Energy, Environment, and Economy (E3™): Evaluation of a Multi-Partner Pilot Program to Improve Sustainability in Manufacturing

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ABSTRACT

Many different initiatives and programs – including federal, state, local and private – have been deployed during the past 30 years in the U.S. to assist the manufacturing sector to become stronger, create or retain jobs, and to rebuild the competitive and productive leadership of American manufacturing. Most of these programs - while somewhat successful at the facility level - have met with little or limited success in terms of meeting the larger national goals. Part of the problem is a perceived tension between programs that are designed to foster manufacturing vs. regulatory pressures from various agencies that are seen to suppress the growth of manufacturing. The other key factor has been lower overseas wages. The result has been the continued outflow of jobs, along with critical strategic skills and capacities, to offshore suppliers while dependence on imported goods – particularly energy – has continued apace.

In the past few years, efforts have been made to address this issue. Several federal agencies have instituted programs that are designed to be national in scope such as the *Superior Energy Performance (SEP)* (Department of Energy) and the *Next Generation Strategies (NGS)* program (Department of Commerce's Hollings Manufacturing Extension Partnership).

This paper will discuss one of the most recent – the *Energy, Environment and Economy (E3)* – program. The E3 Program is a joint effort of several federal departments, but is also designed to include various state and local agencies depending on locale and the nature of the manufacturing base in that locale. Examples of E3 projects in Southern California will be briefly reviewed.

Introduction

The E3 initiative is a coordinated federal, state, and local technical assistance program designed to focus resources to help manufacturers adapt and thrive in an emerging, highly competitive, business paradigm focused on three factors that can be viewed as mutually exclusive – cost controls, productivity, and sustainability.

Working in collaboration with the U.S. Department of Commerce, the U.S. Environmental Protection Agency (EPA), the U.S. Department of Labor, the Department of Energy's Industrial Assessment Centers (IAC), U.S. Department of Agriculture (USDA), and Small Business Administration, the E3 program was established to help small and medium-sized manufacturers become more competitive and profitable while reducing their impact on the environment. The program is national in scope and strategy - with the intent of becoming a recognized brand-enhancement identifier for the participants - but local in implementation. That is, the resources that are available to manufacturers will depend on the extent of contributing organizations in their areas.

The facilitator/coordinator in each geographical area is the local center of the *Hollings Manufacturing Extension Partnership (MEP)* organization which is sponsored by the U.S. Dept. of Commerce, administered by the National Institute of Standards and Technology (NIST), and works closely with the local region of the EPA. The MEP center or EPA will initiate contact with candidate manufacturing operations and then organize and coordinate other resources as appropriate for the area and the needs of the individual manufacturer. CMTC is the center representing the MEP organization and the E3 program in the Southern California area.

For small and medium sized manufacturers (<500 employees) to participate in E3, they must commit to a multi-element site assessment conducted by an E3 Review Team with the local MEP center providing program management. The EPA region provides funding for the Pollution Prevention (P2) element of the assessment. Local utilities offer energy reviews. Resources from other participating agencies and partners are brought to bear as appropriate. The graphic below (figure 1) shows the relationships between federal and state agencies and local partners supplying support and services to qualifying manufacturers.

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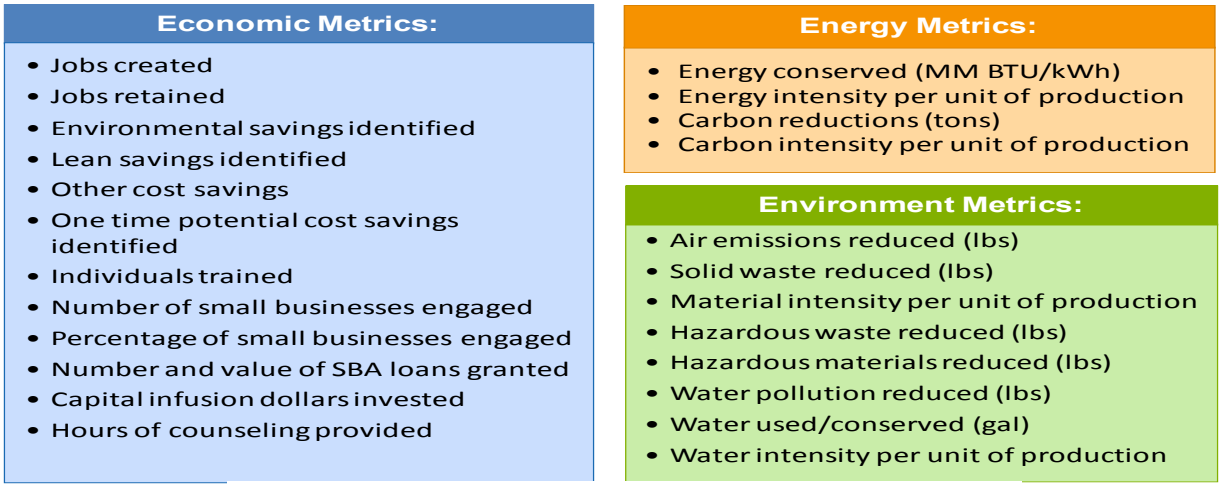
The E3 Framework facilitates collaboration among groups with common interests and a common agenda. This framework focuses on strengthening small to medium sized American manufacturers which represent the largest proportion of the manufacturing sector. State and local communities use the E3 framework to help boost local economies and to achieve their broader sustainability goals.

Each project involves five primary assessments: *Visual Energy and Resource Systems Audit (VERSA™)* (an enhanced Value Stream Map), *Pollution Prevention ("P2")*, *Safety Practices*, *Integrated Demand/Supply Side Management (IDSM)* energy analysis, and a F*inancial Performance Evaluation* where the company is benchmarked against its peers.

E3 Project Goals for Partners and Participants

The following table (figure 2) outlines the high-level metrics – shown in the categories that identify the E3 focus areas - that are envisioned to identify impact from the E3 program. Not all of these will be directly measured from each individual E3 project and each local review team will determine those that may be applicable for the engagement involved.

Figure 2. High-Level National Metrics for E3 Program



Source: Environmental Protection Agency, E3 Task Force

Locally, each project is unique and E3 service providers will tailor their assessments to meet the needs of the specific project. The program goals for Southern California manufacturers, which are designed to align with the MEP Next Generation Strategies, are designed to:

- Increase competitiveness and grow a robust, U.S.-based workforce
- Reduce their environmental footprint and increase their efficiencies through improvements in: Sustainability, Energy, Water, Waste and Materials, and Pollution Prevention, Greenhouse Gas (GHG) Reductions
- Assess and engage in Lean Manufacturing to improve process efficiencies
- Collaborate with a diverse group of experts to help ensure sustainment of gains

Examples of Local Implementation

This paper outlines the results of two projects conducted in Southern California by California Manufacturing Technology Consulting (CMTC), the area NIST/MEP center. These projects were conducted over a 1-year period from August 2012 to July 2013, and the participating manufacturers were selected based on high energy (electricity and natural gas) demand, and environmental footprints including solid waste, water discharge, and GHG.

CMTC also served as the primary Point of Contact for coordination of E3 partner services on behalf of the E3: Southern California program. CMTC worked closely with federal partners and local E3 Review Team members. With EPA's assistance, CMTC provided chemical and solid waste reduction technical assistance through a pollution prevention advisor who provided insights without compliance threats.

Following is a list of the local Public and private-sector organizations with resources to aid these assessments in addition to the federal agencies involved.

State, County, City:

- California Department of Toxic Substances Control (DTSC)
- County of San Bernardino Workforce Development Department
- Los Angeles/ Orange County Environmental Training Center
- Workforce Investment Boards (WIB): Pacific Gateway and South Bay
- City of Los Angeles

Educational:

- N. Orange Community College District - Center for Applied Competitive Technologies
- San Diego State University - Industrial Assessment Center
- Santa Monica College - Small Business Development Center (SBDC)

Utility Companies:

- Los Angeles Department of Water and Power (LADWP)
- The Southern California Gas Company

Client Cost Share and Benefits Summary

E3 is currently being implemented in 19 states, and the funding model is different in each state. Where the state and/or utility have provided additional funding, the programs are generating excellent results. The program in California does not have the additional financial support that other states are providing, so CMTC has had to institute a client cost-share amounting to an average of $12,500 per project. However, the calculated benefits shown in Figure 3 indicate that the potential is there for excellent return on that investment. Moreover, in implementing similar projects over a ten year period, CMTC has calculated that energy savings from process improvements alone often runs from 3:1 to as much as 20:1. Over this period CMTC has published a number of papers demonstrating the cost/benefit relationships.[1,2,3,4] When management is able to take a longer-term view of the benefits, they generally do not see the cost share as a barrier.

[1] Church, G., "Value and Energy Stream Mapping (VeSM) Linking Manufacturing Improvements to Energy Efficiency", Proceedings of the 2005 World Energy Conference, Lilburn, GA: Association of Energy Engineers.
[2] LaPalme, G., Prather, K., Ishii, A., Church, G. 2007. "Generating and Calculating Energy Intensity Savings from Manufacturing Productivity Improvement Projects", 2007 ACEEE Summer Study on Energy Efficiency in Industry, Washington D.C.: American Council for an Energy-Efficient Economy.
[3] Church, G., LaPalme, G., "The Relationship between Manufacturing Efficiency and Energy Productivity", 2011 ACEEE Summer Study on Energy Efficiency in Industry, Washington D.C.: American Council for an Energy-Efficient Economy.
[4] Prather, K., Church, G., Landry, P., "Lessons Learned - Financing & Measuring Manufacturing Process Energy Efficiency Gain as a Utility Incentive Program', 2011 ACEEE Summer Study on Energy Efficiency in Industry, Washington D.C.: American Council for an Energy-Efficient Economy.

Figure 3. E3 Services - Received Value

E3 Services	Value Estimation
Enhanced Value, Energy, Resources, and Systems Audit (VERSA).	$12,500
Pollution Prevention Assessment	$6,000
Utility Audits: *(1 expert for 1-2 days on-site, additional time off-site)*	$3,000
Financial Benchmarking Analysis:	$2,500
Worker Safety Review: *(1 expert for 1 day on-site, additional time off-site)*	$1,000
Various third party equipment assessments including ROI analyses	TBD
SBDC Assistance and training for facility fiscal health, access to loans, etc.	TBD
Workforce Board--Workforce development and training	TBD
TOTAL PROGRAM VALUE	**$25,000 *PLUS THE LONG TERM SAVINGS***

Implementation

The E3 team was comprised of 3-6 experienced professionals with support from the Southern California Gas Company and several local and federal technical assistance providers. Financial consulting services and financial loan assistance were available at no additional cost.

Baseline metrics were collected at the initiation of the E3 review to analyze company operations and identify opportunities for cost savings and efficiency gains. Implementation of the opportunities identified in the review is voluntary on the part of the client, however, the E3 Southern California Team is hopeful that the client will make actual physical and procedural improvements at the facility based on our review and continue to collect report results to the Team after implementation. This data collection and reporting significantly helps companies track their progress towards their goals. It also greatly assists the E3 Team's ability to continue to help U.S. manufacturers in the future. The E3 Team will contact the client at 6 months after implementation activities take place to evaluate project sustainability.

E3 Project Benefits

Based on the results of the pilot programs conducted in Southern California, the following potential benefits have been observed. The realization of actual benefits will depend on the recommendations that are adopted and implemented by management.

Cost Savings

- Significant cost savings resulting from increased process efficiencies and reduced waste
- Improvement in awareness of profitable nature of sustainability practices
- Improvement by as much as 25 percentile against competitors
- Establish culture of continuous improvement

Access to Technical and Financial Resources

- Additional funding through federal and state programs; utility rebates; grants
- Identification of workforce improvement programs (ETP, WIB, etc.)

Post-assessment

- Process improvement opportunities with prioritized implementation action plan
- Follow-up to assist in maintaining program benefits

Quantified Financial Benefits Following Implementation

In addition to the energy and environmental focus, the financial performance of the company is reviewed as part of the *Economy* component of E3. Certain financial performance information is obtained from management and entered into a modeling tool that identifies low performance areas and calculates potential benefits from improvements. Figure 4 is an output from the financial benchmarking analysis obtained from a software tool called the *Transformation Planner* that was developed by the Michigan MEP center and used nationally. The improvements shown in the "proposed" column come from conducting process improvement events and the calculations are consistent with results seen in energy projects that CMTC has conducted. The improvements in Cash Flow, Profitability, and Balance Sheet ratios from process improvements are generally greater than standalone energy equipment projects.

Figure 4. Financial Benchmarking Analysis

Payoff Analysis

The Company **Manufacturing Co.**

Performance Metric	Current		Proposed		Final Target			
	Value	Percentile	Value	Percentile	Value	Percentile	Annual Benefit	One-time Cash Conv.
Utilities	$ 224,000	19%	$ 159,779	44%	$ 200,000	24%	$ 24,000	
Run Hours as % of Available	70.00%	43%	78.99%	68%	75.00%	53%	$ 110,650	
On-time Deliveries	85.00%	25%	92.00%	50%	90.00%	43%	$ 57,075	
Inventory Turns	1.88	5%	5.56	30%	3	6%	$ 229,150	$ 1,527,667
Days Receivables	79.64	8%	54.62	33%	68	15%	$ 15,949	$ 318,986
Freight Premiums	$ 250,000	5%	$ 15,664	30%	$ 200,000	5%	$ 50,000	
Scrap and Rework	8.42%	5%	2.70%	30%	5.00%	10%	$ 264,150	
Employee Turnover	0.00%	95%	0.00%	95%	0.00%	95%	$ -	
Schedule Bumping	15.00%	38%	6.88%	63%	10.00%	50%	$ 33,195	
						TOTAL:	$ 784,169	$ 1,846,653
							GRAND TOTAL:	$ 2,630,822

E3 Project Tasks Include Extensive Data Collection

Working with the manufacturer's management team, CMTC established a project plan with defined tasks and deliverables providing real-time coaching and knowledge transfer throughout the process. The plan included the following specific steps:

Understand and Document Company's Current State

- Perform a top-level overview assessment of company financials and operational performance compared to companies of similar size and industry.
- Collect three year energy and production data for energy intensity and GHG calculations
- "Walk the floor" and interview company employees to create a Value Stream Map depicting the current state of operations and processes, including: raw materials used energy inputs, material outputs and sources of production waste for VERSA™ analysis.
- Work with the Pollution Prevention Advisor to identify uses of chemicals or raw materials and evaluate opportunities to reduce wastes/ by-products (pollution prevention).
- Coordinate assessments of energy equipment for upgrades or efficiencies
- Estimate operational cost savings based on increasing operational performance levels.
- Identify worker safety improvement opportunities.

Consider Options for Improvement to Gain the Future State

- Identify opportunities for improvement in energy use, waste reduction, and productivity.
- Investigate and analyze cost effectiveness ratios of various improvement opportunities.
- Understand the resources needed and the potential barriers to implementing projects.

Post-assessment – Report and Sustain the Gains

- Prepare and present final report to facility managers and team.
- Prioritize implementation actions and discuss implementation plans.
- Help the facility identify the best source of financing for capital investments, including rebates, grants or loan opportunities and training opportunities for facility staff.
- Maintain contact with the facility following the initial assessment to support progress.

E3 Project Deliverables

Each E3 project will have specific deliverables identified for review by management at its completion. While these may vary depending on the needs of the facility involved, the deliverables typically will include an executive summary report and supporting detailed analysis documents with the following outputs:

- A VERSA™ Map (example in Attachment A) depicting the current state of key processes.
- Identified manufacturing raw material, labor and energy inputs and associated material outputs, including hazardous materials, e.g., products, packaging, Green House Gas (GHG) emissions, and production of waste materials with possible recycling identified.
- Recommendations to reduce operating and utility costs based on above findings.
- A Future State Value Stream Map with a "Kaizen" (single improvement event) Opportunity Matrix (see figure 6) that provides a method for prioritizing implementation projects.

- A Worker Safety Review report plus recommendations for training and internal staff development.

E3 Project Results from Prior Programs

In addition to energy savings that result from equipment upgrades/retro commissioning or employee behavior enhancement, CMTC has typically documented energy savings from Lean/Six Sigma projects often enhancing ROI significantly and reducing paybacks from years to months[5]. Figure 5 contains a summary of three California E3 projects that include energy savings from process improvements in addition to gas and electric equipment improvements.

Figure 5. California Project Opportunities From Three E3 Projects

Manufacturing Type	Retro-commissioning Opportunity	Annual Retro-commissioning savings	IDSM Opportunities
Ingot Manufacturer	Increase capacity and reduce operating hours through manufacturing velocity improvments	Estimated 12% kWh reduction	Rotary furnance repair to reduce leaks, waste heat recovery
Food Processor	Cutting scrap reduction	50% water and disposal cost reduction to clarifier	Lighting upgrades in curing warehouse, cooling tower replacement
Print & Dye Manufacturer	Improve quality and scrap rates, lab flow rates, end knot sewing, drying finish time	15,000 therms and 120,000 kWh	Boiler upgrade, lighting upgrades, controls, water consumption, excessive demand

Two Current Case Studies – Highlights of Findings

Company 'A' is a privately held textile dye and finishing company in Los Angeles. They have adapted to the business downturn by shifting the product mix away from commodity cotton dyeing and developing processes that serve a niche market for dyeing synthetic yarns. The company is a contract processor – that is, they have no proprietary products but rather operate as a toll house for many large retailers. The ongoing issues of shifting textile markets in the Los Angeles area and overall in the US have led to the closure of many dye houses while the remaining ones operate on thin margins. The processes required for dyeing involve high levels of consumption of water, chemicals, dye, and energy. In addition, the level of demand creates environmental challenges, especially water treatment issues and carbon footprint. Controlling costs thus involves accurate identification of cost effective improvements with acceptable ROIs critical to survival. In 2011, energy, water and discharge costs were almost $2.4M– representing nearly 25% of revenues.

Opportunities for reducing water usage were identified through the installation of new dye tanks. Energy efficiency opportunities include boiler upgrades, heat recovery equipment, dryer improvements, and variable frequency drives for pump motors along with lighting upgrades. Improvements to other processes such as chemical mixing also improve safety and ensure consistent product quality. Material handling recommendations will support labor

[5]Church, G., LaPalme, G., Stevens, G. "Energy Project Financial Analysis: What Have We Been Missing?", 2009 ACEEE Summer Study on Energy Efficiency in Industry, Washington D.C.: American Council for an Energy-Efficient Economy.

efficiency gains. While several of the targeted improvements require capital investment, financing sources have been evaluated and utility incentives will help with offsetting the cost of some of the programs.

Company 'B' is a meat processing plant that operates in a 75,000 sq. ft. building and produces items such as BBQ pork, pepperoni, salami, pot roast, and pastrami. The facility consists of two major areas: the raw meat section and the processed meat section. Major energy consumption equipment includes boilers, cooking ovens and freezers. The primary sources of waste discharge are cleaning water, which has a high level of COD and solid matter from the meat processing, and GHG from the boiler exhaust. The E3 engagement included an energy assessment which focused on the boilers, a Pollution Prevention (P2) assessment that focused on the contents of the water discharge, a worker safety review, and a financial performance evaluation.

In the areas of energy, emissions (water and air), process improvements, solid waste reduction, and safety improvements, 33 different improvement opportunities were identified. Not all of the improvements were researched to the level of determining actual dollar savings, implementation costs, or ROI but in the case of the energy review of natural gas consumption, the savings estimates amounted to over 33,000 therms reduced per year which amounts to a cost savings of nearly $28,000. This reduction is over 11% of their annual current gas consumption. Actual implementation costs will be determined as identified improvements are implemented.

Comparing E3 with Value & Energy Stream Mapping (VeSM) and Continuous Energy Improvement (CEI) Programs presented at 2013 ACEEE

The topic of sustainability often centers on the triple bottom line of economic considerations, social responsibility and the environment. Today, more and more manufacturers are adopting sustainability into their overall business strategies. They understand how sustainable business practices reduce waste, improve efficiency, and position their firms to be more competitive in the global marketplace. Prior to the E3 program, CMTC participated in two Investor-Owned Utility-sponsored programs for California manufacturers with very similar objectives but slightly different assessments - the VeSM™ program and the CEI program.

The VeSM program used Value Stream Mapping to focus on energy use at the machine/process level - the E3 program takes the same approach. The CEI program employed detailed technical audits and a robust organizational culture survey of management practices to help participating companies develop a long-term strategic plan for energy management aligned with the new ISO50001 standards. The E3 program also focuses on strategic planning. A full description can be found in the ACEEE CEI paper[6]. Results for energy improvements and cost reductions were consistent between these programs and provide a baseline for E3 metrics.

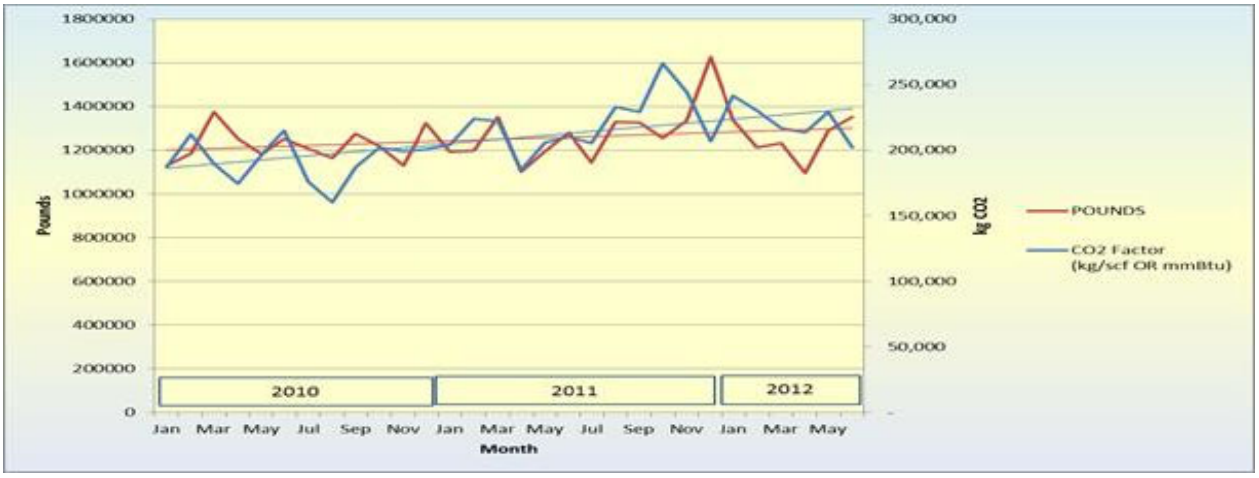
Energy Intensity and GHG Reduction Discussion

Uncontrolled process variability has been a constant in all the programs that CMTC has worked on attempting to reduce energy intensity (EI) (the ratio of energy used per unit of production) and carbon footprint. Figure 6 shows how uncontrolled variability can create short-term changes

[6]Church, G., Widdison, K., Reese, J., G. "Evaluating Continuous Energy Improvement and Retro-commissioning Projects with Different Assessments but Similar Results", 2013 ACEEE Summer Study on Energy Efficiency in Industry, Washington D.C.: American Council for an Energy-Efficient Economy.

that are counter to the desired trend line. For a fuller description on how these types of trends can be managed, readers may review the citations in this paper for solutions.

Figure 6. Production and GHG Graph for Food Processor



Analysis of Improvement Opportunities Identified

Figure 7 is a representation of a Kaizen Impact Matrix that shows how various opportunities are assigned two values: a "difficulty" rating (which includes the cost element) and a "benefits" rating. Based on those two values, the opportunities are placed on the grid as shown to provide a visual method of prioritizing the different opportunities (from "high" in upper-left to "low" in lower-right). The circled items indicate where to look for "quick win" projects.

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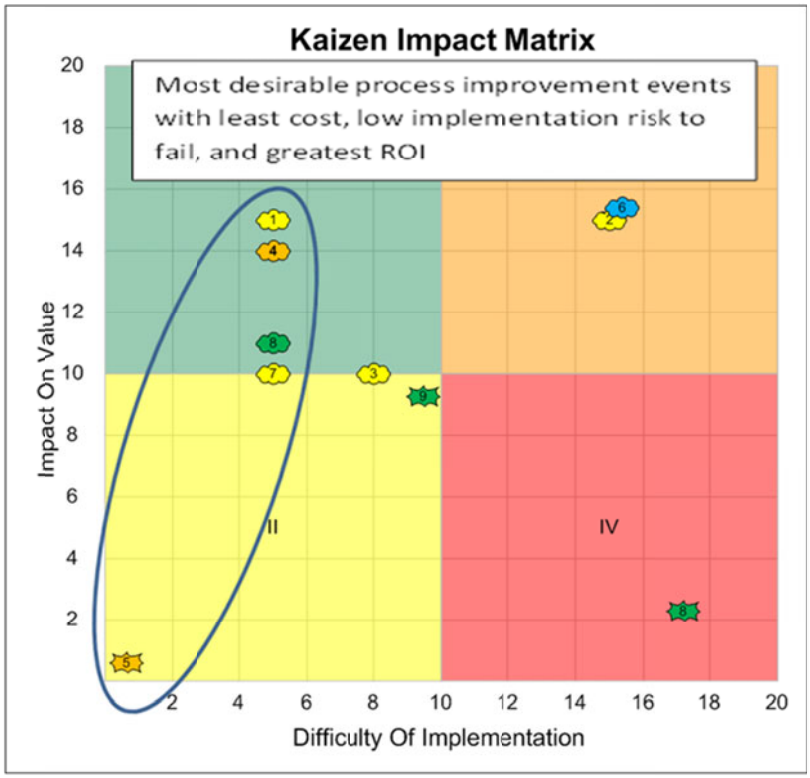

Recommendations to Improve E3

There are over 300,000 U.S. manufacturers that meet the qualification criteria for the E3 program. Less than 150 of these firms have participated during the three-year pilot program. While these projects have resulted in valuable lessons-learned and improvements in the methodology, there are a number of factors that need to be implemented, strengthened or improved in order to achieve greater market penetration and effective impact. Some of these include:

1. Recruitment of companies to participate in E3 assessments could be enhanced through a national recognition program. Recognition considerations might include national listing as a participant, a logo to indicate leadership in national sustainability efforts to be used for marketing and product packaging, certificate of participation signed by the President of the United States, etc.
2. Funding of Assessments: Once the pilot program is completed and full-scale outreach is underway, the question of how to fund ongoing projects becomes an issue as the assessment is viewed as a financial risk if funded entirely by the participant since the outcome is uncertain. Co-funding from the supporting organizations is critical to scale the program and that depends on those organizations seeing alignment with their missions and impact from the program. Thus, a key part of obtaining increased support is providing information on the results achieved and lessons learned in the pilot programs.
3. Delivery Efficiency: Creating greater project delivery efficiencies will reduce the time required for everyone involved in the project, improve effectiveness, increase the impact and benefits to participating manufacturers and provide better models management to sustain the gains long-term.
4. Implementation Support: Each project is a series of assessments but benefits only accrue to the manufacturer and stakeholders after implementation. The program should provide implementation assistance - directly or through improved awareness of available resources.
5. Energy Savings through IDSM: More data need to be collected to review the utilities' needs to demonstrate program cost effectiveness (generally to their state PUC). CMTC modeled cost effectiveness with early data and has documented favorable results similar to the earlier VeSM and CEI programs which were energy-reduction engagements.
6. Increased focus on education for business owners/managers: Because energy and GHG are not immediately visible, managers and employees alike need to be trained to observe, identify, and address areas where energy can be saved and GHG reduced. Many of the opportunities may be relatively low-cost changes such as behavior-oriented tasks (turning off lights in unused areas or improving use of compressed air), while others may be capital intensive and involve complex analysis and ROI calculations which involve new insights and knowledge. Related E3-based awareness campaigns need to be built into the program model to ensure that they are implemented in each project.

Attachment A. Value Stream Map Includes Four Types of Opportunities Matched to the Opportunity Legend at Left