2014 RI Custom Process Impact Evaluation

National Grid

Draft Report

Prepared by DNV GL
10/27/2017

Table of contents

1 EXECUTIVE SUMMARY

This Executive Summary provides a high-level review of the results for Rhode Island's Impact Evaluation of 2014 Custom Process Installations. The evaluation team conducted this impact evaluation for National Grid. In this section, we state the study objectives, summarize the evaluation approach, and present key findings, conclusions, and recommendations.

The scope of work of this impact evaluation covered the 2014 Custom Process impact category in Rhode Island, which included new equipment for which energy consumption and savings is primarily driven by a quantified non-weather load, such as tons of production or total hours of operation. The project was completed between 2016 and 2017.

1.1 Overview of objectives and approach

The objective of this impact evaluation is to provide verification or re-estimation of electric energy and demand savings estimates for a sample of custom electric projects through: Site-specific inspection, monitoring, and analysis.

The results of this study are realization rates for custom process electric energy efficiency measures. Realization rates were determined at the statewide level and also at the combined National Grid territory level in both Rhode Island and Massachusetts. A synopsis of the research approach is as follows:

The DNV GL team developed a stratified sampling design from program participation data provided by National Grid based on agreed assumptions. The final evaluation sample design for this study was expected to achieve a National Grid territorial electric energy savings realization rate result with ±20% relative precision at the 90% confidence interval, and summer and winter peak demand savings realization rate results with ±20% relative precision at the 80% confidence interval.

Site specific measurement and verification (M&V) plans were created for each sampled site. These plans were reviewed and approved by National Grid before data collection was initiated.

The data used in in the estimation of evaluated savings was collected by the team according to the approved M&V plan. The evaluation collected and reviewed all provided program documentation and collected data associated with each sampled project. Data collection methods included interviews of facility personnel, interviews of equipment vendors, on-site monitoring of operating equipment, receipt of data collected by the customer, and receipt of utility meter consumption data.

The evaluation created a custom measure specific analysis for each sampled project. The evaluation created unique site reports for each sampled project. Each report includes a project description, a description of the tracking savings assumption and methodology, a baseline review, a description of the data collected by the evaluation, a description of the evaluation analysis completed, and a discussion of the evaluation results and reasons for the variance between tracking and evaluation estimates of savings. These reports are available in Appendix C.

1.2 Key findings and conclusions

The site level evaluation results were aggregated using the final adjusted case weights. The statewide realization rate is the ratio of the total measured savings to the total tracking savings. Table 1-1 summarizes the results of this analysis. The results presented include realization rates (and associated precision levels) for annual kWh savings, and on-peak demand (kW) savings at the times of the winter and summer peaks, as defined by the ISO New England Forward Capacity Market (FCM). All coincident summer and winter peak reductions were calculated using the following FCM definitions:

1. Coincident Summer On-Peak kW Reduction is the average demand reduction that occurs over all hours between 1 PM and 5 PM on non-holiday weekdays in June, July and August.
2. Coincident Winter On-Peak kW Reduction is the average demand reduction that occurs over all hours between 5 PM and 7 PM on non-holiday weekdays in December and January.

Table 1-1: 2013 (MA), 2014 (RI) Custom Process Results for the National Grid territory (MA+RI)

MA+RI Results	Annual Savings MWh	Summer On-Peak kW	Winter On-Peak kW	% On-Peak kW
Total Tracking Savings	12,644	1,634	1,596	79%
Total Evaluated Savings	9,420	1,105	1,126	73%
Realization Rate	74.5%	67.6%	70.5%	93%
Error Ratio	0.60	0.77	0.94	76%
90% Confidence				
Relative Precision	±15.6%	±18.6%	±23.9%	±17.7%
Error Bound	1,471	206	269	0.13
80% Confidence				
Relative Precision	±12.2%	±14.5%	±18.6%	±13.8%
Error Bound	1,146	160	210	0.10

The results of DNV GL's analysis of realization rates by states follow in Table 1-2. Overall, the study achieved the relative precision targets (90/20) expected based on the sample design.

Table 1-2: Custom Process Results by State

Results by State • MA (n=20) RI (n=4)	Annual Savings MWH		Summer On-Peak kW		Winter On-Peak kW		% On-Peak kW	
	MA	RI	MA	RI	MA	RI	MA	RI
Total Tracking Savings	10,585	2,058	1,369	265	1,341	255	0.82	0.61
Total Measured Savings	7,141	2,279	894	211	1,007	118	0.75	0.64
Realization Rate	67.5%	110.7%	65.3%	79.7%	75.1%	46.2%	91.6%	104.5%
Error Ratio	0.61	0.57	0.85	0.43	1.03	0.20	0.86	0.11
90% Confidence								
Relative Precision at 90% Confidence	±15.9%	±41.1%	±22.0%	±28.5%	±26.7%	±12.9%	±20.5%	±8.7%
Error Bound at 90% Confidence	1,133	937	197	60	269	15	0	0.06
80% Confidence								
Relative Precision at 80% Confidence	±12.4%	±32.0%	±17.2%	±22.2%	±20.8%	±10.1%	±16.0%	±6.7%
Error Bound at 80% Confidence	883	730	153	47	209	12	0.12	0.04

1.3 Recommendations

The evaluation team has the following recommendations based on the data collected, conclusions, results, and process of this impact evaluation. All 4 sampled sites in this study installed IMMs. Therefore, recommendations presented below are primarily for IMMs but the first recommendation can be expanded to other measures.

1. For an IMM retrofit project, DNV GL recommends National Grid to conduct metering of both pre-retrofit or a baseline proxy machines for at least one day to better estimate the average machine consumption.
    - A valid IMM baseline would be available in market for the customer to buy and can be used for producing similar products as the proposed machine.
2. It is also recommended to use installed and baseline average energy intensity (kWh/lb) to calculate savings based on an estimated production weights for any future projects.
3. Furthermore, any adjustments the TA makes should be made to the energy intensity and not to a single parameter such as the cycle time. If single parameter adjustments are determined to be the best option, then high frequency spot metering data should be collected and an adjustment to the average power consumption should also be made.

1.4 Considerations

The following considerations are specific to changes National Grid (Rhode Island only) could make in the delivery of their energy efficiency programs. Additional considerations based on each site's evaluation are summarized in Appendix C.

1. In a retrofit project, consider requiring the collection of at least one day of pre-retrofit equipment's consumption for projects expected to provide more than 100,000 kWh in annual savings. Multiple sampled projects relied on spot metering (15-minutes or less) of pre-retrofit equipment. While any pre-retrofit consumption data is better than no data, there were cases for which it was unknown to the evaluator if the metering data accurately represented the variability in baseline consumption due to the short duration of the metering. Requiring at least one day of metering should improve the accuracy of program savings estimates.
2. Consider including a summary of the baseline selection in the project documentation. Especially given the adoption of a new evaluation baseline framework, the program should document how the baseline was determined for unique custom projects in this impact category and provide clear statements on each decision made.
3. Significant improvements to IMM technology entered the market after 1995. If the only proxy machine available for the baseline was installed before 1995, consider adjusting the baseline energy intensity to account for the more efficient equipment available in today's market.
4. National Grid should review the site-specific considerations summarized in Appendix C.

2 INTRODUCTION

This document presents the final report for DNV GL's Impact Evaluation of 2014 Electric Custom Process Installations, conducted for the National Grid. This custom process impact group represented 4% of the statewide electric large commercial and industrial electric energy efficiency portfolio in 2013 and 7% of the 2013 statewide custom commercial and industrial electric portfolio. National Grid previously completed an impact evaluation of 2010 electric custom process installations.[1]

2.1 Study objectives

The objective of this impact evaluation was to provide verification or re-estimation of electric energy and demand savings estimates for a sample of custom electric projects through site-specific inspection, monitoring, and analysis. Extrapolated realization rates were determined at the statewide level and for a combined MA and RI states (National Grid territory).

The evaluation utilized stratified random sampling to select projects for evaluation. The sample design for this study was expected to achieve a statewide electric energy savings realization rate result with ±20% relative precision at the 90% confidence interval, and statewide summer and winter peak demand savings realization rate results with ±20% relative precision at the 80% confidence interval.

2.2 Methods

DNV GL utilized the following approach for this impact evaluation:

1. Examined the 2014 large C&I population to understand the relative impact of custom process measures in National Grid territory (MA+RI).
2. Designed an efficient sampling plan for the selection of custom process projects for on-site visits to achieve the agreed relative precision targets using the previous evaluation's resulting error ratios.
3. Reviewed the formulas, calculations, and factors used in the development of the tracking savings for each sampled participant to develop site-specific M&V plans.
4. Performed comprehensive data collection at each sample site to support an independent analysis of achieved gross energy and demand savings realization rates.
5. Established a site-specific baseline for each sampled project based on the materials reviewed and additional data collected.
6. Completed an independent custom analysis estimating the achieved gross energy and demand savings for each sampled project.
7. Documented the evaluation activities completed in a comprehensive site specific M&V report.
8. Extrapolated the sample results to the population to estimate statewide and combined National Grid territorial realization rates for the impact category.

[1] KEMA Inc, Impact Evaluation of 2010 Custom Process and Compressed Air Installations, May 30, 2012

3 METHODOLOGY

3.1 Sample development

The DNV GL team developed a sampling population from program participation data provided by National Grid. National Grid determined relative precision and confidence interval targets using this sampling population along with information provided by the DNV GL team. This information included characteristics of the sampling population, the relative impact of the sampling population to each PA's electric portfolio, and historic evaluation targets and results.

Once National Grid set the sampling targets, the DNV GL team selected a primary and back-up sample for the evaluation that minimized the number of sample points required to meet the targets, and provided these samples to National Grid for review. National Grid provided the DNV GL team with documentation supporting the tracked savings for each primary sample point.

3.1.1 Sample targets

Based on the results achieved in the previous study, this study's sample design assumed error ratio of 0.75 for energy. The sampling targets for this study were determined through an in-depth review of the impact category's relative savings impact on National Grid's energy efficiency portfolio. The final sampling targets were set at a desired energy level for National Grid i.e. 90% confidence and a precision of ±20%. Table 3-1 shows the population statistics for the program years 2013 (MA) and 2014 (RI). Note that there was no specific precision target for demand (kW).

Table 3-1: Population Statistics

State	Population	Total Tracked Savings	Average Savings	Minimum	Maximum	Standard Deviation	CV
	N	MWh	kWh	kWh	kWh		
Massachusetts	58	10,585	182,506	638	988,230	178,377	0.98
Rhode Island	11	2,058	187,126	2,069	376,622	202,334	1.08
Total	**69**	**12,644**					

3.1.2 Sample design

The final sample design for this project is shown in Table 3-2. Overall, the project was designed to achieve statewide results with ±20% relative precision for energy savings at the 90% confidence interval, and ±20% relative precision for demand savings at the 80% confidence interval.

Table 3-2: Sample design, anticipated and achieved relative precision of energy savings (kWh)

State	Population	Total Tracked Savings	Sample Sites	Anticipated	Achieved	Achieved
	N	MWh	n	RP @90% CI	RP @90% CI	Error Ratio
Massachusetts	58	10,585	20	±20.00%	±15.9%	0.61
Rhode Island	11	2,058	4	±53.00%	±41.4%	0.57
Total	**69**	**12,644**	**24**	**±19.00%**	**±15.6%**	**0.60**

Table 3-3: Anticipated and achieved relative precision of Summer On-peak demand (kW)

State	Population	Total Tracked	Sample Sites	Achieved	Achieved

		Savings			
	N	kW	n	RP @80% CI	Error Ratio
Massachusetts	58	1,369	20	±17.2%	0.85
Rhode Island	11	265	4	±22.2%	0.43
Total	**69**	**1,634**	**24**	**±14.5%**	**0.77**

Table 3-4: Anticipated and achieved relative precision of Winter On-peak demand (kW)

State	Population	Total Tracked Savings	Sample Sites	Achieved	Achieved
	N	kW	n	RP @80% CI	Error Ratio
Massachusetts	58	1,341	20	±20.8%	1.03
Rhode Island	11	255	4	±10.1%	0.20
Total	**69**	**1,596**	**24**	**±18.6%**	0.94

3.1.3 Sample stratification

The sample design utilized stratification by energy savings in order to achieve the sample targets with the fewest number of sample points. Table 3-5 shows the strata utilized for this project, the original sample size within each stratum, and the probability of selection.

Table 3-5: Original sample by strata

State	Stratum	Population	Sample	Maximum	Probability of selection
		N	n	kWh	
MA	1	41	8	213259	24%
MA	2	15	10	472445	67%
MA	3	2	2	988230	100%
RI	1	8	2	156267	25%
RI	2	3	2	539704	67%

3.1.4 Sample and population changes

The final evaluation sample and assumed population changed during the project. The following changes occurred:

1. Four originally sampled projects in MA were removed from the sample and replaced with other projects during the evaluation. These projects were removed due to refusal to participate in the evaluation study by the site. Each project was replaced with a project within the same stratum.
2. 2 zero savings projects were also removed in MA National Grid territory due to ambiguity and/or lack of proper Industrial Standard baselines for product specific Injection Molding Machines (IMMs).
3. No changes were observed in RI

3.1.5 Final sample

Table 3-5 shows the characteristics of the final sample included in this evaluation. A description of each of the 24 projects is included in Appendix A. A detailed description of each project is provided in the site reports.

3.2 Description of Methodology

This section describes the general methodology used for both the development of site evaluation plans, the execution of the plans, and the final process for producing program results. Each site report in Appendix C describes the site-specific methodology in detail.

3.2.1 Measurement and Evaluation Plans

Following sample selection and prior to beginning any site visits, the evaluation team developed detailed measurement and evaluation plans for each sampled project. If multiple similar measures were to be evaluated at the same site, one plan was created. The plans included: a description of the project, a description of the tracking assumptions and methodology, expected verification method, expected data collection methods and strategies and the anticipated analysis methodology. National Grid provided comments and edits to clarify and improve the plans prior to the plans being finalized. The EEAC consultants reviewed a sample of the plans.

Evaluators anticipated utilizing the savings analysis methodologies from the Technical Assistance Study (TA) whenever possible. However, if the TA methodology was unavailable or found to be incorrect or inappropriate, in those cases, the evaluators planned for an analysis more appropriate to the measure being evaluated and data to be collected. In most cases, adjustments to savings methodologies were presented and agreed to in the measurement and evaluation plans.

3.2.1.1 Site recruitment/interviews

Site recruitment for this project was initiated by each PA, who contacted all sampled sites to inform them of the study and identify the primary contact. National Grid provided a list of contacts to the evaluation team along with approval to contact the customer.

The evaluation team called each site contact to discuss the site details and schedule a site visit. This discussion was used to improve our understanding of the site, the project, and data available for the evaluation. Any new information received at this time was integrated into each site’s M&V plan.

3.2.2 Data Collection for Verification, Analysis, and Reporting

Data collection included physical inspection, an interview with facility personnel, observation of site operating conditions and equipment, metering of equipment usage, and collection of facility provided data. In some cases, multiple facility interviews were completed to ensure an accurate understanding of operating practice. In some cases, the evaluator also interviewed equipment vendors.

The physical inspection focused on verifying measure installation and expected operation. For all but one projects, equipment was found to be installed and operating as expected. In that one case, the measure was found to be installed, but the equipment was operating at significantly lesser hours. Each site report includes the result of measure verification.

Instrumentation such as power recorders, TOU current loggers, and temperature loggers were installed to monitor the usage of operating equipment and conditions of the associated affected spaces. Production data and EMS trends were also collected, when available. Each site report includes a full description of the data collected and received.

A unique savings analyses was created for each sampled project. When required, a typical meteorological year (TMY3) dataset of ambient temperatures was used for temperature sensitive calculations. Energy savings were either calculated by the hour in an 8,760 spreadsheet or allocated to each hour in the year in order to estimate on-peak savings impacts. Each analysis provided estimates for annual kWh savings, on-peak kWh savings, and on-peak demand (kW) savings at the times of the winter and summer peaks, as defined by the ISO New England Forward Capacity Market (FCM). All coincident summer and winter peak reductions were calculated using the following FCM definitions:

1. Coincident Summer On-Peak kW Reduction is the average demand reduction that occurs over all hours between 1 PM and 5 PM on non-holiday weekdays in June, July and August.
2. Coincident Winter On-Peak kW Reduction is the average demand reduction that occurs over all hours between 5 PM and 7 PM on non-holiday weekdays in December and January.

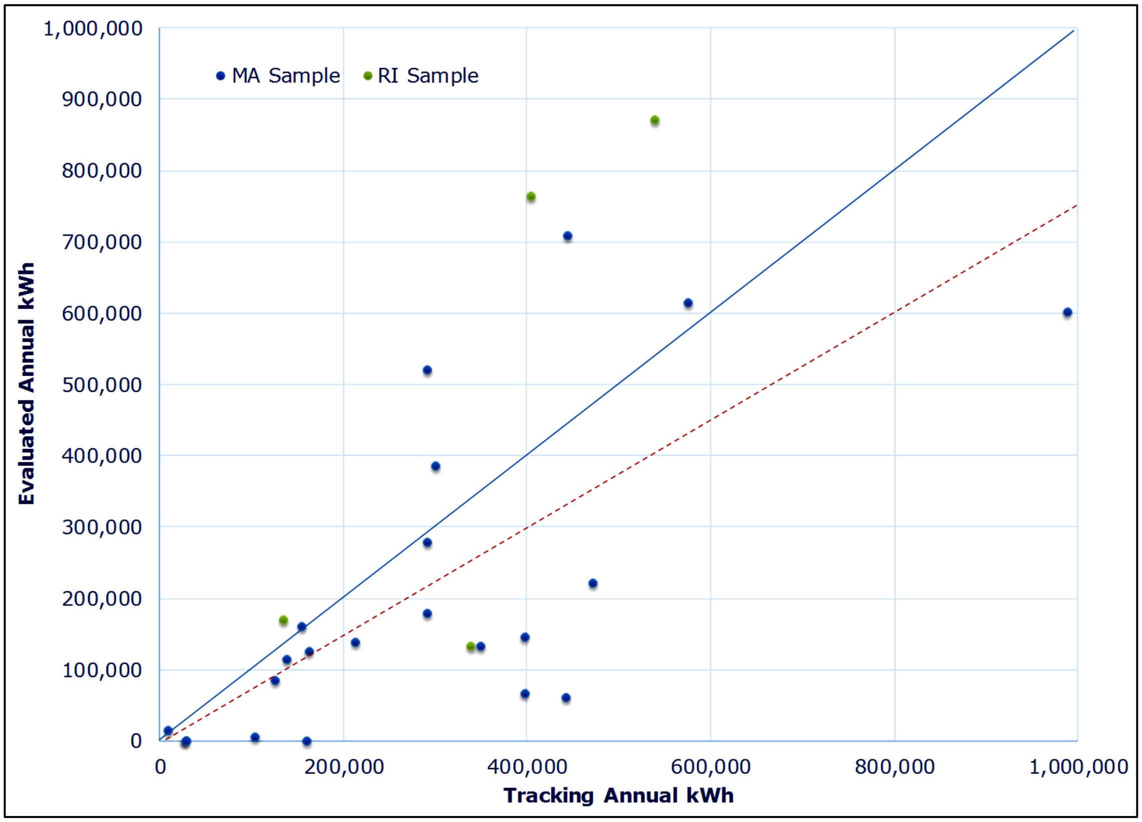
Each site report details the specific analysis methods used for each project including algorithms, assumptions and calibration methods where applicable. Engineers submitted draft site reports to National Grid upon completion of each site evaluation. A sample of reports was also submitted to the EEAC consultants for review. The evaluation team responded to the comments received and submitted revised reports for comment. The final site reports are included in Appendix F. This report provides a concise overview of the evaluation methods and findings only.

4 FINDINGS

4.1 Site-level findings

Figure 4-1 presents a scatter plot of evaluated annual energy (kWh) savings plotted against the National Grid tracking savings. The data points shown are the actual unweighted values. The solid line represents a realization rate of 100%. The slope of the dashed red line is the MA+RI realization rate. Since the dashed line is below the 100% line, the realization rate is less than 100%. The scatter of the data around the dashed line indicates the variation savings between the tracking estimates and evaluated savings. Individual[2] site reports are shown in Appendix C.

Figure 4-1: Annual Energy, Evaluated Savings vs. Tracking Savings



There are many reasons for the differences between evaluated and tracking savings. A summary of these reasons for savings variance is provided in Appendix B. The individual site reports provide a detailed discussion of the savings variance and the discrepancies that drove it. The following reasons occurred at multiple sites:

1. Differences between the as-found annual production volume or hours of operation compared to those assumed in the tracking analysis. This both increased and decreased savings at different projects.
2. Differences between the actual demand or production intensity of the installed equipment based on evaluation monitoring and the demand or intensity estimates used in the tracking analysis.

---

[2] Only Rhode Island site reports are presented in this report. Please see MA full study report for MA site reports.

3. Adjustments to the baseline made by the evaluation. The evaluation adjusted the baseline demand or production intensity to more accurately estimate the consumption of new equipment versus the older and differently sized proxy equipment used to estimate baseline consumption in the tracking analysis.

4.2 Prospective realization rates

The site level evaluation results were extrapolated to the population using the final probabilities of selection. The realization rates were estimated and then applied to each state's[3] total tracking savings to determine their total measured savings. Table 4-1 summarizes the (MA+RI) National Grid territory results of this analysis. The table shows the results for four measures of savings. The results of DNV GL's analysis of realization rates by PA follow in Table 4-2. The realization rates for percent on-peak kWh savings are provided in this table for National Grid.

Table 4-1: 2013 Custom Process Combined National Grid territory (MA+RI) Results

Statewide Results	Annual MWh	Summer On-Peak kW	Winter On-Peak kW	% On-Peak kW
Total Tracking Savings	12,644	1,634	1,596	79%
Total Evaluated Savings	9,420	1,105	1,126	73%
Realization Rate	74.5%	67.6%	70.5%	93%
Error Ratio	0.60	0.77	0.94	76%
90% Confidence	**90% Confidence**			
Relative Precision	±15.6%	±18.6%	±23.9%	±17.7%
Error Bound	1,471	206	269	0.13
80% Confidence	**80% Confidence**			
Relative Precision	±12.2%	±14.5%	±18.6%	±13.8%
Error Bound	1,146	160	210	0.10

Table 4-2: 2013 Custom Process Results by State

Results by State MA (n=20) RI (n=4)	Annual Savings MWH		Summer On-Peak kW		Winter On-Peak kW		% On-Peak kW	
	MA	RI	MA	RI	MA	RI	MA	RI
Total Tracking Savings	10,585	2,058	1,369	265	1,341	255	0.82	0.61
Total Measured Savings	7,141	2,279	894	211	1,007	118	0.75	0.64
Realization Rate	67.5%	110.7%	65.3%	79.7%	75.1%	46.2%	91.6%	104.5%
Error Ratio	0.61	0.57	0.85	0.43	1.03	0.20	0.86	0.11
90% Confidence								
Relative Precision at 90% Confidence	±15.9%	±41.1%	±22.0%	±28.5%	±26.7%	±12.9%	±20.5%	±8.7%
Error Bound at 90% Confidence	1,133	937	197	60	269	15	0	0.06
80% Confidence								

[3] Rhode Island and Massachusetts (National Grid only).

Relative Precision at 80% Confidence	±12.4%	±32.0%	±17.2%	±22.2%	±20.8%	±10.1%	±16.0%	±6.7%
Error Bound at 80% Confidence	883	730	153	47	209	12	0.12	0.04

5 CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions, recommendations, considerations, and opportunities for future research.

5.1 Conclusion

This evaluation achieved its objective and provided the verification or re-estimation of electric energy and demand savings estimates for a sample of custom electric projects through site-specific inspection, monitoring, and analysis. Extrapolated realization rates were determined at both MA (National Grid only) and Rhode Island (state-wide) and Combined MA+RI levels.

The sample design for this study was expected to achieve an overall (MA+RI) electric energy savings realization rate result with ±15.6% relative precision at the 90% confidence interval, and an overall summer demand savings realization rate results with ±20% relative precision at the 80% confidence interval, it did not however meet the winter target of ±20% relative precision at the 80% confidence interval. The evaluation met these targets by achieving ±15.6% relative precision at the 90% confidence interval for energy savings, and an overall summer peak demand realization rate results with ±18.6% relative precision at the 80% confidence interval for summer, and 23.9% for winter.

5.2 Recommendations

The evaluation team has the following recommendations based on the data collected, conclusions, results, and process of this impact evaluation. All 4 sampled sites in this study installed IMMs. Therefore, recommendations presented below are primarily for IMMs but the first recommendation can be expanded to other measures.

1. For an IMM retrofit project, DNV GL recommends National Grid to conduct metering of both pre-retrofit or a baseline proxy machines for at least one day to better estimate the average machine consumption.
    - A valid IMM baseline would be available in market for the customer to buy and can be used for producing similar products as the proposed machine.
2. It is also recommended to use installed and baseline average energy intensity (kWh/lb) to calculate savings based on an estimated production weights for any future projects.
3. Furthermore, any adjustments the TA makes should be made to the energy intensity and not to a single parameter such as the cycle time. If single parameter adjustments are determined to be the best option, then high frequency spot metering data should be collected and an adjustment to the average power consumption should also be made.

5.3 Considerations

The following considerations are specific to changes National Grid could make in the delivery of their energy efficiency programs. Additional considerations based on each site's evaluation are summarized in Appendix C.

1. In a retrofit project, consider requiring the collection of at least one day of pre-retrofit equipment's consumption for projects expected to provide more than 100,000 kWh in annual savings. Multiple sampled projects relied on spot metering (15-minutes or less) of pre-retrofit equipment. While any pre-retrofit consumption data is better than no data, there were cases for which it was unknown to the evaluator if the metering data accurately represented the variability in baseline consumption due to the short duration of the metering. Requiring at least one day of metering should improve the accuracy of program savings estimates.

2. Consider including a summary of the baseline selection in the project documentation. Especially given the adoption of a new evaluation baseline framework, the program should document how the baseline was determined for unique custom projects in this impact category and provide clear statements on each decision made.
3. Significant improvements to IMM technology entered the market after 1995. If the only proxy machine available for the baseline was installed before 1995, consider adjusting the baseline energy intensity to account for the more efficient equipment available in today's market.
4. National Grid should review the site-specific considerations summarized in Appendix C.

APPENDIX A. SUMMARIES OF SAMPLED PROJECTS

The following table provides a summary of the projects included in the final evaluation sample.

Site ID	Project ID(s)	Project Type(s)	Project description (based on program documentation)
National_Grid_06	4139283	New Construction	Installation of 1 (500-tons) injection molding machine (IMM)
National_Grid_08	4460344	New Construction & Retrofit	Installation of 14 (60-tons) IMMs, 6 of which were New Construction and remaining were Retrofitted.
National_Grid_09	4088596	New Construction	Installation of 2 IMMs (1x500 tons, 1x1100 tons)
National_Grid_10	4139798	New Construction	Installation of 3 IMMs (2x500 tons, 1x1100 tons)

APPENDIX B. SITE VARIANCE SUMMARY

The following table provides a brief summary of the primary reasons for the difference between the tracked and evaluated savings.

Site ID	Project ID(s)	Energy RR	Primary reasons for savings variance
National_Grid_06	4139283	127%	The variance in the energy is due to energy intensity (kW/lb) of each part manufactured on each machine. TA assumed significantly higher production but lower energy intensities (kW/lb). Other significant difference between Tracking and Evaluation analysis was found to be the number parts used in the analysis; tracking analysis used only one part (weight) in the savings calculation but evaluation found multiple parts being manufactured on each machine during a calendar year.
National_Grid_09	4088596	188%	
National_Grid_10	4139798	161%	
National_Grid_08	4460344	39%	The savings variance is primarily due to the difference in baseline kW between the evaluated analysis and the tracking estimate. This was a result of using different materials, cycle times, mold, and tonnage between the baseline and proposed machines. Additionally, the annual operating hours for the machines are significantly less than estimated in the tracking analysis.

APPENDIX C. SITE REPORTS

This appendix includes the individual site reports documenting the tracking and evaluated savings for each sampled project.

SITE ID: DNV 08

Program Administrator	National Grid
Project ID(s)	4460344
Project Type	New Construction and Retrofit
Program Year	2013
Evaluation Firm	DNV GL
Evaluation Engineer	Jerry Song
Senior Engineer	Amit Kanungo

Project Description

This document discusses the evaluation of fourteen 60-ton Hybrid injection molding machines (IMMs) installed at a plastics manufacturing facility in 2014. Six of the installed injections molding machines in this facility were new construction to add production capacity to the facility whereas the other eight machines were replacements of older fully hydraulic machines with hybrid machines. The six new constructions also considered installing new hybrid injection molding machines (IMMs) over new fully hydraulic machines. Savings for the project were expected to result from higher efficiency IMMs, resulting in an estimated 338,794 kWh in savings per year for all the fourteen installed machines. Table 3 shows the overall evaluation results for this project.

The project realization rates for the energy savings was 39% and the summer peak demand savings was 49%. The savings variance is primarily due to the difference in baseline kW between the evaluated analysis and the tracking estimate. This was a result of using different materials, cycle times, mold, and tonnage between the baseline and proposed machines. Additionally, the annual operating hours for the machines are significantly less than estimated in the tracking analysis.

Table 3: Project Results

Savings Quantity	Tracking Estimate	Evaluation Estimate	Realization Rate
Electric energy (kWh)	338,794	133,168	39%
% of Energy Savings on Peak	49%	58.7%	120%
Summer On-Peak Demand (kW)	41.28	19.98	48%
Winter On-Peak Demand (kW)	N/A	15.81	N/A

Tracking Savings

This section summarizes the methodology and assumptions used to estimate the tracking savings claimed for the project.

Baseline Assumption

Conventional hydraulic IMM technology was used as the baseline for the fourteen (14) installed hybrid IMMs. In the tracking analysis, an 80-ton hydraulic Nissei FS80S12 ASE injection molding machine was metered for one hour to determine the average baseline power draw (kW). Then, this average baseline kW was multiplied with annual operating hours of the metered IMM to estimate the annual usage of the baseline machine. The annual operating hours of the metered IMM estimated from the machine’s annual production and product cycle time. Table 4 shows the key baseline parameter assumptions utilized in the tracking analysis.

Table 4: Baseline Key Parameters

	BASELINE SYSTEM		
Parameter	**Value(s)**	**Source of Parameter Value**	**Note**
Machine kW	5.009kW	1 hour of power metering at 1 minute intervals	
Annual Operating Hours	7,798 hours	Tracking Analysis Assumption	24/7, 50 hours per week, 8 holidays, 95% utilization rate
Average Cycle Time	14.4 seconds/cycle	Tracking Analysis Assumption	
Shot Weight	0.252 ounces	Tracking Analysis Assumption	

Proposed Condition

The installation of fourteen hybrid IMMs was used as the proposed condition. In the tracking analysis, a 60-ton Nissei PNX 60 III 5A electric hybrid IMM was metered for one hour to determine the average proposed power draw (kW). This average proposed machine kW was multiplied with annual operating hours of the metered IMM to estimate the annual usage of the proposed machine. The annual operating hours of the metered IMM were estimated from the machine's annual production and product cycle time.

Table 5: Proposed Key Parameters

	PROPOSED SYSTEM		
Parameter	**Value(s)**	**Source of Parameter Value**	**Note**
Machine kW	1.892 kW	1 hour of power metering at 1 minute intervals	
Annual Operating Hours	7,798 hours	Tracking Analysis Assumption	Annual hours do not change due to the difference in shot weight. Hours were normalized for production weight
Average Cycle Time	14.5 seconds/cycle	Tracking Analysis Assumption	
Shot Weight	0.251 ounces	Tracking Analysis Assumption	

Tracking Calculation Methodology

The tracking savings were calculated using spreadsheet analysis and monitored power data. The annual savings were estimated by taking the difference between the proposed energy usage and baseline energy usage.

$$Annual\ Energy\ Savings = kWh_{IMM\ Baseline} - kWh_{IMM\ Proposed}$$

The IMM kWh for both the proposed and baseline were calculated by taking the product of the measured power and annual machine hours the IMM. This was then multiplied by the total number of IMMs in the project to estimate the total project energy usage

$$kWh = kW_{IMM} * Hours_{IMM\ Operation} * 14_{Total\ IMMs}$$

Because the proposed case's injection molding machine has a 0.1 second higher cycle time, the operating hours were calculated by normalizing the annual production cycles to that of the baseline case using the formula below.

$$Hours_{Proposed\ IMM\ Operation} = 7{,}798_{Baseline\ Operating\ Hours} * \frac{14.5_{Proposed\ sec/cycle}}{14.4_{Baseline\ sec/cycle}}$$

Evaluator Assessment of Tracking Savings

The evaluation identified the following issues with the tracking analysis:

- Due to the limited documentation, the underlying assumptions used in the tracking calculations, such as annual operating hours and cycle time couldn't be verified.
- Both the retrofit and new construction projects used the same baseline technology for the savings calculations. The rationale behind this assumption was not provided for review.
- The tracking calculation spreadsheet lists the base calculation material to be nylon, while the proposed case material was polycarbonate. This changed both the shot weight and cycle time between the baseline and proposed case. The change in material can have an impact on the energy savings of the machine, which was not taken into consideration in the tracking calculation.
- The baseline injection molding machines were hydraulic 80-ton machines compared to the installed 60-ton hybrid injection molding machines.

Project Evaluation

This section summarizes the methodology and assumptions used to evaluate the savings for the project. Primarily, the site evaluation started with scheduling a site visit, performing physical inspection to verify the installation of the measure, collecting on-site data, performing metering, performing engineering analysis and finally preparing a site report to report the evaluated savings.

Measure Verification

The site visit was conducted to verify the installation of the new hybrid IMMs and collected measure related information from the facility engineer. During the site visit, each project measure was verified to document installation and intended operation of the measure. Table 6 shows how each measure that was verified to be installed and operating.

Table 6: Measure Verification

Measure Name	Verification Method	Verification Result
Nissei PNX 60 III 5A	Quantity & Nameplate Information (Model number, manufacture, rated power, capacity, voltage, along with the operational status etc.)	The installed IMMs match the proposed machine. It is a Nissei PNX 60 III 5A. Six of the fourteen IMMs are currently running. The others are off due to lack of demand.

Data Collection

The evaluator monitored three newly installed injection molding machines using Dent ElitePro loggers for six weeks. The monitored machines were representative of the installed machines at the facility, capturing the three different load profiles to account for variances in operating hours and schedule, cycle times, product types, and materials. The customer provided daily production data to the evaluator for the monitored machines during the second visit to retrieve the monitoring equipment. The data provided included pounds of production, hours of production per day, and cycle time.

Machine	Notes
A01	Same process as A03 (Same material, hours, schedule, cycle time, etc.)
A02	Same process as A03 (Same material, hours, schedule, cycle time, etc.)
A03	Monitored
A04	Same process as A05 (Same material, hours, schedule, cycle time, etc.)
A05	Monitored
A06	Monitored

The evaluator performed an on-site visit on May 19th to monitor the installed injection molding machines and spoke with the plant maintenance supervisor. During the site visit, it was verified that all fourteen injection molding machines were installed and were purchased for use in a specific contract. However, due to production changes, only six (6) of the fourteen (14) installed injection molding machines are currently running. The facility manager claimed the eight (8) idle machines are to operate again in the future, but there was no timeline and future production parameters are not known. In a later follow-up, the facility manager stated that machines typically have a 75% utilization rate and a indicated the eight idle machines started operation again in late October.

ElitePro SP kW loggers were installed on three of the six operating injection molding machines to represent the three IMMs' different materials and cycle times. There were no hydraulic IMMs present at the facility that met the proxy baseline requirements for monitoring, so no hydraulic IMM was monitored to assess the baseline profile of the installed hybrid IMMs.

However, the evaluator contacted multiple injection molding machine manufacturers to obtain performance information for hydraulic and hybrid machines with a 60-ton capacity. One of the manufacturers was able to provide information for a 120-ton comparative energy performance analysis between their own line of hydraulic and hybrid machines. The calculation showed the hybrid machine was 51.6% more efficient than the fully hydraulic machines. This efficiency value was used along with the installed machine kWs to estimate the baseline kWs of the operational machines. This method was deemed more accurate than the one used in the tracking analysis as it keeps the machine size and operating parameters the same between the baseline and installed machines.

Table 7 and Table 8 show the data that were collected as part of this evaluation.

Table 7: Evaluation Data Collection – Installed Equipment

Parameter	M&V Equipment Brand and Model	Metering Start/Stop Dates	Metering Interval
Nissei PNX 60 III 5A – Energy Consumption	3x Dent ElitePro Logger	4 Weeks	5 minutes

Table 8: Evaluation Data Collection – Data Received

Parameter	Source	Interval	Duration
Production volume – baseline and proposed	Site – production logs	Daily production data through monitoring period	4 Weeks
One day of granular production data concurrent with metering	Site – production logs	Could not be collected. Daily production data collected instead	4 Weeks
Production schedule – baseline and proposed	Site interview and production logs	Daily production data through monitoring period	4 Weeks
Cycle time for each product produced – baseline and proposed	Site – production logs	A03: 14.0 sec. A05: 10.4 sec. A06: 14.1 sec.	4 Weeks

Evaluation Savings Analysis

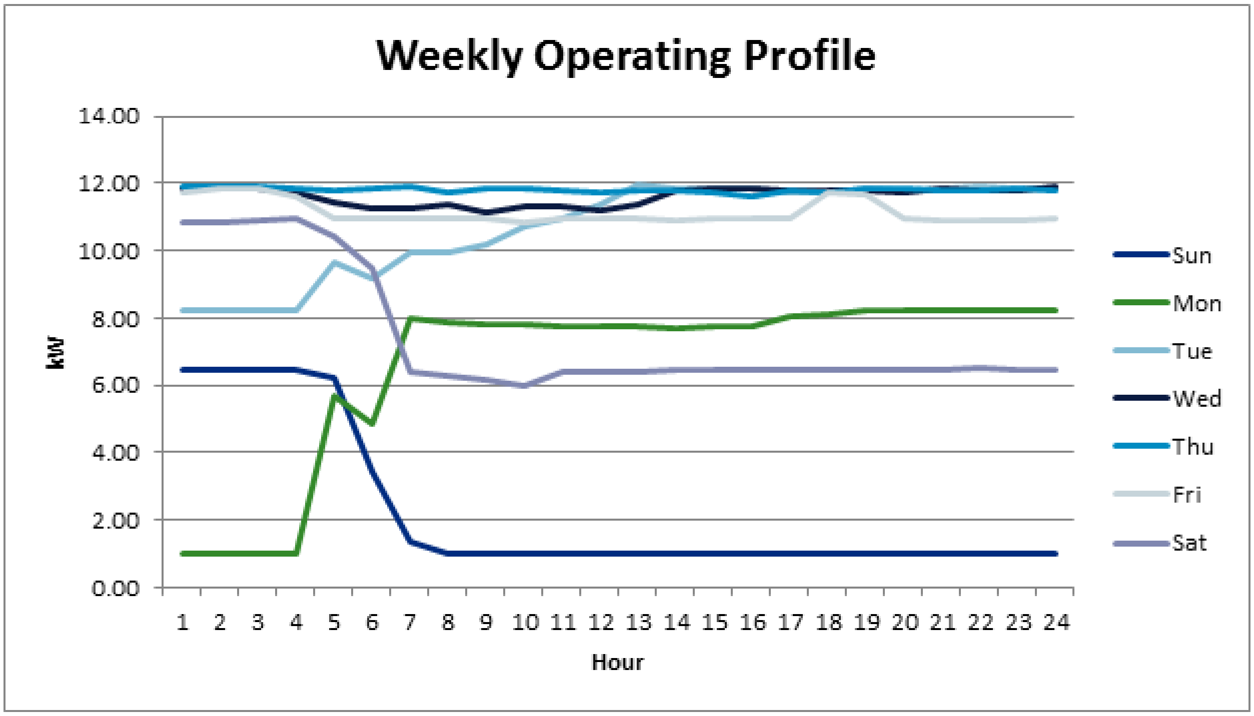
This section briefly describes our basic analysis and shows how the analysis used the data collected to estimate annual energy savings. Overall, the evaluation energy savings were based on the as-found conditions of the installed IMMs, its production hours and production volume, even if the evaluation's findings contrast with the conditions documented in the tracking project files.

Installed Energy Consumption

Monitoring data show the installed equipment generally operated 24 hours per day, 6 days per week, shutting off from 5AM on Sunday to 4AM on Monday. This differed from the 24/7 operation minus holidays assumed in the tracking analysis.

The installed system's annual energy usage was calculated by extrapolating the monitored data. The monitored data from the Elite Pro logger was converted into annual hourly kW values. These values are unique for each hour of the day and each day of the week. The monitored data shows power consumption across all production shifts. A "typical" weekly operating schedule was created from the data. The weekly operating schedules calculated from the installed machine are shown in Figure 2.

Figure 2: Weekly Operating Profile



The weekly operating schedule was confirmed to be representative of a typical week of operation and was used to extrapolate for annual production and operating hours. In addition to the monitored data, it was found that, of the fourteen installed IMMs, only six of the machines were in operation during the monitoring period. Eight were idle (not operating) due to lack of production demand at the time of monitoring. The energy consumption of the six operating machines were calculated based on the three monitored injection molding machines. Based on interviews with the facility manager and production data, the monitored machines are representative of the six operating machines. The eight idle machines resumed operation in late October of 2016. The savings from these machines was calculated by averaging the kW of the monitored machines. From discussions with the facility manager, machines typically had a 75% utilization rate. The 25% additional idle time is primarily due to gaps between contracts, maintenance, and mold changes. Total installed kWh was calculated by multiplying each machine's monitored kW with operating hours. To account for typical idle times, such as those seen in the eight machines idle during monitoring, total machine kW was multiplied by the 75% utilization rate, as shown in the equation below.

$$Total\ Installed\ kWh\ = \sum_{IMM} (Operating\ Hours * kWh) * 0.75\ Utilization\ Rate$$

Baseline Equipment Energy

Based on the interview conducted with the facility manager, the evaluation concludes that a hydraulic machine could be used to meet the current production needs and the standard practice for the customer is to consider all equipment that can meet the specifications of the parts expected to be produced. The customer looked primarily at hydraulic and hybrid machines as they were both capable of producing the parts they were looking to make with the machine. Electric was not considered due to their previous problems with oil leakages in the electric IMM machines. Most the IMMs purchased over the last five years have been hybrid machines with only a couple electric machine purchases. The facility manager stated that, ultimately, the hybrid machine was purchased primarily due to the incentive program. The evaluation therefore agrees that a fully-hydraulic machine is a reasonable baseline that could have been used to fulfil the production needs of the installed hybrid molding machines.

The baseline kW for each IMM was calculated using the flat 51.6% efficiency increase in the installed machine. This efficiency value was used along with the installed machine kWs to estimate the baseline kWs of the operational machines using the equation below. The total baseline kW applied a 0.75 utilization rate to the sum of the baseline IMM kW, as shown in the equation below.

$$Total\ Baseline\ kW = \sum_{IMM} [(Installed\ kW/(1-0.516)] * 0.75\ Utilization\ Rate$$

From the logged data and analysis methodology, it was determined the baseline hydraulic machines used, on average, 3kW each.

Annual Energy Savings

Hourly energy savings was calculated using the following equation for each hour in the 8,760-analysis spreadsheet.

Hourly energy savings (kWh) = Baseline case energy (kWh) – Installed case energy (kWh)

Annual energy savings is calculated as the sum of all hourly energy savings and equal to 80,919 kWh per year.

On-Peak Energy and Peak Demand Savings

The percent on-peak energy savings and demand savings (kW) achieved was calculated using the same 8,760 spreadsheet. Percent on-peak savings was calculated as the sum of hourly savings during the peak period divided by the annual savings estimated. Peak demand savings was calculated as the sum of hourly energy savings during the seasonal peak periods divided by the total hours associated with the period.

Evaluation Results

This section summarizes the evaluation results determined in the analysis above. Table 9 shows the project results compared with the tracking estimates.

Table 9: Project Results by Measure.

Savings Quantity	Tracking Estimate	Evaluation Estimate	Realization Rate
Electric energy (kWh)	338,794	133,168	39%
% of Energy Savings on Peak	49%	58.7%	120%
Summer On-Peak Demand (kW)	41.28	19.98	48%
Winter On-Peak Demand (kW)	N/A	15.81	N/A

The overall realization rate for the project was 39% for the energy savings, 48% for the summer peak demand savings, and 15.81 kW winter peak demand. The discrepancies for energy savings and summer peak demand were primarily because the kW savings per machine was significantly lower than those estimated in the tracking analysis, as shown in **Error! Reference source not found.**. While the installed achine's kW was 27.5% lower than that in the tracking estimate, the overall savings per machine was lower due to a significantly higher baseline kW in the tracking analysis. Another reason for the savings discrepancy was due to the 75% utilization rate, which is 20% lower than estimated in the tracking analysis. In addition, the evaluation found that non-idle machines were typically idle between 5AM on Sunday and 4AM on Monday. The combination of lower operating hours and utilization rate resulted in 2,504 fewer operating hours per year.

Table 10: Comparison of IMM Operation

	Tracking Estimate	Evaluation Estimate	% Difference (Evaluation/Tracking)
Average Baseline kW	5.01 kW	3.02 kW	60%
Average Proposed/Installed kW	1.89 kW	1.47 kW	78%
Average IMM kW Savings	3.12 kW	1.55 kW	50%
Average Annual Operating Hours	7,798	5,294	68%

Comparison of Assumptions

The evaluation analysis assumed a flat savings percentage between the installed machine and baseline machine from discussions with an IMM manufacturer and their estimates. The estimates were based on a generic 30-second cycle time on Haitian's smallest non-custom machine. This estimate is between 16.9-19.6 seconds longer than the cycle times used by the installed machine. Due to the significantly longer cycle time, the baseline energy could differ from the evaluation estimate resulting in a conservative savings estimate. In addition, the size of the machine used in the estimate is a 120-ton Haitian machine, which is double the size of the 60-ton Nissei machines installed. However, this estimate was deemed more accurate than the one used in the tracking analysis, where a different material, cycle time, product, and tonnage were used in the baseline and proposed calculations.

The tracking calculation assumed a 95% machine utilization rate, which differed from the 75% estimated by the facility manager. This accounted for a significant drop in annual operating hours.

Discrepancy Analysis

The savings discrepancies can be attributed to three main factors.

1. The evaluation found the baseline machine ran at a significantly lower kW than in the tracking analysis. The tracking analysis used a larger injection molding machine as a baseline as well as a different material and different number of cavities, resulting in significantly lower evaluated savings
2. The estimated tracking operating hours were 7,798 hours per year as compared to the evaluated annual operating hours of 5,294. The difference was due to fewer operating hours per week and a lower assumed machine utilization rate.

Improvement Opportunities

The accuracy of the energy savings calculation could be improved by ensuring the baseline system's production parameters and size are the same as the ones in the proposed condition. Alternatively, a reasonable power consumption estimate for the baseline machine could be attained from the IMM manufacturer.

SITE ID: DNV 6,9,10

Program Administrator	National Grid
Project ID(s)	4139798, 4139283, 4088596
Project Type	New Construction
Program Year	2013
Evaluation Firm	DNV GL
Evaluation Engineer	Rick Boswell

Project Description

This new construction project installed six hybrid injection molding machines [IMM] at a manufacturing facility distributed between two different locations. The project installed two (2) 500 ton IMM's and two (2) 1,100 ton IMM's in one facility location and, two (2) 500 ton IMM's in another location. Both facilities are owned and operated by the same company and produce the same type of products. Each IMM has the capability to change its mold dependent on the size of the unit produced. Molds are changed regularly with no specific schedule. Hydraulic IMM's were the base-case equipment in the project. This project was classified as new construction because the site added machines while retaining their existing units. Savings for the project were expected to result from higher efficiency IMM's, resulting in a combined (3 applications) estimated annual savings of 1,805,238 kWh. Table 3 shows the overall evaluation results for this project.

Table 11: Project Results

Application	IMM	Annual Tracking Energy	Annual Evaluated Energy	Realization Rate
ID*	Tons (qty)	(kWh)	(kWh)	%
4139283 (#9)	500 (1)	134,018	169,665	127%
4088596 (#6, #10)	500 (1), 1100 (1)	405,686	764,395	188%
4139798 (#1, #4, #7)	500 (2), 1100 (1)	539,704	871,178	161%
Combined	**500 (4), 1100 (2)**	**1,079,409**	**1,805,238**	**167%**

**Numbers in the parenthesis are customer assigned IMM IDs.*

Project Specific Savings

These tables show results by application. One application was completed for each machine. IMM# specific tables are shown in the appendix of this report.

Table 12: Project Results-application 4139283 (#9)

Savings Quantity	Tracking Estimate	Evaluation Estimate	Realization Rate
Electric energy (kWh)	134,018	169,665	127%
% of Energy Savings on Peak	Unknown	49%	N.A.
Summer On-Peak Demand (kW)	13.51	8.32	62%
Winter On-Peak Demand (kW)	13.51	5.31	39%

Table 13: Project Results-application 4088596 (#6, #10)

Savings Quantity	Tracking Estimate	Evaluation Estimate	Realization Rate

Electric energy (kWh)	405,686	764,395	188%
% of Energy Savings on Peak	Unknown	49%	N.A.
Summer On-Peak Demand (kW)	51.09	60.30	118%
Winter On-Peak Demand (kW)	51.10	29.97	59%

Table 14: Project Results-application 4139798 (#1, #4, #7)

Savings Quantity	Tracking Estimate	Evaluation Estimate	Realization Rate
Electric energy (kWh)	539,704	871,178	161%
% of Energy Savings on Peak	Unknown	49%	N.A.
Summer On-Peak Demand (kW)	54.39	64.86	119%
Winter On-Peak Demand (kW)	54.40	30.07	55%

Tracking Savings

This section will summarize the methodology and assumptions used to estimate the Tracking savings claimed for the project.

Baseline Assumption

Conventional hydraulic IMM equipment was specified as the baseline for the six-installed hybrid IMM’s. In the tracking analysis, a Cincinnati-Milacron M-6 1,000 ton hydraulic IMM was used as the baseline for the 1,100-ton installed IMM. A Cincinnati-Milacron M-5 hydraulic IMM was used as the 500-ton baseline for the 500-ton installed IMM. Both facilities operate 24 hours per day, Monday through Friday, with 12 – six day weeks. There are nine holidays and only 40 hours worked during July 4th week. The facility is open 7,937 hours per year. IMM annual operating hours are calculated at 7,540 hours per year based upon a 95% machine utilization rate. Pre-installation monitoring was performed on each of the baseline Cincinnati-Milacron machines. The 1,000-ton baseline IMM was monitored in one minute intervals for one hour and the 500-ton baseline IMM was monitored in one minute intervals for 38 minutes to obtain an average operating kW for each IMM size. Table 4 shows the key baseline parameter assumptions utilized in the tracking analysis.

Table 15: Baseline Key Parameters

	BASELINE SYSTEM		
Parameter	**Value(s)**	**Source of Parameter Value**	**Note**
500-ton Machine [kW]	29.8	38 minutes of power metering in 1-minute intervals	Metered by evaluation/logger removed by site
500-ton Machine Cycle Time [Seconds]	49	Tracking Analysis/Facility Assumption	
500-ton Machine Cycles per Year	553,980	Tracking Analysis/Facility Assumption	
1,000-ton Machine [kW]	52.5	60 minutes of power metering in 1-minute intervals	Metered
1,000-ton Machine Cycle Time [Seconds]	87	Tracking Analysis/Facility Assumption	
1,000-ton Machine Cycles per Year	312,012	Tracking Analysis/Facility Assumption	
Annual Operating Hours	7,540 hours	Tracking Analysis/Facility Assumption	

Proposed Condition

The installation of six hybrid IMM's was used as the proposed condition. In the tracking analysis, one of the two installed 1,100 ton Haitian MA1000 was metered for 67 minutes and one of the four installed 500 ton Haitian MA4700 hybrid IMM's was metered for 60 minutes to determine the average proposed power draw (kW) for each machine size. Facility operating hours remain unchanged from the baseline condition. IMM machine operating hours were based upon new machine cycle time and the number of baseline annual cycles. As the cycle times were shorter for the new installed IMM's with the same number of annual cycles, the IMM annual operating hours were less than the baseline annual operating hours. The adjusted machine operating hours mean that the process throughput is the same between the baseline and installed condition. The metered average kW was multiplied with annual machine operating hours to estimate the annual usage of the proposed machines. Table 16 identifies the proposed IMM variables.

Table 16: Proposed Key Parameters

	PROPOSED SYSTEM		
Parameter	Value(s)	Source of Parameter Value	Note
500-ton Machine [kW]	17.79	60 minutes of power metering in 1-minute intervals	
500-ton Machine Cycle Time [Seconds]	33	Tracking Analysis/Facility Assumption	
500-ton Machine Cycles per Year	553,980	Tracking Analysis/Facility Assumption	
1,100-ton Machine [kW]	22.75	67 minutes of power metering in 1-minute intervals	
1,100-ton Machine Cycle Time [Seconds]	63	Tracking Analysis/Facility Assumption	
1,100-ton Machine Cycles per Year	312,012	Tracking Analysis/Facility Assumption	
Annual Operating Hours	5,460	Tracking Analysis/Facility Assumption	

Tracking Calculation Methodology

The tracking savings were calculated using spreadsheet analysis and monitored power data. The annual savings were estimated by taking the difference between the proposed energy usage and baseline energy usage. Savings are calculated for each machine size. Average base and proposed IMM demand was calculated by the TA monitored data. Baseline cycle times were defined by the TA as 87 seconds and 49 seconds for the 1,000 ton and 500 ton IMM's. Installed cycle times were 63 seconds and 33 seconds for the 1,100 ton and 500 ton IMM's respectively. It is unknown how these cycle times were calculated.

$$Annual\ Energy\ Savings = kWh_{IMM\ Baseline} - kWh_{IMM\ Proposed}$$

The IMM kWh for both the proposed and baseline were calculated by taking the product of the measured power and annual machine hours the IMM.

$$kWh = kW_{IMM} * Hours_{IMM\ Operation}$$

Both installed injection molding machine sizes have lower cycle times, the operating hours were calculated by normalizing the annual production cycles to that of the baseline case using the formula below where 3,600 is the number of seconds in an hour.

$$Hours_{Proposed\ IMM\ Operation} = Baseline\ cycles/year * \frac{Proposed_{sec/cycle}}{3{,}600\ sec}$$

Evaluator Assessment of Tracking Savings

The baseline and installed machines make the same type of parts on-site. In both conditions machine molds changed regularly based upon demand. It is understood that a hydraulic baseline IMM would take longer to produce one unit compared to the installed hybrid IMM. Due to the limited documentation, the underlying assumption used in the tracking calculations such as cycle time, couldn't be verified. Representative IMM's were selected for the baseline and proposed scenarios in the TA and it does not indicate how cycle times are determined. The evaluator has assumed they were obtained from facility engineers and manufacturers specifications.

Baseline monitoring was performed for one hour in one minute increments. The monitoring data measures the average baseline 1,000-ton machine at 80.7 kW. However, notations state that this value, "seemed very far off," and it was reduced to 52.5 kW without further explanation.

Both the retrofit and new construction projects used the same baseline technology for the savings calculations. The rationale behind this assumption was not provided for review. The customer was interviewed to assess if the new construction baseline was appropriate. Although the site would purchase hybrid machines moving forward, evaluators deemed the baseline technology to be accurate as hydraulic machines are standard for this type of manufacturing and are still used on-site.

Project Evaluation

This section summarizes the methodology and assumptions used to evaluate the savings for the project.

Measure Verification

A site visit was performed at the first manufacturing facility on June 21st, 2016 to perform a physical inspection to verify the installation of the measures and install data loggers to monitor energy use. The second facility was inspected on September 15th, 2016 to do the same.

During the site visits, each measure was verified to document installation and intended operation of the measure. Table 6 shows how each measure will be verified to be installed and operating.

Table 17: Measure Verification

Measure Name	Verification Method	Verification Result
1,100-ton hybrid injection molding machine	Make, model, type, name plate information verified by visual inspection	(2) 1,100 ton Haitian MA1000011, MFG: 2013-2014
500-ton hybrid injection molding machine	Make, model, type, name plate information verified by visual inspection	(4) 500 ton Haitian MA4700II, MFG: 2013-2014

Data Collection

Machine Monitoring: The evaluator monitored six-installed hybrid injection molding machines between the two facilities using Dent ElitePro loggers to monitor kW of four 500 ton and two 1,100 ton machines. In addition to the hybrid machines, the evaluator monitored one baseline 1,000 ton hydraulic IMM and one baseline 500 ton hydraulic IMM.

The proposed injection molding machines were installed between two manufacturing facilities owned by the same company manufacturing the same type of parts. Facility 1 installed two 1,100 ton and two 500-ton hybrid IMM's. These IMM's were monitored between 6/21/16 – 8/16/16 for 55 full days. Facility 2 installed two 500-ton hybrid IMM's and were monitored between 9/15/16 – 12/9/16 for 85 full days. Facility 2 also had two baseline hydraulic IMM's, one 1,000 ton and one 500 ton which were metered on-site. The evaluation presented results based on National Grid application ID's as shown in Table 12, Table 13 and Table 14.

The baseline machines monitored by the evaluator at facility 2 as well as a 500-ton hybrid machine experienced issues with the metered data. Upon retrieval of these loggers, it was evident that they had been tampered with as voltage leads were incorrectly attached or not at all. The 1,000-ton baseline data was salvageable with two months of collected data. The 500-ton hybrid and baseline machine data could not be used as less than a day was recorded. An alternative analysis method was used for this machine as is explained later in this report.

Per the tracking documentation, each facility location was supposed to have one 1,100 ton IMM but the customer decided to install both 1,100 ton IMM's at the same location. The metered IMM's capture the different IMM load profiles to consider variances in operating hours and schedule, cycle times, product types, and materials.

Data collected from all IMM's along with production data received from the site was used in the evaluation analysis. Table 7 and Table 20 describes the monitoring installed and completed. Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7 show the monitored equipment power.

Figure 3: IMM#1 Monitored Power kW

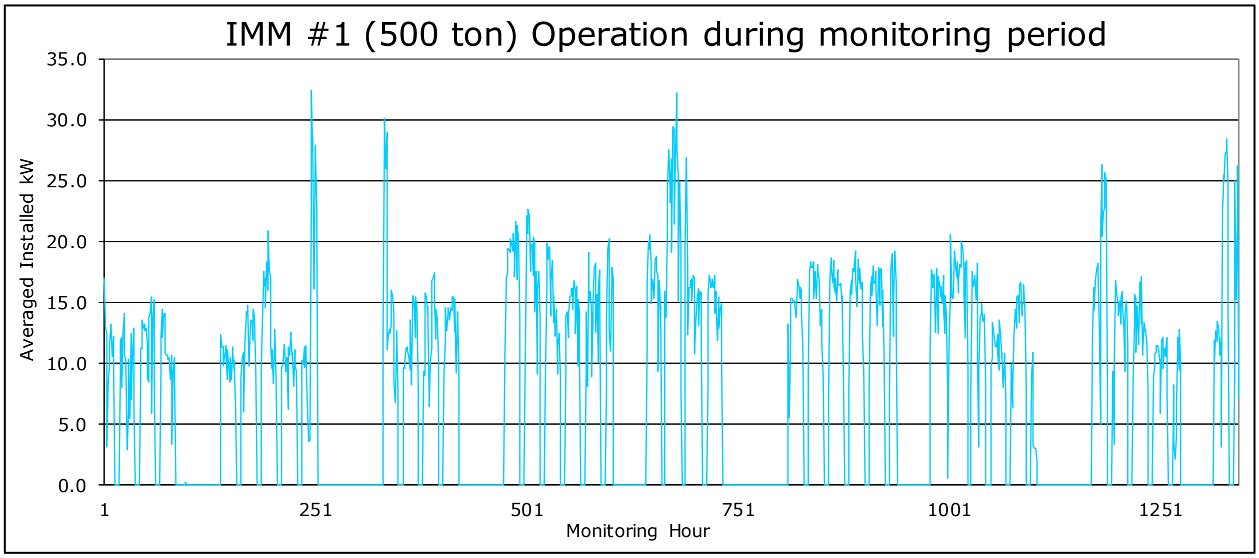


Figure 4: IMM#4 Monitored Power kW

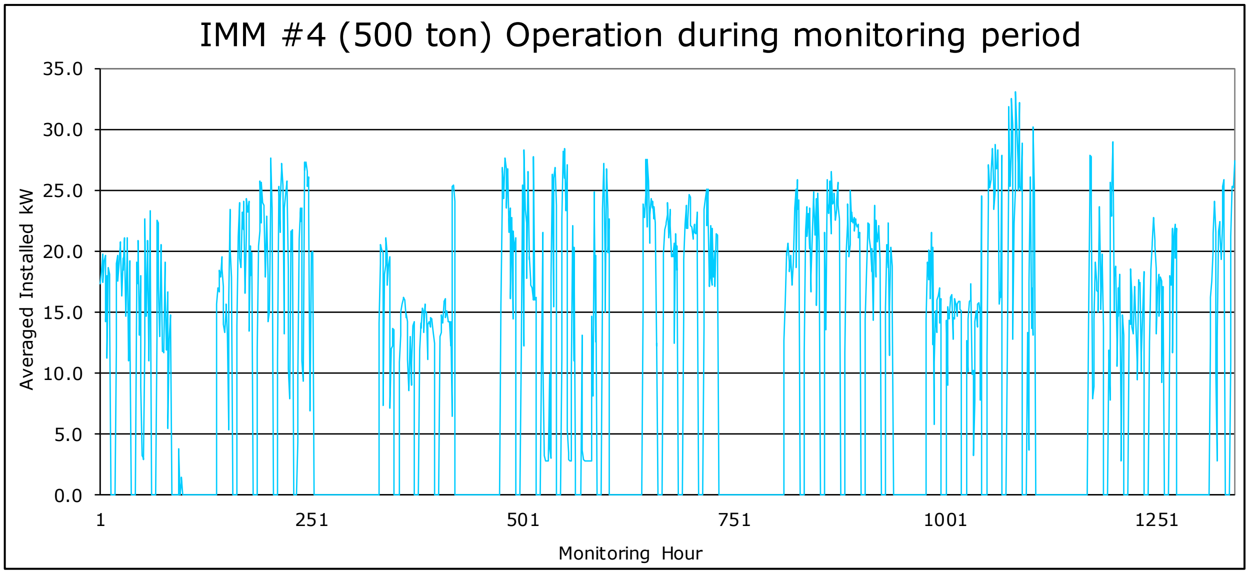


Figure 5: IMM#6 Monitored Power kW

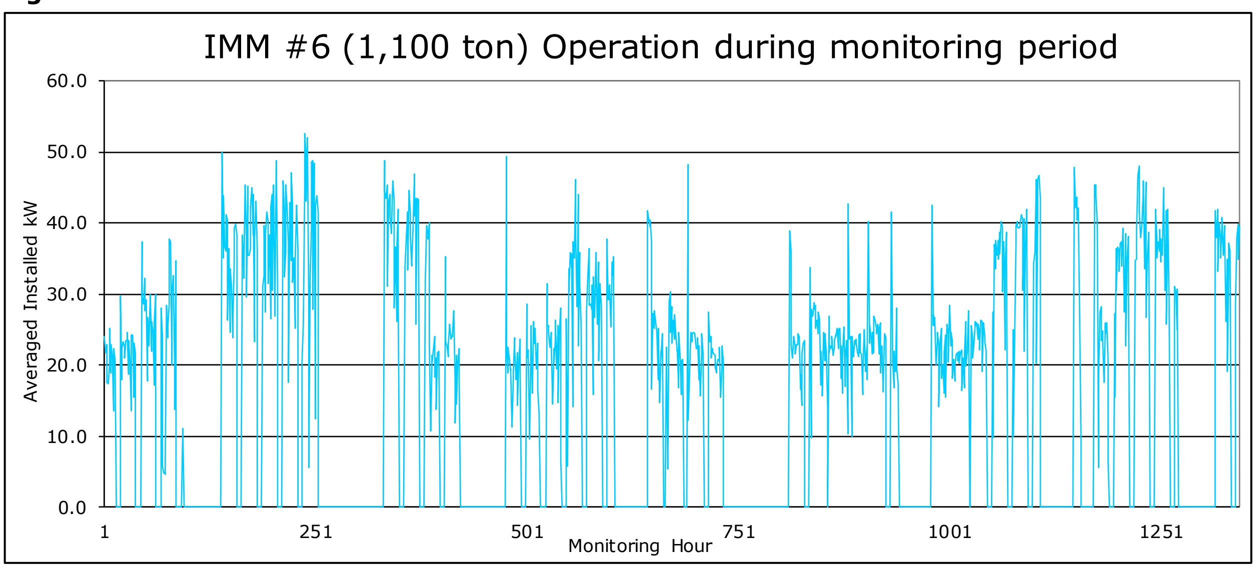


Figure 6: IMM#7 Monitored Power kW

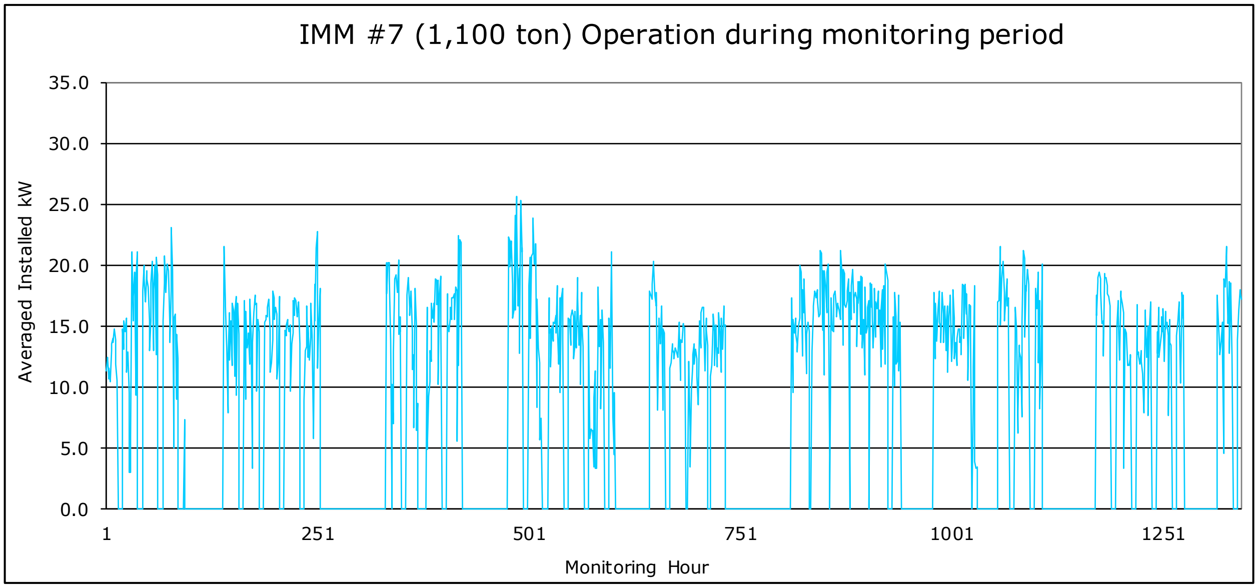
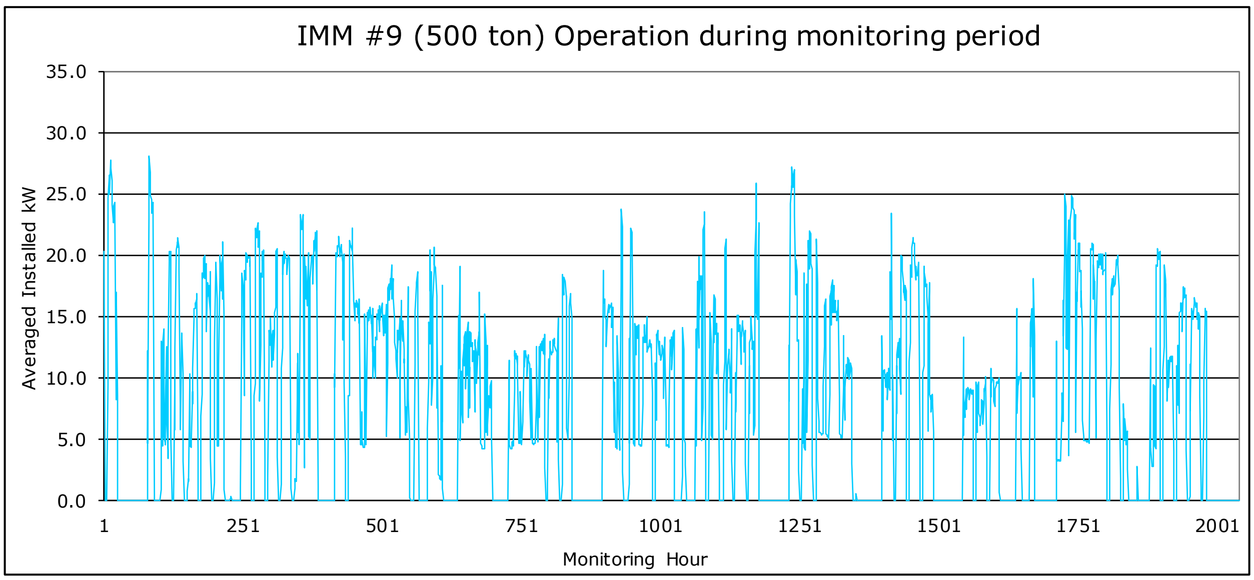


Figure 7: IMM#9 Monitored Power kW



Production Data: The site provided production data to the evaluator a week after the second visit to retrieve the monitoring equipment at facility 2. The production data covers the two installed 1,100-ton hybrid, four 500-ton hybrid as well as the baseline 1,000 ton hydraulic and 500 ton hydraulic IMM metered by this evaluation between the two facilities from 1/2/16 – 12/6/16. The 1,000 ton and 500 ton hydraulic machines represent the baseline for the 1,100 and 500 ton IMM's respectively. Both facilities have three shifts with at least two operating each day. The data provided is aggregated daily by these shifts. However, shift start times are not always the same daily. For example, in the production data, shift 1 in facility 1 can start at 3:50 AM, 6:00 AM, 7:00 AM, 1:30 PM and so on. Shift end times vary similarly. This variance extends across all shifts and both facilities.

Production data identifies the shift, machine number, start time, end time, number of parts made, type of part made and the part weight. The data also contains the number of scrap pieces made and down times of each machine. It is unknown exactly what the down time is, if it it's idle time, or time the machine is offline for. Cycle times for each part made were not provided. There are ten different parts made between each facility with each part capable of varying in weight. That is because the type of part being made is manufactured at different sizes. Table 25 shows the count of different part ID's manufactured and the counts of various part weights per ID.

Table 25: Part-IDs and the counts for each part-weight

Part ID	Part Weight Counts/ID
2ND ROW	32
3RD ROW	8
CARGO	16
DRIVER	67
FRONT SET	4
LEFT REAR	13
PASS THRU	1
PASSENGER	70
REAR SET	35
RIGHT REAR	12

The production data was used to determine the differences in equivalent operating hours between the baseline and proposed cases. The production information was also used in conjunction with the metering data to determine the power usage per part, annual power usage by volume of product produced, and the annual energy savings. Table 7, Table 8, Table 8 and Table 29 show the data that was collected and received as part of this evaluation.

Table 26: Evaluation Data Collection – Installed Equipment (Facility 1)

Parameter	M&V Equipment Brand and Model	Metering Start/Stop Dates	Quantity	Metering Interval
500 ton IMM– Energy Consumption	Dent ElitePro Logger	June 21st/August 16th	2	5 minutes
1,100 ton IMM – Energy Consumption	Dent ElitePro Logger	June 21st/August 16th	2	5 minutes

Table 20: Evaluation Data Collection – Installed Equipment (Facility 2)

Parameter	M&V Equipment Brand and Model	Metering Start/Stop Dates	Quantity	Metering Interval
500 ton IMM– Energy Consumption	Dent ElitePro Logger	Sept. 15th/Dec. 9	2	5 minutes
1,000 ton IMM – Energy Consumption (Baseline)	Dent ElitePro Logger	Sept. 15th/Dec. 9	1	5 minutes
500 ton IMM – Energy Consumption (Baseline)	Dent ElitePro Logger	Sept. 15th/Dec. 9	1	5 minutes

Table 28: Evaluation Data Collection – Production Data Received (Facility 1)

Machine	Source	Interval	Duration

1,100 ton IMM – 7 (MA1000011, Installed)	Site – production logs	Varying	340 days
1,100 ton IMM – 6 (MA1000011, Installed)	Site – production logs	Varying	340 days
500 ton IMM – 4 (MA4700II, Installed)	Site – production logs	Varying	340 days
500 ton IMM – 1 (MA4700II, Installed)	Site – production logs	Varying	340 days

Table 29: Evaluation Data Collection – Production Data Received (Facility 2)

Machine	Source	Interval	Duration
1,000 ton IMM – 6 (H-1000-165, Baseline)	Site – production logs	Varying	
500 ton IMM – 7 (VH500-54, Baseline)	Site – production logs	Varying	340 days
500 ton IMM – 9 (MA4700II, Installed)	Site – production logs	Varying	340 days
500 ton IMM – 10 (MA4700II, Installed)	Site – production logs	Varying	

A list of key questions and their customer responses for the site is provided below:

- What products does each injection molding machine produce? How does this affect their cycle time?
    - The IMM produce all weather car mats. Each IMM changes regularly with no schedule.
- Does each IMM make more than one product? If so, what are their cycle times?
    - Yes. The 500 ton IMM cycle times range from 50s – 70s, the 1,100 ton IMM cycle times range from 65s – 85s.
- Do you have an EMS that tracks manufacturing information?
    - Yes.
- What is the operating schedule for each machine and what are their utilization rates?
    - During the logger installation of facility one it was the slow season. The schedule was two – eight hour shifts, 5 days a week. Otherwise the schedule would normally be two – 12 hour shifts, 6 days a week.
- Are there any seasonal differences in production?
    - Yes. Summer is slower.
- How does the current production schedule compare with previous and expected future production?
    - Current schedule is less hours. Peak production happens September through November when production could be 24/7.
- Have there been any significant changes to the operating schedule beyond those that resulted from the installation of the new IMMs?
    - No.
- How is the hydraulic oil cooled at the facility?

- Heat exchanger intercooler. Each IMM barrel and oil are cooled with their own air cooled chiller.

- Over the past five years, what has been the standard practice for IMM purchases? What percentage of new machines were hydraulic, hybrid, and/or electric? Is there a standard practice for different capacities and use cases? Standard practice for IMM purchases would be to go 100% hybrid.
- What types of machines are currently running at the facility? Mostly hybrid and some hydraulic.
- How do the Pre-retrofit hydraulic machines compare with the new hydraulic machines in terms of the oil displacement pump motor efficiency? Ask on pick up

Evaluation Savings Analysis

This section briefly describes our basic analysis plan and shows how the analysis is going to use the data planned to be collected to estimate annual energy savings. Overall, the evaluation energy savings will be based on the as found conditions with the installed IMM's, its production hours and production volume, even if the evaluation's findings contrast with the conditions documented in the project files.

Some Quick Definitions: The customer manufactures car mats for different car models and car makers, hence multiple part-weights for the same part name or ID. For example, both Sedan and a SUV will have PASSENGER mats etc.

Part ID: These are part names assigned by the manufacturer, ex: PASSENGER, REAR SET, DRIVER etc.

Part-Weight: Each Part ID has multiple part-weights. For example, PASSENGER has 1.39 lb.,1.89lb., 2.30lb etc. and, from Table 25 there are 70 different part-weights for "PASSENGER" part ID.

Part-Weight ID: Each part weight has been assigned an ID (A, B, C. etc., see Table 30)

To reduce the complexity of the calculation, DNV GL created unique ID's for each IMM based on their part weights. Savings for IMMs were calculated using the same methodology and to avoid redundancy in the report the savings calculation for one 1,100 ton IMM (#6) is shown below and the machine specific results are presented in the appendix.

Estimation of IMM#6 Installed Energy Consumption

Production data supplied by the customer has the following parameters for every IMM (Dates: 1/2/16 – 12/6/16).

Part ID	Shift (#)	Date	Start Time	End Time	IMM #
Machine Pieces	Startup Scrap PCS	Scrap Qty PCS	Change Over Time (MIN)	Down Time (MIN)	Part Weight (LBS)

Using this production data, DNV GL calculated:

1. IMM Run Hours
2. Total Manufactured Weight (LBS)
3. Lbs/hr.

DNV GL then identified nine unique part-weights during the monitoring period (6/22/16 thru 8/15/16). To further reduce the complexity, DNV GL used an incremental factor of 10% and assigned IMM specific part-weight ID's for every part as shown in Table 30.

For example, the lowest part-weight in the table is 2.78 lb and a 10% incremental factor would be 3.058 lb. Therefore, all the part-weights in that range (2.78-3.058) have the same part-weight ID "A".

Table 30: Unique part-weights during the monitoring period and their part-weight IDs

Unique part-weights (monitoring period) lbs.	Part-weight ID	Part-weight with 10% incremental factor (lbs.)
2.78	A	3.058
2.95	A	-
3.03	A	-
3.22	B	3.542
4.10	C	4.51
4.18	C	-
4.52	D	4.972
5.48	E	6.028
9.41	F	10.351

For each part-weight ID (as shown in Figure 8), energy intensity was calculated by taking the ratio of hourly averaged monitored kW and total lbs. of product used in that hour (from production data).

Figure 8: Snapshot of IMM#6 energy intensity calculation for a part-weight ID "A"

Part Weight ID	Date	Hour	Average of Monitored kW	Sum of Final lbs/hr		kW/lb
A	⊟ 22-Jun	6	17.26	146.15		0.12
A		7	21.56	146.15		0.15
A		8	23.26	146.15		0.16
A		9	22.68	146.15		0.16
A		10	20.60	146.15		0.14
A		11	23.51	146.15		0.16
A		12	23.34	146.15		0.16
A		13	24.53	146.15		0.17
A		14	19.86	138.54		0.14
A		15	22.71	130.93		0.17
A		16	21.88	130.93		0.17
A		17	12.14	130.93		0.09
A		18	24.29	130.93		0.19
A		19	24.22	130.93		0.19
A		20	15.36	130.93		0.12
A		21	22.91	130.93		0.17
A		22	7.67	32.73		0.23

Average energy intensity (kW/lb) for each part-weight ID and their average part-weights were calculated and presented in the following Table 31.

Table 31: Energy Intensity for each part-weight (monitoring period only)

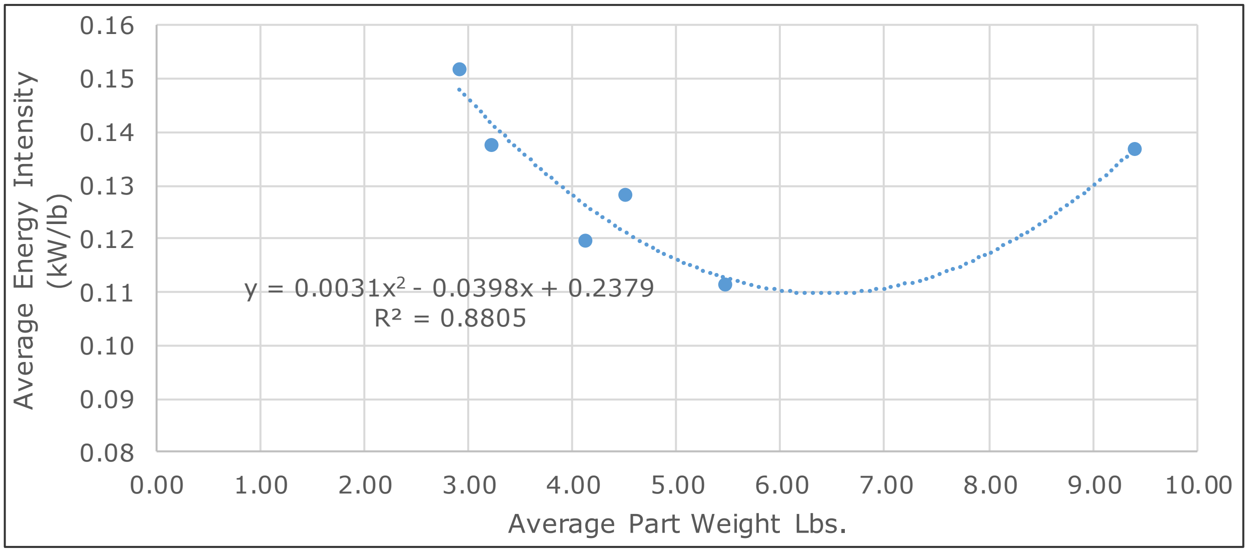
Part-weight ID	Average Part weight (Lbs.)	Average Installed Energy Intensity (kW/Lb)
A	2.92	0.15
B	3.22	0.14
C	4.14	0.12

D	4.52	0.13
E	5.48	0.11
F	9.41	0.14

Annual Expansion

Annual production data for IMM#6 shows 26 unique parts (part-weights) and only nine have been captured in the monitoring period. DNV GL used regression analysis to extrapolate energy intensity for the remaining 17 part-weights as shown below.

Figure 9: Extrapolation of Energy Intensity based on the part-weight using regression analysis



Equation 1:

$y = 0.0031X^2 - 0.0398X + 0.2379$; $R^2 = 0.8805$

Where,

X: Part-weight (Lbs.)

Y: Energy Intensity (kW/Lb)

Using Equation 1, energy intensities for the remaining 17 part-weights have been calculated and presented in Table 32 below. Note that all 17-new part-weights have been given the same part-weight ID- “X”.

Table 32: Installed Average Energy Intensities for IMM#6

S. No	Part-weight ID	Part-weight ID	Average Installed Energy Intensity kW/lb
1	2.16	X	0.17
2	2.29	X	0.16
3	2.30	X	0.16
4	2.50	X	0.16
5	2.58	X	0.16
6	2.78	A	0.15
7	2.95	A	0.15

8	3.03	A	0.15
9	3.22	B	0.14
10	3.24	X	0.14
11	3.28	X	0.14
12	4.08	X	0.13
13	4.10	C	0.12
14	4.15	X	0.13
15	4.18	C	0.12
16	4.52	D	0.13
17	5.04	X	0.12
18	5.05	X	0.12
19	5.15	X	0.12
20	5.18	X	0.11
21	5.24	X	0.11
22	5.28	X	0.11
23	5.48	E	0.11
24	6.46	X	0.11
25	6.70	X	0.11
26	9.41	F	0.14

As mentioned earlier, production data was not provided for a calendar year but only for only 338 days. DNV GL assumed the production to be linear during the remaining 27 days of the year and expanded Annual Installed Run-hours to the entire year (365 days) using linear ratio factor (i.e. 365 days/338 days =1.0798).

Installed Energy Consumption

Equation 2:

Installed energy (kWh)

= Installed Energy Intensity (kW/lb) * Installed Annual Run-hours * (Production Lbs /hour)

Where,

Production/hour = Total Production weight by part-weight/ Total Run-hours

Installed case energy for IMM#6 was calculated to be 126,839 kWh as shown in the Table 33 below.

Table 33: Annually expanded run-hour and total Installed Energy consumption for IMM#6

Part-weight ID	Run-hours in 338 days	Installed Annual Run-hours	Installed Average kW/LB	lbs/hr	Installed kWh
A	479	518	0.15	140	11,019
B	191	206	0.14	162	4,605
C	254	274	0.12	204	6,702
D	346	373	0.13	227	10,872
E	124	134	0.11	230	3,455
F	1,551	1,675	0.14	277	63,561

X	1,080	1,166	0.13	172	26,625
Total	**4,025**	**4,347**	**0.13**	**N.A.**	**126,839**

Estimation of IMM#6 Baseline Energy Consumption

DNV GL metered one 500-ton and one 1,000-ton hydraulic proxy machine for baseline energy calculations. And as mentioned in Data Collection section, only 1,000-ton machine monitored data was salvageable and was used in this analysis.

1,000-ton hydraulic (baseline) proxy

Although the installed machines were 1,100-tons in size and DNV GL assumed metered 1,000-ton proxy baseline which was 1,000-ton IMM to consume the same energy as 1,100-ton units. Baseline energy intensities for the part-weight IDs for the monitoring period were also calculated using the same methodology as installed case in the previous section and are shown in Table 34.

Table 34: Baseline Energy Intensities for the part-weight IDs during the monitoring period

Baseline Part-weight IDs	Average of Part Weight LBS.	Baseline Average Intensity kW/lb
a	1.61	0.80
b	2.99	0.69
c	3.32	0.63
d	4.09	0.63
e	4.38	0.53
f	4.97	0.57
g	5.63	0.54
h	6.23	0.48

Baseline energy intensity for any part-weight can be calculated using the regression analysis equation shown in Figure 10.

Equation 3:

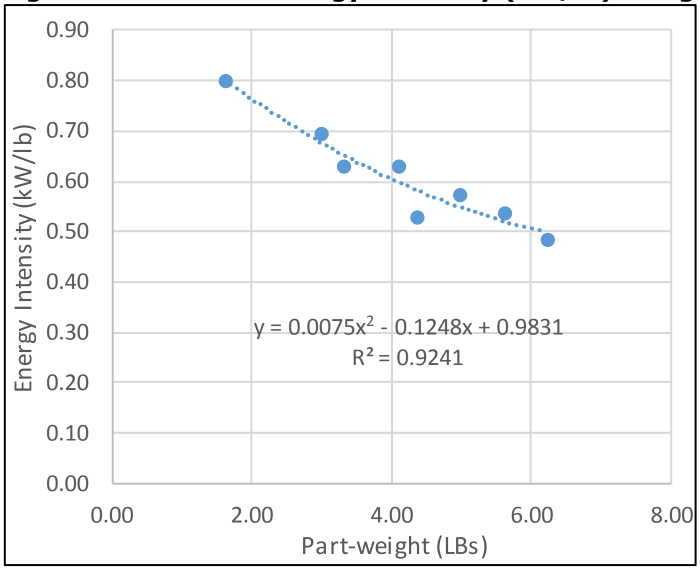
$y = 0.0075x^2 - 0.1248x + 0.9831$; ($R^2 = 0.9241$)

Where,

y: Energy Intensity (kW/lb)

x: part-weight (lbs.)

Figure 10: Baseline Energy Intensity (kW/lb) using part-weight (lb)



For IMM#6, using Equation 3, baseline energy intensity for IMM# 6 is shown in Table 35.

Table 35: Calculated Baseline Energy Intensities for IMM#6

S.No	Part-Weight LBS	Part-weight ID	Calculated Baseline Energy Intensity kW/lb
1	2.16	X	0.75
2	2.29	X	0.74
3	2.30	X	0.74
4	2.50	X	0.72
5	2.58	X	0.71
6	2.78	A	0.69
7	2.95	A	0.68
8	3.03	A	0.67
9	3.22	B	0.66
10	3.24	X	0.66
11	3.28	X	0.65
12	4.08	X	0.60
13	4.10	C	0.60
14	4.15	X	0.59
15	4.18	C	0.59
16	4.52	D	0.57
17	5.04	X	0.54
18	5.05	X	0.54
19	5.15	X	0.54
20	5.18	X	0.54
21	5.24	X	0.54
22	5.28	X	0.53
23	5.48	E	0.52
24	6.46	X	0.49

25	6.70	X	0.48
26	9.41	F	0.47

Baseline Energy Consumption (kWh):

Equation 4:

Baseline energy (kWh)

= Baseline Energy Intensity (kW/lb) * Baseline Annual Run-hours * (Production Lbs /hour)

Where,

Production/hour = Total Production weight by part-weight/ Total Run-hours (For IMM#6)

Installed case energy for IMM#6 was calculated to be 126,780 kWh as shown in the Table 33 below.

Equation 5

Annual Baseline Run-hours = Installed Run-hours*cycle time factor

Cycle time factor = Tracking Baseline Cycle Time/Tracking Installed Cycle time

= 87 seconds /63 seconds

= 1.38

Table 36: Annually expanded run-hours and total baseline Energy consumption for IMM#6

Part-weight ID	Installed Annual Run-hours	lbs/hr	Baseline kW/lb	Baseline Annual Run-hours	Baseline kWh
A	518	140	0.68	715	68,349
B	206	162	0.66	285	30,417
C	274	204	0.59	379	45,926
D	373	227	0.57	515	66,945
E	134	230	0.52	185	22,405
F	1,675	277	0.47	2,313	303,055
X	1,166	172	0.61	1,610	169,147
Total	**4,347**	**N.A.**	**0.59**	**6,002**	**706,244**

Installed case energy for IMM#6 was calculated to be 706,244 kWh as shown in the Table 36 above.

Annual Energy Savings (1,100-ton IMM#6)

Annual energy savings will be calculated using the following equation.

Annual energy savings (kWh) = Baseline case energy (kWh) – Installed case energy (kWh)

=126,839 kWh – 706,244 kWh

=579,405 kWh

Tracking Energy Savings = 271,668 kWh; Therefore,

Realization Rate for #IMM6 = 579,405/271,668 = 213%

500-ton hydraulic (baseline) proxy

Meter that was installed on a 500-ton hydraulic IMM failed, so evaluation used one of the tracking assumptions in calculating the baseline energy intensity (kW/lb) as shown below.

In the Tracking (installed) calculation of 500-ton IMM:

Energy intensity for a 2.057 lb. part = 0.079 kW/lb

From the evaluated analysis for IMM#1:

Energy intensity for the same part weight of 2.057 lb = 0.156 kW/lb

Baseline conversion factor $_{\text{(for IMM\# 1)}}$ = 0.079/0.156 = 1.971[4]

Therefore,

Equation 6

Evaluated Baseline Energy Intensity (kW/lb) $_{\text{for any part-weight of 500-ton IMM}}$

= Evaluated Installed Energy Intensity of the part (kW/lb) * (Baseline Conversion factor of the IMM)

Therefore, for IMM#1,

And for the same part-weight, evaluated baseline energy intensity = 0.156*1.971= 0.308 kW/lb

On-Peak Savings

The percent on-peak savings was calculated by taking ratio of Annual On-peak hours (4,032 hours) to total calendar operating hours. On-peak demand savings (kW) was achieved by calculating savings at each peak hour and the product weight manufactured during that hour. DNV GL used an 8,760 spreadsheet for this calculation.

Interactive Savings

The production floor was unconditioned; therefore, no interactive cooling savings were achieved.

Evaluation Results

Overall, projects are achieving more energy savings than claimed. This is primarily due to energy intensity (kW/lb) of each part manufactured on each machine. TA assumed significantly higher production (see Table 40) but lower energy intensities (kW/lb). Other significant difference between Tracking and Evaluation analysis was found to be the number parts used in the analysis; tracking analysis used only one part (weight) in the savings calculation but evaluation found multiple parts being manufactured on each machine during a calendar year.

[4] The conversion factor changes for every IMM based on its installed energy intensity for a part that weighs 2.057 lbs.

Table 37: Evaluation Results: annual energy savings

Application	IMM	Annual Tracking Energy	Annual Evaluated Energy	Realization Rate
ID	Tons (qty)	(kWh)	(kWh)	%
4139283 (#9)	500 (1)	134,018	169,665	127%
4088596 (#6, #10)	500 (1), 1100 (1)	405,686	764,395	188%
4139798 (#1, #4, #7)	500 (2), 1100 (1)	539,704	871,178	161%
Combined	**500 (4), 1100 (2)**	**1,079,409**	**1,805,238**	**167%**

Table 38: Evaluation results, Summer and Winter on-peak demand reduction

On Peak kW	Tracking		Evaluated	
	Summer	Winter	Summer	Winter
4139283 (#9)	13.51	13.51	8.32	5.31
4088596 (#6,#10)	51.09	51.10	60.30	29.97
4139798 (#1,#4,#7)	54.39	54.40	64.86	30.07

Comparison of Assumptions

The purpose of the below tables (Table 39 through Table 42) is to provide a comparison of the key inputs of the tracking and evaluation calculations to demonstrate the sources of savings discrepancies. The realization rates calculated provide an indication of the discrepancies' contribution to the savings variance.

Table 39: Comparison of installed operating hours (Sum of all IMM operating hours/application)

Application	IMM	TA Assumed	Evaluation	Realization
	Tons (qty)	Total Operating hours	Total Operating hours	Rate
4139283 (#9)	500 (1)	5,078	3,340	66%
4088596 (#6, #10)	500 (1), 1100 (1)	10,538	8,073	77%
4139798 (#1, #4, #7)	500 (2), 1100 (1)	15,616	13,652	87%

Table 40: Comparison of annual production

Application	IMM	TA Assumed	Evaluation	Realization
	Tons (qty)	Lbs	Lbs	Rate
4139283 (#9)	500 (1)	1,139,812	344,544	30%
4088596 (#6, #10)	500 (1), 1100 (1)	2,243,989	1,318,114	59%
4139798 (#1, #4, #7)	500 (2), 1100 (1)	3,383,801	1,995,582	59%

Table 41: Comparison of installed energy intensity

Application	IMM	TA Assumed	Evaluation	Realization
	Tons (qty)	Average (kWh/lb)	Average (kWh/lb)	Rate
4139283 (#9)	500 (1)	0.079	0.177	223%
4088596 (#6, #10)	500 (1), 1100 (1)	0.096	0.154	161%
4139798 (#1, #4, #7)	500 (2), 1100 (1)	0.090	0.135	150%

Table 42: Comparison of baseline energy intensity

Application	IMM	TA Assumed	Evaluation	Realization
	Tons (qty)	Average (kWh/lb)	Average (kWh/lb)	Rate
4139283 (#9)	500 (1)	0.197	0.420	214%
4088596 (#6, #10)	500 (1), 1100 (1)	0.375	0.504	134%
4139798 (#1, #4, #7)	500 (2), 1100 (1)	0.316	0.390	124%

Improvement Opportunities

4. The savings can be better estimated by conducting the onsite metering (both baseline proxy and installed machines) for multiple days when various molds are used. This should improve the estimates of average machine consumption.

5. It is also recommended to use installed and baseline average energy intensity (kWh/lb) to calculate savings based on an estimated production weights for any future projects.

6. Furthermore, any adjustments the TA makes should be made to the energy intensity and not to a single parameter such as the cycle time as was done here. If single parameter adjustments are determined to be the best option, then high frequency spot metering data should be collected and an adjustment to the average power consumption should also be made.

APPENDIX

Table 43: Evaluation Results: annual energy savings by IMM

IMM #	Size	Savings (kWh)		RR
	Tons	Tracking	Evaluated	
IMM #1	500	134,018	164,607	123%
IMM #4	500	134,018	153,300	114%
IMM #6	1100	271,668	579,405	213%
IMM #7	1100	271,668	553,272	204%
IMM #9	500	134,018	169,665	127%
IMM #10	500	134,018	184,990	138%

Table 44: Evaluation Results: annual peak demands (kW) by IMM

IMM #	Size	On Peak	
	Tons	Summer	Winter
IMM #1	500	5.03	3.37
IMM #4	500	2.94	2.02
IMM #6	1100	50.08	24.78
IMM #7	1100	56.90	24.68
IMM #9	500	8.32	5.31
IMM #10	500	10.21	5.19

Table 45: Evaluation Results: average Installed energy intensities (kW/lb) by IMM

IMM #	Size	Installed		
	Tons	Average kW/lb	Min kW/lb	Max kW/lb
IMM #1	500	0.133	0.075	0.163
IMM #4	500	0.163	0.141	0.227
IMM #6	1100	0.131	0.112	0.152
IMM #7	1100	0.110	0.076	0.184
IMM #9	500	0.177	0.006	0.351
IMM #10	500	0.177	0.006	0.351

Table 46: Evaluation Results: average baseline energy intensities (kW/lb) by IMM

IMM #	Size	Baseline		
	Tons	Average kW/lb	Min kW/lb	Max kW/lb
IMM #1	500	0.263	0.148	0.321
IMM #4	500	0.285	0.246	0.397
IMM #6	1100	0.588	0.473	0.683
IMM #7	1100	0.622	0.490	0.809
IMM #9	500	0.420	0.015	0.834
IMM #10	500	0.420	0.834	0.015

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter, and greener.