Impact Evaluation of 2005 Custom Process Installations

Part I

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Executive Summary

Introduction

The purpose of this study was to evaluate the energy savings achieved by fifteen Custom process measures installed in 2005. Savings are quantified by total annual energy use reduction, summer and winter peak diversified demand impact, and the percentage of energy savings occurring during peak periods. National Grid USA Service Company (National Grid, or the Company) contracted with DMI to evaluate the savings of six of the fifteen Custom Process applications.

Description of Evaluation Methodology

DMI's evaluation effort followed guidelines presented in Attachment A of National Grid RFP No. 197-06. The direction provided by National Grid included protocols for contacting the customer, National Grid personnel, and the tracking analyst, conflict of interest guidelines, metering safety requirements, specific requirements for reporting and terminology.

Before the Site Visit

For each application being evaluated, DMI received a copy of the application package and any additional information available from National Grid. DMI reviewed the application and attached documentation to develop an understanding of the measure and of the tracking analyst's savings calculation. As directed by the National Grid study manager, the evaluation plan followed the tracking analyst's methodology to the extent that DMI agreed with that methodology.

DMI devised an evaluation plan for each application, each of which included a measure description, any sources of energy savings or penalties, the estimation approach used in the tracking analysis, the proposed methodology of the evaluator, and how/why the two analyses may differ. Each plan also included an interview questionnaire, a list of observations to make at the site, and a metering plan.

The National Grid study manager reviewed and commented on each evaluation plan, and these comments were incorporated accordingly. Once a site's evaluation plan was approved, DMI or the study manager contacted the customer's National Grid account manager to inform them that the initial evaluation site visit was being scheduled. In some cases, DMI requested that the account manager introduce DMI to the customer as representatives of National Grid and to describe the evaluation process.

At the Site

DMI visited all sites included in this study and observed the installed measures in their current operational state. Customers were interviewed regarding current operations, hours of use, and the base or pre-retrofit condition and sequences of operation.

DMI recorded power measurements where called for by the evaluation plan, noting production variables such as production rate, operating speed, pressure, and/or flow rate. DMI reviewed and collected customer data such as hours of use, operators' log sheets, controls computer electronic data, and other available data pertinent to the specific application.

Additional information and improved understanding of the installations typically occurred during the site visits. Possible changes to the proposed evaluation methodology described in the evaluation plan were discussed with the study manager prior to making alterations.

Data Analysis

DMI used site and metered data to develop estimates of annual energy savings, the percentage of energy occurring during peak hours, and summer and winter super peak diversified demand savings. National Grid guidelines detailed in the Attachments to the Scope of Work were used to determine these parameters.

DMI utilized Microsoft's Excel 2003 as the principal calculation tool in the evaluation analyses. Weather data provided by the National Climatic Data Center's Engineering Weather Data CD, 2000 Interactive Edition, and actual weather data from the National Oceanographic and Atmospheric Agency (NOAA) website was used in the analyses where energy use was affected by outdoor weather conditions. For all sites where such data was available, 15-minute interval data was obtained from National Grid to assist in the determination of facility operating characteristics.

Equipment performance was quantified through direct metering or the use of manufacturer's published performance data or selection software. The make and model of the installed equipment was used in the installed case analyses while base case and pre-retrofit case equipment types were taken from the tracking analysis whenever available. Operating points and sequences were assumed to be the same as those in the tracking analysis unless there was direct proof that the original assumptions were no longer valid.

Presentation of Results

For each application reviewed, DMI submitted a draft evaluation report to the National Grid study manager for review and comment. The study manager discussed project findings with the DMI engineer who performed the evaluation study and requested clarifications within the calculations and report as necessary.

The objective of the site reports is to present not only the results for the four main study parameters, but also to explain why the realization ratios vary from 100%. Reasons for differences may be due to methodology issues in the tracking analysis, inaccurate assumptions used in the original analysis, or changes in site conditions or operating

parameters. The structure of the site reports facilitates the segregation of these three main types of differences.

The attached site reports follow the same general outline. An introductory section presents general findings and a table that compares tracking and evaluated parameters. The installation is described, followed by a description of the tracking analysis methodology. Remarks concerning the tracking methodology are made to support any differences between the tracking and evaluation approaches. The evaluation analysis approach is then described. Calculation assumptions and intermediate results are presented, with the final section devoted to a comparison of tracking and evaluation results. Whenever possible, the sources of differences between tracking and evaluated results are described and the impacts are quantified. Supporting appendices include calculations and plots of metering data and other site data.

The reference numbers for sites included in Group I are used in the enumeration of report pages, figures, and tables. For example, page 3 of the report for Site No. 5 is listed as '5-3', and the third figure in the first appendix of that report is 'Figure 5A-3'.

Description of Sample Projects

Sites 1 through 4 are Design 2000*plus* applications, while Sites 5 and 6 are Energy Initiative applications. Brief descriptions of each project are presented below:

Site 1 installed VSDs on process pumps serving a tangential filtration unit in place of flow control using bypass valves.

Site 2 installed a new air-cooled chiller to cover increased cooling loads rather than installing several small split systems and an additional air-cooled chiller to operate with pre-existing lower capacity plant equipment.

Site 3 installed open screw compressors, an oversized evaporative condenser, and hot gas defrost rather than semi-hermetic reciprocating compressors, a standard-sized evaporative condenser, and electric defrost.

Site 4 installed a heat of compression air dryer rather than a desiccant compressed air dryer.

Site 5 replaced existing oversized centrifugal compressors operating in a load/no-load sequence with smaller air compressors operating under true load/no-load control.

Site 6 installed a magnetic water treatment system on a spray system serving an evaporative condenser at an ice rink.

Results

Annual energy savings as evaluated varied from 91% (Site 4) to 0% (Sites 1 and 6) of the tracking estimate. Tables 1 through 4 list the evaluation results and the tracking estimates for each application studied. The ratios of the total evaluated savings to the tracking savings for total energy, percent on-peak, and total diversified summer and winter demand are 48%, 134%, 66%, and 55%, respectively.

The percent of savings occurring during peak periods and the seasonal diversified demand reduction values were evaluated using the historical peak and super peak definitions that were used by National Grid vendors at the time these studies were completed. In the past, peak hours were 8 AM to 9 PM on weekdays with the exception of 9 standard holidays. Summer super peak periods were on peak days between 11 AM and 3 PM, while winter super peak hours were between 5 PM and 7 PM on peak days.

Table 1

Annual Energy Savings, kWh

Site	Application	Description	Tracking	Evaluation	Evaluation ÷ Tracking
1	D2 218007	VSDs on Process Pumps	75,309	0	0%
2	D2 505566	Process and HVAC Chiller Upgrade	86,488	23,633	27%
3	D2 506673	High-efficiency Refrigeration	591,023	307,154	52%
4	D2 508867	Heat of Compression Dryers	92,448	84,001	91%
5	EI 500224	New Air Compressors	245,318	111,784	46%
6	EI 504461	Magnetic Water Treatment	5,616	0	0%
		Total	1,096,202	526,572	48%

Table 2

Percent of Energy Savings On-peak

Site	Application	Description	Tracking	Evaluation	Evaluation ÷ Tracking
1	D2 218007	VSDs on Process Pumps	72%	0%	0%
2	D2 505566	Process and HVAC Chiller Upgrade	50%	54%	108%
3	D2 506673	High-efficiency Refrigeration	36%	57%	158%
4	D2 508867	Heat of Compression Dryers	0%	41%	-
5	EI 500224	New Air Compressors	38%	36%	95%
6	EI 504461	Magnetic Water Treatment	40%	0%	0%
		Total*	37%	50%	134%

* Total as weighted by estimated energy savings

Table 3
Summer SuperPeak Diversified Demand Reduction

Site	Application	Description	Tracking	Evaluation	Evaluation ÷ Tracking
1	D2 218007	VSDs on Process Pumps	16.1	0.0	0%
2	D2 505566	Process and HVAC Chiller Upgrade	14.7	4.1	28%
3	D2 506673	High-efficiency Refrigeration	40.7	49.7	122%
4	D2 508867	Heat of Compression Dryers	10.7	10.2	95%
5	EI 500224	New Air Compressors	28.0	12.0	43%
6	EI 504461	Magnetic Water Treatment	5.0	0.0	0%
		Total	115.2	75.9	66%

Table 4
Winter SuperPeak Diversified Demand Reduction

Site	Application	Description	Tracking	Evaluation	Evaluation ÷ Tracking
1	D2 218007	VSDs on Process Pumps	16.1	0.0	0%
2	D2 505566	Process and HVAC Chiller Upgrade	9.1	4.1	45%
3	D2 506673	High-efficiency Refrigeration	75.4	49.7	66%
4	D2 508867	Heat of Compression Dryers	10.7	10.2	95%
5	EI 500224	New Air Compressors	28.0	12.0	43%
6	EI 504461	Magnetic Water Treatment	0.0	0.0	100%
		Total	139.2	75.9	55%

National Grid has been in the process of changing the definitions of peak and seasonal super peak periods. Tables 5 through 7 below describe the impact of these changes on the evaluated results. The peak period definition was expanded to include the hours between 6 AM and 10 PM. The number of standard holidays remains the same. The summer and winter super peak periods were changed to cover the worst case demand periods on the entire grid. The summer super peak definition is now the hottest June, July or August peak day from 3 PM to 5 PM, while the new winter superpeak period is the coldest January peak day from 5 PM to 7 PM.

Table 5
Percent of Energy Savings On-peak - Revised Definitions

Site	Application	Description	Evaluation	Revised	Revised ÷ Evaluation
1	D2 218007	VSDs on Process Pumps	0%	0%	100%
2	D2 505566	Process and HVAC Chiller Upgrade	54%	66%	123%
3	D2 506673	High-efficiency Refrigeration	57%	61%	107%
4	D2 508867	Heat of Compression Dryers	41%	49%	120%
5	EI 500224	New Air Compressors	36%	46%	128%
6	EI 504461	Magnetic Water Treatment	0%	0%	100%
		Total*	50%	56%	112%

*Total as weighted by estimated energy savings

Table 6
Summer SuperPeak Coincident Demand Reduction

Site	Application	Description	Evaluation	Revised	Revised ÷ Evaluation
1	D2 218007	VSDs on Process Pumps	0.0	0.0	100%
2	D2 505566	Process and HVAC Chiller Upgrade	4.1	5.5	135%
3	D2 506673	High-efficiency Refrigeration	49.7	48.9	99%
4	D2 508867	Heat of Compression Dryers	10.2	9.6	94%
5	EI 500224	New Air Compressors	12.0	12.1	101%
6	EI 504461	Magnetic Water Treatment	0.0	0.0	100%
		Total	75.9	76.1	100%

Table 7
Winter SuperPeak Coincident Demand Reduction

Site	Application	Description	Evaluation	Revised	Revised ÷ Evaluation
1	D2 218007	VSDs on Process Pumps	0.0	0.0	100%
2	D2 505566	Process and HVAC Chiller Upgrade	4.1	3.9	95%
3	D2 506673	High-efficiency Refrigeration	49.7	36.7	74%
4	D2 508867	Heat of Compression Dryers	10.2	9.2	90%
5	EI 500224	New Air Compressors	12.0	12.3	103%
6	EI 504461	Magnetic Water Treatment	0.0	0.0	100%
		Total	75.9	62.1	82%

Discussion of Results

Table 8 below lists the primary reasons for the differences in annual energy savings estimates. Sites1 and 6 were found to have zero energy savings since the base and proposed cases were found to be the same efficiency. The specific high efficiency equipment at Site 5 was not installed as specified. Cooling loads at Sites 2 and 3 were overestimated.

Table 8
Summary of Annual Energy Savings Discrepancies

Site	Application	Eval/Track	Primary Reason for Discrepancy of Savings Estimate
1	D2 218007	0%	Base case equipment would have been the same as installed case due to manufacturer's standard method of pressure and flow control using VSDs.
2	D2 505566	27%	Cooling equipment is required to operate for fewer hours per year, the improvement in cooling equipment performance was less than expected, and the power demand of an additional secondary chilled water pump was not accounted for in the tracking analysis.
3	D2 506673	52%	The tracking analysis did not account for low loading during non-production periods, the installed case condensing temperatures were higher than expected, and the duration of defrost heating periods were overestimated.
4	D2 508867	91%	The air compressor can generate the required air for the base case dryer more efficiently than was originally assumed.
5	EI 500224	46%	Load/no-load compressors rather than the proposed case VSD-equipped compressors were installed, increased air demand results in improved pre-retrofit case equipment performance.
6	EI 504461	0%	Site data indicates that the installation of the magnetic water treatment system does not have a noticeable impact on condensing pressures, the site does not operate during summer when most savings are expected to occur, and the minimum condensing pressure setpoint is much higher than originally assumed.

DMI's Recommendations for Tracking Analysts Based on This Evaluation

1. All systems are designed to accommodate the worst possible loading situations that are likely to occur. TA analyses should take a more conservative approach when estimating loads based upon design criteria. Observed loading at the site should be used for Energy Initiative projects.
2. In process applications, care should be taken to describe and account for seasonal variations in production load, number of shifts on weekdays as well as weekends, and the effect of scheduled shutdowns.
3. Tracking analysts should utilize 15-minute interval data available from National Grid account managers to verify facility operating hours where ever appropriate. Even in cases where a single production line may not be able to be distinguished in the power demand data for an entire facility, this data will provide an upper bound for the potential line operating hours.
4. Tracking analyses should include complete descriptions of calculation methodologies including information regarding how base case systems were

developed, where equipment performance information was obtained, and basic assumptions that were used to apply the performance information to a particular project.

5. For refrigeration projects, the impact of compressor unloading on savings can be significant. TA studies should clearly describe what assumptions were used to develop unloading characteristics for a particular compressor. For example, the performance of cycling compressors is not adversely affected at low loads while screw compressors operating with slide valve control experience worse performance at lower loads.
6. Tracking analysts should include adequate details in cost estimates to document the quantity of equipment that is expected to be used to achieve the reported savings. In particular, systems that contain redundant equipment that operates on a lead/standby basis should be fully described.

DMI's Recommendations for National Grid Technical Reviewers Based on This Evaluation

7. Technical reviewers should check to make sure that all equipment that may be affected by an installation is included in analyses (e.g. secondary chilled water pumping systems).
8. Technical reviewers should require adjustments to original energy studies if it is found during post-installation inspections and/or commissioning that the studied equipment was not actually installed.
9. National Grid should require trending/data archiving capabilities for all refrigeration projects where an EMS is available. The functionality of this data acquisition system should be verified as part of the post-installation or commissioning process. Data should be able to exported as spreadsheet files.
10. We recommend that post-installation inspections be conducted in a more thorough manner and that findings be more fully documented in typed format. Brief field notes do not seem to convey all of the facts that the National Grid inspector are likely to gather during a site visit.