Energy Mis-Management Systems

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ABSTRACT

Energy management control systems, also known as building automation systems, represent expensive investments for customers and grand opportunity for utility programs. Unfortunately, many times the grand opportunity is a blown opportunity. This paper will use findings from the evaluation of dozens of energy management system implementation projects in North America, identify common attributes of the most successful programs, and offer further recommendations to maximize return on these expensive investments. Energy management systems can control nearly all energy using systems and equipment in commercial and industrial buildings including HVAC, lighting, and even plug loads. The results of this paper will document savings levels relative to key metrics such as building square footage and control strategies implemented. Perhaps even more importantly, this paper will identify key program elements that are common among successful programs and less successful programs. Lastly, this paper will demonstrate the savings left on the table due to program faults and recommend solutions to ensure savings are captured.

Introduction

For many years programs have relied on the CFL and the T8 to reach energy savings goals; however, the world of energy efficiency programs is changing. The age of the T8 and CFL has past. However, there is no clear front-runner to take over to meet the savings levels historically achieved by these lighting programs. One technology that is gaining momentum to fill the void is the energy management system (EMS).

In fact, this may very well be the case, since the potential savings due to the installation of EMS systems are significant. Some sources estimate the savings potential due to the installation of EMS systems to be 10-15% of building energy consumptions or more.

It is important to also note that the EMS, and in the potential savings for EMS projects, is not a new idea. It is also important to note that the difficulties and failures of EMS projects have also been documented. The programs that were designed to promote energy efficient lighting may not be the most effective delivery mechanisms for EMS projects. The delivery of the program is critical to achieving energy savings because once the EMS is installed, for many customers, the opportunity may be lost not only to affect the savings for this specific project, but also for other projects that could potentially occur for the same customer by reprogramming the same EMS system. The question then is “Are existing programs working?”

The Programs

A review of four programs that included EMS projects was completed. Although the programs were varied in nature, the programs overall fell into one of two primary camps, custom or prescriptive. EMS projects have typically been relegated to the custom programs, but recently, the idea of incenting EMS projects through prescriptive programs has started to gain momentum. Each program is described below.

The programs are all evaluated on two factors. The first is the percent of energy savings compared to the facilities annual energy usage for both the ex ante and verified (evaluated) savings. In addition, the

number and types of measures implemented will be investigated. These measures vary widely from night setback (NSB), optimal start stop (OSS), demand controlled ventilation (DCV), temperature based economizer controls, enthalpy based economizer controls, scheduling, discharge air reset (DAR), and the scheduling of lights.

Program A

The first program reviewed was a wide-spectrum program that covered multiple technologies with both prescriptive and custom components. All of the energy management system projects had savings levels calculated using a custom approach, using site-specific information. The incentive levels paid to the customer were base on the expected savings levels.

A small number of the projects completed in the program were similar projects completed at multiple locations for a specific customer. The savings for these projects were "quasi-prescriptive." For these projects, the savings levels were not calculated for these sites individually, but instead a savings value was "deemed" for these projects based on savings levels claimed for similar past projects in other utility jurisdictions. For these projects, minimal information was included in the project files to determine specific energy efficiency control strategies implemented.

The remaining projects reviewed were found to be predominantly vendor driven, where the vendor or controls contractor had completed a site assessment to determine the expected scope of work, including the control strategies expected to be implemented. The vendor also calculated savings for these projects; however, the vendor savings calculations were typically not included with the utility project files. Instead, the utility had a secondary analyst recalculate the savings, which was completed using a standardized calculator using similar assumptions regardless of the control strategies implemented.

There were a total of ten electric projects evaluated for this program. Of the ten projects, five were the "quasi-prescriptive". These projects implemented optimal start stop controls; however, before the project, the units were manually turned on and off at store open and close, resulting in zero or negative savings. Two of the remaining five projects either increased the operating hours of equipment, or were controlled in the same manner before the project, resulting in negative savings. The three remaining projects succeeded in achieving their design intent of reducing energy usage of the facility. The ex ante claimed savings resulted in savings between 1% and 18%, for an average savings of 6%. Due to the challenges outlined above, the verified savings were less at, -10% to 17% for an average of 1% savings. The individual project savings are shown below in Figure 1.

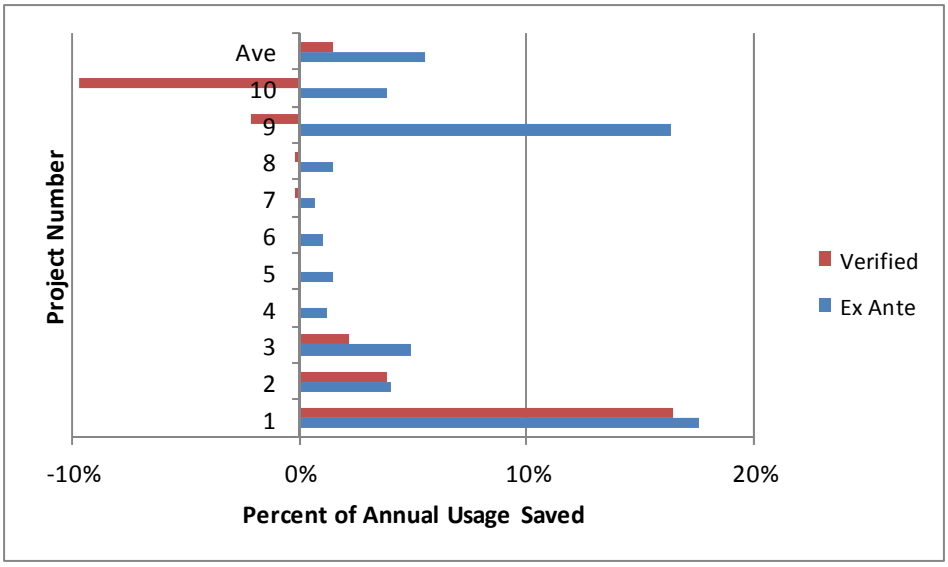

Figure 1: Program A Electrical Project Savings Breakdown

The program used a range of measures to achieve the savings; however, it is still predominantly dependent upon scheduling changes and night setback. The optimal start stop measures all resulted in zero or negative savings. The breakdown of measures used is shown below in Table 1.

Table 1: Program A Electrical Measure Breakdown

Project	Ex Ante % Savings	Verified % Savings	Night Setback	Optimal Start/Stop	Demand Controlled Ventilation	Economizer (temperature)	Economizer (enthalpy)	Scheduling	Discharge Air Reset	Scheduling Lights
1	18%	17%	x	x				x		
2	4%	4%						x		
3	5%	2%			CO2					
4	1%	0%	x	x				x		
5	1%	0%	x	x				x		
6	1%	0%	x	x				x		
7	1%	0%	x	x				x		
8	2%	0%	x	x				x		
9	16%	-2%			CO2			x		
10	4%	-10%		x						x
Total	6%	1%	6	7	2	0	0	8	0	1

There were a total of 23 gas projects evaluated for this program; however, only 16 projects had the annual energy usage and are the only ones shown in Figure 2. All of the measures, except for three, achieved some level of savings. Three projects didn't save energy due to the EMS controls not changing or increasing equipment operation. The remaining projects saved energy using multiple control strategies as shown below in Table 2. The ex ante claimed savings resulted in savings between 7% and 42% of facility gas usage, for an average savings of 17%. The verified savings were less at -7% to 71% for an average of 14% savings.

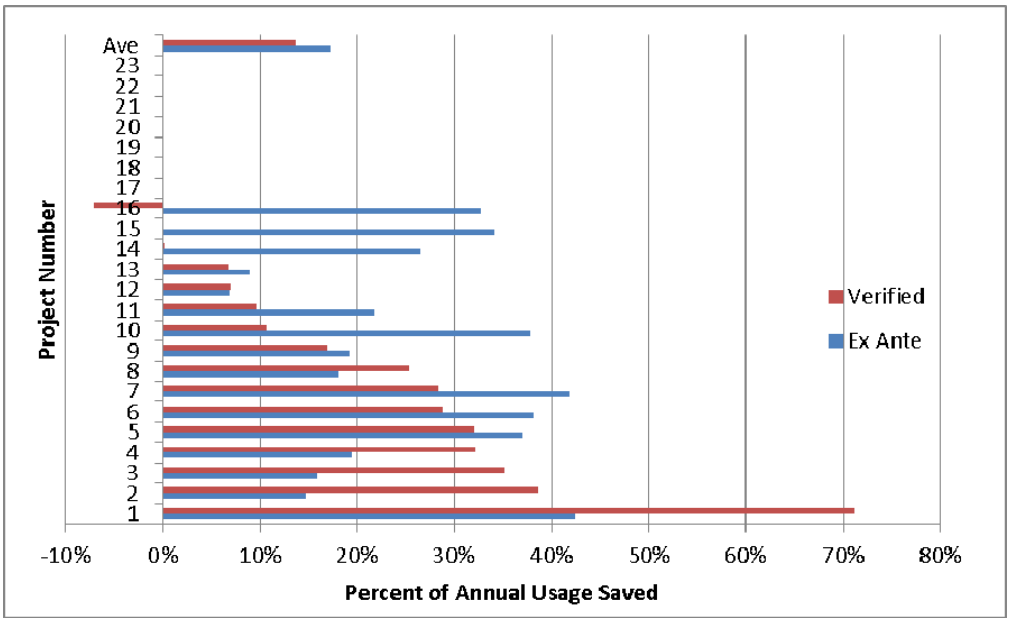

Figure 2: Program A Gas Project Savings Breakdown

Table 2: Program A Gas Measure Breakdown

Project	Ex Ante % Savings	Verified % Savings	Night Setback	Optimal Start/Stop	Demand Controlled Ventilation	Economizer (temperature)	Economizer (enthalpy)	Scheduling	Discharge Air Reset	Scheduling Lights	Boiler Controls	Reduced OA
1	42%	71%	x	x	CO2		x	x				
2	15%	39%	x					x				
3	16%	35%	x									
4	20%	32%	x									
5	37%	32%	x		CO2	x		x				
6	38%	29%	x					x				
7	42%	28%	x					x			x	
8	18%	25%	x	x				x				
9	19%	17%	x									
10	38%	11%	x	x	CO2			x				
11	22%	10%	x									
12	7%	7%			CO2			x				
13	9%	7%	x					x				x
14	27%	0%		x	CO2		x					
15	34%	0%	x		CO2			x				
16	33%	-7%	x					x				
17	N/A	N/A	x					x				
18	N/A	N/A	x					x				
19	N/A	N/A	x					x				
20	N/A	N/A	x					x				
21	N/A	N/A										x
22	N/A	N/A	x									
23	N/A	N/A			CO2							
Total	17%	14%	19	4	7	1	2	15	0	0	1	2

Program B

The second program reviewed is unique in that the program delivery mechanism changed. For the first year reviewed, the two energy management projects were incented through the program and analyzed

using a custom approach. For these projects, the incentive levels were based on the expected savings levels, which were calculated by the program implementer. The program implementer calculated savings based on control sequences submitted by the vendor, using an in-depth approach that was adapted to fit each project. Only two projects were evaluated using this custom approach, with one being electric and the other being gas. The savings and measures achieved are shown below in Figure 3. Included in the figure are the results from the prescriptive program. It should be noted that the custom program only completed one gas and one electric project, so conclusions are limited, but the savings from these projects were over double the verified savings of the prescriptive program.

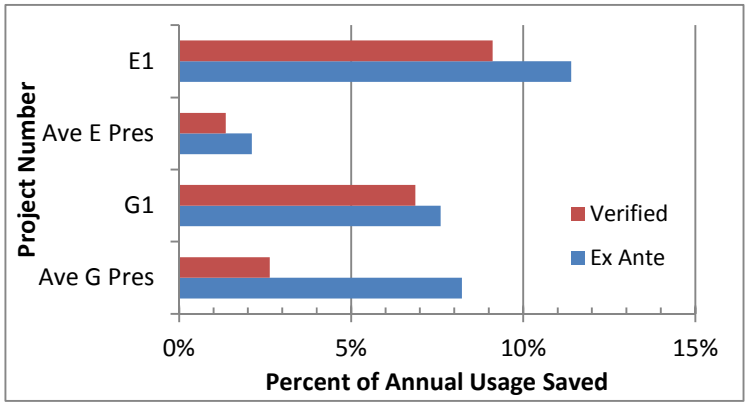

Figure 3: Program B Custom Projects Breakdown

Table 3: Program B Custom Measure Breakdown

Project	Ex Ante % Savings	Verified % Savings	Night Setback	Optimal Start/Stop	Demand Controlled Ventilation	Economizer (temperature)	Economizer (enthalpy)	Scheduling	Discharge Air Reset	Scheduling Lights	Pump Controls
E1	11%	9%	x					x			x
G1	8%	7%			CO2			x			

For the second year reviewed, a prescriptive rebate structure had been established. For these projects, both the expected savings and the incentive level were based solely on the building area. To qualify for the prescriptive rebate, the project had to meet minimum qualification requirements, which included night setback. There were a total of 13 projects evaluated using the prescriptive approach, with one project having both electric and gas savings. There are five electric projects and nine gas projects. Several of the projects do not have annual energy usage data available, and thus do not show a percent of annual energy usage saved. Figure 4 and Table 4 below outline the project savings and measure breakdowns for both the electric and gas projects. The electric projects averaged 4% savings for the ex ante and 6% savings for the verified savings. The gas projects averaged 17% for the ex ante savings and 3% for the verified.

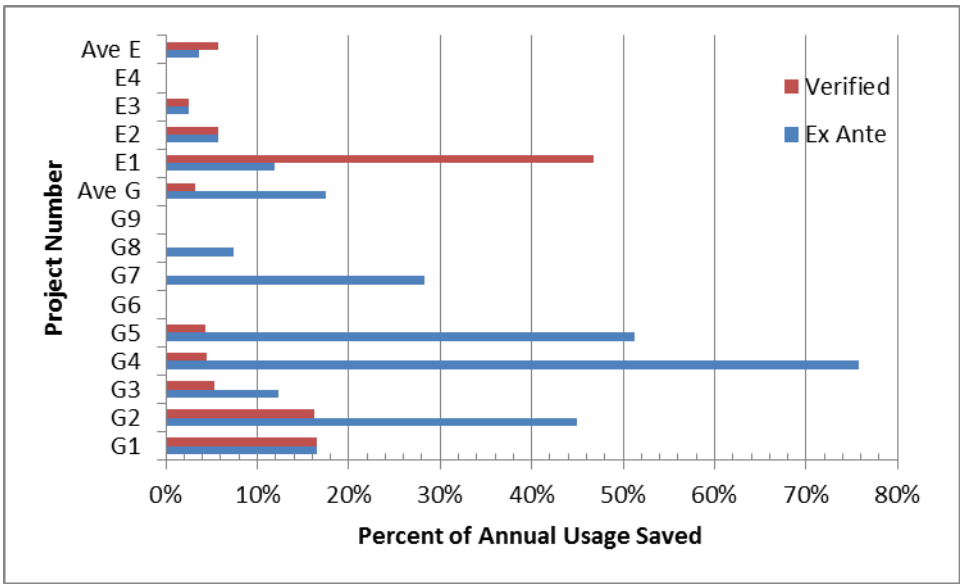

Figure 4: Program B Prescriptive Projects Breakdown

Table 4: Program B Prescriptive Measure Breakdown

Project	Ex Ante % Savings	Verified % Savings	Night Setback	Optimal Start/Stop	Demand Controlled Ventilation	Economizer (temperature)	Economizer (enthalpy)	Scheduling	Discharge Air Reset	Scheduling Lights	Reduced OA	Pump Controls
E1	12%	47%	x		CO2							
E2	6%	6%	x		CO2							x
E3	2%	2%	x									
E4	N/A	N/A	x		CO2							
Total E	4%	6%	4	0	3	0	0	0	0	0	0	1
	7%											
G1	16%	16%	x		CO2			x				
G2	45%	16%	x					x				
G3	12%	5%	x		CO2	x						
G4	76%	4%	x					x	x			
G5	51%	4%	x					x			x	
G6	N/A	N/A	x					x				
G7	28%	0%	x									
G8	7%	N/A	x					x	x			
G9	N/A	N/A	x					x				
Total G	17%	3%	9	0	2	1	0	7	2	0	1	0

Program C

The third program reviewed also had the program delivery mechanism change during the reviewed years. For the first two years reviewed, the two energy management projects were incented through the program and were analyzed using a custom approach. For these projects, the incentive levels were based on the expected savings levels, which were calculated by the program implementer. The program implementer calculated savings based on a review of the billed data and the technologies controlled. Specifically, the billed history was broken down into the expected usages for lighting, HVAC equipment, plug loads and other uses. A savings potential was then assigned to each category, based on if the EMS was expected to control equipment in that category. The resulting savings were calculated by multiplying the billed usage by

the savings potentials. There were a total of six custom projects evaluated over the two program years. Projects 7 and 3 are the same project, with project 7 being the HVAC EMS, and project 3 being the refrigeration EMS controls. Figure 5 below includes the custom project savings, as well as the average results from the prescriptive program. It is evident from the achieved savings that the custom program resulted in much deeper energy savings compared to the prescriptive program. Table 5 shows the measure breakdown for each project as well as a wide range of measures utilized to achieve the project savings. The custom program estimated ex ante savings between 2% and 29% of facility energy usage and had verified savings of 0% to 24% with an average of 14%.

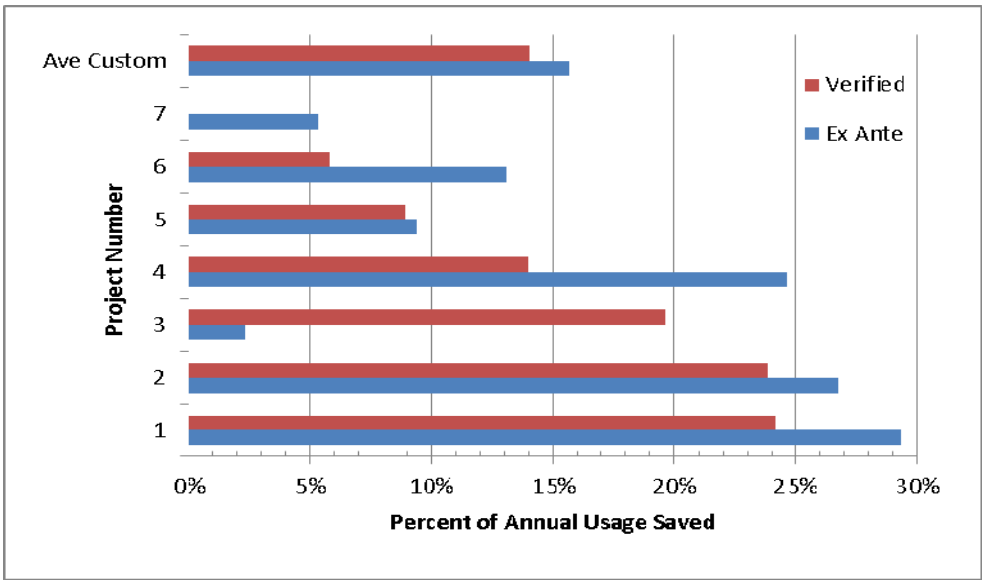

Figure 5: Program C Custom Project Breakdown

Table 5: Program C Custom Measure Breakdown

Project	Ex Ante % Savings	Verified % Savings	Night Setback	Optimal Start/Stop	Demand Controlled Ventilation	Economizer (temperature)	Economizer (enthalpy)	Scheduling	Discharge Air Reset	Scheduling Lights	Refrigation Controls
1	29%	24%	x	x		x		x			
2	27%	24%			Sched			x			
3	2%	20%									x
4	25%	14%				x		x			
5	9%	9%	x		x	x				x	
6	13%	6%	x	x			x	x	x	x	
7	5%	0%				x				x	
Total	16%	14%	3	2	2	4	1	4	1	3	1

For the last years reviewed, EMS projects were incented using a prescriptive methodology, according to building area. To qualify, the project had to meet minimum requirements, which included a graphical user interface, night setback, and advanced control strategies. No definition of advanced control strategies was provided. There were a total of eight projects evaluated. Two of the projects did not have annual energy records, and thus are not shown below. The project level savings are shown below in Figure 6 and include the average custom savings. The prescriptive methodology estimated ex ante savings between 1% and 22% of facility energy usage. The verified savings were between 0% and 19% with an average of 5% savings. The average savings of the prescriptive projects is significantly less than the custom projects

from the prior program years. Additionally, comparing the measure breakdown in Table 6 below, it is evident that the prescriptive methodology does not utilize as many control strategies as was employed in the custom method.

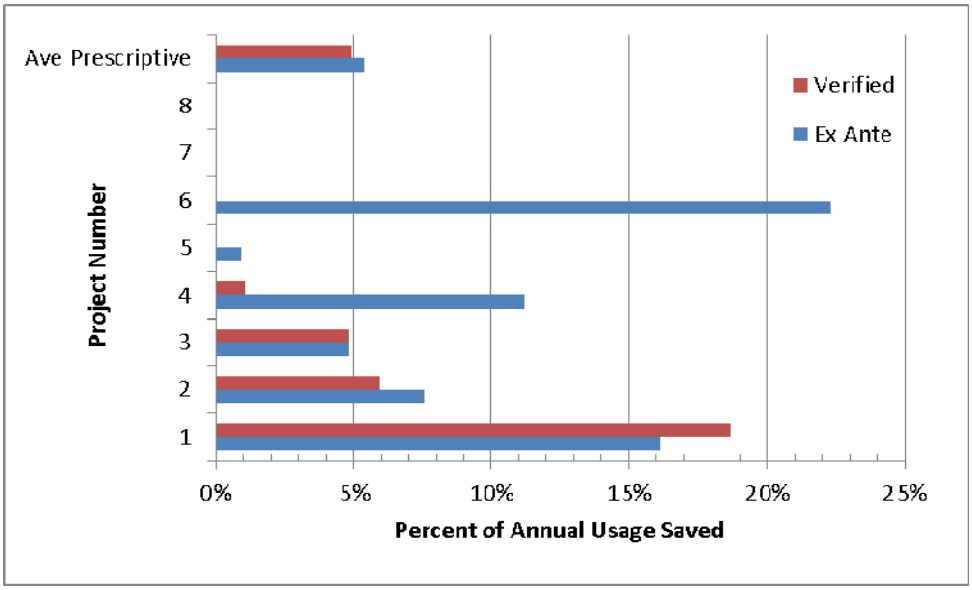

Figure 6: Program C Prescriptive Project Breakdown

Table 6: Program C Prescriptive Measure Breakdown

Project	Ex Ante % Savings	Verified % Savings	Night Setback	Optimal Start/Stop	Demand Controlled Ventilation	Economizer (temperature)	Economizer (enthalpy)	Scheduling
1	16%	19%	x					x
2	8%	6%	x					x
3	5%	5%	x					x
4	11%	1%	x		CO2	x		x
5	1%	0%	x					x
6	22%	0%	x					x
7	N/A	N/A	x	x	CO2	x		x
8	N/A	N/A	x	x	CO2	x		x
Total	5%	5%	8	2	3	3	0	8

Program D

The final program reviewed was the only program reviewed that was a dedicated controls program. For these projects, the incentive levels were based on the expected savings levels, which were calculated by the program implementer. The program implementer calculated savings using a standardized calculation template. This template calculated savings individually for a variety of specific control sequences. The savings levels were then further refined, based on a review of the billed usage history for the site, as well as the analyst's sense of "*lagom.*[1]". The program calculated savings for both electric and gas. There were a total of 21 electric projects and out of those electric projects, 11 included gas savings. The electric program

[1] Lagom is a Swedish word that in essence can be translated "Enough, but not too much."

estimated ex ante savings between 2% and 36% of the facilities energy usage with an average of 9%. The verified savings were between 0% and 26% with an average of 7% savings, as shown below in Figure 7. The program did achieve these savings utilizing multiple different measure types as shown below in Table 7.

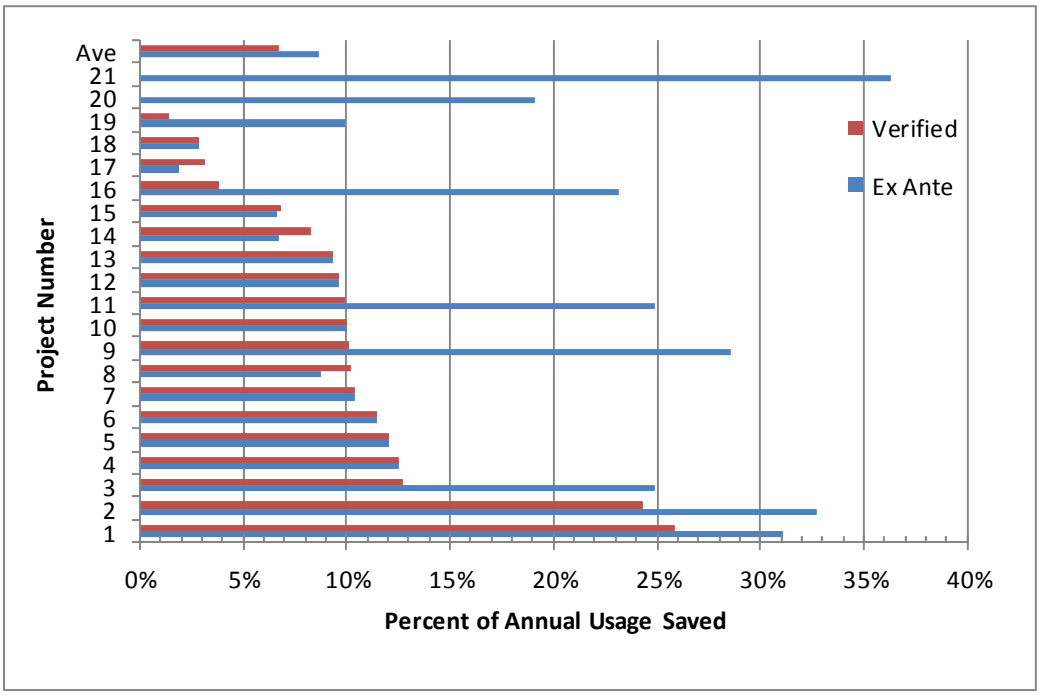

Figure 7: Program D Electric Project Breakdown

Table 7: Program D Electric Measure Breakdown

Project	Ex Ante % Savings	Verified % Savings	Night Setback	Optimal Start/Stop	Demand Controlled Ventilation	Economizer (temperature)	Economizer (enthalpy)	Scheduling	Discharge Air Reset	Scheduling Lights	Reduced OA	Pump Controls	Other
1	31%	26%			CO2		x		x			x	
2	33%	24%						x					
3	25%	13%	x					x			x		
4	13%	13%						x					x
5	12%	12%						x					x
6	11%	11%	x		CO2			x	x	x			
7	10%	10%	x					x					
8	9%	10%	x					x					x
9	29%	10%			CO2		x	x	x			x	
10	10%	10%						x					
11	25%	10%			CO2			x	x	x		x	
12	10%	10%						x			x	x	
13	9%	9%	x					x	x		x		
14	7%	8%					x	x		x		x	x
15	7%	7%								x			
16	23%	4%			CO2			x	x			x	
17	2%	3%	x		CO2				x			x	
18	3%	3%					x				x	x	
19	10%	1%						x		x		x	
20	19%	0%						x			x		
21	36%	0%			CO2			x	x			x	
Total	9%	7%	6	0	7	0	4	17	8	5	5	10	4

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There were a total of 11 gas projects evaluated for this program with ex ante savings ranging between 5% and 39% of the facility energy usage with an average of 18%. The verified savings range between 0% and 44% with an average of 11%, as shown below in Figure 8. These projects, just like the electric projects, utilized multiple control strategies as shown in Table 8.

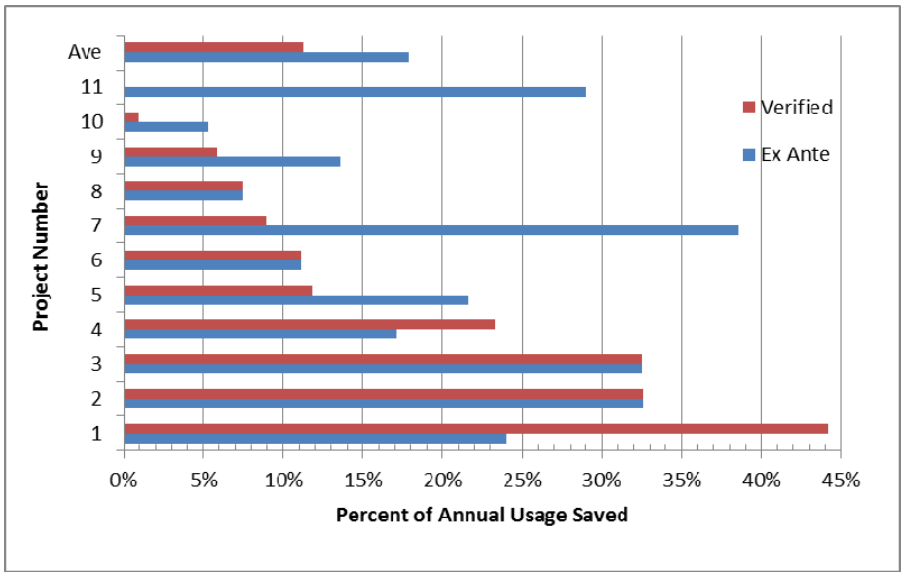

Figure 8: Program D Gas Project Breakdown

Table 8: Program D Gas Measure Breakdown

Project	Ex Ante % Savings	Verified % Savings	Night Setback	Optimal Start/Stop	Demand Controlled Ventilation	Economizer (temperature)	Economizer (enthalpy)	Scheduling	Discharge Air Reset	Scheduling Lights	Reduced OA	Pump Controls	Other
1	24%	44%			CO2			x	x	x		x	
2	33%	33%	x		CO2			x	x	x			
3	32%	32%						x			x	x	
4	17%	23%						x					
5	22%	12%			CO2		x		x			x	
6	11%	11%	x					x	x		x		
7	39%	9%			CO2		x	x	x			x	
8	8%	8%	x					x					
9	14%	6%						x		x		x	
10	5%	1%	x					x					x
11	29%	0%			CO2			x	x			x	
Ave	18%	11%	4	0	5	0	2	10	6	3	2	6	1

Programs Overall

After reviewing these programs, it is evident that the custom programs achieve deeper measure implementation and energy savings for both electric and gas, as shown in Figure 9 and Figure 10.

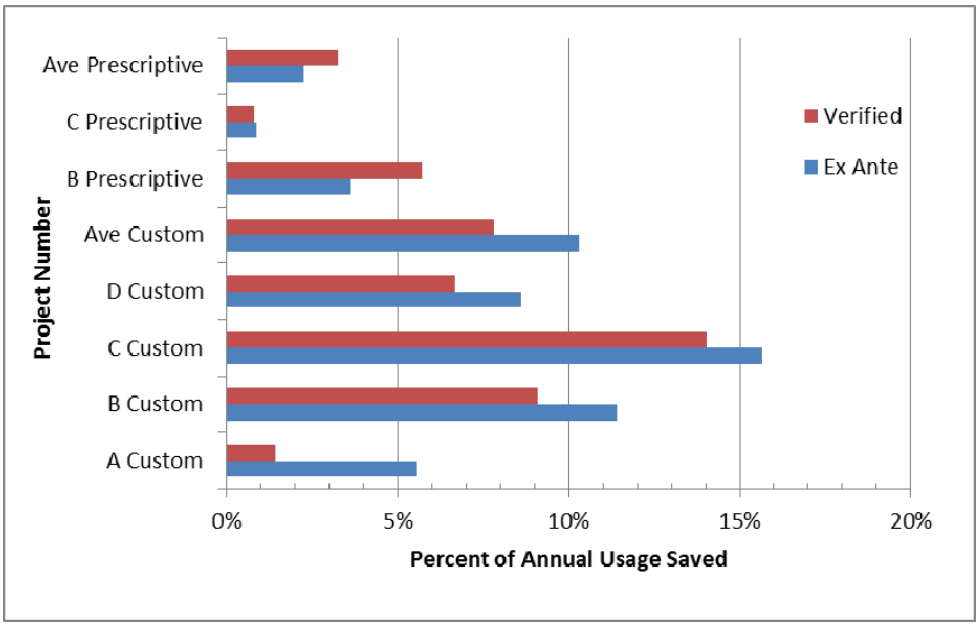

Figure 9: Electric Program Breakdowns

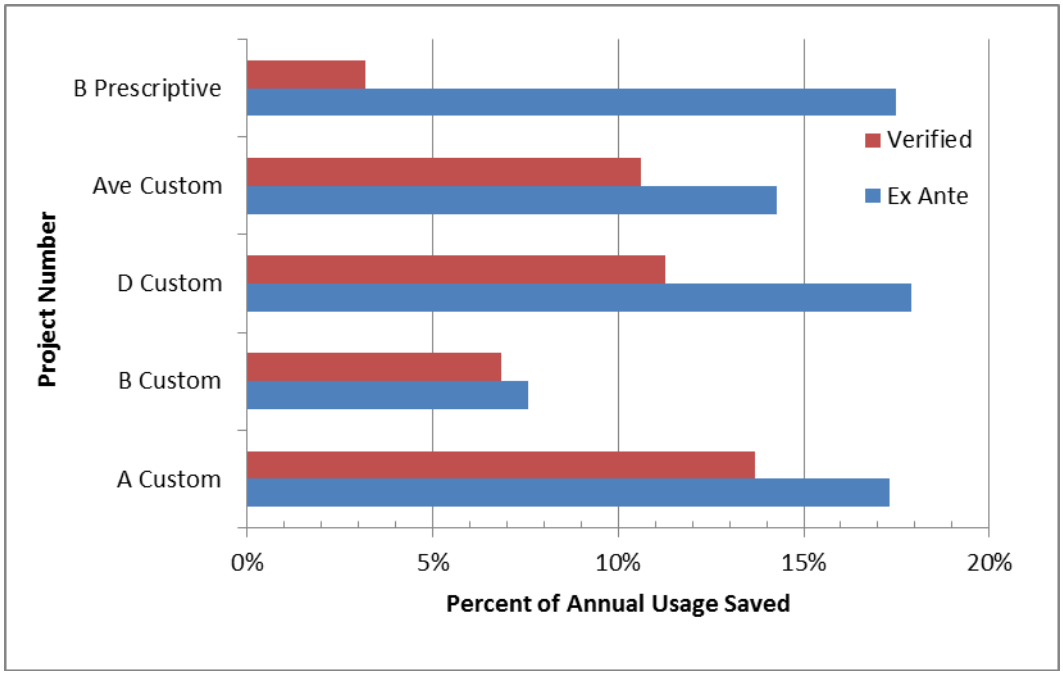

Figure 10: Gas Program Breakdown

So We are Saving Energy, Right?

When reviewing the programs and the projects above, it is important to recognize the limitations of the study. For this study, only four programs were reviewed, and care must be taken when extrapolating these results to the broad spectrum of projects and programs in place throughout the nation. However, the findings and trends observed from these programs can provide us insight that can help to facilitate the discussion on what next steps should be taken in regards to EMS projects and programs. Based on the projects and programs reviewed, several conclusions can be drawn.

Very few programs are dedicated to EMS projects. Based on a review of utility programs nationwide, very few programs could be located that are oriented specifically to EMS projects. This is consistent with the programs included in this review as well, which tended to fit EMS projects into existing prescriptive or custom programs.

Prescriptive programs had greater levels of participation. Prescriptive programs tended to have greater numbers of participants than custom programs (excluding the one controls program). This is especially apparent for the programs that changed from a custom delivery mechanism to a prescriptive delivery mechanism. For these programs, participation dramatically increased. For one program, the number of prescriptive projects processed the first year exceeded ten times the custom EMS projects processed the prior year.

EMS projects are underperforming their potential. The savings levels achieved varied drastically by project; however, overall EMS projects are underperforming the expected potential savings for the installation of an energy management system. Overall, the projects reviewed were found to only reduce electrical usage by 7% and gas usage by 9%.

Prescriptive projects tend to underperform more than custom projects. The savings levels achieved varied drastically by project; however, overall prescriptive EMS projects are underperforming to a greater extent than custom EMS projects. Prescriptive electric projects were found to reduce electrical usage by 5% and gas usage by 3%. Custom electric projects were found to reduce electrical usage by 8% and gas usage by 11%. This is likely, at least in part, to the number and types of control strategies implemented per project. Prescriptive projects tended to have fewer advanced control strategies implemented than custom projects, but instead seemed to be more limited to scheduling and night setback.

Where do We Go From Here?

EMS projects do have an incredible amount of potential for energy savings. However, it is important to recognize that energy management systems are fundamentally different than light bulbs, variable speed drives, and ENERGY STAR® appliances in that in that the installation of the EMS system does not save any energy in and of itself. It is only by programming the EMS with control strategies that meet the needs of the customer, while minimizing energy usage, can savings levels be achieved.

Programs must adapt to this brave new world to make the most of this opportunity. They need to provide the ease of the prescriptive program to promote participation, as well as provide the attention to customer needs and potential control strategies that are found in the custom program.