

**National Grid USA**

***Small Business Services***

***Custom Measure  
Impact Evaluation***

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## Executive Summary

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This document summarizes the evaluation activity that RLW performed for National Grid USA's 2005 Small Business Services energy efficiency program. There were a total of twenty sample sites selected and on-site engineering savings estimates were performed using short term monitoring equipment to quantify gross savings impacts.

### **Purpose of Study**

The objective of this study is to perform in-field verification or re-estimation of electric energy and demand savings estimates for twenty Custom Measure projects through site-specific inspection, monitoring, and analysis.

This impact study consists of the following four tasks:

1. Develop Site Measurement and Evaluation Plans
2. Site Visit Administration
3. Data Gathering and Analysis
4. Report Writing and Follow-up

### **Scope**

The SBS program assists small commercial, industrial, institutional and governmental customers in the National Grid's Massachusetts, Rhode Island and New Hampshire service territories to install a wide range of prescriptive and custom energy efficiency measures. The SBS program is a direct installation program that is vendor-delivered and over 90% of the program savings come from the installation of prescriptive measures. Over the past three years, vendors have been encouraged to identify and install custom measures as well and custom measures are a growing percentage of savings in the SBS program.

### **Sample Projects**

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The population savings data was divided into two sectors, Custom Lighting and Custom Non-lighting measures. The Custom Non-lighting sector was then further split into Custom Other measures and Custom Refrigeration measures. The project savings within each of the sectors were then stratified into five savings strata based upon the gross energy savings. Two sample sites were selected from each of the strata of the Custom Lighting projects and one sample site was selected from each of the strata for the Other measures and the Refrigeration measures. Table i - 1 provides the tracking savings estimates for the ten sample Custom Lighting projects, the five sample Custom Other projects and the five sample Custom Refrigeration projects. The sample Custom Lighting projects account for about two thirds to three quarters of the total energy savings and demand reductions captured by the sample. The Custom Other sites represent approximately 20% to 30% of the energy savings and demand reductions and

the Custom Refrigeration projects account for the remaining 5% of the savings contained within the sample sites.

Project #	Appl No.	End-Use Category	Stratum	Total Gross kWh
1	504400	CUSTOM LIGHTING	1	1,485
2	511636	CUSTOM LIGHTING	1	800
3	508788	CUSTOM LIGHTING	2	11,757
4	505040	CUSTOM LIGHTING	2	14,226
5	509074	CUSTOM LIGHTING	3	26,775
6	506776	CUSTOM LIGHTING	3	27,272
7	507504	CUSTOM LIGHTING	4	41,108
8	508578	CUSTOM LIGHTING	4	47,803
9	506737	CUSTOM LIGHTING	5	65,415
10	506736	CUSTOM LIGHTING	5	99,730
<b>CUSTOM LIGHTING TOTALS</b>				<b>336,372</b>
11	511112	CUSTOM OTHER	1	7,665
12	510821	CUSTOM OTHER	2	14,425
13	508705	CUSTOM OTHER	3	20,000
14	507259	CUSTOM OTHER	4	23,310
15	508706	CUSTOM OTHER	5	34,985
<b>CUSTOM OTHER TOTALS</b>				<b>100,385</b>
16	505402	CUSTOM REFRIGERATION	1	1,529
17	506828	CUSTOM REFRIGERATION	2	2,997
18	506354	CUSTOM REFRIGERATION	3	4,690
19	509933	CUSTOM REFRIGERATION	4	6,674
20	504980	CUSTOM REFRIGERATION	5	8,342
<b>CUSTOM REFRIGERATION TOTALS</b>				<b>24,232</b>

**Table i - 1: Sample Project Savings Data**

## **Description of Measures**

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### **Sample Measures**

The twenty sample sites from the three end-use categories were organized based upon the types of installed measures and were grouped into eight different measure categories based upon common measure types for developing monitoring and evaluation techniques. There were four different measure types contained within the Lighting end-use category, three different measure types for the Other measures and one measure type for the Refrigeration end-use as presented in Table i - 2.

End Use	Measure Description	# of Sites
Lighting	Lighting Retrofit (8,760 hours)	3
Lighting	Lighting Retrofit (Schedule)	4
Lighting	Lighting Variable Power	2
Lighting	Vending Machine Misers	1
Other	Car Wash Controllers	2
Other	Energy Management System (EMS)	2
Other	Variable Frequency Drive (VFD)	1
Refrigeration	ECM Evaporator Fan Motors	5

**Table i - 2: Frequency of Measure Types**

### **Lighting End Use Measures**

There were ten sample sites selected that had lighting end-use savings. Seven of the ten were sites that had undergone lighting retrofits where the existing fixtures were replaced with energy efficient fixtures on either a one-to-one basis or on an equivalent lumen output basis. Of the six lighting retrofit sites three of the sites had lighting that operated continuously and four had lighting that had an operating schedule that could be monitored. There were also two lighting sites that had variable power consumption based upon either occupancy or ambient lighting levels in the space. Finally there was one lighting site that involved the installation of Vending Machine Misers, control equipment that puts a soda vending machine into sleep mode when there are no people in the immediate area of the machine.

### **Other End Use Measures**

There were five sample sites selected with other end-use savings. Two of the five were sites that had car wash controllers installed that reduce the speed of the blower motors when there are no cars approaching the blow drying area of the car wash. Two of the sites had upgrades to their Energy Management Systems (EMS) to allow for the programming of occupied and unoccupied set points and schedules to control space temperatures and fan operation. The final other measure involved the installation of a Variable Frequency Drive (VFD) to control the operation of a pool pump motor.

### **Custom Refrigeration Measures**

There were a total of five refrigeration sample sites selected for inclusion in the evaluation and all of the projects involved the installation of Electrically Commutated Motors (ECM) on the evaporator fans in the walk-in coolers.

### **Summary of Evaluation Activity**

Although the measure evaluation activities were somewhat different for each of the different types of measures the following generic activities were used to evaluate impacts:

- **Measure Inventory** confirm quantity and type of installed measure,
- **Measure Operation** confirm that measure and or controls are operational,

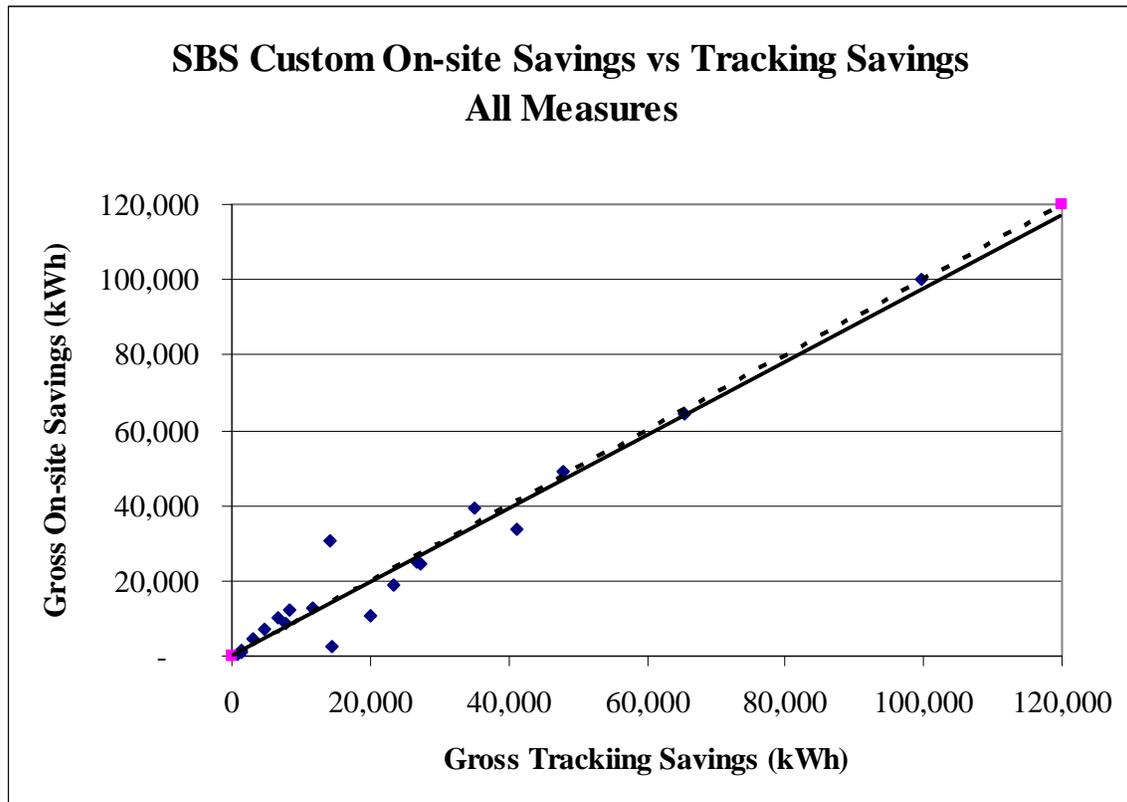
- **Measure Operating Schedule** confirm operating schedule and or control settings and assumptions,
- **Power Measurements** confirm full load power consumption for the measure,
- **Power Monitoring** confirm the operating profile for the measure using either direct interval power measurement or time of use event loggers and spot power measurement where appropriate, and
- **Interactive Effects** evaluate the impact of the measure on the operation of other electrical equipment at the facility.

## Results

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### Major Findings and Observable Trends

Figure i - 1 provides a graphical representation of the un-weighted gross on-site savings versus the gross tracking savings. The dotted line represents a trend showing a one to one correspondence between on-site savings and tracking savings. The solid line is a trend line through the actual on-site savings results, which shows an extremely close correlation to the "one to one" line. The trend line shows that the un-weighted on-site savings estimates for the sample projects have a realization rate slightly below 100% of the tracking savings with most of the on-site savings close to the tracking values.



**Figure i - 1: SBS Custom On-site Savings vs. Tracking Savings for All Measures**

As previously discussed the sample was divided into three sectors based upon the measure types as follows:

- Custom Lighting Measures
- Custom Other Measures
- Custom Refrigeration Measures

The following sections will examine the on-sites savings results by each the three savings sectors.

### Custom Lighting Measures

There were a total of ten Custom Lighting sites included in the sample and a scatter plot of the on-site lighting measure savings is presented in Figure i - 2. Once again the dotted trend line represents a one to one correspondence between the on-site and tracking savings and the solid line is the trend line through the on-site savings. The lighting measures show a high correspondence with the 100% realization line and the individual savings points also are fairly tightly clustered around the line. This is fairly typical of lighting measures and indicative that the tracking savings estimates accurately represent the savings that are actually being achieved.

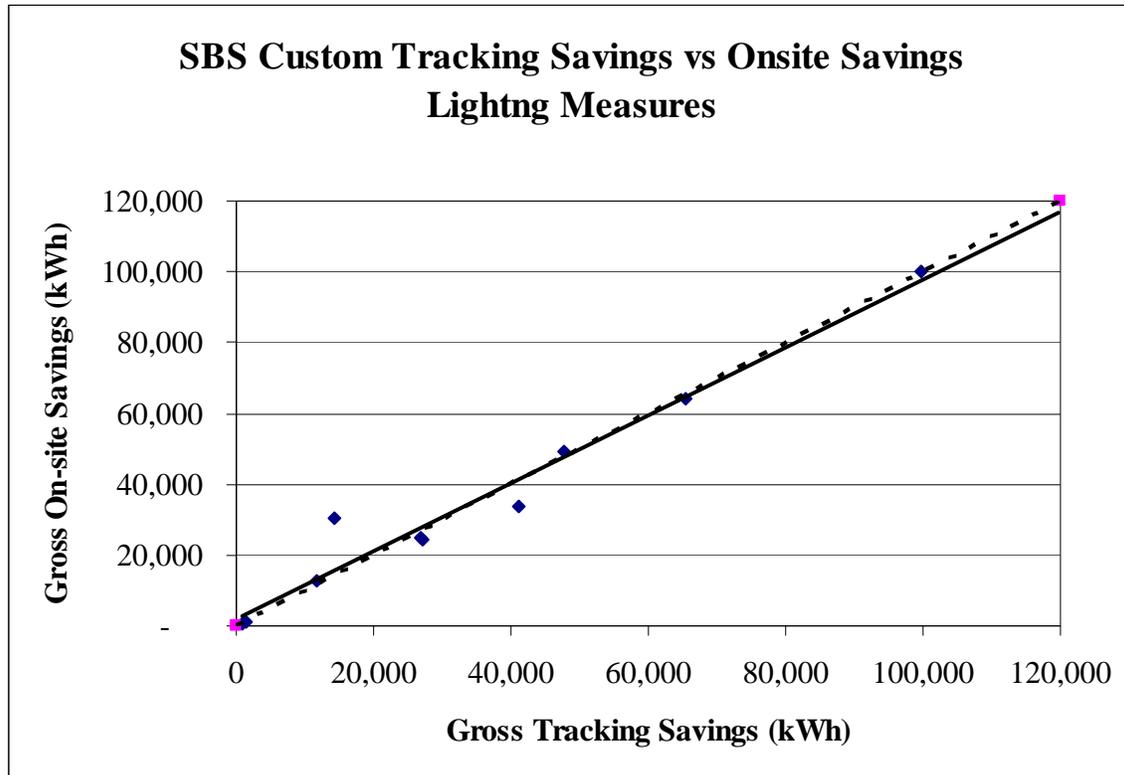
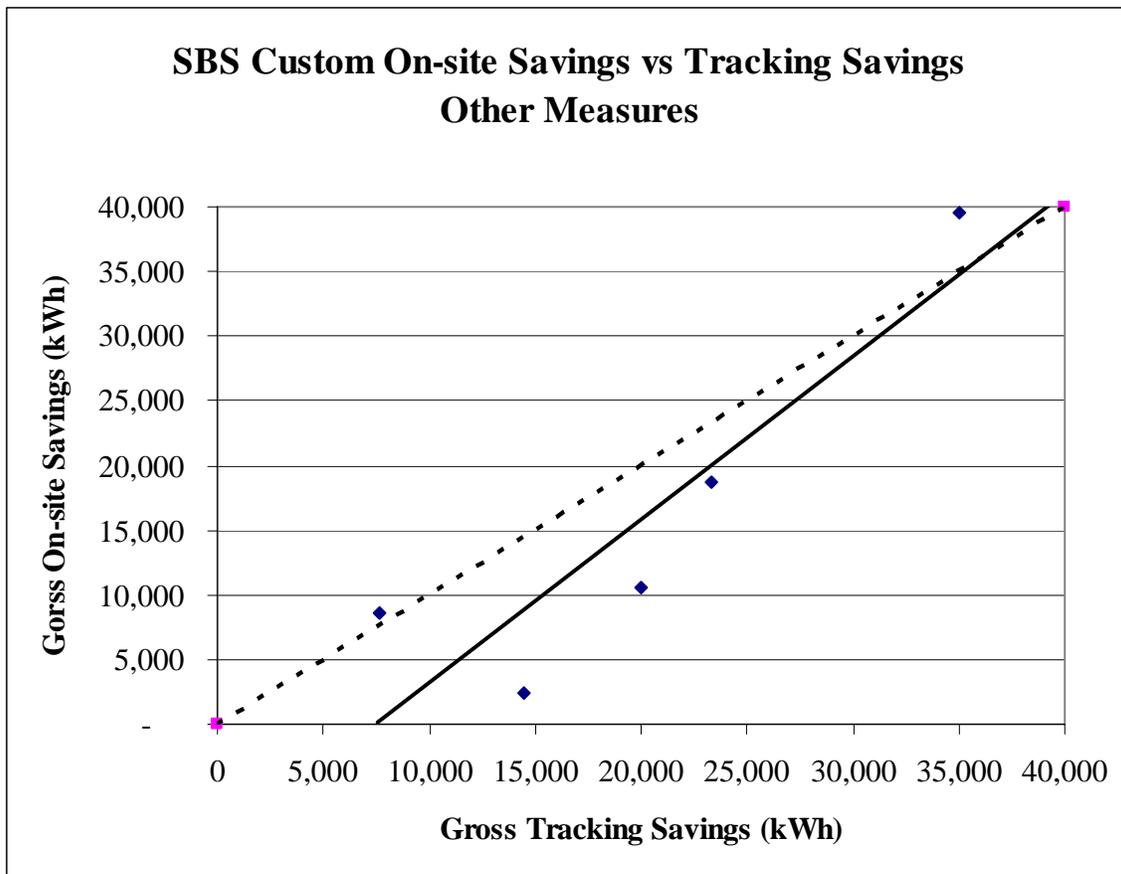


Figure i - 2: Custom Lighting Measures On-site vs. Tracking

### **Other Custom Measures**

There were five Custom Other measures that consisted of three VFD applications and two HVAC control measures. Figure i - 3 shows a scatter plot of on-site savings versus the tracking savings with the on-site trend line and the 100% realization rate trend line. These measures have a lower realization rate and have much more variation in the on-site savings than the lighting measures with points both above and below the 100% realization line. This is fairly typical of these types of measures where it is difficult to estimate the potential savings at a site because it varies based on load. There were two sample sites that had on-site savings significantly lower than the tracking savings that are causing the on-site trend line to dip significantly below the 100% realization line at the low end of the graph. Since the lower strata sites typically have a higher weight than the higher strata sites this will exert downward pressure on the weighted savings expansion.



**Figure i - 3: Custom Other Measures On-site vs. Tracking**

### Custom Refrigeration Measures

There were five projects with Custom Refrigeration measures and all of the measures involved the installation of Electrically Commutated Motors (ECMs) in evaporator fan units. Figure i - 4 shows a scatter plot of the on-site savings along with trend lines for both the tracking and on-site savings, which shows a strong linear relationship between the on-site savings that is significantly higher than the tracking savings. This is a classic example of systematic error that is consistently causing the tracking savings to underestimate the actual savings being achieved.

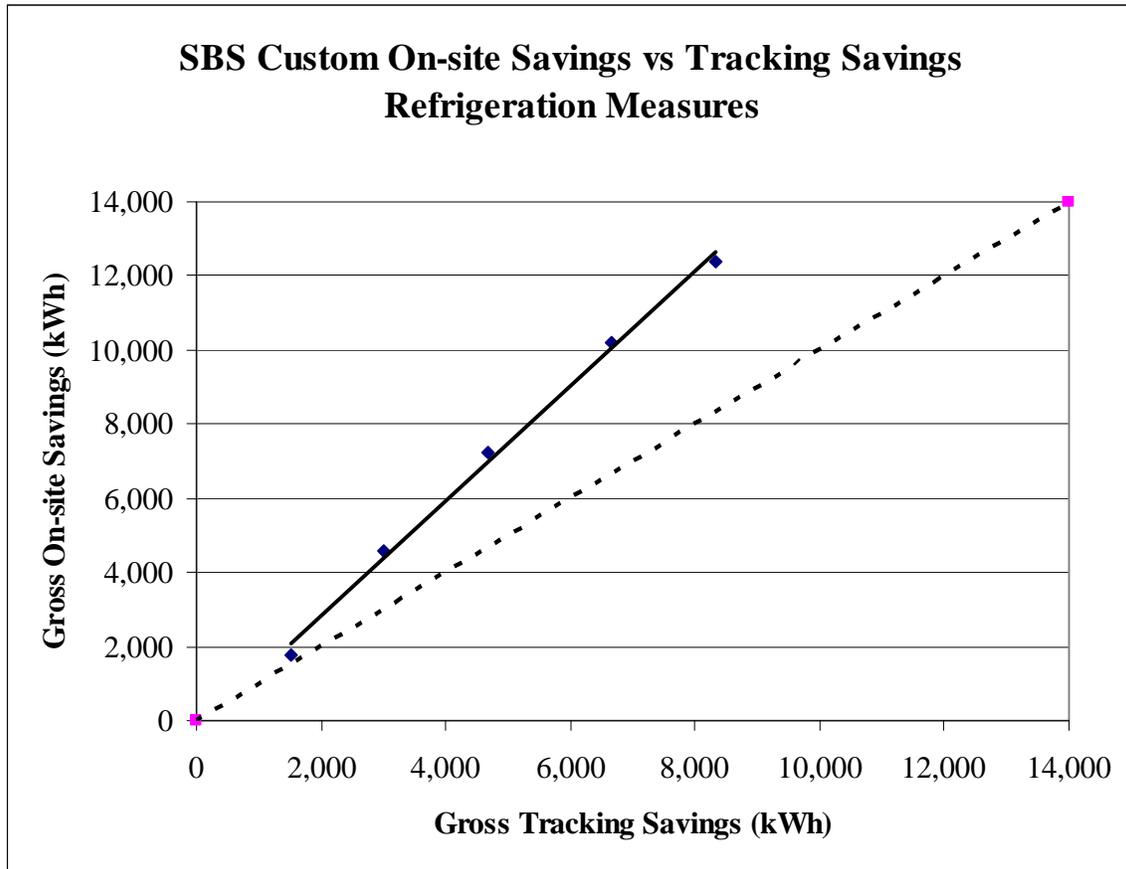


Figure i - 4: Custom Refrigeration Measures On-site Vs. Tracking

This result was anticipated and was due to the method used to calculate the direct demand reduction of the motors, which assumes a 40% reduction in demand for the ECMs.

## Presentation of Results

Table i - 3 presents a summary of the site level savings results for the twenty sample sites. The first ten projects are Lighting sites which have an energy onsite to tracking ratio ranging from 75% to 215%. The next five projects (11 – 15) are Other projects that have an on-site to tracking energy savings ratio 17% to 113%. The last five projects are the Refrigeration projects that have an on-site to tracking savings ratio of 115% to 154%.

RLW ID	Customer Type Application #	N-GRID Tracking Savings				RLW On-Site Savings				Ratio RLW/Tracking			
		Energy Savings kWh/yr	On Peak %	Peak Coincidence		Energy Savings kWh/yr	On Peak %	Peak Coincidence		Energy Savings kWh/yr	On Peak %	Peak Coincidence	
				Summer kW	Winter kW			Summer kW	Winter kW			Summer kW	Winter kW
1	Restaurant Application #, 504400	1,485	69%	0.44	0.27	1,224	70%	0.00	0.00	82%	102%	0%	0%
2	Education Admin. Building Application #, 511636	800	69%	0.09	0.05	603	28%	0.09	0.05	75%	41%	101%	93%
3	Retail Store Application #, 508788	11,757	69%	2.28	1.40	12,966	74%	3.58	2.92	110%	107%	157%	209%
4	Automotive Maintenance Shop Application #, 505040	14,226	69%	4.06	2.49	30,648	100%	10.53	6.78	215%	146%	259%	272%
5	Warehouse Application #, 509074	26,775	69%	7.11	4.36	24,837	95%	7.75	5.37	93%	138%	109%	123%
6	Ice Rink Application #, 506776	27,272	69%	5.99	3.68	24,299	74%	7.62	4.06	89%	108%	127%	110%
7	Distribution Warehouse Application #, 507504	41,108	69%	10.41	6.39	33,861	100%	11.01	4.12	82%	146%	106%	65%
8	Apartment Building Application #, 508578	47,803	69%	4.68	2.87	49,196	46%	5.62	5.62	103%	67%	120%	195%
9	Parking Garage Application #, 506737	65,415	69%	6.41	3.93	64,286	48%	7.37	7.38	98%	70%	115%	188%
10	Parking Garage Application #, 506736	99,730	69%	9.77	5.99	100,004	46%	11.42	11.42	100%	67%	117%	190%
11	Distribution Warehouse Application #, 511112	7,665	16%	0.77	1.36	8,539	35%	0.67	0.79	111%	216%	86%	58%
12	Boys & Girls Club Application #, 510821	14,425	39%	0.85	0.73	2,482	46%	0.27	0.27	17%	117%	32%	37%
13	Car Wash Application #, 508705	20,000	39%	4.00	3.42	10,550	57%	2.56	0.64	53%	146%	64%	19%
14	Nursing Home Application #, 507259	23,310	16%	3.21	5.66	18,660	35%	3.28	0.00	80%	216%	102%	0%
15	Car Wash Application #, 508706	34,985	39%	4.00	3.42	39,515	51%	8.63	5.67	113%	131%	216%	166%
16	Convenience Store Application #, 505402	1,529	39%	0.17	0.14	1,762	42%	0.37	0.13	115%	107%	218%	87%
17	Restaurant Application #, 506828	2,997	39%	0.33	0.28	4,560	50%	0.93	0.39	152%	127%	284%	138%
18	Liquor Store Application #, 506354	4,690	39%	0.29	0.24	7,213	40%	0.99	0.76	154%	103%	346%	311%
19	Liquor Store Application #, 509933	6,674	39%	0.73	0.63	10,183	44%	1.86	0.85	153%	113%	254%	135%
20	Liquor Store Application #, 504980	8,342	39%	0.92	0.78	12,395	47%	2.77	1.01	149%	120%	301%	128%
<b>Totals</b>		<b>460,989</b>		<b>66.51</b>	<b>48.10</b>	<b>457,782</b>		<b>87.30</b>	<b>58.20</b>	<b>99%</b>		<b>131%</b>	<b>121%</b>

**Table i - 3: Detailed Site Results**

## Summary of Discrepancies

Table i - 4 provides a summary of the site level savings discrepancies along with a brief explanation of the primary cause for the discrepancy. In general most the lighting projects had on-site savings within  $\pm 20\%$  of the tracking savings, with the exception of project numbers 2 and 4. Project 2 each had a decrease in on-site savings related to lower hours of use or decreased hours of controlled reduction, while project 4 had a large increase due to increased hours of controlled reduction. The Other measure projects had two projects that had on-site savings more than  $\pm 20\%$  of the tracking savings, projects 12 and 13. Projects 12 and 13 each had decreases due to decreases in VFD control load reductions. All but one of the Refrigeration projects were outside  $\pm 20\%$  of the tracking savings, range and all of the projects had on-site savings that exceeded the tracking savings estimate. This is due to a systematic error in the savings calculation from the under estimates the direct demand reduction for the fan motors.

RLW ID	Customer Type Application #	Ratio RLW/Tracking				Primary Reason for Discrepancy
		Energy Savings kWh/yr	On Peak %	Peak Summer kW	Peak Winter kW	
1	Restaurant Application #, 504400	82%	102%	0%	0%	The on-site hours of use were lower and did not go much beyond 2:00PM
2	Education Admin. Building Application #, 511636	75%	41%	101%	93%	There was more daytime activity around the vending machine than with a typical installation
3	Retail Store Application #, 508788	110%	107%	157%	209%	The increase in savings was due to a decrease in the insatllted fixture wattage
4	Automotive Maintenance Shop Application #, 505040	215%	146%	259%	272%	The increase was due to a large increase in the Equivalent Full Load Hours of Reduction for the controlled lighting fixtures
5	Warehouse Application #, 509074	93%	138%	109%	123%	The decrease was due to higher insatllted fixture wattages and slight decrease in hours
6	Ice Rink Application #, 506776	89%	108%	127%	110%	The decrease was assumed to be due to a change in the type of fixtures being controlled and a large reduction in controlled wattage
7	Distribution Warehouse Application #, 507504	82%	146%	106%	65%	The decrease was due to a decrease in the annual operating hours of the lighting fixtures
8	Apartment Building Application #, 508578	103%	67%	120%	195%	The slight increase was due to greater number of fixtures being installed
9	Parking Garage Application #, 506737	98%	70%	115%	188%	The slight decrease was due to a slight decrease in annual operating hours
10	Parking Garage Application #, 506736	100%	67%	117%	190%	The slight increase was due to a slight increase in annual operating hours
11	Distribution Warehouse Application #, 511112	111%	216%	86%	58%	The increase is due to an increase in the on-site cooling savings measured during the evaluation metering
12	Boys & Girls Club Application #, 510821	17%	117%	32%	37%	The decrease was due to a large decrease in the demand reduction of the pump motor
13	Car Wash Application #, 508705	53%	146%	64%	19%	The decrease was due to a decrease in the number of hours that the blower fan motors operated at low speed
14	Nursing Home Application #, 507259	80%	216%	102%	0%	The decrease was due a decrease in the winter fan cycling savings because the occupied winter temperature setting was higher
15	Car Wash Application #, 508706	113%	131%	216%	166%	The increase in savings was due to an increase in the number of hours that the blower fan and pump motors operated at low speed
16	Convenience Store Application #, 505402	115%	107%	218%	87%	The increase in savings was due to an increase in the direct demand reduction for the evaporator fan motors
17	Restaurant Application #, 506828	152%	127%	284%	138%	The increase in savings was due to an increase in the direct demand reduction for the evaporator fan motors
18	Liquor Store Application #, 506354	154%	103%	346%	311%	The increase in savings was due to an increase in the direct demand reduction for the evaporator fan motors
19	Liquor Store Application #, 509933	153%	113%	254%	135%	The increase in savings was due to an increase in the direct demand reduction for the evaporator fan motors
20	Liquor Store Application #, 504980	149%	120%	301%	128%	The increase in savings was due to an increase in the direct demand reduction for the evaporator fan motors

**Table i - 4: Summary of Site Level Discrepancies**

## Conclusions

The Custom Lighting projects had reasonably accurate savings estimates and there was really only one site that had a large variation in the on-site savings estimate, project 4,

which had on-site savings that were 115% higher than tracking. This project involved the installation of an occupancy based dimming system that operated at reduced power for approximately twice as many hours as originally estimated. This type of error is bound to happen on a site by site basis and although the underestimation of controlled hours resulted in a fairly large discrepancy at this site there is no reason to believe that this is a systematic error. In general the tracking lighting savings estimates seem to be fairly accurate and there does not seem to be any systematic error in the estimates that needs to be addressed.

There were two of the five Custom Other Measures that did have relatively large variations between the on-site and tracking savings measures, projects 12 and 13. Project 12 had the largest variation with on-site savings being 83% lower than the tracking savings. This project involved the installation of a Variable Frequency Drive (VFD) to replace a throttling valve on a pool filter pump application and essentially run the pump at a lower constant speed. At some point the facility replaced the pump motor with an energy efficient motor, and apparently the throttling valve was closed almost to the original setting, resulting in virtually no savings.

Project 13 involved the installation of VFD controls for blower fans at a car wash and the on-site savings were 47% lower than the tracking savings. In this case the savings were lower because they are driven by the level of activity at the site since the savings are only realized when consecutive cars are going through a "tunnel" style car wash. This type of process measure is strongly dependent on the amount of activity during the metering period, which occurred during the slowest time of year (the summer). Project 15 also involved the installation of VFD controls on blower fan motors at a car wash with the same metering period and the on-site savings were actually 14% higher than the tracking savings. One difference between the two sites is that the savings per controlled blower fan was 5,004 kWh/yr for project 13, and 3,960 kWh/yr for project 15. Lowering the tracking savings per fan for project 13 would provide a savings estimate that is closer to the on-site savings; however it would still be 37% higher than the on-site savings. Once again there does not seem to be a systematic error here. This is a process measure that is highly variable and driven by the activity level at the site which is often difficult to predict.

The five Custom Refrigeration measures all involve the installation of Electrically Commutated Motors (ECMs) in evaporator fan units in walk-in coolers and freezers. This measure does have systematic error in place that causes the tracking savings to consistently under estimate the actual installed savings. As discussed previously in this report, the main error is due to the current savings form that is being used to evaluate these measures, because no data is collected to determine the size of the motors being replaced. Instead nameplate or measured amps for the fans are listed and than a flat 40% demand reduction is assumed for all fans. In most cases this 40% reduction would be accurate for a baseline motor that is a Split Capacitor (SC) style motor in the 1/15 hp to 1/20 hp size range. This assumption is conservative because the motors that

are currently installed and available in evaporator units are Shaded Pole (SP) style motors that are not as efficient as the SC style motors.<sup>1</sup>

There are a couple of adjustments that could be made to the current savings form to more accurately estimate savings based upon the results of this on-site evaluation. Table i - 5 provides a summary of the current values used and the recommended changes to the vendor savings form. The first change deals with the percentage reduction in motor load (Line 4) when the fans are replaced, which we recommend increasing by 15% from 40% to 66%. The second change has to do with average refrigeration system efficiency that is used to calculate the interactive savings based upon reduced heat load to the space. The vendor form uses a value of 2.25 kW/Ton and we recommend that the efficiency be reduced to 1.3 kW/ton, which is more consistent with the seasonal average efficiency of the refrigeration systems that are expected to be encountered.

PART III				
ANALYSIS OF REPLACING EVAPORATOR MOTORS WITH ECM MOTORS:		NRM	RLW	% Change
4)	Estimated Percentage Reduction in Motor Load	40%	66%	66%
6)	Savings due to reduced cooling load from evaporator fans.	2.25	1.3	-42%

**Table i - 5: Recommended Changes to ECM Savings Calculation Form**

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<sup>1</sup> As an example, the following link to a Larkin walk-in evaporator unit model LCA shows electrical data for 1/15 hp shaded pole fan motors that are currently being shipped with this unit.  
<http://www.larkinproducts.com/products/overview.asp?pid=63>.