

Combined Pollution Prevention Assessments

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ABSTRACT

Reported herein are results of 25 1996-97 Colorado State University Industrial Assessment Center (CSU IAC) combined pollution prevention assessments at small and medium-size manufacturing plants. The assessments were conducted by engineering faculty members and students associated with the CSU IAC. Each assessment includes a full-day plant visit and follow-up engineering and economic analyses of data pertaining to plant operations. Each assessment report includes recommendations for practices that can provide cost-effective energy conservation, pollution prevention, and productivity improvement. The total number of assessment recommendations is 176. The total is comprised of 92 energy conservation recommendations, 54 pollution prevention recommendations, and 30 productivity improvement recommendations. Implementation of recommended practices can provide annual cost savings of \$4.6 million, with a payback period of 0.44 years for recovery of implementation costs. For the three categories of assessment recommendations, annual cost savings averages are \$1,759/yr., \$7,029/yr., and \$133,679/yr., respectively, for energy conservation, pollution prevention, and productivity improvement. Based upon these results, it is concluded that addition of productivity improvement can profoundly enhance the impact of the outreach assistance provided by the CSU IAC. Moreover, addition of productivity improvement expands the breadth of the learning experience for students.

INTRODUCTION

Supported by the U.S. Department of Energy, the CSU IAC performs combined assessments for small and medium-size manufacturing firms. We have previously reported on predecessor CSU outreach programs for pollution prevention¹ and the combination of pollution prevention with energy conservation². In 1996, productivity improvement was added as an area of IAC technical assistance. Presented herein are results for combined assessments for the 12-month period beginning October 1, 1996.

ASSESSMENT PROTOCOL

Objectives

The overall objective is to recommend industrial practices that, when implemented, can save money and conserve resources. The specific objectives of a combined assessment are to identify and evaluate opportunities to conserve energy, prevent pollution, and improve productivity. In manufacturing plants, typical energy utilization functions include lighting, operating electric motors and electronic equipment, generating and utilizing compressed air, generating and utilizing steam, heating, cooling, and transportation. Energy conservation opportunities, with

emphasis upon industrial operations in the western states, have been compiled³. Wastes include hazardous and nonhazardous process-generated wastes in the forms of air emissions, liquid wastes, and solid wastes. A handbook of pollution prevention practices has been assembled⁴. Productivity issues include scheduling of tasks, timely transfers of materials, set-up procedures, production bottlenecks, downtime, production equipment and capacity, inspection and testing, and operator training.

Tasks

Each CSU IAC assessment includes the following sequence of tasks:

- Select manufacturing plant and schedule visit.
- Acquire pre-assessment data.
- Select team and visit plant.
- Identify potential assessment recommendations (ARs).
- Evaluate potential ARs.
- Prepare and submit assessment report.
- Conduct implementation survey.

The following criteria are used to select the manufacturing plants for CSU IAC assessments:

- SIC Code 20-39.
- Gross annual sales do not exceed \$75 million.
- No more than 500 employees at the plant site.
- Annual utility bills \$75,000 - \$1.75 million.
- No in-house professional staff to perform the assessment.

Additionally, the plant should be located within 150 miles of the CSU campus in Fort Collins. The assessment is provided at no out-of-pocket cost to the participating company. The plant incurs no obligation to act on any of the CSU IAC recommendations. The CSU IAC is one of 15 western IACs managed by University City Science Center. The 15 eastern IACs are managed by Rutgers University.

Plant Visit

A team of faculty members, graduate students, and undergraduate students visits the manufacturing plant for a full working day. The host and guide for the plant tour is usually a plant engineer with responsibility for facilities, production, and waste management. The visit includes a guided tour of production facilities and waste-generating operations. CSU IAC personnel interview plant personnel and observe production operations. Utility and waste data for the 12-month period immediately prior to the date of the plant visit are obtained. The day closes with a wrap-up session with the host and other plant personnel.

Assessment Report

The main function of the assessment report is to convey recommendations to the plant manager. The recommendations are to implement specific, cost-effective practices in the areas of energy conservation, pollution prevention, and productivity improvement. Recommendations are based upon analysis of data pertaining to plant operations. The assessment report is normally sent to the plant manager within 60 days after the plant visit date. The report normally summarizes pertinent utility, equipment, and waste data. For example, CSU personnel often perform a lighting survey and inventory major plant equipment, including electric motors, compressors, boilers, fans, ovens, and refrigeration equipment. Current energy conservation and pollution prevention practices are identified. A process flow diagram is prepared. Monthly electric, gas, water, sewer, and waste management costs are quantified for the 12-month period immediately prior to the date of the plant visit. The report then recommends implementing specific practices to save money and conserve resources. The technical and economic analyses that support each recommendation are given, including assumptions, equations, and implementation data. An executive summary is provided that includes a table of the recommended energy conservation, pollution prevention, and productivity improvement recommendations. For each recommendation, the table quantifies resource savings, annual cost savings, implementation costs, and payback periods. Six to twelve months after the assessment, the plant manager is contacted by CSU IAC personnel to obtain information concerning implementation of the recommendations.

RESULTS

Table 1 gives the SIC codes and principal products for each of the 25 manufacturing plants served by the CSU IAC during the 12-month period beginning October 1, 1996. Table 2 gives the number of assessment recommendations (ARs) in the three AR categories for each of the 25 plants. The total of 176 ARs is composed of 92 energy conservation ARs, 54 pollution prevention ARs, and 30 productivity improvement ARs. Table 3 compares the three categories of ARs in terms of total annual cost savings, implementation costs, and payback periods for recovery of implementation costs. Average annual cost savings for the three AR categories are compared on a per AR basis in Table 4.

Energy Conservation

Implementation of the 92 energy conservation ARs can reduce expenditures for electricity, natural gas, and district steam by \$161,870 per year for the 25 plants. The most common energy conservation ARs are as follows: (1) install energy efficient lighting, (2) install energy efficient replacement motors, (3) use outside air for compressor intake, (4) reduce compressed air leaks, and (5) recover waste heat. Cost savings for energy conservation ARs average \$1,759 per year.

Pollution Prevention

Implementation of the 54 pollution prevention ARs can reduce expenditures for materials and waste management by \$379,590 per year. The most common pollution prevention ARs are as follows: (1) recycle burned out fluorescent lamps, (2) recycle cardboard, (3) recover and reuse waste raw material, (4) improve cutting fluid management, and (5) install a solvent recovery unit. Cost savings for pollution prevention ARs average \$7,029 per year.

Productivity Improvement

Implementation of the 30 productivity improvement ARs can generate cost savings of approximately \$4.01 million per year. The most common productivity improvement ARs are as follows: (1) reduce set-up time or improve material flow, (2) improve inspection or testing procedure, (3) improve scheduling of job or task, (4) add or upgrade equipment, and (5) relieve production bottleneck. Cost savings for productivity improvement ARs average \$133,679 per year.

Synergism and Conflict

A synergism is regarded as a cooperative effect, such as acquisition of new equipment that increases production and reduces expenditures for energy. The recommendation to replace conventional painting with powder coating at plant CO0385 can improve productivity and reduce expenditures for electricity. The recommendation to replace a varnish-based conformal coating with a silicone coating at plant CO0393 can reduce air emissions of solvent vapor and reduce energy costs for operation of a curing oven.

A conflict occurs when the desirable effect, such as reducing waste, is accompanied by an undesirable effect, such as increased expenditures for energy. The recommendation to install a solvent recovery unit at plant CO0390 can reduce generation of waste solvents but requires increased expenditures for electricity to operate the solvent recovery unit. Purchase of additional dryers at plant CO0397 can improve productivity but requires increased expenditures for electricity.

Educational Benefits

Graduate and undergraduate students representing three engineering majors participated in the CSU IAC program during the 1996-97 academic year. The students are listed in Table 5, with their academic majors, expected graduation dates and status. Participating students receive valuable experience in recognizing and evaluating practical, cost-effective ARs. The CSU IAC experience provides students with part-time employment related to their majors. The experience also complements the traditional classroom and laboratory learning experiences with practical exposure to current manufacturing operations. The recent addition of productivity improvement broadens the learning experience and is especially relevant for students seeking employment in manufacturing.

CONCLUSIONS

The results demonstrate that it is feasible to conduct a combined assessment with a single crew of CSU IAC personnel. The combined assessments described herein confirm that small and medium-size manufacturing plants can benefit by implementing energy conservation, pollution prevention, and productivity improvement practices. On a per AR basis, the potential cost savings for productivity improvement ARs are considerably greater than for energy conservation and pollution prevention ARs. The very large potential economic benefit for productivity improvement may thus provide an additional incentive for manufacturing firms to periodically examine plant operations for resource conservation opportunities.

REFERENCES

1. Edwards, H. W.; Kostrzewa, M. F. "Pollution Prevention at Small Manufacturing Plants," Paper No. 93-WA-87.07, 86th Annual Meeting & Exhibition, Air & Waste Management Association, 1993.
2. Edwards, H. W.; Kostrzewa, M. F. "Combining Pollution Prevention and Energy Conservation at Small Manufacturing Plants," Paper No. 94-RP137.04, 87th Annual Meeting & Exhibition, Air & Waste Management Association, 1994.
3. National Renewable Energy Laboratory. *DSM Pocket Guidebook. Volume 4: Industrial Technologies*; prepared for U.S. Department of Energy and Western Area Power Administration, 1994.
4. Higgins, T. E. *Pollution Prevention Handbook*; CRC Lewis: Boca Raton, 1995.

Table 1. Manufacturing plants served by the Colorado State University Industrial Assessment Center, October 1, 1996 - September 30, 1997.

| Plant | SIC | Principal Product |
|--------------|------------|-----------------------------------|
| CO0381 | 2024 | Ice cream and yogurt |
| CO0382 | 2086 | Soft drinks |
| CO0383 | 3679 | Automotive sensors |
| CO0384 | 3845 | Electrosurgical equipment |
| CO0385 | 3531 | Aerial manlifts |
| CO0386 | 2434 | Counter tops |
| CO0387 | 2034 | Cooked dried beans |
| CO0388 | 3824 | Flow sensors |
| CO0389 | 3089 | Injection molded plastic parts |
| CO0390 | 2752 | Printed materials |
| CO0391 | 2816, 3339 | Metal compounds |
| CO0392 | 3842 | Personal respiratory equipment |
| CO0393 | 3822 | Electronic controls |
| CO0394 | 3728, 3769 | Aerospace hardware |
| CO0395 | 2082 | Beer |
| CO0396 | 3931 | Music stands |
| CO0397 | 3089 | Injection molded plastic parts |
| CO0398 | 2834 | Vitamins, nutritional supplements |
| CO0399 | 3993 | Commercial signs |
| CO0400 | 3713 | Truck and van bodies |
| CO0401 | 2752 | Printed materials |
| CO0402 | 2541 | Wooden cabinets |
| CO0403 | 2082 | Beer |
| CO0404 | 2048 | Livestock feeds |
| CO0405 | 3443, 3471 | Fabricated metal products |

Table 2. Classification and frequency of assessment recommendations (ARs).

| Plant | Energy Conservation | Pollution Prevention | Productivity Improvement | Total |
|--------------|----------------------------|-----------------------------|---------------------------------|--------------|
| CO0381 | 4 | 1 | 1 | 6 |
| CO0382 | 5 | 4 | 1 | 10 |
| CO0383 | 4 | 2 | 1 | 7 |
| CO0384 | 4 | 2 | 2 | 8 |
| CO0385 | 4 | 2 | 2 | 8 |
| CO0386 | 4 | 2 | 2 | 8 |
| CO0387 | 6 | 1 | 2 | 9 |
| CO0388 | 5 | 3 | 1 | 9 |
| CO0389 | 3 | 1 | 3 | 7 |
| CO0390 | 4 | 2 | 1 | 7 |
| CO0391 | 4 | 2 | 0 | 6 |
| CO0392 | 2 | 2 | 1 | 5 |
| CO0393 | 4 | 3 | 1 | 8 |
| CO0394 | 2 | 5 | 1 | 8 |
| CO0395 | 2 | 1 | 0 | 3 |
| CO0396 | 5 | 0 | 1 | 6 |
| CO0397 | 4 | 4 | 1 | 9 |
| CO0398 | 2 | 2 | 2 | 6 |
| CO0399 | 4 | 2 | 2 | 8 |
| CO0400 | 3 | 2 | 1 | 6 |
| CO0401 | 2 | 3 | 1 | 6 |
| CO0402 | 2 | 4 | 2 | 8 |
| CO0403 | 5 | 0 | 1 | 6 |
| CO0404 | 4 | 1 | 0 | 5 |
| CO0405 | 4 | 3 | 0 | 7 |
| Total | 92 | 54 | 30 | 176 |

Table 3. Economic data for assessment recommendations (ARs).

| AR Category | Annual Cost Savings | Implementation Cost | Payback Period |
|--------------------------|----------------------------|----------------------------|-----------------------|
| Energy conservation | \$161,870/year | \$314,610 | 1.94 years |
| Pollution prevention | \$379,590/year | \$556,570 | 1.47 years |
| Productivity improvement | \$4,010,380/year | \$1,133,250 | 0.28 years |
| Total | \$4,551,840/year | \$2,004,430 | 0.44 years |

Table 4. Comparison of annual cost savings on a per AR basis.

| AR Category | Average Annual Cost Savings |
|--------------------------|------------------------------------|
| Energy conservation | \$1,759/year |
| Pollution prevention | \$7,029/year |
| Productivity improvement | \$133,679/year |

Table 5. CSU IAC students.

| Student | Major | Degree | Year | Status |
|-------------------|--------------|---------------|-------------|-----------------------|
| Nicole Ball | Chem. Engr. | B.S. | 1997 | Graduated |
| Doug Batten | Mech. Engr. | M.S. | 1998 | Graduate Student |
| Bo Bowman | Civil Engr. | M.S. | 1998 | Graduate Student |
| Pat Bruckhart | Mech. Engr. | M.S. | 1998 | Graduate Student |
| Klint Combs | Mech. Engr. | B.S. | 1997 | Graduated |
| Paul Davis | Mech. Engr. | M.S. | 1997 | Graduated |
| Matt Goulais | Mech. Engr. | B.S. | 1998 | Undergraduate student |
| Matt Kottenstette | Mech. Engr. | B.S. | 1998 | Undergraduate student |
| Dorson Mahooty | Civil Engr. | B.S. | 1997 | Graduated |
| Emilie McCarthy | Chem. Engr. | B.S. | 1998 | Undergraduate student |
| Colleen Miller | Chem. Engr. | B.S. | 1998 | Undergraduate student |
| Corey Rhodes | Mech. Engr. | B.S. | 1998 | Undergraduate student |
| Julie Sieving | Mech. Engr. | B.S. | 1997 | Graduated |
| Niki Singlaub | Mech. Engr. | B.S. | 1997 | Graduated |
| Cindy Strecker | Mech. Engr. | M.S. | 1997 | Graduated |
| Laurie Williams | Mech. Engr. | Ph.D. | 2001 | Graduate student |
| Ron Zach | Mech. Engr. | B.S. | 1998 | Undergraduate student |
| Jack Zentner | Mech. Engr. | B.S. | 1999 | Undergraduate student |
| Michelle Zolock | Mech. Engr. | B.S. | 1997 | Graduated |