Total Assessment Audits (TAA) in Iowa

William G. Haman, Iowa Energy Center

ABSTRACT

Traditionally, energy, waste reduction and productivity audits are performed for a manufacturing facility independent of one another. Auditors generally deliver recommendations for improvement based on their specialized expertise (energy, waste reduction, productivity, etc.) without regard to how those recommendations may impact other, sometimes less obvious, subsystems or processes within the facility. The audits are typically performed in isolation from the plant upper management and commonly without adequate knowledge of how inherent interrelated operational constraints may directly or indirectly influence the success of audit recommendations.

The Total Assessment Audit (TAA) concept originated from the belief that a manufacturing facility is better served using a holistic approach to problem solving rather than the more conventional isolated approach. The total assessment audit methodology partners the upper management team of a company with a multi-disciplined team of industry-specific specialists to collectively ascertain the core opportunities for improvement in the company and then to formulate a company oriented continuous improvement plan. Productivity, waste reduction, and energy efficiency objectives are seamlessly integrated into a single service delivery with the TAA approach. Nontraditional audit objectives that influence profitability and competitiveness such as business management practices, employee training, human resource issues, etc. are also subject to evaluation in a TAA. The underlying premise of this approach is that the objectives are interrelated and that simultaneous evaluation will produce synergistic results. Ultimately, it is believed that the TAA approach can motivate a manufacturer to implement improvements it might not otherwise pursue if it were focused only on singular objectives.

Introduction

Nature's ecosystems are delicately balanced communities sensitive to even modest fluctuations in their given order. Each living creature whether animal, insect, plant or microorganism is dependent on the ecosystem functioning as a unit in order to maintain that balance. Upsets to the balance (i.e. disease, drought, fire or other natural disaster) not only affects the afflicted component, but also every other component of that community.

Manufacturing facilities are similar to ecosystems. A well run manufacturing facility receives orders for product, produces product and ultimately sells product for a profit. A breakdown within any aspect of the material flow into, through, and out of the plant to the marketplace, creates repercussions that are felt throughout the entire facility. Symptoms of an unbalanced facility may surface in areas such as: the plant's capacity utilization level, cash flow, cost overruns, expedited jobs, missed shipment targets, order backlogs, inventory levels, scrap rate, stressed worker or customer relations, etc., any of which adversely affect the company's ability to achieve it's overall goal of making money. Like an ecosystem, a manufacturing facility should operate as an integrated system of interrelated dependent subsystems and processes, rather than a compilation of isolated subsystems and processes.

Traditionally in manufacturing facilities, energy, waste reduction and productivity audits have been performed independent of one another. The auditor concentrates on and delivers recommendations for improvements based on their specialized expertise (energy, waste reduction, productivity, etc.) without regard to how those recommendations may impact other, less obvious, subsystems or processes within the facility. The audit is generally performed in isolation and without knowledge of inherent interrelated facility constraints that may directly or indirectly influence the success of audit recommendations and ultimately the company. Sometimes even the most simplistic straight forward recommendations can have crosscutting influences.

How often has an energy auditor examined the energy impact resulting from tuning-up a boiler or insulating steam lines without considering the steam end-use requirements? Consider the impact to the manufacturer's profits if the auditor could instead recommend that a boiler be throttled or eliminated based on a system evaluation of the process end-use temperature and pressure requirements. While the energy savings opportunities for the boiler tune-up and pipe insulation may offer reasonable economic paybacks, they may pale in comparison to the potential savings associated with eliminating any quantity of steam consumed at a higher energy state than the ultimate end-use process requires.

How often has a waste reduction auditor examined a manufacturer's paint line and recommended improving the operators' technique or the installation of paint baffles as opportunities for improving the paint transfer efficiency rate or reducing the quantity of filters consumed, without understanding the interrelationships between the paint line and the production speed and quality control constraints? Consider the impact to the throughput and ultimately the manufacturers' profit line if the mentioned opportunities were coupled with improvements that delivered faster line speeds with fewer scrapped parts by; 1) installing sequenced programmable logic controlled spray-nozzles optimally configured in series-stacked spray booths and 2) incorporating state-of-art parts cleaning and paint drying technology to the process line.

Finally, how often have production engineers added horsepower capacity to a compressed air system to alleviate low line air pressure complaints without examining the air distribution system design and end-use requirements? Consider the impact to the company profits if the engineer could instead recommend the elimination of a compressor based on an evaluation of; 1) the distribution piping design; 2) the quantity of unregulated compressed air system leaks and inappropriate uses; 3) the volume and placement of compressed air storage in the system and; 4) the control strategies for sequencing the supply side compressors in conjunction with regulating the demand-side end-use pressures.

These simplistic examples illustrate how opportunities for dramatic improvements might easily be overlooked during routine assessments.

The Total Assessment Audit (TAA) Concept

The Total Assessment Audit (TAA) concept originated from the belief that a manufacturing facility is better served using a holistic approach to problem solving rather than the more conventional isolated approach. The TAA methodology integrates the expertise of disciplines associated with achieving three primary objectives: productivity improvement, waste reduction, and energy efficiency. The underlying premise is that the objectives are interrelated and that simultaneous evaluation will produce synergistic results. Ultimately, it is believed that the TAA approach can motivate an industry to implement improvements it might not otherwise pursue if it were focused only on singular objectives.

The TAA idea was conceived after the Northeast-Midwest Congressional Coalition drafted legislation for the Energy Policy Act of 1992 that would have encouraged electric and gas utilities to provide integrated energy efficiency, productivity and waste reduction assistance to industry. The Northeast-Midwest Institute, the Coalition's research organization, worked under a grant from the Kellogg Foundation to research and assist in the development of an integrated audit program in three states, including Iowa. To facilitate efforts in Iowa, a working group was established that included participation from state government, electric power utilities and industrial outreach centers. The collaboration was convened to strategize methods that would improve industrial energy efficiencies through productivity enhancements. Although no funds were ever appropriated by Congress to implement the collaboration's strategies, the Total Assessment Audit concept had been formulated and needed to be tested through demonstration.

Variations of TAA type services have been developed and are available across the country including: PRISSM Plus™ offered in Ohio by the Institute of Advanced Manufacturing Sciences; EPRI Partnership for Industrial Competitiveness (EPIC) offered to appropriate subscribers of the Electric Power Research Institute and; FlexTech available in New York State through the New York State Energy Research and Development Authority. The Department of Energy sponsors Industrial Assessment Centers (IAC) at engineering colleges and universities across the country which offer free 1-3 day audits to small and medium-sized companies. IAC offerings are completed with engineering students and faculty mentors but are generally less vigorous than those available through a TAA or comparable service.

The Total Assessment Audit Methodology

The methodology utilized for conducting Total Assessment Audits in Iowa has evolved over the past six years based on the combined experiences acquired in performing twenty-five Total Assessment Audits during three demonstration projects sponsored by the Iowa Energy Center[1]. Several different approaches and TAA team compositions have been tried with varying degrees of success. The methodology described herein represents the model currently being utilized in ongoing TAA demonstration projects in Iowa.

Each TAA project has reconfirmed the importance of concentrating on productivity and throughput themes which are universal regardless of the industry type being served. Aside from legislated energy efficiencies and waste reduction mandates, energy issues generally receive a low priority from manufacturer's management teams. Energy costs for U.S. manufacturers typically represent only 1-7% of the total product cost (Hopkins & Jones

[1] The Iowa Energy Center is a research, demonstration and educational organization dedicated to increasing Iowa's energy efficiency and use of renewable fuels. Established under the State of Iowa's Energy Efficiency Act (Sec. 266.39c Code of Iowa), the Center was created to conduct and sponsor research on energy efficiency and renewable energy production systems and to assist Iowans assess energy-related technologies.

1995; Moore 1996). Energy related costs are often buried in an accountant's ledger as an overhead expense and consequently not directly attributable to the operating costs of production. Even when significant energy efficiencies can be identified, their impact is often subdued by the reality that only fractional improvements to the total product costs will be realized. Hypothetically, a spectacular fifty percent reduction in direct energy costs may only represent a 1-3% reduction in the total product cost, whereas, a ten percent throughput improvement may reap 10-30% increases on the ledger's net profit line. Based on the potential for larger investment returns, it is clearly prudent to dedicate capital and human resources to projects that address productivity and throughput issues, especially during periods of expanding global markets. Energy efficiencies and waste reductions will follow logically as byproducts of improved productivity and throughput. One can readily demonstrate that every productivity gain has an associated energy efficiency gain and/or a reduction in waste.

Targeted Iowa Industries

The TAA demonstration projects have targeted small to mid-sized manufacturing firms. They are responsible for the bulk of all new jobs created and innovative product and process developments. Across Iowa, there are approximately 5,800 manufacturing firms having fewer than 500 employees. More than eighty-seven percent (87%) of these have less than 50 employees. Nationally, there are more than 380,000 such firms.

In Iowa, manufacturing's importance to the State's economy is increasing and now accounts for approximately twenty-five (25%) or about $18.5 billion dollar of the Gross-State-Product (GSP). Within the past ten years, manufacturing revenues have surpassed agriculture as the largest component of the Gross-State-Product. The increase in manufacturing jobs during the past decade may be traced back to the emergence of a more diversified industrial base that followed the farm recession of the late 70's and early 80's.

As the industrial sector has assumed a larger component of the Iowa economy, it has also widened the margin as the largest energy consuming sector in Iowa, using 41% of the total energy consumed in the state in 1995, an increase from 35% in 1985 (Iowa Department of Natural Resources 1998).

Despite their innovative management and manufacturing practices, small to mid-sized manufacturing firms rank among the least efficient of all manufacturers (Hopkins & Jones 1995; Modernization Forum 1996). These firms generally do not benefit from the economies of scale available to their larger counterparts. Resources, capital and staff, are often scarce or dedicated towards immediate issues related to day-to-day survival in an increasingly competitive international marketplace. Engineering studies and strategic continuous improvement planning efforts are often overlooked as higher short term priorities and urgent matters preoccupy staff time.

Management Partnership

Establishing a strong partnership between the manufacturer's and TAA management teams is critical to the successful execution and implementation of a TAA. Each team in the partnership must entrust and respect the special skills and knowledge each party brings to the partnership. The partnership members must also acknowledge upfront that there is a substantial time and resource commitment associated with dedicated TAA work that may span a time period ranging from a few weeks to several months. Memorandums of Understanding are useful to outline the responsibilities and expectations of each party.

The manufacturer's management team responsibilities revolve around their acceptance to champion the project for their facility. In this light, representation at a vice-president or higher level is essential on the manufacturer's management team. Equally important is a progressive management style that welcomes new ideas and innovation. Management teams that are complacent with their competitiveness in the marketplace or are without authorization to implement internal changes are poor candidates for pursuing a TAA.

The TAA management team ideally consists of engineering or business professionals having significant experience in industrial environments. Ideally they would have direct experience with the specific industry they expect to serve, however, their basic understanding of the industry is normally adequate. Their responsibilities revolve around identifying short and long term strategic problems within the facility and assembling an appropriate team of expertise to address those problems. Their success and ability to work with the manufacturer's management team hinges on their professional credibility, the establishment of a mutual trust and timely responsiveness to the clients needs for assistance.

Action Plan

Recognizing that the manufacturer's management team understands their business and barriers to success better than any outsider can, the TAA management team must work closely with them to jointly identify areas of need so that a focus for the assessment audit can be established. Benchmarking exercises and energy usage analyses have been excellent tools for setting the stage and identifying improvement opportunities. An action plan report prepared by the joint team summarizes the needs priorities and documents a roadmap for improvement. The plan serves as the cornerstone for the full team total assessment audit.

Team Formation

Based on the findings of the action plan, the TAA management team organizes a TAA team of specialists having expertise that matches the issues and improvement opportunities identified in the action plan. In the spirit of the TAA concept, mandatory team members include productivity, waste reduction and energy professionals. Additional team members are recruited from a network of specialists in government, academia, power utility companies and private consultants.

Iowa is fortunate to have dozens of technical centers of expertise residing at universities and community colleges. Key contributors to the TAA projects have included: the Metal Casting Center, the Iowa Waste Reduction Center and the Plastics Technology Center at the University of Northern Iowa; the Industrial Assessment Center, the Center for Industrial Research and Service and the Iowa Energy Center at Iowa State University; and the Graphics Art Technology Center and the Manufacturing Technology Center at the Community Colleges. Each center shares the common mission of assisting industry to become more competitive by offering either free or for-fee technical services. Despite their shared objective and client base, most had not worked with one another in a team setting until the Total Assessment Audit projects surfaced.

The energy service provider is an important stakeholder to the TAA process, especially for the small and medium sized manufacturers. Aside from their energy efficiency expertise, energy service providers can influence the mode of operations and perhaps even the production schedule based on the economies associated with flexible power rate schedules. Time-of-day and interruptible service rates often offer significant incentives to the manufacturer in exchange for committing to a flexible production schedule. The electric utilities in Iowa have assumed a unique leadership role in the development and disposition of Total Assessment Audits. As restructuring of the electric utility industry continues across the country and the competition for customers intensifies, the role of the local power supplier in the TAA model becomes more impelling.

Private consultants fill a void where specific expertise can not otherwise be located. Consultants hired for the demonstration projects have had both specific expertise and significant industrial experience. Additionally, consultants that are recognized as experts in their field add genuine credibility to the entire effort.

Total Assessment Audit

Proceeding from the action plan, a total assessment audit is conducted on-site with the assembled TAA team. The initial 2-3 day on-site portion of the audit is conducted with the aid of key facilities operating and management personnel. TAA team experts are paired with the appropriate facilities personnel to collect specific data, gather a working knowledge of the operations and identify opportunities for improvement. Workshops are conducted at the end of each day to exchange information and are structured to encourage open discussion and debate regarding the merits of each identified opportunity. Key to the TAA team concept and workshop format are the synergies that are generated during the opportunities assessment phase. An apparently good opportunity to one team member may create a negative impact elsewhere in the operations, whereas, seemingly weak opportunities may contribute additional value to opportunities in need of additional justification.

More detailed analysis of mutually agreed targeted opportunities are developed by the team experts after the on-site audit is completed. Follow-up visits and interactions with the company are common. Feasibility studies and preliminary designs are formulated from which an economic analysis is prepared. As the studies progress, additional workshops for the collective teams are conducted to focus on proposed recommendations for improvement. Based on the recommendations, an implementation plan report is jointly prepared by the TAA and manufacturing management teams.

Implementation Phase

The implementation phase is the climax of the Total Assessment Audit. The strategic plan for short term and sustained improvements are placed into action during this period. Based on the level of capital resources required for implementation, the implementation phase may extend across several fiscal years.

Too often, audit services reports end up collecting dust on a shelf soon to be forgotten because they were packaged without an implementation phase. Consequently, no benefits are realized from the effort. This parody often results as facility managers become stranded with project recommendations that either overwhelm their understanding, ability or time to pursue.

The Total Assessment Audit process differs from the aforementioned situation since it's foundation is developed on the partnership created and nurtured between the two parties throughout the TAA process. Although the manufacturer must champion the implementation activities, the TAA management team must commit to the partnership by providing assistance and follow-up actions throughout the implementation phase.

TAA Case Study Demonstration Projects in Iowa

The Iowa Energy Center has sponsored three demonstration projects associated with the Total Assessment Audit concept between 1993 and 1999. A total of 25 companies have participated in the combined projects. Following the success of the initial demonstration project, subsequent projects were sponsored to:

1. Demonstrate that the TAA concept is transferable across all industries and is not limited to just energy intensive ones.
2. Examine the TAA methodology to determine the most effective way to conduct them.
3. Examine the extent to which TAA concepts can be integrated into private enterprise.
4. Develop case study reports that document the value TAA can have to industry.

The following two case study examples illustrate how the TAA approach was used and the magnitude of impact it had on the company's productivity and competitiveness based on data collected during and after improvements were implemented. The measured data are presented as a percentage improvement or as a nondescript standard unit in order to protect the participating company's more specific but privileged information.

The Foundry With a Future: A Demonstration Project for the Iowa Foundry Industry to Provide Energy Savings by the Improvement of Process Manufacturing Efficiencies

The first Total Assessment Audit conducted in the U.S. was undertaken as a demonstration project between 1992-1995 at the Crane Valve-Washington company, located in Washington, Iowa. Crane-Washington, wholly owned by Crane Company of Stamford, Connecticut, is a leading manufacturer of ball, butterfly, check, gate and globe valves made from ferrous and nonferrous materials. The Crane-Washington facility, established in 1968, primarily manufactures gray and ductile-iron valves for the industrial, chemical, petroleum and water treatment markets. Product demand was high at that time and the U.S. foundry industry was healthy. Over the next two decades however, competition from foreign metal casters grew dramatically forcing the closure of many U.S. foundries. By 1990, the survival of the Crane-Washington foundry was clearly in jeopardy.

Under the initial leadership of Iowa Southern Utilities[2], a Total Assessment Audit was conducted at the Crane-Washington facility. The assessment phase of the project was

[2] Iowa Southern Utilities merged with Iowa Electric Light and Power Company in 1993 to create IES Utilities. In 1998 IES Utilities merged with Interstate Power Company and Wisconsin Power and Light to create Alliant Energy.

completed in approximately six months and linked several key areas of production needs with expertise offered by the TAA core team consisting of (expertise in parenthesis):

1. IES Utilities (project management and energy efficiency).
2. Metal Casting Center, University of Northern Iowa, (foundry productivity).
3. ADM Associates (energy efficiency).
4. Iowa Waste Reduction Center, University of Northern Iowa, (waste management).
5. Center for Industrial Research and Service, Iowa State University, (productivity).
6. Kirkwood Community College, (productivity).
7. Iowa Energy Center, (project funding and case history publication).

Sixty-three *Opportunity Ideas* were identified and organized into functional categories by the TAA team. The ideas were evaluated, refined and presented to Crane-Washington in the form of a continuous improvement plan having five major focuses:

1. **Quality Management** - installing a total quality management (TQM) program to address quality, internal scrap rate, process control and employee empowerment issues that formalized and documented testing and inspection of materials, processes, and product.
2. **Synchronous Manufacturing** - integrated with the TQM program to address real-time inventory control and scheduling of materials, production, patterns, and cores.
3. **Waste Management** - reinforcement of an existing waste management system addressing scrap reductions, water use reductions, recycling materials and the disposal and reuse of foundry sand.
4. **Energy Management** - capital investments contributing to equipment energy efficiencies and lower energy consumption and non-capital demand side management improvements to take advantage of time-of-day scheduling and interruptible power rates.
5. **Future Marketing** - strategic marketing planning identifying target markets to expand into, profitable casting characteristics (sizes, weights, types, etc.) for foundry operations, internal communications and pursuit of ductile-iron product niches.

The improvement plan was implemented by the company with the technical assistance of the TAA team between 1993-1995. An immediate impact was apparent even during implementation as documented in two case study reports (Metal Casting Center 1996, 1998). Traditional foundry metrics were monitored over a period of four years at the facility to measure the effectiveness of the TAA. The impact to the Crane-Washington operations was apparent within the first year as illustrated by the statistics presented in Table 1.

Table 1. Initial Year Measurements (Metal Casting Center 1996)

Performance Measurement Item	% Change: Nov 1993-Sept 1994
Number of foundry wage employees	up 30%
Average tons per day poured	up 78%
Good molds poured[3]	up 42%
Man-hours per ton poured	dn 27%
Percentage of bad molds[4]	dn 28%
Cost of scrap per ton poured[4]	dn 39%
Kilowatt-hours per ton melted	dn 29%

[3] Comparison based on year-to-date daily averages
[4] Comparison based on year-to-date monthly averages

The Iowa Energy Center commissioned a three-year follow-up study of the Crane-Washington operations to determine whether the continuous improvement plan implemented at the facility had a sustained impact to the facility over several years. The full value of TAA services is best measured by the impacts that can be sustained and continue to improve the overall facility operations without significant leveling or declines after the initial effects normalize. The follow-up study (Metal Casting Center 1998) documents that continuous improvements were sustained long after the departure of the TAA team.

Although the net energy consumed at the facility has increased during the study period, Figure 1[5] illustrates the energy consumed per ton poured has steadily declined.

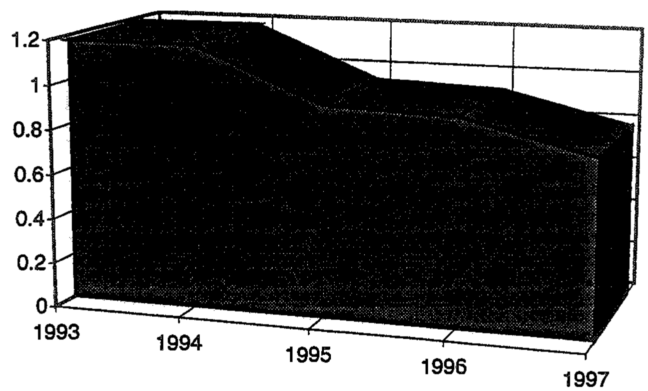

Figure 1. Energy (kWh) per Ton Poured Expressed as Standard Units (Metal Casting Center 1998)

The TAA team identified the scrap rate within the facility as a short and long term opportunity for improvement. Similar to the energy usage, the scrap rate at the foundry was significantly reduced despite a dramatic increase in net tons poured as illustrated in Figure 2[5].

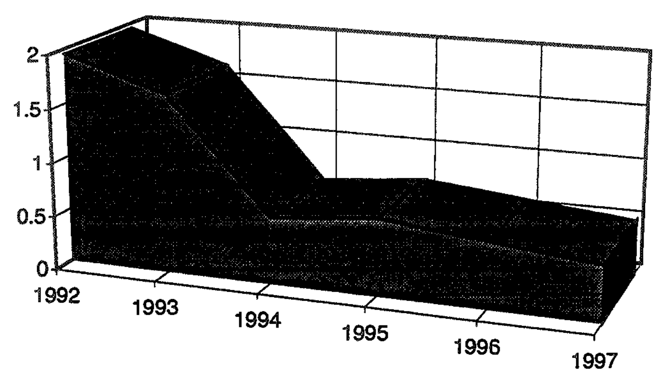

Figure 2. Scrap Cost per Ton Expressed as Standard Units (Metal Casting Center 1998)

[5] Standard units are used for the purpose of graphing the data and are a statistical manipulation which provides numeric values as a function of the standard deviation, the mean, and the actual values. The manipulation of data was required to provide anonymity for the foundry, but the values provide a standard score which allows for trend comparisons between groups.

The quality improvements associated with the mold forming and casting operations paid dividends across the entire range of operations. The production of consistently higher quality castings freed in-house resources previously dedicated to rework issues for other tasks. Marketing efforts, springboarded by a newly acquired ISO certified plant designation, proved extremely successful securing outside sales that went far to more fully utilize the plant's capacity. As a result, the implementation of a continuous improvement plan provided the catalyst necessary for sustainable growth in the company during a period when growth throughout the U.S. gray and ductile iron industry was relatively flat as shown in Figure 3[6].

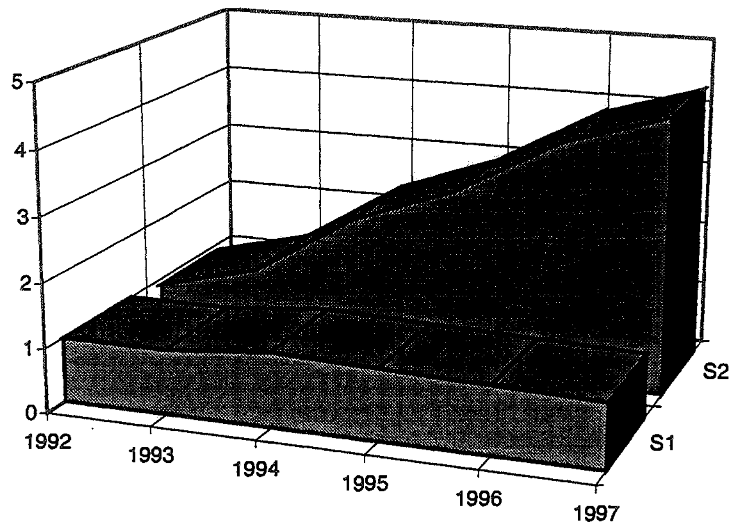

Figure 3. TAA Foundry Performance (S2) vs. U.S. Gray and Ductile Iron Industry Performance (S1) Expressed as Standard Units (Metal Casting Center 1998)

Field Study of Energy Savings Achieved in Manufacturing Industries: Total Assessment Audit and Demonstration

The ongoing TAA research and demonstration project is being conducted by Iowa State University. The project attempts to integrate the lessons learned from previous TAA project audits with the goal of duplicating the success experienced at Crane Valves-Washington. The project scope includes five TAA case studies at companies having SIC codes that represent the prevalent industries in Iowa. The industries chosen include: metal casting, metal fabrication, plastic injection molding, food processing and printing. The studies are at varying levels of the implementation and post-implementation/monitoring phases. Although none of the case study reports are yet published (scheduled to be published in 1999), below are preliminary results of the case study at the metal fabrication plant.

[6] Standard units are used for the purpose of graphing the data and are a statistical manipulation which provides numeric values as a function of the standard deviation, the mean, and the actual values. The manipulation of data was required to provide anonymity for the foundry, but the values provide a standard score which allows for trend comparisons between groups.

A Metal Fabricator of office furniture was experiencing high scrap and rework rates but was also dealing with sales that exceeded production levels despite operating around the clock six days per week. The TAA team identified over thirty opportunities to reduce energy consumption and waste but focused primarily on addressing the productivity issues facing the company. Specifically, the work-in-progress was considered exceptionally high for the size of facility and the material flow through the plant was not optimum for a mass production line. All aspects of the production line were studied ranging from the raw materials purchasing and inventory, stamping and welding, surface finishing, assembly and packaging.

The TAA holistic evaluation identified the paint line as a bottleneck and a significant source of scrap and rework. It was determined that the antiquated paint line design was responsible for limiting the overall production line speed and product quality. Additionally, odors transmitted by the paint line exhaust were a concern of the adjacent neighborhood. The following paint line improvements were implemented and had the associated impacts noted:

- Nuisance odors were addressed through a paint conversion project where solvent based paints were replaced with water based paints.
- The parts preparation, cleaning and drying systems were enhanced to accommodate the new water based paints but also to improve the final surface finish. Combined with new part hanger designs, higher product quality was achieved that contributed to fewer reworks and higher throughput;
- Lengthening the paint line to accommodate additional high efficiency rotary and spot spray nozzles in conjunction with a state-of-art PLC control system improved the transfer efficiency rate, reduced the paint consumption per unit and allowed for other changes that increased the facility's production line speed;
- Replacement of standard booth filters with high efficiency filters and baffles increased the time interval needed between filter changes resulting in reduced down-time and higher product throughput.

Table 2 provides a summary of unpublished improvements based on preliminary measurements made eight months after key implementation measures were installed.

Table 2. Preliminary Initial Year Measurements

Performance Measurement Item	% Change: May 1997-Dec 1998
Throughput (units)	up 80%
Production line speed (fpm)	up 12%
Paint transfer efficiency (%)	up 25%
Parts inventory (tons)	dn 60%
Work-in-progress (hr)	dn 90%
Rework (units)	dn 60%
Scrap (tons)	dn 50%
Kilowatt-hours per unit	dn 33%

Conclusions

Industrial manufacturers in Iowa are prospering during the current expanding economic climate. The internal resources of manufacturers are often stretched just trying to maintain their current level of productivity. Management teams in small to medium sized companies are often taxed with the day-to-day tasks and emergencies and do not have sufficient opportunity to assess their operations or complete strategic planning.

There are four critical ingredients crucial to the success of the Total Assessment Audit concept. First, the environment for change needs to be present in the company and the offer of an audit is seen as a mechanism for facilitating improvement actions. Second, the ability to benchmark and analyze the company's operations and practices quickly. Third, the ability to work with the company in a partnership relationship throughout the process and implementation. Fourth and perhaps most important, the ability to establish credibility of the entity offering the assistance.

The TAA model can impact industrial energy efficiency through a nontraditional method that focuses on improving the productivity of the company. The Total Assessment Audit concept offers a mechanism through which specialty assistance can be tailored and channeled for the specific needs of industry. Specific needs may be fulfilled by either simply offering preexisting assessment tools, training and information or by integrating more technical and research resources for the development of a comprehensive strategic plan.

References

Hopkins, Mark and Ted Jones. 1995. *Getting in Gear: How Energy Efficiency Can Help Smaller Manufacturers Compete in the Global Marketplace.* Washington, D.C.: The Alliance to Save Energy.

Iowa Department of Natural Resources. 1998. *Iowa Comprehensive Energy Plan, 1998 Energy Plan Update.* Des Moines, IA. Iowa Department of Natural Resources, Energy and Geological Resources Division.

Metal Casting Center, 1995. *Turning the Corner at Crane-Washington.* University of Northern Iowa, Metal Casting Center.

Metal Casting Center, 1998. *Turning the Corner: Part II.* University of Northern Iowa, Metal Casting Center.

Modernization Forum. 1996. *Manufacturing a Stronger America: Progress Depends on Small Firms.* Modernization Matters, May 1996. Dearborn, MI.

Moore, Taylor. 1996. *Industrial Partnerships Yield EPIC Results.* EPRI Journal, Vol. 21, No. 1. Palo Alto, CA: Electric Power Research Institute.