WITH VVO ALWAYS ON

The kWh savings determined for 2015 were used to project the annualized kWh savings that would result were VVO always to be on.

The projected annual kWh savings were VVO always “On” are reported in Table 6-7 for the Hacienda circuits, in Table 6-8 for the Lincoln circuits, and in Table 6-9 for the State circuits. Also reported in these tables are the kWh savings according to season and type of day. Table 6-10 provides a summary of annual kWh savings by station and circuit for these stations for which full year data were available.

Table 6-1. kWh Savings in 2015 with VVO On for Hacienda Circuits, by Circuit, Phase, Season and Day of Week

Circuit Name ID	Season	Day of Week	kWh Savings			
			Phase A	Phase B	Phase C	Sum of Phases
Hartford (4933525)	Heating	Weekdays	54,138	56,277	52,959	163,373
		Weekends	-858	8,575	11,186	18,902
	Cooling	Weekdays	187,928	198,009	207,063	593,000
		Weekends	52,278	47,235	45,858	145,371
Annual kWh Savings, Hartford Circuit			293,486	310,095	317,065	920,647
Wheelock (4933526)	Heating	Weekdays	19,701	20,559	20,771	61,031
		Weekends	10,653	11,367	15,331	37,351
	Cooling	Weekdays	198,406	179,639	197,777	575,822
		Weekends	57,357	48,752	48,860	154,968
Annual kWh Savings, Wheelock Circuit			286,117	260,318	282,738	829,173
Schwartz (4933527)	Heating	Weekdays	5,027	5,545	7,053	17,625
		Weekends	5,407	6,554	4,912	16,873
	Cooling	Weekdays	88,966	98,071	89,090	276,127
		Weekends	12,603	23,027	21,128	56,758
Annual kWh Savings, Schwartz Crcuit			112,003	133,197	122,182	367,383
Totals, All Hacienda Circuits	Heating	Weekdays	78,867	82,381	80,782	242,030
		Weekends	15,202	26,496	31,428	73,126
	Cooling	Weekdays	475,300	475,719	493,930	1,444,949
		Weekends	122,238	119,014	115,846	357,098
Annual kWh Savings, All Hacienda			691,606	703,610	721,986	2,117,203

Table 6-2. kWh Savings in 2015 with VVO On for Lincoln Circuits, by Circuit, Phase, Season and Day of Week

Circuit Name ID	Season	Day of Week	kWh Savings			
			Phase A	Phase B	Phase C	Sum of Phases
Hartzell (4051821)	Heating	Weekdays	137,204	68,489	87,439	293,132
		Weekends	57,458	27,052	37,085	121,595
	Cooling	Weekdays	102,559	23,768	25,350	151,677
		Weekends	38,720	4,577	8,190	51,487
Annual kWh Savings, Hartzell Circuit			335,940	123,886	158,064	617,891
Maysville (4051822)	Heating	Weekdays	195,187	183,316	167,642	546,145
		Weekends	83,603	80,275	73,707	237,585
	Cooling	Weekdays	29,520	13,007	-1,719	40,808
		Weekends	7,297	-5	-3,015	4,277
Annual kWh Savings, Maysville Circuit			315,608	276,593	236,615	828,815
Parrott (4058124)	Heating	Weekdays	2,048	-3,175	9,377	8,250
		Weekends	-460	857	3,897	4,293
	Cooling	Weekdays	-15,086	-25,887	-11,883	-52,856
		Weekends	-5,116	-1,764	-1,326	-8,206
Annual kWh Savings, Parrott Circuit			-18,614	-29,970	65	-48,518
Totals, All Lincoln Circuits	Heating	Weekdays	334,439	248,630	264,458	847,527
		Weekends	140,601	108,183	114,689	363,473
	Cooling	Weekdays	116,993	10,888	11,748	139,629
		Weekends	40,900	2,809	3,849	47,558
Annual kWh Savings, All Lincoln Circuits			632,934	370,510	394,744	1,398,188

Table 6-3. kWh Savings in 2015 with VVO On for State Circuits, by Circuit, Phase, Season and Day of Week

Circuit Name ID	Season	Day of Week	kWh Savings			
			Phase A	Phase B	Phase C	Sum of Phases
Brentwood (4928721)	Heating	Weekdays	7,628	13,830	972	22,430
		Weekends	34,210	26,982	28,703	89,896
	Cooling	Weekdays	119,969	88,942	114,313	323,225
		Weekends	71,875	46,416	59,202	177,492
Annual kWh Savings, Brentwood Circuit			233,682	176,170	203,191	613,044
Lahmeyer (4928722)	Heating	Weekdays	24,235	36,314	33,005	93,554
		Weekends	33,222	34,473	41,749	109,443
	Cooling	Weekdays	246,709	265,328	277,246	789,283
		Weekends	143,800	171,141	195,102	510,043
Annual kWh Savings, Laymeyer Circuit			447,965	507,256	547,101	1,502,322
Trier (4928723)	Heating	Weekdays	144,265	176,178	149,576	470,019
		Weekends	119,317	148,342	124,870	392,530
	Cooling	Weekdays	266,402	256,543	250,942	773,887
		Weekends	173,051	187,164	171,105	531,321
Annual kWh Savings, Trier Circuit			703,036	768,228	696,494	2,167,758
Totals, All State Circuits	Heating	Weekdays	176,128	226,322	183,553	586,003
		Weekends	186,749	209,798	195,322	591,869
	Cooling	Weekdays	633,080	610,813	642,502	1,886,395
		Weekends	388,726	404,721	425,409	1,218,856
Annual kWh Savings, All State Circuits			1,384,683	1,451,654	1,446,787	4,283,124

Table 6-4. Summary of Annual kWh Savings in 2015 for Stations in EECO Program for Full Year, by Station and Circuit

Station	Circuit	Annual kWh Savings
Hacienda	Hartford	920,647
	Wheelock	829,173
	Schwartz	367,383
	Total, Hacienda circuits	2,117,203
Lincoln	Hartzell	617,891
	Maysville	828,815
	Parrott	-48,518
	Total, Lincoln circuits	1,398,188
State	Brentwood	613,044
	Lahmeyer	1,502,322
	Trier	2,167,758
	Total, State Circuits	4,283,124
Total, All Circuits		7,798,515

Table 6-5. kWh Savings in 2015 with VVO On for Weekdays for Eastside 1, Eastside 2 and Elcona Circuits, by Circuit, Phase, Season and Day of Week

Station	***Circuit***	***Season***	***kWh Savings***			
			Phase A	***Phase B***	***Phase C***	***Sum of Phases***
Eastside 1	F3124	Heat	6,270	10,522	20,183	36,975
		Cool	62,470	50,822	63,630	176,922
		Total	68,740	61,343	83,814	213,897
	F3125	Heat	3,348	7,674	4,733	15,754
		Cool	42,717	46,006	53,392	142,116
		Total	46,065	53,680	58,125	157,870
	F3126	Heat	7,494	18,870	22,187	48,550
		Cool	25,306	36,597	31,392	93,295
		Total	32,800	55,467	53,579	141,845
	All Eastside 1	Heat	17,111	37,065	47,103	101,280
		Cool	130,493	133,425	148,414	412,333
		Total	147,604	170,490	195,517	513,612
Eastside 2	F3221	Heat	599	-9,048	3,847	-4,602
		Cool	25,575	33,744	32,337	91,657
		Total	26,175	24,696	36,184	87,055
	F3222	Heat	24,852	17,513	17,376	59,741
		Cool	100,440	85,882	106,340	292,662
		Total	125,293	103,395	123,716	352,404
	F3223	Heat	15,860	21,503	29,297	66,659
		Cool	90,376	86,281	97,946	274,604
		Total	106,236	107,784	127,243	341,263
	All Eastside 2	Heat	41,311	29,968	50,519	121,799
		Cool	216,392	205,907	236,624	658,923
		Total	257,703	235,876	287,143	780,722
Elcona	F8121	Heat	100,561	148,568	122,519	371,648
		Cool	-4,269	18,397	-12,742	1,386
		Total	96,292	166,965	109,777	373,034
	F8122	Heat	28,568	55,390	40,521	124,478
		Cool	69,944	98,875	128,660	297,479
		Total	98,512	154,265	169,181	421,957
	F8123	Heat	54,059	93,670	62,367	210,096
		Cool	-25,587	6,312	-45,414	-64,689
		Total	28,472	99,982	16,953	145,407
	All Elcona	Heat	183,188	297,627	225,407	706,222
		Cool	40,087	123,584	70,504	234,176
		Total	223,275	421,212	295,911	940,398

Table 6-6. kWh Savings in 2015 with VVO On for Weekdays for Harper, South Bend, and Spy Run Circuits, by Circuit, Phase, and Season

Station	Circuit	Season	kWh Savings			
			Phase A	Phase B	Phase C	Sum of Phases
Harper	F8821	Heat	22,631	12,459	18,778	53,868
		Cool	13,415	9,679	20,435	43,530
		Total	36,047	22,138	39,213	97,398
	F8822	Heat	14,461	14,620	12,758	41,839
		Cool	-557	24,673	26,496	50,612
		Total	13,904	39,293	39,254	92,451
	All Harper	Heat	37,093	27,078	31,536	95,707
		Cool	12,858	34,352	46,932	94,142
		Total	49,951	61,431	78,467	189,849
South Bend	F0321	Heat	6,079	23,400	19,160	48,639
		Cool	36,632	-2,452	46,680	80,860
		Total	42,710	20,948	65,841	129,499
	F0322	Heat	28,993	13,771	28,270	71,034
		Cool	44,383	44,260	25,289	113,931
		Total	73,377	58,031	53,558	184,966
	F0323	Heat	3,242	9,157	11,504	23,903
		Cool	26,603	34,394	30,877	91,873
		Total	29,845	43,551	42,381	115,776
	All South Bend	Heat	38,314	46,329	58,934	143,576
		Cool	107,617	76,201	102,846	286,664
		Total	145,932	122,530	161,780	430,241
Spy Run	F3321	Heat	17,576	30,719	28,603	76,897
		Cool	404	926	697	2,027
		Total	17,979	31,645	29,299	78,923
	F3322	Heat	81,688	106,571	90,132	278,391
		Cool	1,081	1,394	1,496	3,971
		Total	82,769	107,965	91,628	282,362
	All Spy Run	Heat	99,263	137,289	118,735	355,287
		Cool	1,485	2,320	2,193	5,998
		Total	100,749	139,609	120,927	361,285

Table 6-7. Projected Annual kWh Savings Were VVO Always On for Hacienda Circuits, by Circuit, Phase, Season and Day of Week

Circuit Name ID	Season	Day of Week	kWh Savings			
			Phase A	Phase B	Phase C	Sum of Phases
Hartford (4933525)	Heat	Weekdays	193,843	266,575	252,562	712,980
		Weekends	-1,868	44,588	58,165	100,885
	Cool	Weekdays	341,206	359,034	368,742	1,068,982
		Weekends	91,978	89,132	85,234	266,345
Annual kWh Savings, Hartford Circuit			625,160	759,329	764,703	2,149,192
Wheelock (4933526)	Heat	Weekdays	68,508	97,452	98,427	264,387
		Weekends	38,545	59,111	79,720	177,376
	Cool	Weekdays	359,870	323,833	350,734	1,034,437
		Weekends	102,075	92,913	91,388	286,376
Annual kWh Savings, Wheelock ircuit			568,999	573,309	620,269	1,762,577
Schwartz (4933527)	Heat	Weekdays	14,307	25,537	33,337	73,181
		Weekends	18,008	34,081	25,540	77,629
	Cool	Weekdays	155,879	174,640	156,218	486,737
		Weekends	26,689	47,795	43,422	117,906
Annual kWh Savings, Schwartz Crcuit			214,882	282,054	258,518	755,454
Totals, All Hacienda Circuits	Heat	Weekdays	276,658	389,564	384,326	1,050,549
		Weekends	54,685	137,780	163,425	355,890
	Cool	Weekdays	856,956	857,507	875,694	2,590,157
		Weekends	220,742	229,841	220,044	670,627
Annual kWh Savings, All Hacienda			1,409,041	1,614,692	1,643,490	4,667,223

Table 6-8. Projected Annual kWh Savings Were VVO Always On for Lincoln Circuits, by Circuit, Phase, Season and Day of Week

Circuit Name ID	Season	Day of Week	kWh Savings			
			Phase A	Phase B	Phase C	Sum of Phases
Hartzell (4051821)	Heat	Weekdays	203,950	105,814	168,048	477,812
		Weekends	84,452	40,518	65,495	190,465
	Cool	Weekdays	231,904	57,164	63,860	352,929
		Weekends	81,635	10,276	15,777	107,688
Annual kWh Savings, Hartzell Circuit			601,940	213,773	313,180	1,128,894
Maysville (4051822)	Heat	Weekdays	289,760	279,446	314,865	884,071
		Weekends	123,113	119,429	129,180	371,722
	Cool	Weekdays	66,879	33,903	-3,748	97,034
		Weekends	16,966	3,154	-6,859	13,260
Annual kWh Savings, Maysville Circuit			496,717	435,933	433,437	1,366,087
Parrott (4058124)	Heat	Weekdays	3,926	-6,231	16,235	13,929
		Weekends	-1,088	1,442	7,047	7,401
	Cool	Weekdays	-33,825	-58,159	-28,638	-120,621
		Weekends	-10,679	-3,257	-3,677	-17,613
Annual kWh Savings, Parrott Circuit			-41,665	-66,205	-9,033	-116,903
Totals, All Lincoln Circuits	Heat	Weekdays	497,635	379,030	499,148	1,375,812
		Weekends	206,477	161,389	201,722	569,589
	Cool	Weekdays	264,959	32,909	31,474	329,341
		Weekends	87,922	10,173	5,241	103,336
Annual kWh Savings, All Lincoln Circuits			1,056,992	583,501	737,585	2,378,078

Table 6-9. Projected Annual kWh Savings Were VVO Always On for State Circuits, by Circuit, Phase, Season and Day of Week

Circuit Name ID	Season	Day of Week	kWh Savings			
			Phase A	Phase B	Phase C	Sum of Phases
Brentwood (4928721)	Heat	Weekdays	16,957	31,293	2,729	50,979
		Weekends	76,658	60,712	65,532	202,902
	Cool	Weekdays	156,228	115,968	151,995	424,191
		Weekends	84,139	54,457	69,784	208,380
Annual kWh Savings, Brentwood Circuit			333,982	262,431	290,040	886,452
Lahmeyer (4928722)	Heat	Weekdays	55,717	83,546	78,236	217,499
		Weekends	74,566	77,477	95,094	247,138
	Cool	Weekdays	322,489	347,820	369,219	1,039,528
		Weekends	167,859	199,767	229,401	597,027
Annual kWh Savings, Laymeyer Circuit			620,631	708,610	771,950	2,101,191
Trier (4928723)	Heat	Weekdays	332,979	406,546	354,211	1,093,737
		Weekends	267,529	333,086	284,567	885,182
	Cool	Weekdays	355,126	342,620	340,701	1,038,448
		Weekends	211,248	228,595	210,713	650,556
Annual kWh Savings, Trier Circuit			1,166,883	1,310,847	1,190,193	3,667,922
Totals, All State Circuits	Heat	Weekdays	405,652	521,385	435,177	1,362,214
		Weekends	418,753	471,275	445,193	1,335,221
	Cool	Weekdays	833,844	806,408	861,915	2,502,167
		Weekends	463,246	482,819	509,898	1,455,963
Annual kWh Savings, All State Circuits			2,121,496	2,281,887	2,252,182	6,655,565

Table 6-10. Summary of Projected Annual kWh Savings Were VVO Always On from 2015 EECO Program, by Station and Circuit

Station	Circuit	Annual kWh Savings
Hacienda	Hartford	2,149,192
	Wheelock	1,762,577
	Schwartz	755,454
	Total, Hacienda circuits	4,667,223
Lincoln	Hartzell	1,128,894
	Maysville	1,366,087
	Parrott	-116,903
	Total, Lincoln circuits	2,378,078
State	Brentwood	886,452
	Lahmeyer	2,101,191
	Trier	3,667,922
	Total, State Circuits	6,655,565
Total, All Circuits		13,700,866

APPENDIX A: FILES FOR CALCULATION OF CVR FACTORS & ENERGY SAVINGS

This appendix provides Excel files that document the calculation of energy savings and CVR factors and kWh savings for the nine stations and twenty five circuits included in I&M's 2015 EECO program. There are nine Excel files, one for each station. Each station file contains tabs, delineated by circuit / phase / day of week. Power demand for each circuit / phase were calculated under two voltage conditions: VVO off and VVO on. The hourly savings percentages are reported and used to calculate the daily CVR factor. The hourly savings values are used to calculate seasonal and annual kWh savings with VVO on. The savings values are calculated for two scenarios: for only those days during 2014 when VVO was "On" and, hypothetically, for VVO always being "On" during the year.

FILES PROVIDED UNDER SEPARATE COVER