Continuous Improvement in Industrial Facilities: Best Practices, Successes and Opportunities

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ABSTRACT

Industrial continuous improvement programs are quickly gaining popularity as deeper energy savings become more challenging to find. Continuous improvement programs identify energy saving opportunities and achieve energy savings by helping industrial facilities implement energy management techniques. As these programs continue to expand, it is crucial for energy efficiency program implementers to understand the key factors that contribute toward program successes. This paper presents results from the 2014 evaluation of Consumers Energy's Industrial Continuous Improvement Pilot (ICIP,) identifying best practices and key factors that contribute toward program successes and challenges. The ICIP program is designed to help industrial facilities integrate Energy Management Systems (EnMS) into continuous improvement processes to help reduce energy consumption, emissions, and operational costs. Key findings from the paper include data on motivation for participation in the ICIP program, factors that contribute toward participant satisfaction, best practices in performing energy audits and gap analyses, a discussion of measurement and verification (M&V) methods, direct and indirect energy savings impacts, and a discussion of program successes and opportunities. Findings discussed in this paper will aid any program in raising participation levels, identifying savings potential, and ultimately help to achieve deeper energy savings in the industrial sector.

Introduction

This paper describes results from the 2014 evaluation of the Industrial Continuous Improvement Pilot Program (ICIP). The ICIP program is designed to help industrial facilities integrate Energy Management Systems (EnMS) into continuous improvement processes to help reduce energy consumption, emissions, and operational costs.

Consumers Energy launched the Industrial Continuous Improvement Pilot Program in June 2012 to encourage industrial customers to develop energy efficiency energy management practices for continuous improvement processes and facilitate achieving energy management certifications. The pilot targets large industrial facilities with average energy consumption of at least 1,000 MWh or 30,000 MCF to encourage strategic management of their energy use through the continual adoption of new energy efficiency technology and energy management practices. The Pilot accomplishes this by: (1) providing technical assistance from energy advisors and engineers, (2) supporting facilities in setting energy targets and policies, (3) encouraging the adoption of energy management certifications (e.g., ISO 50001/SEP, and ENERGY STAR Challenge for Industry), and (4) providing financial incentives for verifiable reductions in

energy intensity and meeting major strategic milestones.

The overall objective of this study is to provide guidance on the current pilot structure by identifying successes, challenges, and opportunities for the Pilot, as well as assessing its overall scalability to an on-going program. To conduct the study, EMI Consulting first reviewed the Pilot's approach to documenting energy impacts attributable to ICIP. The research team then conducted four in-depth interviews with the Pilot's participants in order to gather feedback on the Pilot design, Pilot processes, and customer experiences with the Pilot. Lastly, EMI Consulting performed a simple cost effectiveness calculation to better understand overall impacts as they relate to direct program costs.

Based on a review of the pilot, the research team identified the following key findings:

- ICIP energy impacts can be quantified with standard methods used to calculate "custom" measures.
- The researchers concluded that the current data captured in the audit report was adequate for determining the pre-case conditions against which the post-condition could be compared.
- Based on in-depth interviews with Pilot participants, EMI Consulting found that interviewees were satisfied with the Pilot and would like to see ICIP continue into the future.
- Interviewees indicated they were unaware of most low- and no-cost energy efficiency opportunities until they were identified through the ICIP process. For measures that interviewees had previously identified, The ICIP energy audit report helped interviewees implement energy efficiency measures much faster than they would have otherwise done.
- ICIP interviewees found the energy audit reports and gap analyses to be the most helpful and valuable service provided by the Pilot.
- ICIP is successfully promoting the integration of energy management practices into participant workflows.

Overall, the researchers found the Pilot to be working smoothly. The research team expects to be able to verify energy savings for ICIP through custom calculation methods. Most importantly, the ICIP program structure was working well. Participants indicated satisfaction with the Pilot and they were implementing ICIP-recommended measures. Additionally, EMI Consulting observed that ICIP participants were actively engaged with energy management and were discovering new ways to monitor and save energy.

The remainder of this study summarizes the findings of our overall approach to evaluating energy savings impacts from ICIP measures, details results from the in-depth participant interviews, and summarizes our results and best practices.

Recommended Approach to Calculating Energy Impacts

To better understand how to verify energy impacts attributable to ICIP, the research team conducted a review of program data and identified a method to verify energy impacts. This

section presents the research team's recommendations for verifying energy impacts and identifies project data needed to verify savings.

Method to Verify Energy Impacts

Given the nature of industrial facilities, the measures included as part of the ICIP program, defined as both energy saving equipment and operational or behavioral modifications, vary widely between participants. Therefore, the research team recommends calculating energy savings similarly to how "custom" measures are typically calculated in energy efficiency programs. These methods typically compare pre- and post- conditions to calculate savings, such as measuring load factors, efficiencies, schedules, etc. As such, these measures would be evaluated in a manner similar to the custom projects. Below presents the steps the research team would take to verify the calculated energy savings.

1. **Obtain project files from Program Implementer.** The research team expects to collect project documentation consisting of both electronic data and paper records. At minimum, it will be necessary for the research team to obtain savings estimates from ICIP staff as well as the approved calculation methods used to produce the ex-ante and savings estimates for each measure. The research team will determine if appropriate estimate calculation methods were used, attempt to replicate calculations to the extent practical, compare results, and check for calculation errors.

2. **Finalize measurement and verification plans.** The research team will develop an on-site data collection protocol for each project while taking into consideration project complexity, savings magnitude, and measure technologies. Protocols will vary for each project depending on the type of equipment but, in general, will include customer interviews, on-site data collection and instrument installation guidelines or desk review, specific instructions for how many power or energy measurements and/or data loggers to use, and whether to use spot power measurements, extended-duration power metering, equipment run-time loggers or some combination of these.

3. **Conduct on-site assessments**. The research team will follow methods outlined in the International Performance Measurement & Verification Protocol (IPMVP.) The IPMVP outlines four research methods. The four IPMVP approaches are described in Table 1.

   The specific IPMVP approach taken for each project will be based on criteria such as:

   - Which energy efficiency savings measure performance parameters may reasonably be considered invariant when the measure is reducing energy use and demand
   - Expected impacts (sensitivity and risk) associated with uncertainty in each of the measure's parameters included in the performance calculation
   - Availability and physical accessibility of performance parameters for measurement
   - Cost to determine a performance parameter versus impact on accuracy, etc.

4. **Calculate energy savings**. The research team will calculate energy savings for the each implemented measure attributable to the ICIP.

Table 1: International Performance Measurement & Verification Protocol Approaches

IMPVP Option	Used For	Examples
A. Retrofit Isolation with Key Parameter Measurement	Calibrating energy models where metering all points is cost-prohibitive for the amount of savings, or not possible.	Spot check on lighting power plus logging hours of usage; using an on/off logger to estimate packaged air conditioning unit load.
Retrofit Isolation with All Parameter Measurement	Determining loading and duty cycle for measures that have significant savings and where all significant parameters can be metered.	Determining the duty cycle of a variable frequency drive; measuring the duty cycle and output of a large chiller.
C. Whole Facility	Projects that are expected to save at least 10% of facility/ meter consumption.	Multiple measure/ comprehensive facility projects such as retrocommissioning, new control systems, or major system replacements or upgrades.
D. Calibrated Simulation	New construction primarily, or major retrofit projects and complex projects that are expected to save less than 10% of the facility/ meter consumption.	New construction and retrocommissioning projects where the quantity of affected equipment and systems results in prohibitively expensive alternate M&V methods.

Review of Available Data

To verify energy savings, evaluators will need to understand operations before the measures were implemented (e.g., the pre-case condition). To do so, evaluators will rely heavily on the information presented in the original project documentation or collected through the audit process prior to project completion. To assess whether the audit reports provide sufficient data to determine pre-case conditions, EMI Consulting reviewed the ICIP participant energy audit reports. Based on this review, EMI Consulting determined that the audit reports were adequate for establishing the pre-case condition against which the post-condition would be compared. As such, EMI Consulting strongly recommends that Consumers Energy continue producing energy audit reports for each site.

Additionally, EMI Consulting's initial review of the audit reports found that implementers sufficiently defined recommended measures. However, project documentation did not include any formal data regarding the extent to which participants implemented ICIP energy audit recommendations. While EMI Consulting expects participants can provide this information

as they are required to record measure implementation for internal purposes, participants are not required to formally submit this information to Consumers Energy. If Consumers Energy would like to claim energy savings for measures implemented (such as low and no-cost measures) in addition to those savings claimed through the Business Solutions Program, EMI Consulting recommends that Consumers Energy formally collect information regarding the extent to which program participants implement audit recommendations. Consumers Energy will collect this information, and plans to claim these savings through the Business Solutions Program. Figure 1 is a representative sample of low and no-cost measures that have already been implemented by customers from the audit report.

Figure 1: Sample of low and no-cost measures

Measure	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (Mcf)	Annual Energy Cost Savings ($/yr)	Estimated Measure Cost ($)	Simple Payback Period (yrs)
RTU Economizer Repair	187,690	0	18,300	1,800	0.1
Reduce Compressed Air Pressure and Change Undersized Valve	71,700	0	5,642.8	185	0.0
Improve Steam Demand Control	0	10,624	42,500	0	0.0
Pressure Stage Air Compressors	73,080	0	7,125	0	0.0
Optimized Air Compressor Controls	790,152	0	77,040	2,500	0.0
Heat Recovery on Heat Treat Furnace	0	1,839	12,321	5,000	0.4
Repair Compressed Air Leaks	208,488	0	20,515	2,250	0.1
Repair Laser Cutter	17,836	0	1,755	500	0.3
Optimize Molten Metal Recovery	43,924	0	4,735	1,200	0.3
Optimize Compressed Air Dryer Operation	20,270	0	2,185	0	0.0
Reorder Air Compressor Operation	777,000	0	59,130	0	0.0
Install Interlock for Blast Dust Collector	298,656	0	22,728	5,000	0.2
Use Compressed Air Nozzles and Leaf Blowers	119,349	0	9,082	3,344	0.4
Weekend Air Compressor Operation	95,154	0	9,515	0	0.0
Total	2,703,299	12,463	292,575	21,779	0.1

Finally, EMI Consulting found that measure life was typically not specified in the energy audit reports. As measure life is an important consideration for Consumer Energy to meet new performance metrics, we recommend that it is clearly specified during the energy auditing process.

ICIP Participant Interview Findings

As part of EMI Consulting's 2014 evaluation of the Industrial Continuous Improvement Pilot (ICIP) Program, the research team conducted on-site and telephone interviews with four of the Pilot's participants: two from the International Standard Organization (ISO) 50001 pathway and two from the ENERGY STAR Challenge for Industry pathway. The ISO 50001 pathway involves a commitment from facilities to take the necessary steps in order to achieve ISO 50001 certification, while the ENERGY STAR pathway involves formulating an energy team, tracking energy consumption, and setting a goal to improve energy performance of the facility by 10 percent within five years. For each pathway, EMI Consulting interviewed one customer that was new to the Pilot and one customer that had completed the Pilot or was close to completing the Pilot. The overall purpose of the interviews was to gather feedback on the program design, program processes, and customer experiences with the Pilot.

Summary of Key Findings

EMI Consulting identified several key findings from the participant interviews. We found that all interviewed participants were happy with the ICIP program and wanted to see the program continue into the future. ICIP's energy audit was a universal favorite among all participants that completed the energy audit. Interviewees indicated they were unaware of most low- and no-cost energy efficiency opportunities until they were identified through the ICIP process. ISO 50001 interviewees also found the gap analysis highly beneficial, due to the clarity it provided for remaining requirements needed to meet certification criteria. Motivations for participating in the program appeared to vary. Customers participated either to discover energy savings opportunities or for certification. All customers expressed the importance of ICIP having a low cost of participating. Finally, EMI Consulting found that ISO reporting template could be more user-friendly and the website needed to be updated to reflect current program operations.

Overview of Interviewees

EMI Consulting selected the following participants for the on-site interviews based on: Pilot pathway (two ENERGY STAR and two ISO) length of time participated (older participants, newer participants.) Table 2 lists the participants selected and interviewed.

Table 2: List of ICIP Participant Interviewees

Interviewees	Path	Started
Participant A	ISO 50001	July 2012
Participant B	ISO 50001	October 2012
Participant C	ENERGY STAR	October 2013
Participant D	ENERGY STAR	March 2014

Participant A

The Participant A facility, located in Grand Rapids, MI, produces large metal dies used to form sheet metal parts for the automotive industry. The facility has approximately 220 shop employees that operate two shifts per week. Participant A joined the ICIP program in July 2012 and completed the ISO 50001 certification in the summer of 2014. They were the only participant to have completed all requirements of the ICIP program, as of the time of this writing.

Participant B

Participant B is a corrugated box manufacturer located in Mason, MI. This facility has approximately 163 employees and typically operates 24 hours/day, 6 days per week. Participant B joined the ICIP program in October of 2012 and was working toward ISO 50001 certification.

Participant C

Participant C is a plastic injection molding facility with 85 employees and is located in Sheridan, MI. Participant C joined ICIP in October of 2013 under the ENERGY STAR path and is currently working toward certification.

Participant D

Participant D is a plastic injection molding facility located in East Tawas, MI. This facility has approximately 80 employees and joined ICIP in March 2014 under the ENERGY STAR pathway. This facility is still in the early stages of participation and has not completed the ICIP energy audit yet. Participant D was the only interviewee that EMI Consulting interviewed over the phone instead of an on-site visit.

Motivations to Participate in ICIP

EMI Consulting identified several motivations for customer participation. While all interviewees stated that ICIP provided an opportunity to identify deeper energy savings, only two interviewees reported energy savings to be their primary motivation to participating in the ICIP. The other two interviewees were primarily motivated because they wanted to receive certification. Another important motivator for all interviewees was no upfront participation costs. EMI Consulting found that interviewees who were motivated to join ICIP because of energy savings shared similar views, which were in contrast to the views shared by interviewees motivated by certification. Table 3 summarizes interviewee viewpoints, grouped primary motivations. These findings suggest that ICIP should continue to offer services that cater to both groups, focusing on assistance with achieving certification as well as identifying and implementing energy savings.

Table 3: ICIP Interviewee Viewpoints, Grouped by Primary Motivation

	Motivated by Certification	Motivated by Energy Savings
Views on certification:	Corporate/customer push for certification	Certification seen as a “bonus”
Understanding of energy savings:	Some understanding of energy savings opportunities	Limited understanding of energy savings opportunities
Views on ICIP process:	ICIP is an additional tool for their energy management practices	ICIP is a tool to learn about energy saving opportunities

The research team also asked interviewees about why they chose either the ENERGY STAR or ISO 50001 pathway. Interviewees that chose the ENERGY STAR pathway (instead of ISO 50001) indicated that they viewed ENERGY STAR as the easier, more informal of the two

pathways. These interviewees were primarily motivated to join the ICIP for energy savings, and viewed certification as a secondary bonus of participating in ICIP. Neither of the ISO 50001 interviewees had the option to choose ENERGY STAR at the time of their participation; however Participant B indicated interest in switching to ENERGY STAR if given the opportunity. This is because Participant B is having difficulty keeping a record of energy management activities for ISO reporting. Participant A was involved in a corporate initiative to receive ISO 50001 certification, and would have still selected the ISO pathway.

Customer experiences

All interviewees expressed satisfaction with the ICIP program and EMI Consulting identified several factors that contributed to successful customer experiences. These included the energy auditing process, energy audit report, gap analysis, and flexibility of program staff.

First, the energy auditing process was a universal favorite among interviewees. The auditors were seen as personable and knowledgeable. All interviewees indicated that the energy audit walk-though was an enjoyable experience. Second, they also highly regarded the ICIP energy audit report. Participant A expressed that the ICIP energy audit report was better than several other energy audit reports they received from other consultants. All interviewees used and referred to the energy audit reports regularly. EMI Consulting observed that the energy audit report was regarded as the centerpiece of the ICIP experience. Additionally, ISO pathway interviewees also indicated that the gap analysis was very helpful. Participant B expressed that the gap analysis was the most valuable service received from the ICIP program. Finally, all interviewees expressed appreciation in the flexibility offered by ICIP. Interviewees did not view ICIP program as imposing, but rather as readily available. While all interviewees appreciated the minimal time and disruption the ICIP posed on staff and facility operations, interviewees also reported to have successfully integrated energy management into their daily workflow. This success is attributed to the workshops, training, and assistance provided by Consumers Energy program staff.

EMI Consulting identified some challenges relating to ISO 50001 reporting and the ICIP website. Both ISO 50001 pathway interviewees expressed dissatisfaction with the ISO reporting templates offered by ICIP. Participant B and Participant A independently described the template as difficult to use and confusing. Participant A indicated that other consultants provided a more user-friendly template developed by the U.S. Department of Energy. Participant B also reported that the ISO reporting requirements remained difficult despite ICIP support. Finally, Participant C indicated that the ICIP website did not have current information listed, and caused some initial confusion at the time Participant C considered participation.

ICIP Direct and Indirect Impacts

The research team also asked interviewees about impacts the ICIP had on facility operations and receiving certification. The research team found that interviewees had carried out or planned to carry out ICIP- related measures and they had received certification or continued to be working towards certification. Additionally, one interviewee reported to have installed additional energy efficiency measures as a result of participating in the ICIP. This sub-section describes these impacts in more detail.

Implementation of ICIP-identified measures

Interviewees indicated they were unaware of most low- and no-cost energy efficiency opportunities until they were identified through the ICIP process. In all cases, EMI Consulting observed that interviewees first implemented no/low cost measures before higher cost measures. In cases where the ICIP recommendations identified energy efficiency opportunities of which the interviewees were already aware, interviewees indicated that ICIP motivated them to conduct the energy efficiency upgrades faster than they would have otherwise. For example, Participant B indicated that there was uncertainty regarding the actual savings and cost effectiveness of these measures, but that ICIP's energy audit report helped to bring clarity and allowed Participant B to prioritize and approve the implementation of these measures. Participant B indicated that these efficiency projects were implemented two to three years earlier than would have otherwise occurred without ICIP participation.

EMI Consulting found that interviewees had already implemented, or planned to implement a majority of the ICIP-identified energy efficiency opportunities. Measures with longer payback periods generally had lower priority than the low/no cost measures. However, interviewees had not implemented (nor planned to implement) some of the recommendations, including low- and no-cost measures, because they conflicted with the interviewees' process or workflow, or would result in undesirable effects. For example, ICIP recommended that Participant C insulate injection molding barrels to minimize heat loss. Participant C indicated that this would also increase the time of barrel cooling, causing delays when barrels needed to be cooled down for when plastic granules need to be replaced.

Certification

Only one interviewee had completed certification, as of the time of this writing. They indicated that ICIP helped them achieve ISO 50001 certification "much faster" than they could have done on their own. Prior to their participation in ICIP, their parent company had also provided Participant A with certification assistance by performing two gap analyses. Participant A indicated that ICIP's gap analysis was much better than the prior consultants', and the certification assistance provided by ICIP was very valuable due to the thorough nature of the assistance provided. Participant B also indicated that ICIP's gap analysis was very valuable, and plans to complete certification upon meeting all ISO 50001 requirements.

Identification and implementation of additional measures

One of the interviewees, Participant C, indicated that ICIP taught them about the value of energy efficiency and as a result, are enthusiastic to find more energy savings opportunities. For example, their facility recently made a decision to purchase a new energy-efficient injection-molding machine, which qualifies for Consumers Energy Business Solutions incentives. Participant C indicated that other injection molding machines might be upgraded or replaced with more efficient models in the future. Additionally, Participant C shared ICIP results and successes with their sister facility, located in DTE territory and indicated that the sister facility has begun to implement several ICIP recommendations.

Summary and Best Practices

Overall, the research team found the Pilot to be working smoothly. The research team expects to be able to verify energy savings for ICIP through custom calculation methods. Most importantly, the ICIP program structure was working well. Participants indicated satisfaction with the Pilot and they were implementing ICIP-recommended measures. Additionally, the research team observed that ICIP participants were actively engaged with energy management and were discovering new ways to monitor and save energy.

Based on the research team's findings, the following list captures best practices for conducting an industrial continuous improvement program:

- Provide participants with free energy audit reports and gap analyses: These services were highly regarded and valued by participants.
- Offer two pathways for prospective participants: the ENERGY STAR certification pathway and the ISO certification pathway. EMI Consulting found that some participants joined ICIP for help with ISO certification while other participants were primarily interested in joining ICIP for identifying energy savings opportunities, and preferred the ENERGY STAR pathway for its ease and simplicity
- Explore ways to improve the ICIP ISO reporting templates or identify alternative ISO templates. Participants indicated that the ICIP template was difficult to use and could be improved.
- Collect data to inform custom calculations for verification. For an evaluator to perform energy savings verification, the following actions must be taken:
    - Collecting pre-case conditions through the audit reports.
    - Presenting data on all measure recommendations.
    - Report measure life for all measure recommendations, whenever possible.