Impact Evaluation of 2006 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 2006. 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. 250-07A, including the new ISO metering requirements. 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.

For all sites where such data was available and required for the evaluation analysis, 15-minute interval data was obtained from National Grid to assist in the determination of facility operating characteristics. This was particularly useful for one of the six sites where long-term production data could not be obtained from the site.

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.

One of the six tracking studies included power metering data that was able to be used in the evaluation analysis. Slight adjustments were required to account for the production of new product types that had not been handled by the equipment when the pre-retrofit case metering was performed.

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 and 2 are Design 2000*plus* applications, while Sites 3 through 6 are Energy Initiative applications. Brief descriptions of each project are presented below:

Site 1 installed rotary screw vacuum pumps capable of providing adequate vacuum for high speed manufacturing lines rather than refurbishing pre-existing liquid ring pumps and adding booster pumps.

Site 2 installed additional sludge cake handing equipment that allows storage silos and other conveyance systems to be bypassed.

Site 3 replaced inlet guide vane flow and pressure controls on four process blowers with variable speed controls.

Site 4 replaced standard split capacitor motors serving refrigerated display cases with electronically commutated magnet motors.

Site 5 replaced standard split capacitor motors serving refrigerated display cases with electronically commutated magnet motors.

Site 6 reconfigured return activated sludge (RAS) piping in a wastewater plant, replaced three oversized RAS pumps, and installed variable speed drives on five RAS pumps.

Results

Annual energy savings as evaluated varied from 210% (Site 1) to 7% (Site 2) 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 146%, 122%, 156%, and 146%, respectively but are heavily influenced by the results of the largest site. These results will be combined with the results of the other nine sites in this sample to produce a properly weighted realization rate.

The percent of savings occurring during peak periods and the seasonal diversified demand reduction values were evaluated using the current peak and super peak definitions. Peak hours are 6 AM to 10 PM on weekdays with the exception of nine standard holidays. Summer super peak periods are on the hottest days in each of June, July, and August between 3 PM and 5 PM, while winter super peak hours are on the coldest day in January between 5 PM and 7 PM.

Table 1

Annual Energy Savings, kWh

Site	Application	Description	Tracking	Evaluation	Evaluation ÷ Tracking
1	D2 508123	New Vacuum System	423,605	888,030	210%
2	D2 512403	New Sludge Screw Conveyor	95,114	7,080	7%
3	EI 500447	VSDs on Process Fans	118,710	156,020	131%
4	EI 515046	Evaporator Fan ECM Motors	14,069	9,432	67%
5	EI 515198	Evaporator Fan ECM Motors	8,453	8,443	100%
6	EI 516325	VSDs on RAS Pumps, Improved Piping	213,971	262,354	123%
		Total	873,922	1,331,358	152%

Table 2

Percent of Energy Savings On-peak

Site	Application	Description	Tracking	Evaluation	Evaluation ÷ Tracking
1	D2 508123	New Vacuum System	58%	62%	107%
2	D2 512403	New Sludge Screw Conveyor	26%	60%	230%
3	EI 500447	VSDs on Process Fans	39%	46%	118%
4	EI 515046	Evaporator Fan ECM Motors	42%	48%	114%
5	EI 515198	Evaporator Fan ECM Motors	42%	46%	109%
6	EI 516325	VSDs on RAS Pumps, Improved Piping	39%	46%	118%
		Total*	47%	57%	121%

* Total as weighted by estimated energy savings

Table 3
Summer SuperPeak Diversified Demand Reduction

Site	Application	Description	Tracking	Evaluation	Evaluation ÷ Tracking
1	D2 508123	New Vacuum System	58.8	137.1	233%
2	D2 512403	New Sludge Screw Conveyor	24.4	0.0	0%
3	EI 500447	VSDs on Process Fans	13.6	17.8	131%
4	EI 515046	Evaporator Fan ECM Motors	1.0	1.2	118%
5	EI 515198	Evaporator Fan ECM Motors	0.6	1.0	175%
6	EI 516325	VSDs on RAS Pumps, Improved Piping	17.2	29.9	175%
		Total	115.6	187.0	162%

Table 4
Winter SuperPeak Diversified Demand Reduction

Site	Application	Description	Tracking	Evaluation	Evaluation ÷ Tracking
1	D2 508123	New Vacuum System	58.8	137.1	233%
2	D2 512403	New Sludge Screw Conveyor	32.6	0.0	0%
3	EI 500447	VSDs on Process Fans	14.0	17.8	127%
4	EI 515046	Evaporator Fan ECM Motors	1.0	1.1	107%
5	EI 515198	Evaporator Fan ECM Motors	0.6	0.9	160%
6	EI 516325	VSDs on RAS Pumps, Improved Piping	17.2	29.9	175%
		Total	124.1	186.8	151%

The New England ISO Forward Capacity Market (FCM) uses slightly different peak demand period definitions relative to National Grid's current program guidelines.

- FCM summer demand peak hours are from 1 PM to 5 PM on non-holiday weekdays in June, July, and August; National Grid's summer peak demand period is from 3 PM to 5 PM on the same days and during the same months.
- FCM winter demand peak hours are from 5 PM to 7 PM on non-holiday weekdays in December and January; National Grid's winter peak demand period is during the same hours and days but is limited to the month of January.
- The FCM demand reduction is calculated as an average during these periods rather than National Grid's approach of estimating the demand reduction for the warmest/coldest hour of the peak demand period.

Tables 5 and 6 on the following page compare the evaluated coincident power demand reduction using the National Grid and Forward Capacity Market methodologies and peak definitions.

Table 5
Forward Capacity Market Demand Reduction - Summer

Site	Application	Description	National Grid	FCM	FCM ÷ National Grid
1	D2 508123	New Vacuum System	137.07	137.07	100%
2	D2 512403	New Sludge Screw Conveyor	0.00	0.00	N/A
3	EI 500447	VSDs on Process Fans	17.81	17.81	100%
4	EI 515046	Evaporator Fan ECM Motors	1.17	1.10	94%
5	EI 515198	Evaporator Fan ECM Motors	1.03	0.96	93%
6	EI 516325	VSDs on RAS Pumps, Improved Piping	29.95	29.95	100%
		Total	187.03	186.89	100%

Table 6
Forward Capacity Market Demand Reduction - Winter

Site	Application	Description	National Grid	FCM	FCM ÷ National Grid
1	D2 508123	New Vacuum System	137.07	137.07	100%
2	D2 512403	New Sludge Screw Conveyor	0.00	0.00	N/A
3	EI 500447	VSDs on Process Fans	17.81	17.81	100%
4	EI 515046	Evaporator Fan ECM Motors	1.06	1.06	100%
5	EI 515198	Evaporator Fan ECM Motors	0.95	0.95	100%
6	EI 516325	VSDs on RAS Pumps, Improved Piping	29.95	29.95	100%
		Total	186.84	186.84	100%

Discussion of Results

Table 5 on the following page lists the primary reasons for the differences in annual energy savings estimates. The following major factors were observed to impact realization ratios for the six sites:

- Only one site (Site 1) was significantly impacted by changes in production that were not anticipated in the tracking study.
- Sites 1 and 6 were impacted by assumptions that were deliberately used to make savings estimates more conservative.
- Site 2 was adversely affected by a misunderstanding on the part of the tracking analysis of how the base case system would have operated.
- Sites 4 and 5 were impacted by the use of estimated refrigeration equipment performance values that were worse than what was found in the field.
- Sites 3 and 6 were significantly impacted by mathematical and reporting mistakes.
- Site 1 was impacted by the use of different production levels in the base and proposed cases.

Regarding the change in peak demand definitions, five sites under consideration had loads which were not dependent on time of day or periods in question and the last site (Site 2) did not operate during either peak period. Sites 4 and 5 included savings from

refrigeration savings that were impacted slightly by the change in summer peak definitions. Non-refrigeration process applications are less likely to be effected (Sites 1, 3, 6). Though there were no HVAC applications in this group, they tend to be more likely to be effected by the change in demand peak definitions due to the role ambient conditions play in operating loads and equipment performance.

Table 5
Summary of Annual Energy Savings Discrepancies

Site	Application	Eval/Track	Primary Reason for Discrepancy of Savings Estimate
1	D2 508123	210%	The following factors increased project savings: the base case performance was derated to account for the discrepancy between actual and claimed equipment performance observed in the installed equipment; the base case equipment staging assumptions were changed; the base case was adjusted to include a greater number of booster pumps to match the number of machines that required their use; production levels were found to be greater than expected, and the tracking analysis did not assume the same airflow requirements in base and proposed cases. Project savings decreased since there was no evidence to support the tracking analysis claim that pumps operated in idle mode during production.
2	D2 512403	7%	Base case motors were found to be less loaded than originally assumed and the run hours of the base case equipment are approximately 40% of the tracking estimate.
3	EI 500447	131%	The tracking study made an addition error when determining the power savings associated with two supply fans.
4	EI 515046	67%	The refrigeration performance was found to be better than originally assumed and the difference between metered base and installed case power demand was found to be less than expected.
5	EI 515198	100%	The improvement in refrigeration performance offset lower than expected improvements in fan power demand.
6	EI 516325	123%	A scaling factor applied by National Grid to account for manual speed control of VSDs offset a reporting error in the tracking study (the proposed case annual energy use was claimed as savings), the tracking analysis used a pump curve for the wrong pump, flow rates increased, and annual operating hours were underestimated.

DMI's Recommendations for Tracking Analysts Based on This Evaluation

1. Savings calculations should be clearly organized and formatted to prevent incorrect values from being reported (Site 6).
2. The sources of savings for each measure should be clearly explained; similarities and differences between the base and proposed case equipment operating periods, motor loading, and power demand should be justified (Site 2).
3. Assumptions that are included in calculations to intentionally generate conservative estimates of savings should be clearly explained in the text of the energy study report (Site 1).

4. Power measurements for retrofit type projects should be incorporated into the analysis, and these power measurements should be taken on the equipment that is to be replaced whenever possible (Sites 4 and 5).
5. All calculations should be thoroughly checked for mathematical and reporting errors before they are sent to National Grid for review (Sites 3 and 6).
6. For retrofit applications, equipment performance data should match the equipment that is already on site that is to be impacted by the measure (Site 6).

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

7. Technical reviewers should become familiar with typical ranges of refrigeration equipment performance for low-temperature and medium-temperature applications (Sites 4 and 5). For ECM motors the Company should develop more standardized assumptions for refrigeration equipment performance.
8. Applications that involve a comparison of systems where one handles product more quickly than the other should receive fairly detailed scrutiny regarding the amount of material handled and the amount of time the equipment operates (Site 2). Care should be taken that pre/base and post systems are analyzed on an equal production basis.
9. We recommend that post-installation inspections be conducted in a more thorough manner and that findings be more fully documented on the written post installation form. 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 (Sites 2 and 6).
10. Part of the technical review should include a check of whether the energy savings reported in screening tool pages and the text of the energy study report match the supporting calculations (Site 6).