Table 19. Results of Linear Fluorescent Lighting M&V Study

Site		Building Type	kWh Savings			NCP kW Savings			CP kW Savings		
			M&V	Program Planning	RR	M&V	Program Planning	RR	M&V	Program Planning	RR
LF-1	[redacted]	Office	16,172	12,596	1.28	2.38	3.33	0.72	2.38	2.56	0.93
LF-2	[redacted]	Warehouse	63,699	59,643	1.07	23.81	15.74	1.51	17.86	12.12	1.47
LF-3	[redacted]	Public Assembly	3,896	9,783	0.40	3.35	2.58	1.30	1.34	1.99	0.67
LF-4	[redacted]	Office	172,737	33,458	5.16	23.35	8.83	2.64	22.89	6.80	3.37
LF-5	[redacted]	Public Order Safety / Institutional	1,867	6,464	0.29	0.89	1.71	0.52	0.69	1.31	0.52
LF-6	[redacted]	Healthcare	2,763	2,182	1.27	0.72	0.58	1.24	0.64	0.44	1.44
LF-7	[redacted]	Industrial	36,890	49,969	0.74	13.78	13.19	1.04	7.86	10.16	0.77
LF-8	[redacted]	Office	2,073	4,946	0.42	1.21	1.31	0.93	0.58	1.01	0.58
LF-9	[redacted]	Warehouse	320	1,664	0.19	0.17	0.44	0.40	0.01	0.34	0.02
LF-10	[redacted]	Small Box Retail	73,063	16,766	4.36	10.52	4.43	2.38	10.21	3.41	3.00
		Total	**373,480**	**197,472**	**1.89**	**80.19**	**52.13**	**1.54**	**64.44**	**40.14**	**1.61**

Table 20. Results of Occupancy Sensor M&V Study

Site		Building Type	kWh Savings			NCP kW Savings			CP kW Savings		
			M&V	Program Planning	RR	M&V	Program Planning	RR	M&V	Program Planning	RR
OS-1	[redacted]	Education	25,442	62,092	0.41	5.89	16.52	0.36	12.39	12.72	0.97
OS-2	[redacted]	Public Order/Safety	1,862	3,433	0.54	0.38	0.92	0.41	0.21	0.71	0.29
OS-3	[redacted]	Warehouse	39,196	43,157	0.91	15.99	11.62	1.38	9.41	8.94	1.05
OS-4	[redacted]	Industrial	15,849	9,318	1.70	5.26	2.51	2.10	3.27	1.93	1.69
OS-5	[redacted]	Small Box Retail	3,869	3,923	0.99	0.59	1.06	0.56	0.86	0.81	1.06
OS-6	[redacted]	Office	1,190	981	1.21	0.24	0.26	0.89	0.28	0.20	1.38
OS-7	[redacted]	Education	5,461	5,885	0.93	1.45	1.58	0.91	1.51	1.22	1.24
OS-8	[redacted]	Education	42,181	65,057	0.65	10.92	17.24	0.63	20.37	13.28	1.53
OS-9	[redacted]	Education	7,058	65,300	0.11	3.59	17.32	0.21	19.89	13.33	1.49
OS-10	[redacted]	Office	14,729	22,069	0.67	0.44	5.94	0.07	1.79	4.57	0.39
		Total	**156,838**	**281,215**	**0.56**	**45**	**75**	**0.60**	**70**	**58**	**1.21**

A comparison of the assumptions used in the calculations for linear fluorescent measures is shown in Table 21. Total installed measure count, baseline fixture watts, and installed fixture watts assumptions from the program tracking database or program design work papers were compared to verified values from the M&V study. Although there were some small differences between the number of fixtures recorded in the program tracking database versus the number of fixtures in the field, the overall installation verification rate was very close to 1. Program planning and M&V estimates of baseline fixture wattage were within 4%, due largely to a discrepancy in the baseline fixture type at site LF-1, which had 3 foot fixtures as baseline rather than the 2 foot fixtures listed in database. M&V estimates of efficient fixture watts were an average of about 25% lower than program planning estimates, due primarily to a discrepancy in the efficient fixture type at site LF-4, where 2-lamp fixtures were installed rather than 4 lamp fixtures, and the use of conservative values of fixture watts during program design.

A comparison of the assumptions used in the calculations for occupancy sensor measures is shown in Table 22. Total installed measure count, sensor connected load, energy savings and demand savings factor assumptions from the program tracking database and program design work papers were compared to verified values from the M&V study. The number of occupancy sensors verified in the field is very close to 1. Verified connected load was on average about 31% lower than program design assumptions. Energy savings (a percentage of the uncontrolled energy consumption) was 54%, or about 1.8 times larger than the program design assumption of 30%. Coincident demand savings (as a percentage of connected kW) was 46%, or about 1.5 times larger than the program design assumption of 30%.

Table 21. Comparison of Linear Fluorescent Measure Savings Assumptions

Site	Customer Name	Building Type	Duke Name	Quantity			Baseline Fixture Watts			Efficient Fixture Watts		
				M&V	Tracking	Ratio	M&V	Program	Ratio	M&V	Program	Ratio
LF-1	[redacted]	Office	T8 8ft 2 lamp	40	40	1.00	123.0	123.0	1.00	109.0	109.0	1.00
			T8 2ft 2 lamp	11	11	1.00	81.0	56.0	1.45	46.0	32.0	1.44
			HPT8 4ft 2 lamp, T8 to HPT8	9	9	1.00	59.0	58.0	1.02	47.0	49.7	0.95
			HPT8 4ft 2 lamp, T12 to HPT8	32	32	1.00	72.0	72.0	1.00	59.0	49.7	1.19
			HPT8 4ft 2 lamp, T12 to HPT8	52	52	1.00	72.0	72.0	1.00	59.0	49.7	1.19
LF-2	[redacted]	Warehouse	T8 4ft 4 lamp	410	410	1.00	144.0	144.0	1.00	96.0	112.0	0.86
LF-3	[redacted]	Public Assembly	Low Watt T8 lamps, 4ft	538	538	1.00	37.0	32.0	1.16	32.0	28.0	1.14
LF-4	[redacted]	Office	LW HP T-8 4ft 1L replace T-8 4ft 1L	56	56	1.00	31.0	32.0	0.97	25.0	25.0	1.00
			LW HP T-8 4ft 2L replace T-8 4ft 2L	200	200	1.00	59.0	59.0	1.00	49.0	49.0	1.00
			LW HP T-8 4ft 4L[10] replace T-8 4ft 4L	276	276	1.00	112.0	112.0	1.00	49.0	94.0	0.52
LF-5	[redacted]	Public Order Safety / Institutional	LW HPT8 4ft 2 lamp, replace T8	63	83	0.76	59.0	59.0	1.00	51.0	49.0	1.04
			LW HPT8 4ft 4 lamp, replace T8	0	4	0.00	NA	112.0	0.00	0.0	94.0	NA
			T8 4ft 2 lamp	40	40	1.00	72.0	72.0	1.00	65.0	59.0	1.10
LF-6	[redacted]	Healthcare	T8 4ft 4 lamp	15	15	1.00	144.0	144.0	1.00	102.0	112.0	0.91
LF-7	[redacted]	Industrial	LW HP T-8 4ft 1L replace T-8 4ft 1L	10	10	1.00	31.0	32.0	0.97	23.3	25.0	0.93
			LW HP T-8 4ft 2L replace T-8 4ft 2L	356	356	1.00	59.0	59.0	1.00	47.0	49.0	0.96

[10] M&V Survey found that 2-lamp fixture was installed, rather than 4-lamp fixture. Values shown on this line compare program planning 4-lamp fixture to existing 2-lamp fixture.

Site	Customer Name	Building Type	Duke Name	Quantity			Baseline Fixture Watts			Efficient Fixture Watts		
				M&V	Tracking	Ratio	M&V	Program	Ratio	M&V	Program	Ratio
			LW HP T-8 4ft 4L replace T-8 4ft 4L	409	409	1.00	112.0	112.0	1.00	92.6	94.0	0.99
LF-8	[redacted]	Office	T8 4ft 4 lamp	34	34	1.00	123.0	144.0	0.85	96.0	112.0	0.86
LF-9	[redacted]	Warehouse	T8 4ft 2 lamp	6	6	1.00	72.0	72.0	1.00	48.0	59.0	0.81
			T8 4ft 4 lamp	0	9	0.00	NA	144.0	NA	NA	112.0	NA
LF-10	[redacted]	Small Box Retail	Low Watt T8 lamps, 4ft	922	922	1.00	29.5	32.0	0.92	20.5	28.0	0.73
		Wt Average				0.99			0.99			0.73
									Efficient Fixture Watts weighted average with 2-lamp fixture comparison.			0.93 [11]

Table 22. Comparison of Occupancy Sensor Measure Savings Assumptions

Site	Customer Name	Building Type	Duke Name	Quantity			Connected Load			Energy Savings Factor			Demand Savings Factor		
				M&V	Tracking	Ratio	M&V	Program	Ratio	M&V	Program	Ratio	M&V	Program	Ratio
OS-1	[redacted]	Education	Occ Sensors over 500W	29	29	1	0.23	0.55	0.42	0.42	0.30	1.41	0.52	0.30	1.72
			Occ Sensors under 500W	54	54	1									
OS-2	[redacted]	Public Order/Safety	Occ Sensors under 500W	7	7	1	0.15	0.36	0.41	0.31	0.30	1.03	0.17	0.30	0.56
OS-3	[redacted]	Warehouse	Occ Sensors under 500W	88	88	1	0.23	0.36	0.63	0.91	0.30	3.03	0.47	0.30	1.58
OS-4	[redacted]	Industrial	Occ Sensors under 500W	19	19	1	0.35	0.36	0.98	0.82	0.30	2.73	0.49	0.30	1.63

[11] Updated efficient fixture ratio resulting from replacing 2-lamp fixture for 4-lamp fixture in Program fixture assumption. See Footnote 10 for more information.

Site	Customer Name	Building Type	Duke Name	Quantity			Connected Load			Energy Savings Factor			Demand Savings Factor		
				M&V	Tracking	Ratio	M&V	Program	Ratio	M&V	Program	Ratio	M&V	Program	Ratio
OS-5	[redacted]	Small Box Retail	Occ Sensors under 500W	8	8	1	0.37	0.36	1.03	0.55	0.30	1.82	0.26	0.30	0.86
OS-6	[redacted]	Office	Occ Sensors under 500W	2	2	1	0.34	0.36	0.93	0.45	0.30	1.49	0.35	0.30	1.17
OS-7	[redacted]	Education	Occ Sensors under 500W	8	12	0.67	0.46	0.36	1.27	0.41	0.30	1.36	0.33	0.30	1.09
OS-8	[redacted]	Education	Occ Sensors over 500W	41	41	1	0.48	0.67	0.71	0.45	0.30	1.49	0.48	0.30	1.59
			Occ Sensors under 500W	30	30	1									
OS-9	[redacted]	Education	Occ Sensors under 500W	33	33	1	0.50	0.66	0.76	0.32	0.30	1.07	0.43	0.30	1.44
			Occ Sensors over 500W	40	40	1									
OS-10	[redacted]	Office	Occ Sensors under 500W	45	45	1	0.15	0.36	0.41	0.34	0.30	1.13	0.27	0.30	0.90
			Weighted Average			0.99			0.69	0.54	0.30	1.80	0.46	0.30	1.53

Gross Savings Analysis – Variable Frequency Drives

Paper file applications and supporting documentation were obtained for each site. The data in the application files were reviewed and compared to the program tracking database and onsite survey observations. Discrepancies were noted and corrected for the impact evaluation. These discrepancies are reported in Table 23.

Table 23. Tracking System and Paper File Discrepancies for VFDs

Measure	Site	Discrepancy
VFD	9	200 HP VFD penciled in on paper application and installed onsite; Tracking system listed 50HP VFD.
	6	5 HP VFDs installed instead of 7.5 HP VFDs; 7.5 HP VFDs installed instead of 10 HP VFDs

Since there were relatively few VFDs per site, and they often operated independently, their performance was evaluated on an independent basis, and instead of reporting on a site level, the results are reported on a per-VFD level. In limited cases where multiple VFDs were controlled at the same speed, i.e., cooling tower fans, they are reported on a single line in Table 24. Table 25 summarizes the results for each VFD technology and compares these results to the target savings.

In general, the realization rates were quite low. However, at site VFD-9, a 200HP VFD was installed rather than a 50HP VFD, resulting in a realization rate greater than 6. The high realization rate for this VFD caused the overall weighted energy realization rate for VFD fans to be 81%.

Table 24. Results of VFD M&V Study

Key	Customer	VFD Type	Tracking HP	M&V HP	Target Annual kWh Savings	Target Annual NCP kW	Target Annual CP kW	M&V Energy Savings kWh	M&V NCP Savings kW	M&V CP Savings kW	Energy RR	NCP RR	CP RR
VFD-1		HVAC Fan	30	30	37,283	8.05	5.85	13,819	2.08	0.93	0.37	0.26	0.16
VFD-1		HVAC Fan	30	30	37,283	8.05	5.85	28,379	7.20	-0.39	0.76	0.89	-0.07
VFD-1		HVAC Fan	30	30	37,283	8.05	5.85	176	3.15	-0.83	0.00	0.39	-0.14
VFD-2		HVAC Fan	7.5	7.5	9,321	2.01	1.46	956	0.73	0.00	0.10	0.36	0.00
VFD-2		HVAC Fan	15	15	18,641	4.02	2.92	3,899	7.18	0.00	0.21	1.78	0.00
VFD-3		HVAC Fan	7.5	7.5	9,321	2.01	1.46	1,364	0.87	0.00	0.15	0.43	0.00
VFD-3		HVAC Fan	15	15	18,641	4.02	2.92	4,407	2.40	0.00	0.24	0.60	0.00
VFD-4		HVAC Fan	40	40	49,710	10.73	7.80	43,865	7.71	6.70	0.88	0.72	0.86
VFD-5		HVAC Pump	40	40	141,618	30.57	12.32	54,024	9.46	8.65	0.38	0.31	0.70
VFD-5		HVAC Pump	40	40	141,618	30.57	12.32	88,392	15.78	13.73	0.62	0.52	1.11
VFD-5		HVAC Pump	40	40	141,618	30.57	12.32	62,243	13.64	6.24	0.44	0.45	0.51
VFD-6		HVAC Fan	7.5	5	9,321	2.01	1.46	5,066	0.75	0.60	0.54	0.37	0.41
VFD-6		HVAC Fan	7.5	5	9,321	2.01	1.46	3,242	0.75	0.43	0.35	0.37	0.29
VFD-6		HVAC Fan	10	7.5	12,428	2.68	1.95	7,469	1.14	0.69	0.60	0.42	0.36
VFD-7		HVAC Fan	5	5	6,214	1.34	0.97	6,403	0.62	0.23	1.03	0.46	0.24
VFD-8		HVAC Fan	40	40	49,710	10.73	7.80	5,956	0.67	0.00	0.12	0.06	0.00

Key	Customer	VFD Type	Tracking HP	M&V HP	Target Annual kWh Savings	Target Annual NCP kW	Target Annual CP kW	M&V Energy Savings kWh	M&V NCP Savings kW	M&V CP Savings kW	Energy RR	NCP RR	CP RR
VFD-9	[redacted]	HVAC Fan	30	30	37,283	8.05	5.85	33,168	4.46	0.15	0.89	0.55	0.03
VFD-9	[redacted]	HVAC Fan	50	200	62,138	13.41	9.75	376,837	27.96	21.12	6.06	2.08	2.17
VFD-9	[redacted]	Process Pump 1-50 HP	20	20	18,213	4.95	4.06	1,643	0.89	0.85	0.09	0.18	0.21
VFD-9	[redacted]	Process Pump 1-50 HP	30	30	27,320	7.43	6.09	14,896	2.12	1.59	0.55	0.28	0.26
VFD-10	[redacted]	HVAC Fan	20	20	24,855	5.36	3.90	15,179	5.54	5.53	0.61	1.03	1.42
VFD-10	[redacted]	HVAC Fan	5	5	6,214	1.34	0.97	1,357	0.90	0.88	0.22	0.67	0.90
VFD-11	[redacted]	HVAC Fan	20	20	24,855	5.36	3.90	17,729	5.50	0.00	0.71	1.03	0.00
VFD-12	[redacted]	HVAC Pump	10	10	35,405	7.64	3.08	13,720	1.58	1.57	0.39	0.21	0.51
VFD-13	[redacted]	HVAC Pump	25	15	88,512	19.11	7.70	41,817	2.38	2.00	0.47	0.12	0.26
VFD-14	[redacted]	HVAC Pump	20	9	70,809	15.28	6.16	27,443	0.00	0.00	0.39	0.00	0.00
VFD-15	[redacted]	HVAC Fan	15	15	18,641	4.02	2.92	11,108	4.72	3.65	0.60	1.17	1.25
VFD-15	[redacted]	HVAC Pump	40	40	141,618	30.57	12.32	36,912	9.86	7.90	0.26	0.32	0.64
VFD-15	[redacted]	HVAC Pump	30	30	106,214	22.93	9.24	24,444	6.77	6.35	0.23	0.30	0.69
VFD-15	[redacted]	HVAC Fan	10	10	12,428	2.68	1.95	3,823	1.73	1.45	0.31	0.64	0.74
VFD-15	[redacted]	HVAC Fan	15	15	18,641	4.02	2.92	21,365	2.81	1.61	1.15	0.70	0.55
VFD-16	[redacted]	HVAC Fan	30	30	37,283	8.05	5.85	2,590	3.56	0.00	0.07	0.44	0.00
VFD-17	[redacted]	HVAC Fan	40	50	49,710	10.73	7.80	16,863	9.17	0.00	0.34	0.86	0.00
VFD-17	[redacted]	Process Pump 1-50 HP	60	80	54,640	14.86	12.17	18,644	2.52	1.84	0.34	0.17	0.15
VFD-	[redacted]	HVAC Fan	60	60	74,566	16.09	11.70	79,643	9.33	7.98	1.07	0.58	0.68

Key	Customer	VFD Type	Tracking HP	M&V HP	Target Annual kWh Savings	Target Annual NCP kW	Target Annual CP kW	M&V Energy Savings kWh	M&V NCP Savings kW	M&V CP Savings kW	Energy RR	NCP RR	CP RR
18	[redacted]												
VFD-18	[redacted]	HVAC Fan	30	30	37,283	8.05	5.85	26,305	6.36	0.00	0.71	0.79	0.00

VFD-9 with a 200HP fan, is greater than the 50HP allowed under the program. However, it provided savings, and so is included in the analysis. Similarly, VFD-18 included VFDs that were factory installed in a new packaged unit. Under the program, this application would not be allowed. However, a rebate was paid and therefore is included in the analysis.

Table 25 summarizes the results by VFD type. Although the energy savings realization rate for HVAC fans is substantially higher than shown for HVAC pumps and process pumps, this is driven largely by the savings attributed to the 200HP VFD-9. If the 200HP VFD-9 is not included in the calculations, the energy realization rate is about 55%.

Table 25. VFD summary by capacity

VFD Type	Target Annual kWh per HP	Target Annual NCP kW/HP	Target Annual CP kW/HP	M&V kWh per HP	M&V NCP kW per HP	M&V CP kW per HP	RR Energy Savings	RR NC P	RR CP
VFD HVAC Fan	1242.8	0.27	0.19	1,011.7	0.16	0.07	0.81	0.61	0.36
VFD HVAC Pump	3540.5	0.76	0.31	1,558.0	0.27	0.21	0.44	0.35	0.67
VFD Process Pump 1-50 HP	910.7	0.25	0.20	270.6	0.04	0.03	0.30	0.17	0.16

Gross Savings Analysis – Overall Realization Rates

The estimated achieved sampling precision in the realization rates for all three measure categories is shown in Table 26. Due to the higher than expected variability in the savings from the M&V activity relative to the program planning values, the achieved relative precision was higher than the targeted value.

Table 26. Realization Rate Achieved Sampling Precision

Project Type	Population Size	Sample Size	Actual Sample cv	Relative Precision
Linear Fluorescent	925	10	0.94	+/- 49%
Occupancy Sensor	672	10	0.61	+/- 31%
VFD-Fan	195	25	1.65	+/- 51%
VFD-Process	14	3	0.41	+/- 34%
VFD-Pump	54	8	0.32	+/- 17%
Total				+/- 23.1%

There are additional considerations to be made that can improve the relative precision results. The first is examination of the high coefficient of variation (CV) values in this study. The high CV for linear fluorescents is unexpected, but is related to 1) the wide variation in actual operating hours (which ranges from a low of 1,255 to nearly 8,200), and 2) discrepancies between the fixture types discovered during M&V field activities and those recorded in the tracking system. The high CV for the VFD-Fan is driven primarily by the 200HP VFD that was represented in the tracking system as a 50HP VFD. This was an early application from 2009 and was allowed despite the requirements of Prescriptive program. If the CV for the VFD-Fan is recalculated without this measure in the sample, the CV improves to 0.70, which improves the overall precision to 18.6%, as shown in Table 27.

Table 27. Realization Rate Achieved Sampling Precision with Adjusted VFD Coefficient of Variation

Project Type	Population Size	Sample Size	Actual Sample cv	Relative Precision
Linear Fluorescent	925	10	0.94	+/- 49%
Occupancy Sensor	672	10	0.61	+/- 31%
VFD-Fan	195	25	0.70	+/- 21%
VFD-Process	14	3	0.41	+/- 34%
VFD-Pump	54	8	0.32	+/- 17%
Total				+/- 18.6%

Secondly, if the high-bay lighting CV results from the earlier M&V study are included, in addition to the adjusted VFD-Fan CV, the overall precision improves further to 11.7%. The improvement in precision with these adjustments is shown in Table 28.

Table 28. Realization Rate Achieved Sampling Precision including High Bay Sample and Adjusted VFD Coefficient of Variation

Project Type	Population Size	Sample Size	Actual Sample cv	Relative Precision
Lights-Hi Bay	1,134	20	0.39	+/- 14%
Linear Fluorescent	925	10	0.94	+/- 49%
Occupancy Sensor	672	10	0.61	+/- 31%
VFD-Fan	195	25	0.70	+/- 21%
VFD-Process	14	3	0.41	+/- 34%
VFD-Pump	54	8	0.32	+/- 17%
Total				+/- 11.7%

Finally, if the precision is calculated with the original VFD-Fan CV of 1.65 and the high-bay lighting results are added, the overall precision is 13.9%, as shown in Table 29.

Table 29. Realization Rate Achieved Sampling Precision including High Bay Sample

Project Type	Population Size	Sample Size	Actual Sample cv	Relative Precision
Lights-Hi Bay	1,134	20	0.39	+/- 14%
Linear Fluorescent	925	10	0.94	+/- 49%
Occupancy Sensor	672	10	0.61	+/- 31%
VFD-Fan	195	25	1.65	+/- 51%
VFD-Process	14	3	0.41	+/- 34%
VFD-Pump	54	8	0.32	+/- 17%
Total				+/- 13.9%

Net to Gross Analysis

Freeridership

TecMarket Works utilized two different sets of questions asked of each surveyed participant which are scored independently, and then combined to estimate freeridership.

For the first set of calculations, the primary "gateway" question asks if they would have purchased the same equipment without the program and when that would have occurred. The second question within this set asks those who say they would have delayed their purchase to estimate how long they would have delayed the purchase. Together these two questions provide the foundation from the first set of questions used for estimating the level of energy impacts that are attributable to freeridership rather than savings that are program induced (net savings).

The first question within the first set of questions asked survey respondents what their behavior would have been if the Smart $aver rebate had not been available. The four categories of responses were:

a.) bought the same unit at the same time
b.) bought the same unit at a later time
c.) bought a used unit at the same time
d.) continued to use the currently installed unit and not purchase a new or used unit

The breakdown of responses to the gateway question can be seen in Table 30. Participants who indicated that they would have bought the same unit at the same time were assigned 100% freeridership. Participants answering that they would have continued using the currently installed unit were assigned 0% freeridership.

Freeridership for participants who indicated that they would have bought their units at a later time are asked an additional question for determining when they would have purchased the units in the absence of the program. Each response to this question was converted to a foundation freerider percentage as presented in Table 30 separately for Linear Fluorescent Lighting (FL), Occupancy Sensors (OS) and Variable Frequency Drives (VFD).

From the foundational set of questions, the equivalent freerider rate (the number of units that count toward freeridership) in the case of customers who indicated they would have purchased the unit at a later time, is the product of the freerider percentage multiplied by the number of respondents/units (each respondent was surveyed about one recently installed unit).

Table 30. Program Freeridership by Rebated Measure

Gateway Question Response	Linear Fluorescent Lighting Count (Responders)	Occupancy Sensor Count (Responders)	Variable Frequency Drive Count (Responders)
Same unit at same time (100% freerider)	10 (10)	2 (2)	3 (3)
Same unit within 6 months (75% freerider)	0 (0)	0 (0)	0 (0)
Same unit 6-12 months later (50% freerider)	0 (0)	0 (0)	0 (0)
Same unit 12-24 months later (25% freerider)	7 (1.75)	1 (0.25)	0 (0)
Same unit more than 24 months later (0% freerider)	3 (0)	2 (0)	0 (0)
Same unit, don't know when (mean % freerider of the five rows above = 58.8% for Fluorescent Lighting, 45.0% for Occupancy Sensors, 100% for VFD)	4 (2.35)	1 (0.45)	1 (1)
Used unit at the same time or later time (same as row above = 100% for VFD) [12]	0 (0)	0 (0)	1 (1)
Continued using old unit (0% freerider)	10 (0)	6 (0)	1 (0)
TOTAL COUNT	**34**	**12**	**6**
Freeriders	**14.1**	**2.70**	**5**
Freerider %	**41.5%**	**22.5%**	**83.3%**

The second set of freerider calculations is based on an additional set of questions which ask what participants would have done without the Smart $aver incentive, and without the Smart $aver program information and technical assistance.

The three categories of responses to these questions were:

a.) bought unit with at least the same efficiency level
b.) bought a unit with a different efficiency level
c.) not sure what organization would have done

The breakdown of responses to these questions can be seen in Table 31 and Table 32. Participants who indicated that they would have bought the same efficiency level without the incentive or program information were assigned the average freeridership calculated for participants who said they would purchase the same unit in Table 30: 58.8% for Fluorescent Lighting (FL), 45.0% for Occupancy Sensors (OS) and 100% for Variable Frequency Drives

[12] Used VFD units in the category: "Used unit at the same time or later time" are treated as new units in the category: "same unit, don't know when" for computing freeridership.

(VFD). Participants answering that they would have selected a different efficiency level were assigned 0% freeridership.

Table 31. Program Freeridership Based on Financial Incentive by Rebated Measure

Response for "without financial incentive"	Linear Fluorescent Lighting Count (Responders)	Occupancy Sensor Count (Responders)	Variable Frequency Drive Count (Responders)
Would have selected same efficiency level without financial incentive (freerider percent based on planned time of purchase: 58.8% FL, 45.0% OS, 100% VFD)[13]	19 (11.16)	4 (1.80)	4 (4)
Would have made a different choice without financial incentive (freerider 0%)	11 (0)	6 (0)	1 (0)
Not sure what company would have done without financial incentive (freerider percent based on mean of two columns above)	4 (1.49)	2 (0.36)	1 (0.80)
TOTAL COUNT	**34**	**12**	**6**
Freeriders	**12.65**	**2.16**	**4.80**
Freerider %	**37.2%**	**18.0%**	**80.0%**

Table 32. Program Freeridership Based on Information and Assistance by Rebated Measure

Response for "without program information and technical assistance"	Linear Fluorescent Lighting Count (Responders)	Occupancy Sensor Count (Responders)	Variable Frequency Drive Count (Responders)
Would have selected same efficiency level without program information/technical assistance (freerider percent based on planned time of purchase: 58.8% FL, 45.0% OS, 100% VFD)[14]	16 (9.40)	7 (3.15)	4 (4)
Would have made a different choice without program information/technical assistance (freerider 0%)	8 (0)	3 (0)	1 (0)
Not sure what company would have done without program	10 (3.92)	2 (0.63)	1 (0.80)

[13] These percentages represent the average freeridership of respondents indicating they would purchase the same unit as seen in row 5 of Table 30.
[14] These percentages represent the average freeridership of respondents indicating they would purchase the same unit as seen in row 5 of Table 30.

information/technical assistance (freerider percent based on mean of two columns above)			
TOTAL COUNT	**34**	**12**	**6**
Freeriders	**13.32**	**3.78**	**4.80**
Freerider %	**39.2%**	**31.5%**	**80.0%**

Since the program included both an incentive payment and technical assistance/program information, each of which can motivate a decision to go with the more efficient choice, a two path analysis approach was used for assessing freeridership within the second set of questions. One path was scored for the influence of the incentive and another path was scored for the analysis of the effect of the technical assistance or program information. The final per-participant freeridership estimate is the lower of the two estimates from each of the two paths. These results are presented for each measure in Table 31 and Table 32. Thus, freeridership for the Smart $aver program in Ohio and Kentucky is estimated at 37.2% for Fluorescent Lighting, 18.0% for Occupancy Sensors and 80.0% for Variable Frequency Drives. Note that this freerider analysis was conducted using a sample of surveyed participants. The evaluation plan was not designed to achieve statistically significant estimates of freeridership at the measure level. These values are shown for informational purposes only. Only the overall program freeridership should be used.

Validity and Reliability of the Freerider Estimation Approach

The field of freeridership assessment as specified in the California Evaluation Protocols basic estimation approach requires the construction of questions that allow the evaluation contractor to estimate the level of freeridership. The basic approach used in this evaluation is based on the results of a set of freerider questions incorporated into participant survey instruments that meets the reliability standards for freerider questions. The approach used in this assessment examines the various ways in which the program impacts the customer's acquisition and use of equipment incented as part of the Non-Residential Smart $aver Prescriptive program, and allocates a freeridership factor for each of the types of responses contained in the survey questions. The allocation approach assigns high freeridership values to participants who would have acquired the same equipment on their own, and that factor is influenced by their stated intentions regarding the timing and efficiency level of this acquisition. The scoring approach is proportional to the degree to which the participant would have acquired and used equivalent equipment on their own.

Spillover

In order to estimate the spillover savings attributed to the program several questions were added to the participant questionnaire. These questions were asked to determine the extent to which the program's information and incentives caused additional non-incented spillover actions to be taken by the participants. A total of 52 survey participants answered the net to gross question battery.

Survey participants were asked if they had taken any actions above and beyond those rebated by the program at their company or at any other locations. If the respondent indicated that they had not purchased or installed any other type of high efficiency equipment or made energy efficiency improvements since their participation in the program, the spillover level was set to zero and no spillover credit was provided. Respondents that had taken additional measures were asked about

the type of equipment and where it was installed. However, no spillover was provided to those respondents that took additional actions unless they also indicated that their experience with the program caused, to some degree, the action to be taken by rating the influence of their experience with the program on their decision to do so on a scale from one to ten with ten being the most influential. This rating is referred to as the participant's attribution score.

If a participant indicated that the program was influential in their purchase and use decision, then their spillover savings was adjusted by the fractional amount of the strength of their attribution score. That is, if the respondent indicated an attribution score of seven out of ten, then their spillover savings were multiplied by 0.7 to estimate their spillover contribution to the program net to gross ratio.

Table 33. Spillover Measures and Attribution

Measure	Quantity	Attribution Score	EUL[15]	kWh Savings	Spillover kWh Savings
T8 lighting	88	9	12	5,201	4,681
Occupancy sensors	12	9	10	5,884	5,296
Occupancy sensors	80	8	10	39,233	31,386
Occupancy sensors	11	8	10	5,395	4,316
T5 lighting	30	7	12	954	668
T8 lighting	20	10	12	1,182	1,182
T8 lighting	188	10	12	11,111	11,111
Occupancy sensors	10	7	10	4,904	3,433
TOTAL/AVERAGE		**8.5**	**10.5**	**73,865**	**62,073**

Table 33 shows each measure taken by the 52 survey participants for which enough information was provided to calculate energy savings. Spillover energy savings were estimated from the customer description of the measure taken and ex-ante savings estimates from Duke Energy work papers for that measure. The expressed spillover actions taken as a result of the program and the associated savings were not subjected to ex-post evaluation or verification inspections. Actions taken by respondents that provided insufficient data to estimate impact received zero spillover credit. That is, it is likely that spillover savings are higher than those reported above, however, beause of the inability to obtain enough information on the configuration and use of these actons, we do not estimate or credit any savings toward those actions. Actions that were determined, or believed, to be implemented outside of Duke Energy territory also received zero spillover credit. Furthermore, spillover estimates are limited to only those measures that are eligible to receive a rebate through the program. Although the spillover savings were not subject to ex-post evaluation, the approach taken is believed to provide the spillover estimates that are significantly below the actual achieved spillover savings.

Figure 5 graphically shows the estimated spillover impacts over the lifetime of the spillover measures. The only spillover measures reported are linear fluorescents and occupancy sensors.

[15] EUL = Effective Useful Life

Thus, a large drop-off occurs at ten years when the occupancy sensors reach the end of their Effective Useful Life (EUL). Savings continue to year 12, the end of the linear fluorescent EUL.

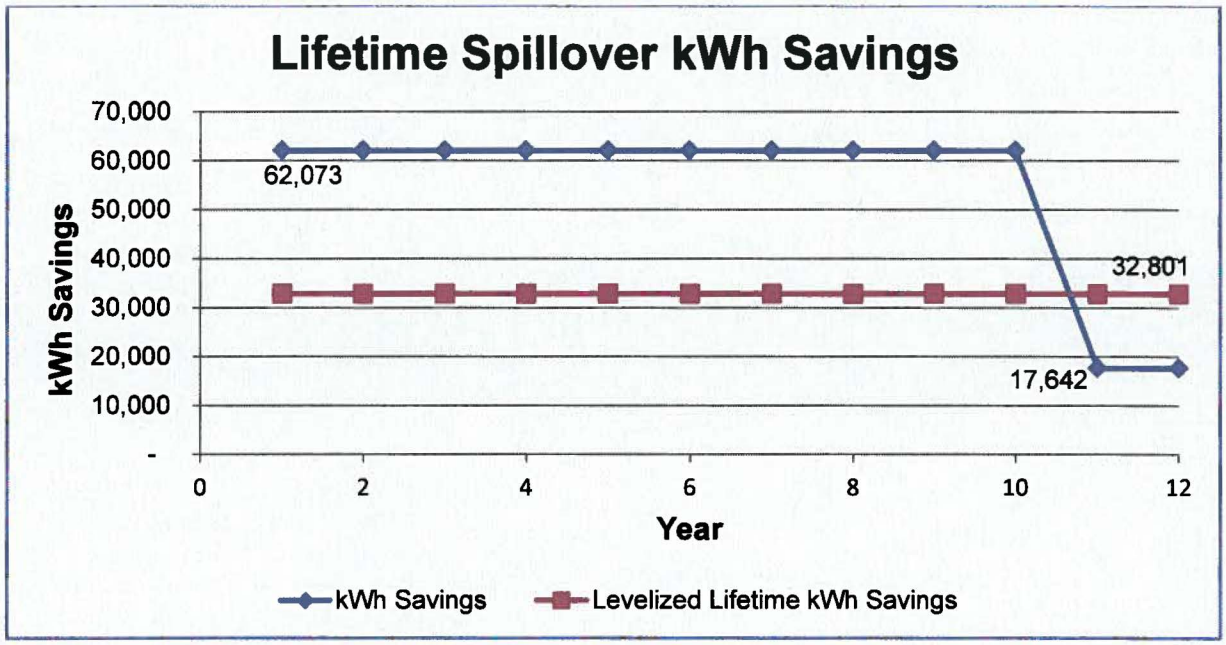


Figure 5. Lifetime Spillover kWh Savings

Table 34 shows the spillover percentage for the program of 6.6%.

Table 34. Spillover Percentage

Survey Respondent kWh Savings Excluding Spillover	Survey Respondent Spillover kWh savings	Spillover Percentage
946,097	62,073	6.6%

While TecMarket Works notes that the spillover savings documented in this report are lower than actually achieved, it should be understood that the assignment of spillover is, to a limited degree, subjective in that its accuracy depends on the ability of the attribution score to accurately estimate the degree of causation as well as the recall ability of the participant. However, the overall average causation score for the assessed spillover cause is high. That is, on average the attribution score provided by participants is 8.5 on a 10 point scale. This score represents that this program has significant influence on participants' actions well beyond those measures incented by the program.

The study of the Non-Residential Smart $aver Prescriptive Program in the Carolina System showed spillover values that were much higher than those observed in Ohio. This is the result of three very large projects that received high attribution scores from survey participants. Efforts were made to eliminate projects from spillover consideration that were rebated through another program or the same program at a later date. Because there was no indication that this was the

case with any of the three and there was enough information to estimate spillover, these projects were included. If these three very large projects are not counted, spillover levels between Ohio and the Carolina System look very similar (6.6% compared to 7.3%).

Program Net to Gross Adjustment

To estimate the overall program-level net to gross adjustment, it is necessary to first determine the weighted average program freeridership. For the purposes of this calculation, high bay lighting is included. Including high bay lighting provides a more accurate estimate of the overall program freeridership. Linear fluorescents accounted for 14%, occupancy sensors accounted for 18%, VFDs accounted for 21%, and high bay lighting accounted for 47% of the total kWh savings achieved. The average program wide net to gross ratio for this program is 0.682. It should be noted that this net to gross ratio only includes adjustments for free ridership and short term participant spillover. Estimates for short and long term non-participant spillover and short and long term market effects are not included in this study and would be savings in addition to that documented in this report. While a short term participant net-to-gross ratio of 0.682 indicates the program saved less energy that what is reflected in the gross energy projected savings estimates, this savings level is only part of the savings that are achieved by energy efficiency programs. Additional evaluation efforts are needed to document short and long term non-participant spillover and short and long term market effects.

Freeridership scores presented in this report are weighted by their measure's contribution to overall kWh savings and calculated as follows:

Program Freeridership = (14% * Linear Fluorescent FR) + (18% * Occupancy Sensor FR)
+ (21% * VFD FR) + (47% * High Bay FR)
= (14% * 37.2%) + (18% * 18.0%) + (21% * 80.0%) + (47% * 28%[16])
= 38.4%

The net to gross ratio is then calculated as follows:

NTGR = 1 + (spillover – freeridership)
= 1+ (0.066 - 0.384)
= 0.682

The program level gross savings is discounted (1 – NTGR) by 31.8% to yield the total net savings.

Total Gross and Net Impacts

The total first year gross and net savings are tabulated for each of the measures studied in the evaluation. These estimates were calculated by applying the gross realization rates for kWh, NCP kW and CP kW to the program planning estimates for each measure. The evaluated first year gross and net impacts are summarized in Table 35.

[16] Evaluation of the Non-Residential Smart $aver Prescriptive Program in Ohio, August 29, 2010.

Table 35. First Year Gross and Net Savings by Measure

Metric	Result
Number of Program Participants from 1-1-2009 to 2-29-2012	2439 Projects
Gross Coincident Peak kW per unit	kW/unit
HPT8 4ft 2 lamp, T12 to HPT8	0.033
HPT8 4ft 2 lamp, T8 to HPT8	0.012
Low Watt T8 lamps, 4ft	0.006
LW HPT8 4ft 2 lamp, replace T8	0.015
LW HPT8 4ft 4 lamp, replace T8	0.027
LW HP T-8 4ft 1L replace T-8 4ft 1L	0.010
LW HP T-8 4ft 2L replace T-8 4ft 2L	0.015
LW HP T-8 4ft 4L replace T-8 4ft 4L	0.027
T8 2ft 2 lamp	0.036
T8 4ft 2 lamp	0.019
T8 4ft 4 lamp	0.047
T8 8ft 2 lamp	0.021
Occupancy Sensors under 500 W	0.123
Occupancy Sensors over 500 W	0.302
VFD HVAC Fan	0.070
VFD HVAC Pump	0.207
VFD Process Pump 1-50 HP	0.033
Gross kWh per unit	kWh/unit
HPT8 4ft 2 lamp, T12 to HPT8	191.6
HPT8 4ft 2 lamp, T8 to HPT8	72.4
Low Watt T8 lamps, 4ft	35.0
LW HPT8 4ft 2 lamp, replace T8	86.0
LW HPT8 4ft 4 lamp, replace T8	154.8
LW HP T-8 4ft 1L replace T-8 4ft 1L	60.2
LW HP T-8 4ft 2L replace T-8 4ft 2L	86.0
LW HP T-8 4ft 4L replace T-8 4ft 4L	154.8
T8 2ft 2 lamp	206.3
T8 4ft 2 lamp	111.8
T8 4ft 4 lamp	275.1
T8 8ft 2 lamp	120.4
Occupancy Sensors under 500 W	273.5
Occupancy Sensors over 500 W	684.8

Metric	Result
VFD HVAC Fan	1011.7
VFD HVAC Pump	1558.0
VFD Process Pump 1-50 HP	270.6
Gross therms per unit	N/A
Freeridership rate	38.40%
Spillover rate	6.60%
Self Selection and False Response rate	0.00%
Total Discounting to be applied to Gross values	68.20%
Net Coincident Peak kW per unit	kW/unit
HPT8 4ft 2 lamp, T12 to HPT8	0.023
HPT8 4ft 2 lamp, T8 to HPT8	0.008
Low Watt T8 lamps, 4ft	0.004
LW HPT8 4ft 2 lamp, replace T8	0.010
LW HPT8 4ft 4 lamp, replace T8	0.018
LW HP T-8 4ft 1L replace T-8 4ft 1L	0.007
LW HP T-8 4ft 2L replace T-8 4ft 2L	0.010
LW HP T-8 4ft 4L replace T-8 4ft 4L	0.018
T8 2ft 2 lamp	0.025
T8 4ft 2 lamp	0.013
T8 4ft 4 lamp	0.032
T8 8ft 2 lamp	0.014
Occupancy Sensors under 500 W	0.084
Occupancy Sensors over 500 W	0.206
VFD HVAC Fan	0.048
VFD HVAC Pump	0.141
VFD Process Pump 1-50 HP	0.023
Net kWh per unit	kWh/unit
HPT8 4ft 2 lamp, T12 to HPT8	130.7
HPT8 4ft 2 lamp, T8 to HPT8	49.4
Low Watt T8 lamps, 4ft	23.9
LW HPT8 4ft 2 lamp, replace T8	58.7
LW HPT8 4ft 4 lamp, replace T8	105.6
LW HP T-8 4ft 1L replace T-8 4ft 1L	41.1
LW HP T-8 4ft 2L replace T-8 4ft 2L	58.7
LW HP T-8 4ft 4L replace T-8 4ft 4L	105.6
T8 2ft 2 lamp	140.7

Metric	Result
T8 4ft 2 lamp	76.2
T8 4ft 4 lamp	187.6
T8 8ft 2 lamp	82.1
Occupancy Sensors under 500 W	186.5
Occupancy Sensors over 500 W	467.0
VFD HVAC Fan	690.0
VFD HVAC Pump	1062.6
VFD Process Pump 1-50 HP	184.5
Net therms per unit	N/A
Measure Life	12yr (linear fluorescent) 10yr (occupancy sensor)

Lifecycle savings were estimated by applying the following EUL assumptions[17] to each measure.

Table 36. Effective Useful Life for Lighting Measures

Measure	EUL (years)
Linear Fluorescent	12
Occupancy Sensor	10
VFD	15

Applying the EUL estimates listed above to each measure, the lifecycle gross and net kWh savings are shown in Table 37.

[17] EUL data taken from Duke Energy workpapers prepared by Franklin Energy Systems.

Table 37. Gross and Net Lifecycle Savings

Metric	Result
Number of Program Participants from 1-1-2009 to 2-29-2012	2439 Projects
Gross lifecycle kWh per unit	kWh/unit
HPT8 4ft 2 lamp, T12 to HPT8	2,299
HPT8 4ft 2 lamp, T8 to HPT8	869
Low Watt T8 lamps, 4ft	420
LW HPT8 4ft 2 lamp, replace T8	1,032
LW HPT8 4ft 4 lamp, replace T8	1,858
LW HP T-8 4ft 1L replace T-8 4ft 1L	722
LW HP T-8 4ft 2L replace T-8 4ft 2L	1,032
LW HP T-8 4ft 4L replace T-8 4ft 4L	1,858
T8 2ft 2 lamp	2,476
T8 4ft 2 lamp	1,342
T8 4ft 4 lamp	3,301
T8 8ft 2 lamp	1,445
Occupancy Sensors under 500 W	2,735
Occupancy Sensors over 500 W	6,848
VFD HVAC Fan	15,176
VFD HVAC Pump	23,370
VFD Process Pump 1-50 HP	4,060
Net lifecycle kWh per unit	kWh/unit
HPT8 4ft 2 lamp, T12 to HPT8	1,361
HPT8 4ft 2 lamp, T8 to HPT8	514
Low Watt T8 lamps, 4ft	249
LW HPT8 4ft 2 lamp, replace T8	611
LW HPT8 4ft 4 lamp, replace T8	1,100
LW HP T-8 4ft 1L replace T-8 4ft 1L	428
LW HP T-8 4ft 2L replace T-8 4ft 2L	611
LW HP T-8 4ft 4L replace T-8 4ft 4L	1,100
T8 2ft 2 lamp	1,466
T8 4ft 2 lamp	794
T8 4ft 4 lamp	1,954
T8 8ft 2 lamp	855
Occupancy Sensors under 500 W	1,619
Occupancy Sensors over 500 W	4,054

Metric	Result
VFD HVAC Fan	8,984
VFD HVAC Pump	13,835
VFD Process Pump 1-50 HP	2,403
Measure Life	12yr (linear fluorescent) 10yr (occupancy sensor) 15yr (VFD)

Conclusions and Recommendations for Program Changes

Significant Impact Evaluation Findings for Linear Fluorescent Measures

- Energy and coincident peak demand savings realization rates for kWh and coincident peak kW for linear fluorescent lighting were 1.89 (energy) and 1.61 (demand) respectively, indicating the program planning estimates were conservative estimates of linear fluorescent lighting savings.
- Measurement and verification (M&V) activities conducted for this study produced an estimate of 5,155 lighting equivalent full load hours (EFLH), compared to a program planning estimate of 4,144 EFLH.
- M&V activities estimated a coincidence factor (CF) of 0.80, compared to a program planning estimate of 0.77.
- Although there were some small differences between the quantity of fixtures recorded in the Duke Energy program tracking database versus the number of fixtures in the field, the overall installation verification rate was 1.00.
- Program planning and M&V estimates of baseline fixture wattage were within 1%. M&V estimates of efficient fixture watts were an average of about 7% lower than program planning estimates, indicating conservative values of fixture watts were used during program design.

Significant Impact Evaluation Findings for Occupancy Sensor Measures

- Energy and coincident peak demand savings realization rates for kWh and kW for occupancy sensor measures were 0.56 and 1.21 respectively, indicating the program planning estimates were conservative estimates of occupancy sensor coincident peak kW savings, but overestimated occupancy sensor kWh savings.
- M&V activities conducted for this study produced an estimate of 3,078 lighting equivalent full load hours (EFLH) before the installation of occupancy sensors, compared to a program planning estimate of 4,144 EFLH.
- M&V activities produced an estimate of connected lighting kW per occupancy sensor that was 31% lower than the program assumption. Many of the occupancy sensors in the study were controlling a single fixture, which contributed to the reduced connected watts per sensor.
- M&V activities estimated an average kWh savings of 54% of the uncontrolled consumption and an average kW savings of 46% of the uncontrolled demand, compared to the program estimate of 30% for both kWh and kW. Although the kW savings as a percentage of the baseline estimated from M&V was higher, the connected load per sensor was less, thus the overall demand savings per sensor from M&V was less than the program estimate.

Significant Impact Evaluation Findings for VFD Measures

VFD energy and coincident peak demand savings realization rates were lower than program planning estimates. On average, the realization rates for energy, non-coincident peak, and peak

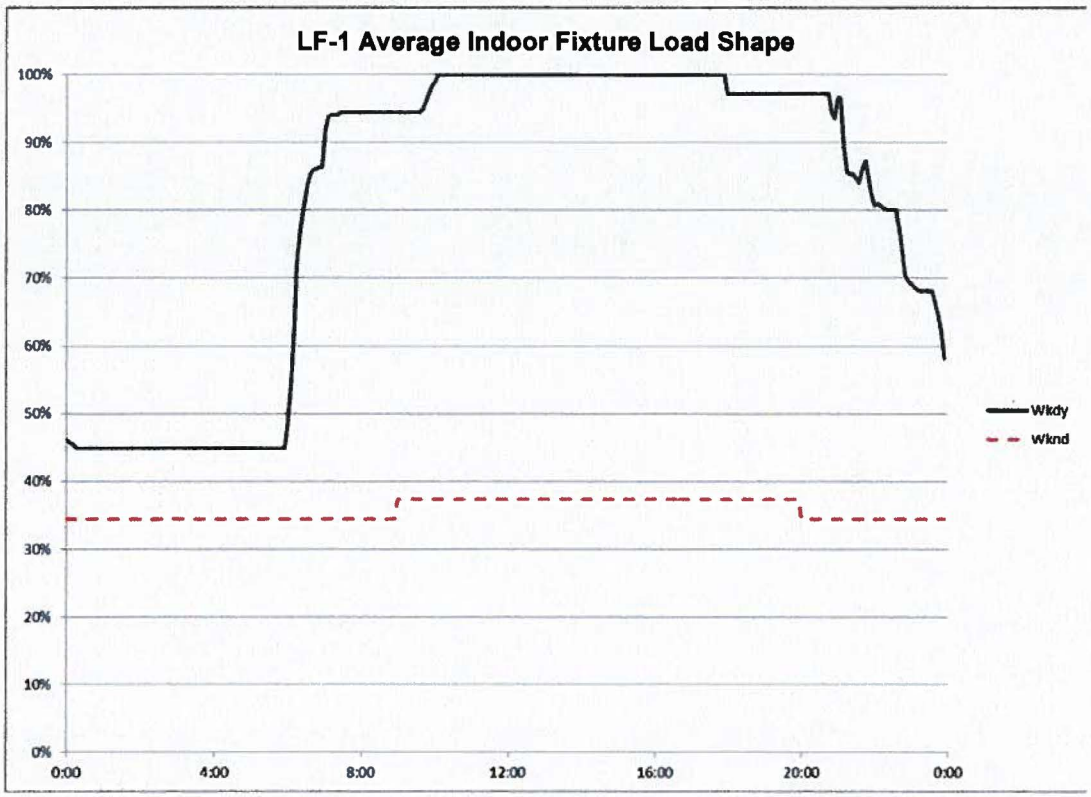
demand savings were about 62, 46, and 43% respectively. HVAC fans had the highest realization rates, and process pumping had the lowest realization rate
Based on the results of the impact evaluation, the TecMarket Works team has the following recommendations:

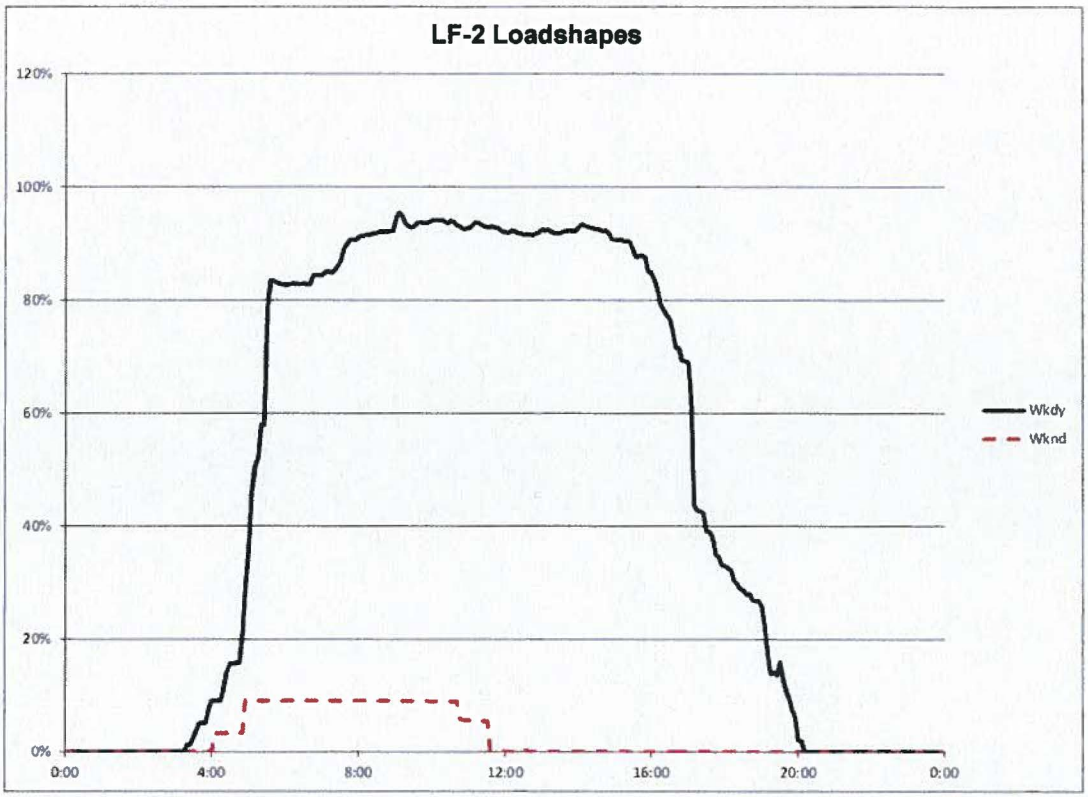
1. Conservative estimates of lighting EFLH should be updated with M&V results.
2. The weighted average self-reported operating hours were 4,944 EFLH, which represents a better estimate of lighting EFLH than the standard estimate of 4,144 EFLH. Consider including the self-reported operating hours in the ex-ante estimates of measure savings.
3. The measured coincidence factor of 0.80 was slightly higher than the program planning estimate of 0.77. Consider revising the coincidence factor assumption to 0.80 for future program planning activities.
4. The M&V savings for VFDs was significantly lower than program estimates, especially for HVAC pumps and process pumps. Consider reducing the annual savings estimates to the M&V results.

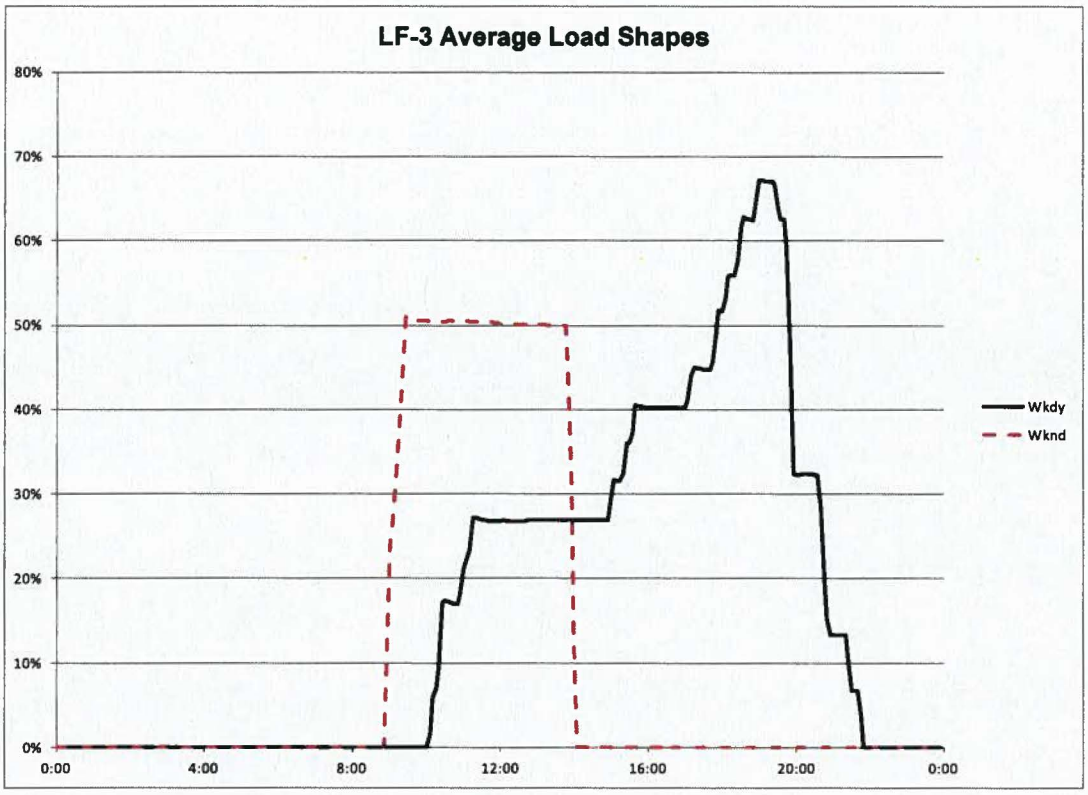
Appendix A: Load Shapes

Average weekday and weekend/holiday load shapes from the logger data are shown for each site in the study.

Linear Fluorescent Sites




LF-2 Loadshapes
120%
100%
80%
60%
40%
20%
0%
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Wkdy
Wknd


LF-3 Average Load Shapes
80%
70%
60%
50%
40%
30%
20%
10%
0%
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Wkdy
Wknd