The DOE's In-Plant Training (INPLT) Model to Promote Energy Efficiency in the Industrial Sector

Nasr Alkadi and Sachin Nimbalkar, Oak Ridge National Laboratory
Andre de Fontaine, U.S. Department of Energy
Fred Schoeneborn, FCS Consulting Services, Inc.

ABSTRACT

In-Plant Training (INPLT) is a new model for developing energy efficiency expertise within the US manufacturing companies participating in the U.S. Department of Energy's (DOE's) Better Buildings, Better Plants Program. That program is a nationwide initiative to drive a 25% reduction in industrial energy intensity in 10 years. INPLTs are designed to fill a niche by providing hands on training in a real world manufacturing plant environment. Through INPLTs, participants from multiple manufacturing plants, supply chains, utilities, and other external stakeholders learn how to conduct energy assessments, use energy analysis tools to analyze energy saving opportunities, develop energy management systems, and implement energy savings projects. Typical INPLT events are led by DOE-certified Energy Experts and range from 2-4 days. Topics discussed include: identification of cross-cutting or system specific opportunities; introduction to ISO 50001 Energy Management Systems; energy project implementation and replication. This model is flexible, and can be tailored to suit the needs of specific industries. The INPLTs are a significant departure from the traditional single plant energy assessment model (ESA Model) previously employed by DOE. INPLTs shift the focus from the concept of a single-plant's energy profile to a broader focus on training and capacity building among multiple industrial participants. The objective is to enable trainees to identify, quantify, implement and replicate future energy saving projects without continued external assistance. The paper discusses lessons learned from the previous DOE's energy saving assessments (ESAs) and then discusses the INPLT model and highlights some of the initial outcomes from the successfully delivered INPLTs. Finally, the paper shows the overall impact of the INPLT Model in terms of numbers of plants/participants trained, impacted energy footprints, and potential replication of identified opportunities.

Introduction

The Advanced Manufacturing Office (AMO) conducts In-Plant Trainings (INPLTs) with companies participating in the Better Buildings, Better Plants Program. INPLTs give U.S. manufacturers the tools and motivation to accelerate the implementation and replication of energy efficiency projects. INPLTs can build capabilities within partner companies on technical aspects of energy management and fill a market niche by providing hands on training in a real world environment. The INPLT events are delivered at the "host plants" where several other plants (called participating plants) are invited to participate. A host plant must be enrolled in the DOE Better Plants Program as a Better Plant or Challenge program partner plant. Also, a host plant should be willing to make their engineering or technical staff members available for the event, provide a conference room with overhead projector, and other tools for the training participants. The participating plants may be affiliated with the host company or from the other manufacturing plants including supply chains. The event can also be attended by other entities such as nearby Industrial Assessment Centers (IACs), state energy offices, utility representatives as well as industrial vendors.

The INPLTs are delivered with the five major objectives (also called Five Pillars) in mind: 1) **I**dentification of energy saving opportunities through system specific energy assessments, 2) **N**etworking between energy experts, Better Plants partners, supply chains, utilities, IACs, and state energy offices to spread the benefits beyond the walls of the host facility, 3) **P**romotion of implementation and replication of identified energy projects, 4) **L**everaging resources including state, utilities, and other organizations, and 5) **T**raining and enhancing the energy efficiency expertise of the Better Plants companies.

History of DOE and Manufacturing Industry Partnership for Energy Efficiency

In October 2005 (FY2006), the AMO (formerly Industrial Technologies Program) launched the Save Energy Now initiative, featuring a new form of system-based energy savings assessment (ESA). The ESAs replaced both Collaborative Targeted Assessment (CTAs[1]) and Plant Wide Assessments (PWAs[2]) but drew heavily on the existing resources and knowledge of these earlier programs. The FY2006 ESAs focused primarily on assessments of steam and process heating systems, which are estimated to account for approximately 74% of all natural gas use in U.S. manufacturing plants. Because of the success of the initial ESAs conducted in FY2006, the assessment focus was expanded in FY2007, FY2008, FY2009, FY2010, and FY2011 to include pumping, compressed air, and fan system assessments in addition to steam and process heating assessments. Two hundred ESAs were performed in calendar year 2006, 258 were completed in 2007, 260 were completed in 2008, 159 were completed in 2009, 102 were completed in 2010 and another 38 were successfully completed in 2011 – a total of 1,017 assessments in the six year period. The numbers of ESAs were lower in 2010 and 2011 than the three previous years due to program transitioning that resulted in a hold on scheduling ESAs in 2010 and introduction of Better Plants program in 2011. The plants involved with the Energy Savings Assessments were contacted 6 months, 12 months, and 24 months after individual assessments were completed so that assessment implementation results could be identified.

[1] Collaborative Targeted Assessments (CTAs) – CTAs focused on a single energy system such as steam, compressed air, or process heating. CTAs were conducted at plants that sponsor a BestPractices training session as a means of demonstrating the application of the software tool. The CTA was conducted at large-sized plants by trained engineers or BestPractices Qualified Specialists.

[2] Plant-wide Assessments (PWAs) – PWAs helped large plants with high potential for energy savings identify opportunities to reduce energy use. Interested companies were invited to submit proposals in response to an annual competitive solicitation. After a plant was selected for a PWA, BestPractices Qualified Specialists conducted a cost-shared (up to $100,000) energy assessment. During a PWA, an industry-defined team carried out an on-site analysis of total energy use and identified opportunities to save energy. The PWA highlighted opportunities for best practices in energy management, including the adoption of new, energy-efficient technologies, as well as process and equipment improvements. BestPractices Energy Experts promoted and encouraged replication of assessment results and methodologies as a key strategy to increase savings results.

Lessons Learned from Previous Energy Saving Assessments (ESAs)

Lesson 1: 2006-2011 Follow-Up Data Shows That There Is an "Implementation Gap"

Evaluation of the 6, 12 and 24-month implementation data from the 2006 to 2011 assessments show that there is an "implementation gap" [A. L. Wright, 2011] — a considerable portion of the savings identified by the ESAs have not been implemented. For example, from the latest available implementation data, for 720 assessments with the follow up reports, annual savings opportunities of about $931 million have been identified, $172.8 million (19%) were implemented, $181.2 million (20%) are in progress, $267.1 million (29%) are in the planning stage, and the remaining 32% were rejected. Oak Ridge National Laboratory (ORNL) has evaluated implementation follow-up results and plant feedback to identify real barriers to ESA implementation and identified potential solutions that AMO is offering while delivering In-Plant Trainings.

Lesson 2: Payback Time Is Not the Only Impediment To Implementation

The available implementation data also shows that almost 50% of the total cost savings identified so far is either in progress or in planning status. Inexpensive implementations and projects with short payback periods are implemented more frequently than those with longer payback periods. But payback time is not the only impediment to the implementation as over 71% of recommended actions had paybacks of less than 2 years. Company policy, process limitations, lack of in-house engineering expertise and budget priorities are some of the other challenges to implementation.

Lesson 3: ESA Process Struggled to Independently Replicate the Identified Opportunities at the Company's Other Facilities

The ESAs struggled to replicate identified opportunities in the host-plant at other facilities within the companies. In many cases, the plants/companies did not keep detailed records of results of project implementation or replication, especially with regard to energy savings realized. The ESAs did not have a strong training component designed to teach industrial plant personnel from other facilities (non-host plants) how to use DOE's opportunity assessment software tools. The approach taken by the in-plant trainings has the advantages of promoting strong buy-in of plant personnel for the assessment and its outcomes and preparing them better to independently replicate the assessment process at the company's other facilities.

Lesson 4: The Plant Size and the Type of Systems Assessed Has a Significant Impact on Assessment Results

The impacts of ESAs would have been enhanced if: 1) priority was given to large plant assessments; 2) pumping, compressed air, and fan assessments were conducted in large plants when at all possible to maximize the potential benefits of these assessments; and 3) a focus on steam and process heating assessments in large plants was continued. In summary, impacts would have been enhanced if there were efforts to pre-screen the plant applicants to identify the systems that had the best potential for recommended savings in future assessments.

Transition from ESAs to INPLTs

Based on the lessons learned from ESAs, DOE decided to depart from single-plant ESAs to a model that promotes greater leverage and replication of energy efficiency opportunities. The kick-off of the INPLT program started late 2011with the objective of training staff from multiple facilities on energy management principles and energy saving measures. INPLT events are competitive-based awards. DOE Better Plants Partners have to apply for these events using an INPLT application form that includes four basic criteria to help DOE determine a plant's eligibility to host an INPLT event. Application criteria includes a) permitting a certain number of trainees to attend, including representatives from states, utilities, and IACs, b) allowing complete or limited access to plant floor and information sharing, c) level of energy consumption at the host plant, and d) level of cost share characterized as cash provided by the host facility to offset the direct costs to the government, which allows DOE to conduct more training events in a given year

The In-Plant Training Model

The in-plant training model includes a base component with elements present at every training event, as well as add-ons that can be incorporated when appropriate with cost-sharing support from partners to respond to their specific technical needs. The components of the base model include an approximately three-hour, web-based "pre-training," on-site field training, and a "technical" classroom session. The "pre-training" is designed to prepare participants for the event. They receive an overview of the energy system being analyzed within the plant, and become familiar with DOE's on-line suite of tools and resources including its web-based, self-paced energy management module. Recently, the pre-training webinars were made available to all Better Plants partners even though they may not all participate in the actual INPLT event. This is to support promotion and dissemination of best practices of target energy systems among the greater population of manufacturing plants. The field training session includes training on specific energy saving practices such as measuring air leaks using ultra sonic leak detectors or conducting a combustion analysis on a boiler or furnace exhaust stack, as well as implemented best practices at the host facility. The DOE energy expert demonstrates the effectiveness of using DOE tools in one or more energy systems in the host plant such as steam systems, process heating systems, compressed air systems, pumping systems, fans systems and paper machines.

The classroom sessions present the technical aspects of energy saving opportunities, and AMO tools and best practices within a single or multiple energy system(s). A DOE Energy Expert leads these sessions focusing on one or more of the specific industrial energy systems evaluated during the in-plant training. During the classroom session, the DOE expert guides participants in performing analyses with DOE software tools and developing savings estimates. The results are typically documented in a report detailing: (1) a technical evaluation of the energy saving options; (2) the economics (investment, payback period); and (3) an implementation action plan. The classroom session concludes with a special focus on strategies to implement energy saving projects. Participants are taught how to identify and overcome common barriers to project implementation and receive copies of the Energy Department's *Guiding Principles for Successfully Implementing Industrial Energy Assessment Recommendations (DOE, 2011)*. In addition, host plant representatives brief senior plant management on the opportunities uncovered through the INPLT event. It should be mentioned that Some plants has lost a number of key engineers due to retirement and attrition - many of which were experts on various energy systems (i.e. compressed air, fans, pumps, steam, process heat) and/or participated in DOE's ESA's throughout the company. As a result, these plants no longer have an internal expert that can turn to regarding these energy systems. As such, host plants are willing to invest in these INPLT to train and engage a new group of current, and up-coming engineers and maintenance leaders so that they have the knowledge, tools and ability to improve the operational and energy efficiency of these plants and energy systems, rather than having to default to vendors and consultants for their expertise and input.

Table 1 shows the main components of the INPLT Model and the associated timeline for each component. As shown in table 1, an INPLT event requires significant planning to ensure that the event is successful. As such, the preparation starts as early as 2-3 months prior to the actual event where the curriculum is discussed and agreed upon with the energy expert and the host and participating plants. This includes the target energy system to be assessed, required technical data related to this energy system, and the energy measurements needed. The pre-training webinar usually takes place up to 3 weeks prior to the actual INPLT event, the field training lasts for (2-4) days depending on the scope of the INPLT event, and finally, within 12 months, DOE follows up on the implementation of the identified energy opportunities that resulted from the INPLT event.

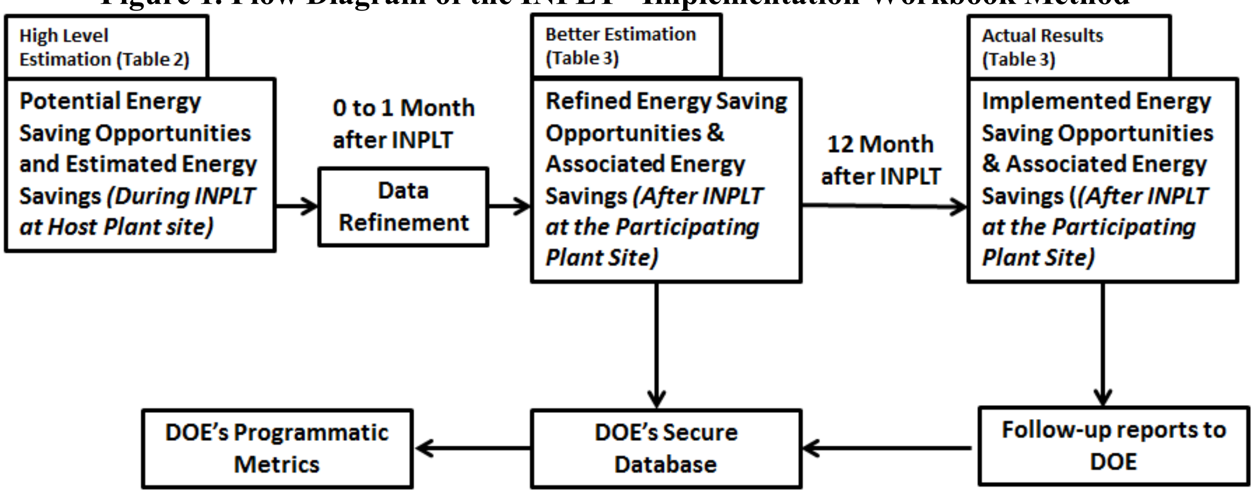
Table 1. Timeline for In-Plant Training Planning and Delivery

INPLT Component	Duration/Schedule	Description
Preparation	2-3 months prior (Phone calls and emails)	- Scope development
Pre-Training	3 weeks prior (Webinar)	- Orientation on safety rules and other logistics - Webinar on target system energy efficiency improvement, and related DOE software tool.- Technical discussions
Field Training	2-4 days (At the host plant site)	- Technical sessions - Energy management and replication session - Evaluation - Close out session
Follow up	12 months after (Phone calls and emails)	- Correspondence with Host and Participating Plants on the status of implemented energy saving projects identified due to the INPLT event.

Estimation and Tracking of Implemented Energy Savings at the Participating Plants Using the "Implementation Workbook Method"

The INPLT event involves hands-on training of technical individuals from the participating manufacturing plants within the DOE's Better Plants program on identifying opportunities to save energy in systems such as compressed air, process heating, pumps, fans, and paper machines. An implementation workbook for each of these energy systems was designed as a training tool intended to assist trainees with identifying, quantifying, and tracking progress of energy efficiency opportunities in their own facilities based on the curriculum covered during the INPLT event. Figure 1 describes the implementation workbook method used. It shows the data flow from the high level estimates that only give an idea on the size of the opportunity that may exist in each participating plant to the actual results of associated energy savings. This is accomplished using top energy saving opportunities that are explained during the INPLT event. A more refined estimation using measured parameters is completed within one month after the INPLT event at the participating plants sites using in-house expertise that attended the INPLT event. Finally, and upon the implementation of the energy projects, actual energy savings results are reported. The diagram also shows the flow of data to and from the DOE secure database to develop different metrics that support decisions for further improvement.

Figure 1. Flow Diagram of the INPLT "Implementation Workbook Method"



In order to support trainees in early identification of key opportunities, a top 10 list of common/typical energy saving recommendations (gathered from past DOE assessment programs) along with average savings estimates from these recommendations (based on prior experience) is provided. As an example, top recommendations from compressed air systems are shown in Table 2 below. The check marks in the table represent typical ranges of savings opportunity based on data from prior DOE assessments. Energy savings are estimated in million British thermal units per year (MMBtu/yr).

Table 2. Top Energy Saving Opportunities in Compressed Air Systems (Example)

Top Energy Saving Opportunities	<1%	1%-5%	6%-10%	>10%	Estimation of Energy Savings (MMBtu/yr) (Calculated)*
1. Improve Trim Compressor Part Load Efficiency				✓	
2. Multiple Compressor Control (install / improve)				✓	
3. Open Blowing				✓	
4. Reduce Demand Side Pressure				✓	
5. Condensate Drain				✓	
6. Add Primary Receiver Volume				✓	
7. Improve End Use Efficiency			✓		
8. Reduce Run Time			✓		
9. Reduce Air Leaks			✓		
10. Reduce System Air Pressure			✓		
Others (Participating Plants may add other opportunities as well).					

* Estimated source energy savings = Plant's total annual energy consumption × % of energy used by specific system × average % energy savings based on historical DOE ESA data or plant representative's estimated value.

The workbook is intended to be a "living" document that trainees can utilize before, during and after the INPLT event to continuously identify opportunities and capture actual implementation savings. DOE collects identified and implemented savings data, including the status of projects: a) implemented, b) in progress, c) in planning, and d) rejected. As such, INPLT participants are also asked to complete the information shown in Table 3 to capture the implemented energy projects.

Table 3. Refined Estimates and Actual Results based on the implementation of Top Energy Saving Opportunities in Compressed Air Systems (Example)

Top Energy Saving Opportunities	Implementation Status	Refined Estimate of Source Energy Savings (MMBtu/yr)	Implemented Source Energy Savings (MMBtu/yr)	Payback (Years)
1. Improve Trim Compressor Part-Load Effi	Implemented	6,600	6,550	0.3
2. Install Multiple Compressor Control	Implemented	9,000	8,950	0.7
3. Open Blowing	In-Progress	9,850	-	-
4. Reduce Demand Side Pressure	In-Progress	6,400	-	-
5. Condensate Drain	Rejected	1,900	-	-
6. Add Primary Receiver Volume	In-Planning	1,150	-	-
7. Improve End Use Efficiency	In-Progress	5,050	-	-
8. Reduce Run Time	Implemented	6,200	7,250*	1.5
9. Reduce Air Leaks	Implemented	9,150	7,950	0.6
10. Reduce System Air Pressure	Implemented	4,650	5,350*	0.5
Others – Adjust Cascading Set Points (added by the participating plant)	Implemented	5,000	3,200	0.2

*In some cases, implemented energy savings may be higher than identified savings.

The data captured in the workbooks is then provided to DOE to gauge the impact of the INPLT and to provide guidance to instructors and DOE on curriculum improvement needs and overall improvement in the effectiveness of the INPLT event. Trainees are provided detailed descriptions of how to utilize the workbook tool as well as specific descriptions of each data collection cell during the training event.

The Evolution of the INPLT Model

The design of the INPLT model has evolved since the launch of the INPLT program around mid-2011 to respond to continuous feedback from industry, energy experts, and other parties involved in the program. For example, recently, local utilities and State energy office representatives were invited to attend the last day of the INPLT event at the host plant. The objective was to build and strengthen relationships between local resources (represented by utilities and state agencies) so that the host plant may benefit from incentive programs offered by utilities and leverage resources that may be available at the State agencies. Also, cost sharing is now gaining more importance as one of the five criteria that qualify for an INPLT event. Cost sharing is defined as dollars provided by the host plant to offset the direct costs to the government, which allows DOE to conduct more training events in a given year. In addition, pre-training webinars which were originally open only for plants participating in the INPLT events are now open to all plants participating in the Better Plants program. The pre-training webinars are usually scheduled one week before an INPLT and provide an overview of the software tool(s) that will be used during the INPLT, as well as an overview of the energy system to be analyzed. The webinar participants will then be able to apply what they learned through the pre-training webinars in their own facilities, thus effectively extending the expertise to more plants. Moreover, the INPLT program will now also allow small plants to participate; in this case the INPLTs are shorter in duration than a typical INPLT (2 days vs. 4 days) and may include local IACs to provide multi-system analysis in addition to a one-day focus on a specific system analysis. These examples show that the INPLT model continually evolves and is flexible enough to respond to the ever changing industry demand to better serve other stake-holders involved in this program.

INPLT Preliminary Results

The following chart shows the available results from the 20 delivered INPLT events to demonstrate initial trends and substantiate the foregoing conclusions on the INPLT model.

Figure 2 shows the number of trainees per INPLT event. To date, a total of 379 trainees including personnel from Better Plants, supply chains, IACs, appropriate state energy offices and utilities representatives and vendors attended a total of 20 INPLT events. The average number of attendees per INPLT event was approximately 20. In Figure 2, INPLT's delivered are arranged in ascending order based on delivery date starting 2011 to date.

Figure 2. Count of Trainees per INPLT Event (20 INPLTs Conducted Since 2011)

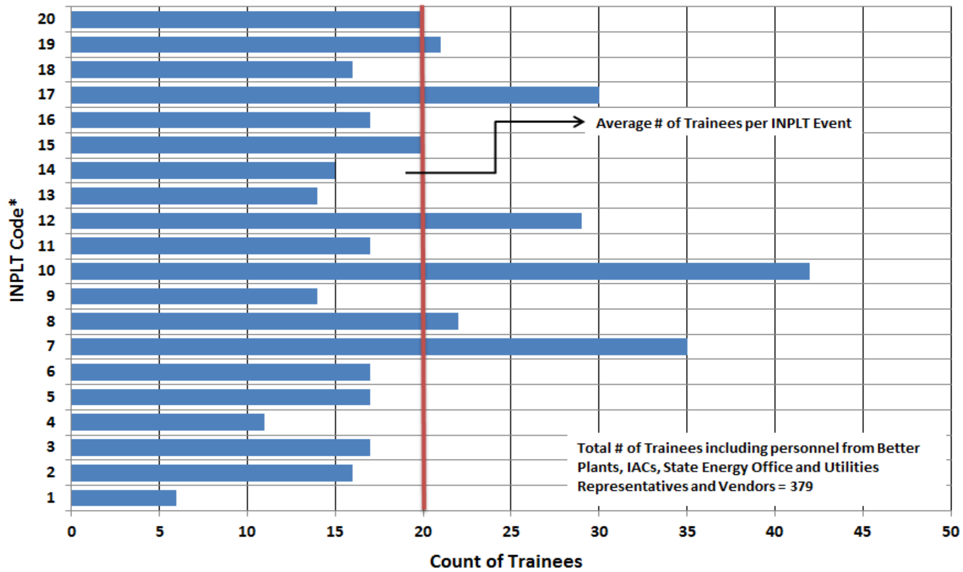
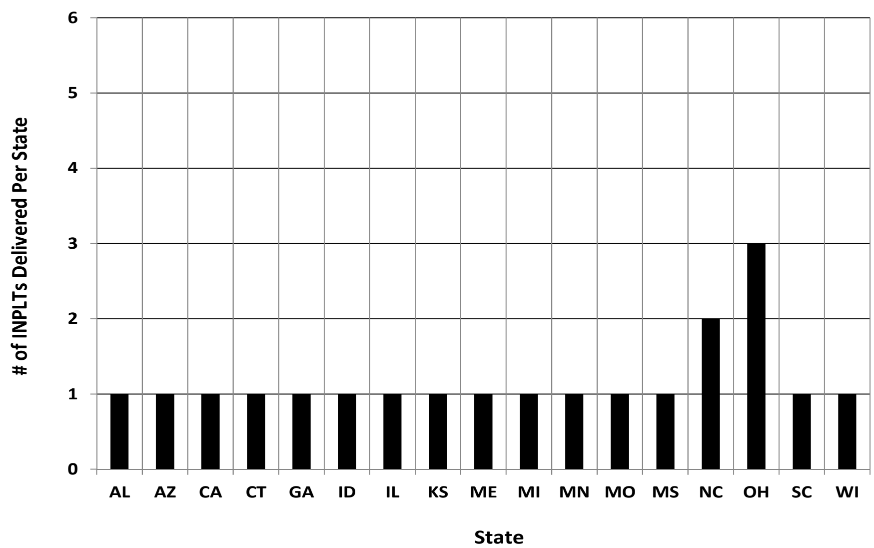


Figure 3. Geographical Distribution of the 20 INPLT Events Delivered Since 2011



Locations shown represent the location of INPLT event at the Host Plant.

Figure 3 shows the geographic diversity of the locations of the INPLT events at the Host Plant by state. These were distributed in 17 states. As shown, more than one INPLT was conducted in the States of North Carolina and Ohio reflecting the concentration of Better Plants Partner facilities in these two states. Table 4 shows the total and average identified energy savings and energy cost savings at "Host Plants" per INPLT energy system type for the five energy systems that were subject of the INPLTs investigation during the 20 INPLTs delivered to date. As can be seen, process heating system INPLT comes first in terms of the size of the direct energy savings, followed by steam, compressed air and pumps/fans systems. This is a typical trend as evidenced by the previous experience in DOE ESA Program (2006-2010).

Table 4. Identified Energy Savings at the Host Plants per INPLT by Energy System Type

Description	Energy System Type				
	Compressed Air	Process Heating	Pumps/ Fans*	Steam	Paper Machines*
Number of INPLTS delivered for this type of energy system	9	5	3	2	1
Total identified source energy savings (MMBTU/yr)	245,700	849,600	25,100	48,300	NA
Total identified energy cost savings (Million $/yr)	$1.9	$3.5	$0.5	$0.3	NA
Average identified source energy savings (MMBTU/yr) **	27,300	169,900	8,400	24,150	NA
Average identified energy cost savings (Million $/yr) **	$0.21	$0.69	$0.24	$0.13	NA

* Energy Cost Savings for INPLT #15 (Pumps & Fans Systems) and INPLT 18 (Paper machines) are not available at this time.
** Average numbers for Pumps/Fans represent average of 2 INPLT results only.

Figure 4. Distribution of INPLT by System Type (20 INPLT since 2011)

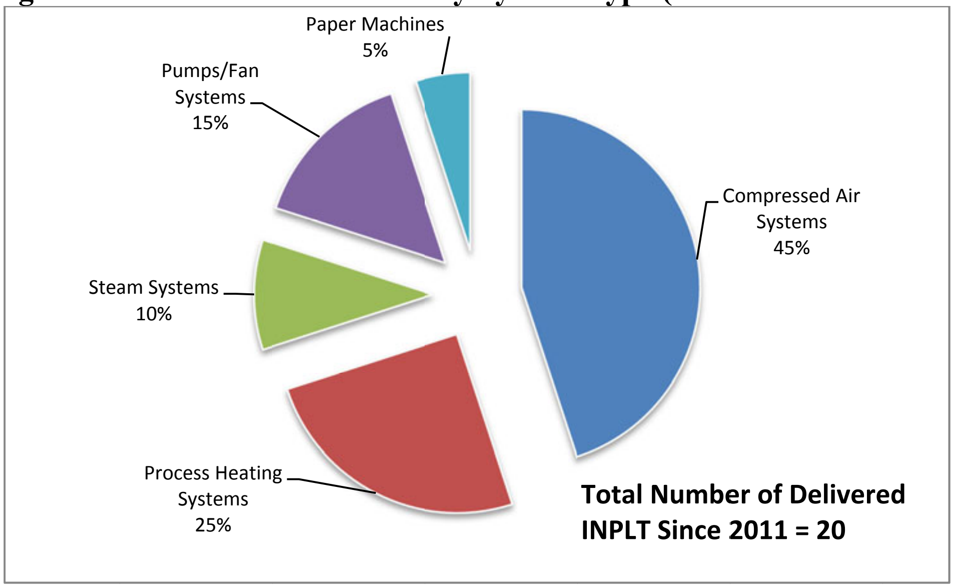
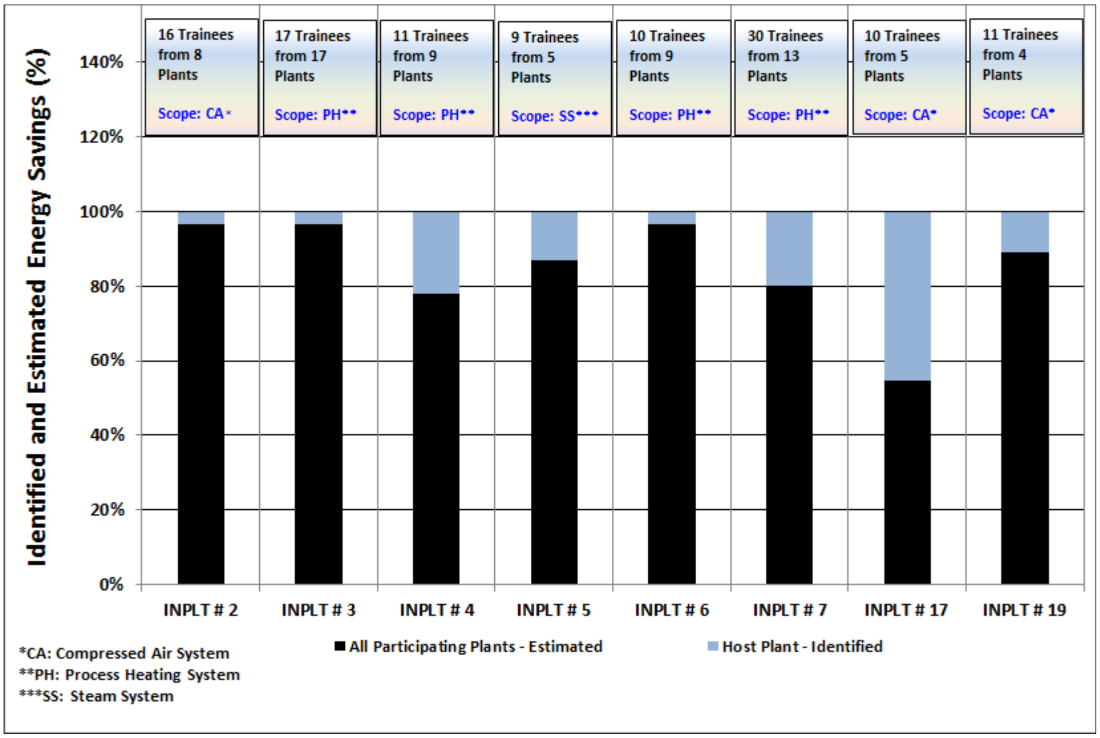


Figure 4 shows that the most frequent type of delivered INPLTs to date were compressed air systems. This gives some indication to the industry's focus on improving efficiency of the compressed air systems as it uses electricity more than any other type of equipment (DOE, 2003). Inefficiencies in compressed air systems can therefore be significant. Energy savings from system improvements can range from 20 to 50 percent or more of electricity consumption. For many facilities this is equivalent to thousands, or even hundreds of thousands of dollars of potential annual savings, depending on use (DOE-EERE).

A closer look at a sample of eight delivered training events validates the intent of the INPLT program. Figure 5 shows the percentages of identified and estimated energy savings per system type at the Host and Participating Plants during the period (2011-2012). As a general trend, the percentage of identified savings at the host plant is very small compared to the estimated savings at participating plants.

Figure 5. Percentage of Identified/Estimated Energy Savings per System Type at Host and Participating Plants during INPLT Events Results Represent a Sample of 8 Conducted INPLT Events



The energy savings estimates for the participating plants are not accurate at this stage as more refinement in these estimations are still needed as explained in Figure 1, the trend of this chart still holds. The chart also shows the number of trainees and the number of plants represented by these trainees, along with the target energy system that was subject of investigation in this sample during different INPLT events. It shows that the involvement of participating plants in an event multiplies the benefits.

Longitudinal Analysis (ESAs versus INPLTs)

It would be beneficial to perform a longitudinal analysis to spot the different metrics generated from the INPLT and ESA models to see how these metrics differ within each model. Table 5 shows five basic metrics that shape this analysis.

Table 5. Longitudinal Analysis

Metric	INPLT Model	ESA Model
Selection Process	More rigorous selection criteria to ensure commitment from host plant that the INPLT is supported by plant management, hence achieve better results.	Simpler application process – first come first serve.
Scope	One or more energy system training – energy management training – IACs may be included to perform multi-system analysis – event length ranges from 2 to 4 days.	One energy system – event length is 3 days.
Audience	Multiple participants from the host plant/company as well as from other invited plants/companies, in addition to non-facility external participants such as utility and state agency representatives.	Plant personnel at which ESA is conducted.
Benefits	Host plants, participating plants	Only plant at which ESA is conducted.
Cost to DOE	Slightly higher due to larger scope and expanding focus on replication at participating plants.	Relatively lower due to limited focus on single plant.
Challenges	Follow up on implementation at participating plants is a challenge that may be addressed by the use of implementation workbooks.	Limited replication of the identified opportunities at other plants.

Conclusions

This paper described the INPLT model as a new approach developed by DOE's AMO to support the U.S. manufacturing sector with the tools and motivation to accelerate and scale the implementation and replication of energy efficiency projects. The paper discussed the lessons learned from the previous ESA program and provided longitudinal analysis for both ESA and INPLT models. The paper highlighted available results from the delivery of 20 INPLTs to date. A total of 379 participants were trained on identification and calculations of energy saving opportunities in 7 energy systems (compressed air, steam system, process heating, fans, pumps, and paper machines). Approximately 1.2 TBtu in annual energy savings equivalent to $6 million in cost savings, were identified in host plants. INPLTs spread the benefits beyond the walls have other plants actually replicated the activities of the host plant and will continue to be used to identify opportunities for process efficiency throughout the coming years.

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