UTS Energy Engineering LLC

Final Report for

National Grid USA Service Company

Evaluation of

2006 Custom Process Installations—Part II

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Supplementary data follows each site report.

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SECTION 1. EXECUTIVE SUMMARY

1.1 Introduction

National Grid provides technical and financial assistance to their commercial and industrial customers for equipment and building energy efficiency improvements. Improvements can be either custom-engineered or selected from a list of prescribed measures. This impact evaluation study is Part II of three parts, and reviews seven Custom process projects that fall into five categories: process systems (2), process cooling (2), refrigeration controls (1), industrial refrigeration (1) and non-HVAC VFDs (1).

The seven projects included the installation of an all electric plastic injection molding machine, efficient snow making guns, supermarket refrigeration controls, a dairy product process cooling economizer, an ammonia refrigeration system, cooling water flow restrictors on a process cooling system and specialized chillers for cooling metal plating baths.

1.2 Purpose of Study

National Grid seeks to quantify the actual energy and demand savings attributable to these Custom process projects in order to:

- More accurately determine energy and demand savings achieved
- Demonstrate cost-effectiveness to regulators and other interested parties
- Set appropriate financial incentive levels and eligibility criteria for future years

1.3 Scope

UTS Energy Engineering, LLC (UTS) was commissioned in August 2007 by National Grid to evaluate seven Custom industrial process projects installed in 2006. The specific goal of this study was to confirm the annual energy savings (kWh per year), the percent of energy savings that occurs on-peak, and the summer and winter peak coincident demand savings (kW) attributable to the projects at each site program. For this year, the goals of the study also included determining peak demand savings using the ISO-NE (New England's Independent

System Operator) Forward Capacity Market (FCM)-based definitions, which were not in place for the 2006 programs, but which National Grid is using currently.

Three of the evaluated projects were Design 2000*plus* (D2) projects and the other four Energy Initiative (EI) projects. The Design 2000*plus* program is meant for new construction or new systems and for old systems that are being replaced and redesigned to meet new conditions, where the base-case is not the pre-existing system, but one that is designed to meet the anticipated load. Energy Initiative projects replace existing equipment or systems for the sole purpose of saving energy.

1.4 Survey and Analysis Methods

National Grid selected the seven specific sites for this evaluation from a random sample of custom process projects to be evaluated. The evaluation involved physical inspection of every installation, on-site metering, interviews with facility staff members, and engineering analyses. The following paragraphs describe the general approach taken to evaluate each site.

1.4.1 Review Application and Original Savings Methodology

UTS reviewed the descriptions of the projects and the savings calculation methodologies provided in the original applications. In particular, we assessed the reasonableness of the original approach to calculating savings. Whenever it was technically appropriate and possible, we attempted to mirror that approach in our re-evaluation of savings. Based on this review, we developed site measurement and evaluation plans for each site.

1.4.2 Visit Sites

We performed the following tasks, during our site visits:

1. Inspected and collected nameplate data for the new equipment.
2. Obtained scheduling and operational data through interviews with facility operators.
3. Took spot readings of amperage, voltage, power factors, and kW of affected equipment with a hand-held multi-meter and recording power meter.
4. Installed data loggers on equipment to be evaluated, and allowed loggers to record for 4 weeks or more.

5. Recorded all system-installed meter or gauge data (run time, temperatures, pressures, etc.) when we were at the site to install our metering equipment and later to remove it.

1.4.3 Analyze Data

General Approach

UTS's general approach for process projects starts with identification of the key parameters that affect the energy consumption and savings of the system. These include process load, weather, work and time off scheduling and equipment efficiencies. Metering is done for 4 weeks or more to understand the relationships between the variables. If the relationships are simple, the analysis may rely on a single calculation to represent annual energy use. If they are complex, a multivariable regression used in a bin-type of analysis may be warranted. UTS tries to adopt the methodology used in the application if it is reasonable and does not leave out important parameters and considerations.

1.5 Description of Evaluated Projects

Site 1 was purchasing a new plastic injection molding machine (IMM) and two choices were available: hydraulic or all electric. The hydraulic IMM was less expensive and maintenance issues were well known because many of the plant's other IMMs were hydraulic. They decided to purchase an all-electric IMM with utility incentives partially offsetting the more expensive first costs. The advantages of the all electric IMM go beyond using less energy; production is more repeatable and easier to set up thus reducing waste.

Site 2, a ski mountain, purchased more efficient snow making equipment, which uses less compressed air to make a given amount of snow. Site 3, a grocery store, had controls installed for their walk-in cooler door heaters and evaporator fans to limit their run time. They also installed switches to shut off beverage refrigerators when the store was closed and replaced evaporator fan motors with ECM motors.

At Site 4, a dairy pasteurizes its products with steam and then cools it back down quickly. They used a cooling tower to reject heat from the product instead of having their ammonia refrigeration system reject the heat, thereby saving energy. A fish freezing warehouse, Site 5, installed new chillers and ancillary equipment that were ammonia-based instead of freon-based to save energy. At Site 6, the manufacturer used cooling water at many stations and installed controls to bypass stations that did not need cooling water at the time, thereby allowing the VFD to slow down the pump and save energy.

The last site, Site 7, anodized aluminum in acid baths. The baths must be kept cold, and the choice of cooling was to install a stainless steel heat exchanger to separate the acid solution from a glycol solution which was in turn chilled by a standard chiller, or purchase a chiller with stainless steel heat transfer surfaces to chill the acid solution directly. The special chiller's temperature set point didn't need to be as low as the standard chiller's because there was no intermediary heat exchanger inefficiency to overcome, thus saving chiller energy, plus fewer pumps were needed resulting in less pumping energy.

1.6 Results

1.6.1 Numerical Results

For the seven applications that UTS evaluated, verified total unweighted energy savings comprised 85% of the annual energy savings claimed in the original Energy Initiative and Design 2000*plus* applications. We determined that 62% of energy savings for these seven projects occurs during the on-peak period compared to 41% on the original application estimates. Some of the difference is due to a redefinition of the length of the on-peak energy period between 2005 and 2006, which changed from 13 hours to 16 hours per non-holiday week day.

Total un-weighted verified summer and winter peak coincident demand savings were 125% and 115% of the original projections, respectively, using NGrid's definitions and 123% and 117% using the FCM-based definitions. Detailed comparisons using the NGrid's definition are shown in Table 1-2 and for FCM-based definitions in Table 1-3 at the end of this section.

The ammonia refrigeration system serving the fish freezing warehouse instead of freon-based systems dominated the savings figures. That project accounted for 71% of the evaluated kWh savings for all projects combined, compared to 47% of the applications' estimates. The ammonia refrigeration system project's evaluated energy savings was 127% of its application's estimate. The other projects' evaluated savings were 47% of their applications' estimated energy savings.

1.6.2 Reasons for Differences between Tracking Estimates and Evaluation Results

For these seven projects, realization rates varied from a high of 145% to a low of 18%. Each site had its own reasons for the difference in savings.

Savings estimates are provided for six quantities: summer and winter coincident peak kW for both the National Grid and FCM-based definitions and % on-peak kWh and annual kWh. Table 1-1 lists the primary reasons for the differences in annual energy savings between the evaluation results and the projected savings.

Table 1-1: Summary of Annual Energy Savings Discrepancies

Site	Application	Eval/Track	Primary Reason for Discrepancy of Savings Estimate
1	New Injection Molding Machine	145%	Demand of both the pre and post equipment was different then originally metered
2	New Snow Making Guns	18%	Significant over estimate of snow making capabilities leading to most rebated equipment not being used
3	Walk-in Cooler Controls	75%	Evaluated component run times were different then estimated .
4	Process Economizer Cooling	26%	Over estimate of load and runtime.
5	Industrial Refrigeration Upgrades	127%	Over estimate of load increased VSD compressor savings relative to base-case, and evaporator fan runtimes were lower than estimated.
6	Process Water Flow Restrictors	23%	Significant over estimate of speed, flow and head reduction.
7	New Process Chillers	26%	Over estimate of loads and system runtime.

Reasons for savings discrepancies fell into the following categories:

1. *Assumed annual operating hours affected savings.* At Sites 2, 3, 4, 5, and 7 component runtimes were less than predicted. Site 2 runtimes were 87% less than predicted, while at

other sites runtimes were 10% to 40% less than predicted in the applications. At Sites 1 and 3 some components had approximately 25% greater runtime. Savings are tied directly to operating hours; fewer hours with all else being held constant, mean lower savings, while more hours mean larger savings.

2. *Assumptions of component demand or system loads affected savings.* At Sites 1, 3 and 5 some component demands were about 25% lower than noted in the applications, while at Sites 1, 3 and 4 some components metered demands were about 25% higher than anticipated. The sites with ammonia refrigeration systems, Sites 4 and 5, had refrigeration loads that were 40% and 38% lower than anticipated, respectively.

3. *Some applications did not include savings analyses for components that received incentives or calculated savings for components that were not installed.* At Site 3 the vendor listed 34 refrigerator/freezer doors to receive anti-sweat heater controls; however, the site only had 29 doors. Only 4 beverage refrigerators were being controlled where the vendor listed 6. Energy use of Site 4's cooling tower sump heater was not considered in the application but had use throughout the winter. Site 1 purchased 20 new snow guns, but for the past year only used at most 4 and 15 were ultimately removed from the site.

1.7 Recommendations

Most tracking analyses' results were substantially different from the evaluated results. The main reasons for the differences are noted above. In general, the parameters that can be improved upon, almost universally, are:

- Better estimate operating hours and system loads.
  Detailed conversations with operations staff and plant management are needed to better understand seasonal production cycles and plans for use of new equipment in relation to existing equipment.
- Include changes to other systems and all energy using components of the new system.
  Applicants need to include the impact changes will have on other systems, such as HVAC and lighting. Energy use by all components of the new equipment needs to be accounted for; an example is cooling tower or equipment sump heaters that are typically ignored.

- Clearly define what is being installed and its operation.

  Applications need to be clear as to what is being installed and how those components will be operated. A sequence of operation for the updated system is needed for complicated systems. The same goes for the base-case conditions; describing what is there and how it operates is critical to accurately assess savings.

- Insist on better measure counts and updates to vendor calculation methodologies.

  Perhaps the most challenging situation is when vendors, who are calculating savings and submitting application on behalf of their customers, overestimate runtime or load or report incorrect measure counts. More effort should be put into post installation verification of estimates.

1.8 Description of How Results Are Used in Savings Calculation

The site-specific results reported here will be used to calculate case-weighted realization rates for each of the four savings parameters for the entire Custom process group population. These realization rates will be applied to all sites in tabulating the post-evaluation gross energy and demand savings.

Table 1-2: Custom Process Projects—Summary of Results
(with National Grid definitions of On-Peak Energy and Summer and Winter Peak Demand periods)

					NGrid TRACKING EST. SVGS				UTS EVALUATION SVGS				RATIO UTS / TRACKING			
						On-Peak	Peak Coinc.			On-Peak	Peak Coinc.			On-Peak	Peak Coinc.	
UTS ID	EI / D2	LOC ID	APPL #	CUSTOMER TYPE & LOCATION	kWh/yr	%	Sum. kW	Wint. kW	kWh/yr	%	Sum. kW	Wint. kW	kWh/yr	%	Sum. kW	Wint. kW
1	D2	7416398	510157	Plastic Manufacturer, RI	239,464	39%	27.70	27.70	347,942	43%	37.84	37.19	145%	111%	137%	134%
2	EI	6039964	516930	Ski Mountain, NH	138,459	0%	0.00	0.00	25,204	31%	0.00	2.00	18%			
3	EI	4220865	515324	Supermarket, MA	57,824	33%	3.77	3.59	43,262	63%	6.80	10.50	75%	191%	180%	292%
4	EI	231885	509615	Dairy, MA	366,332	37%	82.42	66.01	96,633	59%	20.32	9.68	26%	159%	25%	15%
5	D2	7350466	503579	Freezer Facility, RI	1,255,286	38%	141.72	149.40	1,597,960	65%	358.42	317.44	127%	170%	253%	212%
6	EI	2125684	500238	Semi-Conductor Manufacturer, MA	177,826	37%	20.30	20.30	40,963	46%	4.70	4.70	23%	124%	23%	23%
7	D2	7538824	513043	Metal Finishing, RI	419,417	69%	97.12	87.40	107,938	97%	37.11	25.57	26%	141%	38%	29%
				EI Subtotal	740,441	30%	106.49	89.90	206,062	54%	31.82	26.88	28%	180%	30%	30%
				D2 Subtotal	1,914,167	45%	266.55	264.50	2,053,840	63%	433.37	380.20	107%	140%	163%	144%
				Total	2,654,608	41%	373.04	354.40	2,259,902	62%	465.19	407.08	85%	152%	125%	115%

Table 1-3: Custom Process Projects — Summary of Results (with FCM-based definitions of On-Peak Energy and Summer and Winter Peak Demand periods)

					NGrid TRACKING EST. SVGS				UTS EVALUATION SVGS				RATIO UTS / TRACKING			
						On-	Peak Coinc.			On-	Peak Coinc.			On-	Peak Coinc.	
UTS ID	EI / D2	LOC ID	APPL #	CUSTOMER TYPE & LOCATION	kWh/yr	Peak %	Sum. kW	Wint. kW	kWh/yr	Peak %	Sum. kW	Wint. kW	kWh/yr	Peak %	Sum. kW	Wint. kW
1	D2	7416398	510157	Plastic Manufacturer, RI	239,464	39%	27.70	27.70	347,942	43%	37.71	37.19	145%	111%	136%	134%
2	EI	6039964	516930	Ski Mountain, NH	138,459	0%	0.00	0.00	25,204	31%	0.00	1.50	18%			
3	EI	4220865	515324	Supermarket, MA	57,824	33%	3.77	3.59	43,262	63%	6.60	10.60	75%	191%	175%	295%
4	EI	231885	509615	Dairy, MA	366,332	37%	82.42	66.01	96,633	59%	20.38	15.15	26%	159%	25%	23%
5	D2	7350466	503579	Freezer Facility, RI	1,255,286	38%	141.72	149.40	1,597,960	65%	357.44	318.18	127%	170%	252%	213%
6	EI	2125684	500238	Semi-Conductor Manufacturer, MA	177,826	37%	20.30	20.30	40,963	46%	4.70	4.70	23%	124%	23%	23%
7	D2	7538824	513043	Metal Finishing, RI	419,417	69%	97.12	87.40	107,938	97%	33.27	25.79	26%	141%	34%	30%
				EI Subtotal	740,441	30%	106.49	89.90	206,062	54%	31.68	31.95	28%	180%	30%	36%
				D2 Subtotal	1,914,167	146%	266.55	264.50	2,053,840	205%	428.42	381.16	107%	141%	161%	144%
				Total	2,654,608	41%	373.04	354.40	2,259,902	62%	460.10	413.11	85%	152%	123%	117%