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A PRELIMINARY REVIEW OF ENERGY SAVINGS FROM EADC PLANT AUDITS

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Handout

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PURPOSE

This paper reviews the long-term energy savings attributed to industrial plant energy audits conducted under the U.S. Department of Energy's (DOE's) Energy Analysis and Diagnostic Center (EADC) Program. By the end of FY91, this program is expected to have performed over 3600 plant energy audits since it began in late 1976. During FY91, 500 of the 3600 are expected to be completed. Currently, 18 universities participate in the program. DOE's expansion plan, as specified in the *National Energy Strategy*, calls for adding three universities to the program during FY92.[a]

The EADC Program is funded by the Office of Industrial Technology (OIT). The Program's mission is to analyze the operating characteristics and energy requirements of small- and medium-sized manufacturers to identify and recommend specific opportunities to conserve energy and/or use alternate energy sources through energy audits. The EADC then reports its audit findings to the manufacturer together with estimates of implementation costs, payback periods, and returns on investment. From 6 to 12 months after the audit the EADC calls the plant contact to identify which Energy Conservation Opportunities (ECOs) will be implemented during the 2-year period following the audit. This information is then used to calculate long-term program energy savings.

This review, requested by the OIT as part of their program planning effort, is preliminary and limited in scope. The primary purpose of this paper is to independently assess the accuracy of past energy savings reporting, specifically:

- whether a 2-year assessment horizon for identifying implemented ECOs captures all the ECOs implemented under the program
- whether the number of implemented ECOs and thus, the energy savings associated with program audits, significantly decrease in years 3 through 7 after the audit.

(a) National Energy Strategy, p. 58.

CONCLUSIONS

On the basis of the limited samples of ECOs in this report (161), the ECO status, as compiled by the University City Science Center (Science Center) during their callback,[b] is generally consistent with the current status as established by the Pacific Northwest Laboratory (PNL) callback in March 1991.[c] As a result of this analysis, the following conclusions were established.

1. **The ECO implementation status remained unchanged for 88% of the ECOs when compared to the status as established by the EADC callback.**

2. **For the plants in this audit, it was uncommon for implemented ECOs to be dropped (e.g., only 4 of 99 implemented ECOs have been discontinued from service).** For example, plant contacts indicated that they have not returned to purchasing conventional motors once the move to high-efficiency motors has been made. They also disclosed that their plants continue maintenance programs for boiler tuning, steam-line leak reduction, and compressed air leak reduction. Although no actual measurements have been conducted to verify the current energy savings associated with implemented ECOs, it appears that there is only a very small reduction in energy savings as the result of ECOs being dropped or their efficiency being diluted during years 4 through 7 after the plant audit.

(b) The EADC callback was conducted from 6 to 12 months after the plant audit was completed. During that callback the EADC obtained an opinion from the plant contact as to which ECOs will be implemented within the initial 2 years of the audit.
(c) The PNL callback was conducted in this study, or from 4 to 7 years after the plant audit. Plant contacts were asked to identify which recommended ECOs had been implemented and when. They were also asked if any ECOs had been dropped.

3. **If annual energy savings calculations are based solely on the number and timing of implemented ECOs, then the difference in implementation status between the EADC assessment and the PNL assessment create slightly different energy savings results.** Comparing these two assessments suggests that the energy savings as calculated under the EADC methodology may overestimate long-term energy savings by 10% to 12% primarily because: 1) the initial decision to implement some ECOs was never followed up; 2) several ECOs were implemented, then later withdrawn from operation; and 3) a few nonincremental ECOs were implemented later than projected in the EADC calculations. Only a marginal contribution to the overestimation may be attributed to replacing conventional equipment over an extended time period with more energy-efficient equipment. Relevant examples include upgrades to lighting and electric motors and building "housekeeping" measures (e.g., weatherstripping). Adding to the overestimation may be that a few of the firms may no longer be in operation.

4. **Offsetting the factors contributing to any overestimation of the energy savings is the fact that a few firms have decided to implement ECOs after the EADC callback.** In addition, some plants implemented additional energy-efficiency measures that were not a part of the audit recommendations. A typical situation occurs when plants have added new warehouse capacity and have installed energy-efficient lighting in the new space. Placing efficient heating systems in new plant capacity is also typical. Many respondents reported that the ongoing purchase of efficient equipment was partly because of a heightened awareness of energy use resulting from the audit. This appears to be an important but not easily quantifiable benefit of the program. No energy savings information was obtained for these measures.

5. **As indicated in this assessment of ECOs, the stream of benefits (annual energy savings) continues unabated throughout the 4- to 7-year period analyzed.** The results of the analysis suggests, however, that an additional assessment 4 to 7 years after the plant audit is performed could enhance the 2-year assessment currently used by the EADC Program.

6. **The EADC audit information compiled by the Science Center provides a very important profile of industry-wide ECOs and their applicability for small- and medium-size manufacturing firms operating in the United States.** It is recommended that DOE perform evaluations using EADC plant data for analysis of industrial information pertaining to ECOs and applications. For example, EADC data may be particularly important in developing realistic conservation supply curves for selected ECOs. Supply curves are often used as input to mathematical models that characterize industrial operations and relationships, which could be used to help analyze impacts of energy policy issues.

BACKGROUND

The program was initiated in 1976 with only two EADCs and has grown to 18 EADCs. By the end of the 1989-1990 EADC reporting period, approximately 3168 audits for small- and medium-size industrial manufacturing plants had been conducted (see Appendix A).[a] EADCs, located within accredited university engineering departments across the nation, are staffed by engineering faculty, and graduate and undergraduate students who work under faculty direction.

An EADC audit team of four to six members conducts a 1-day audit to analyze the energy use and manufacturing operations of the plant. The team then prepares an individual audit report

(a) The University City Science Center prepares summary information on a yearly basis for the Pacific Northwest Laboratory (PNL). This information addresses the number of EADC plant audits conducted to date, the energy conserved, and cost saved. PNL uses the EADC Program information along with information about other DOE-funded technologies in tracking energy savings associated with various DOE Office of Industrial Technology projects.

recommending specific ECOs[a] and estimates their associated costs and benefits.

Six to 12 months after the audit report is presented to the plant management, the EADC follows up with a callback to the plant contact to determine which recommended ECOs have been implemented or are expected to be implemented within 2 years of the audit. For purposes of calculating program energy savings, the EADC Program assumes that for ECOs that are implemented over time, energy savings should be calculated on the basis that all implementation occurred within the first 2 years after the audit.[b]

APPROACH

The following describes the sample procedure, data collection, and data analysis.

SAMPLE PROCEDURE

The EADC Program incorporated limitations on specific plant data without plant consent. In addition, the time for obtaining the information was limited. Within this context, the process of selecting plants to be interviewed was to ask six EADCs having audit programs from 1980 through 1988 to participate in identifying six plants each for callback, as well as identifying plant contacts. The purpose of the callback was to compare the current ECO implementation status with information obtained through the EADC callback. The EADCs contacted each plant in advance to ensure company willingness to participate in the program. In the brief time available, one EADC could identify the name of only one plant as being willing to participate. In one other case, the plant contact, when called, declined participating. In other instances repeated attempts to reach the appropriate plant contact were unsuccessful.

PNL recognizes the presence of bias in this survey. First, the study was limited to audits which were selected by the EADCs. The results are based upon an analysis of the population convenient to sample, as opposed to being representative of the entire population which could have been achieved by using random samples. The survey was also limited to contacting only six of the 13[c] EDACs that performed audits between 1984 and 1987. During this period, a total of 1238[d] plants were audited. This paper addresses only 2.1% of these EADC-audited plants. Since the plants interviewed were selected on the basis of plant contacts agreeing to provide implementation information, and not by random sample, and because the plant count is very limited, no statistical inferences can be made concerning the collected information. However, in view of the brief time available for gathering information, the plant information does provide valuable insight to the energy savings from program-recommended ECOs.

DATA COLLECTION

As mentioned above, the PNL callback information examined in this paper is provided with the consent of each plant and is based on conversations with plant personnel representing 26 plants who underwent EADC audits from 1984 through 1987. The PNL callback was a follow-up of the EADC callback conducted 6 to 12 months after the plant audit. The EADC callback is conducted as a standard element of the DOE audit program.

(a) The University City Science Center has developed an extensive listing of ECOs and has organized them hierarchically to allow data analysis at several levels. See *Directory of Industrial Energy Conservation Opportunities, (DIECO)*.

(b) Some ECOs are implemented incrementally. This means that changes in equipment are actually made when old equipment burns out and not before. Examples of incremental implemented ECOs are lighting and motor replacements.

(c) Four of the 13 EADCs initiated operation in 1986 and thus did not cover the full 4-year period (1984 through 1987). An additional 2 of the remaining 9 EADCs are no longer in operation.

(d) *Energy Conserved and Costs Saved by Small- and Medium-Size Manufacturers, 1987-88 EADC Program Period.*

The Science Center identified and described the ECOs recommended by plant energy audits for each of the EADC-nominated plants. The Science Center facilitates ECO assessment in two important ways: by assigning each ECO a Directory of Industrial Energy Conservation Opportunities (DIECO) code, which allows similar ECOs to be analyzed together (discussed in more detail below), and by annually compiling plant audit information from all the participating EADCs in a centralized data system. However, to protect business-sensitive information, the compiled data does not contain plant names. Instead, plant information is coded by a plant identification designation supplied by the EADC. The match between the plant identification code and the plant name, address, and contact is retained by the EADC that conducted the audit.

The number of plants contacted by each of the EADCs in developing a list of plants willing to participate in this review varied. One EADC reported that in screening for 6 plants willing to participate in the callback they had a success rate of only 20% because of business closures, retirements, and other personnel changes. Other EADCs had higher success rates. However, once agreement had been obtained between the plant and the EADC for the plant's participation in this review, the EADC forwarded its list of 6 nominated plants, by plant name and plant identification code, to PNL. The plant code information was then forwarded by PNL to the Science Center who compiled the list of ECOs recommended for each plant. The Science Center information for each recommended ECO included the assigned DIECO number, the ECO description as provided by the audit, the energy savings associated with each ECO, and whether the ECO was implemented as determined in the EADC callback.

In March 1991, each of 26 plant contacts identified by the EADC program was contacted by PNL staff and asked if and when each ECO was implemented. The callback information obtained earlier by the EADCs and by PNL is discussed later in this paper.

DATA ANALYSIS

The data obtained through the data sample and data collection process was analyzed to identify differences in implemented ECOs and associated energy savings between the EADC callback and the PNL callback.

Implemented ECOs

Each of the recommended ECOs was briefly described and the plant contact questioned if the ECO was implemented and, if so, when. The finding of the PNL callback conducted in March 1991 was then compared with the finding from the EADC callback conducted anywhere from 6 months to 1 year after the audit.

Energy Savings

The energy savings information provided by the Science Center for each ECO is based on operation performance and engineering information developed during the audit process. In PNL's callback there was no attempt to have the plant contact speculate on or remeasure energy savings from currently implemented ECOs. Thus the annual energy savings rate associated with each implemented ECO is assumed to be unchanged when calculating the energy savings associated with each ECO implemented in the EADC callback and in the PNL callback. Comparisons of the energy savings between the two callbacks is strictly a function of the type and number of ECOs assumed implemented for each year after the audit.

FINDINGS

Selected characteristics of the 26 plants included in the assessment are shown in Table 1. The plants provide manufactured goods in a broad array of industries from food processing to chemicals to fabricated metals. Plant employment ranges broadly from 20 to 400 employees; nine plants employ between 250 to 400 people. In addition, the plants are disbursed geographically but are generally located

Table 1. Selected Characteristics of 26 Industrial Plants in the Sample

Breakout by Industry

Number of Plants	Industry
3	Food Processing
5	Textile Mills
1	Apparel
2	Printing
1	Chemicals
2	Petroleum
2	Rubber
1	Stone/Clay/Glass
2	Primary Metals
2	Fabricated Metals
1	Machining and Equipment
1	Transportation
1	Instrumentation
1	Miscellaneous Manufacturing
26	

Breakout by Employment

Number of Plants	Employment
10	20 - 99
8	100 - 249
8	250 - 400
26	

Breakout by Audit Year

Number of Plants	Audit Year
11	1984
6	1985
6	1986
3	1987
26	

Breakout by Energy Analysis and Diagnostic Center (EADC)

Number of Plants	EADC
5	Colorado State University, Fort Collins, Colorado
1	University of Dayton, Dayton, Ohio
6	Georgia Tech Research Institute, Atlanta, Georgia
3	University of Massachusetts, Amherst, Massachusetts
6	Oklahoma State University, Stillwater, Oklahoma
5	University of Tennessee, Knoxville, Tennessee
26	

within 150 miles of one of the following EADCs: Colorado State University (5 plants), University of Dayton (1 plant), Georgia Tech Research Institute (6 plants), University of Massachusetts (3 plants), Oklahoma State University (6 plants), and the University of Tennessee (5 plants). The largest portion o f the 26 plants was audited in 1984 (11), with 6 plants audited in each of the following years, and 3 audited in 1987. Specific findings of the study are discussed in the following sections.

ECO IMPLEMENTATION RESULTS

The EADC audits for the 26 plants recommended a total of 161 ECOs. Each of the plants was contacted by the EADC 6 months to 1 year after the audit to determine whether the recommended ECOs were implemented. Based on the EADC callback, 95 ECOs had either been implemented or were to be implemented within 2 years of the audit. The data from the EADC callback are provided in Table 2. Eighty-five (85) of the 161 recommended ECOs were identified as implemented at the time of EADC callback and confirmed as still implemented at the time of the PNL callback. Another 56 of the 161 recommended ECOs were identified in the EADC callback as not being implemented, and their status was reconfirmed at the time of the PNL callback. However, the PNL callback disclosed that the status for an additional 20 ECOs had changed (or 12.4% of the 161 ECOs). Nine (9) ECOs are situations where the plant later

Table 2. Recommended Energy Conservation Opportunities

Number of ECOs	EADC Callback	PNL Callback
Status Unchanged		
85	Implemented	Implemented
56	Not Implemented	Not Implemented
141		
Status Changed		
9	Not Implemented	Implemented
7	Implemented	Never Implemented
4	Implemented	Later Dropped
20		
161 Total		

implemented the ECO, even though the ECO was not reported as implemented at the time of the EADC callback. Another 7 ECOs, although reported in the EADC callback as being implemented during the 2 years following the audit, were actually never implemented because of a change in plant plans. The PNL callbacks also found 4 situations where ECOs that had been implemented were later dropped for one reason or another.

Review of the ECO DIECO information and the data from the EADC and PNL callbacks indicated that the ECOs implemented by the interviewed plants fall into six broad categories:

1. combustion equipment - efficiency changes, equipment maintenance and replacement, heat recovery, and heat confinement

2. steam equipment - upgrading and repair, and system changes

3. utilities and other energy forms - includes electricity, compressed air, water, fossil fuels, and purchased steam

4. scheduling equipment - plant scheduling, packaging, shipping, handling, and transportation

5. process equipment - maintenance, repair, replacement, operations and equipment process design, process heat recovery, and process heat confinement

6. buildings - lighting, space heating, space cooling, ventilation, and building grounds.

Specific information was obtained about each of these ECO categories during the PNL callback. A summary of this information is provided in Appendix B. Appendix C provides additional single-plant, energy conservation information on a plant-by-plant basis.

ECO ENERGY SAVINGS RESULTS

The EADC audit calculated a specific level of energy savings associated with each implemented ECO. This information was developed on the basis of engineering data collected at the time of the plant audit. In this review, the relationship between the ECO and the energy saved is used to calculate energy savings associated with implementation status discovered during the PNL callback. Importantly, discussions with plant contacts did confirm that the plants continue to support maintenance and operations schedules and procedures that maintain the ECO's integrity. For example, boiler tune-ups continue to be performed on a periodic basis, repair of steam and compressed air leaks continues, and energy-efficient lighting and motors continue to be installed. In addition, of the 89 ECOs included in the study, which were implemented 5 or more years ago (i.e., prior to 1987), 85 remain in operation today.

The annual energy savings associated with the EADC and PNL callbacks for ECO implementation information is shown in Table 3. The EADC callback columns show the level of annual energy savings from all ECOs planned for implementation by end of year 2 after the audit. For incrementally and non-incrementally implemented ECOs, the EADC program assumes that no change in implementation will occur after the first 2 years. The PNL callback columns show energy savings for years 2, 3, and 4 after the audit. Differences

Table 3. Annual Energy Savings by Major Energy Conservation Opportunity Group and Year (Million Btu)

	EADC Callback	PNL Callback		
ECO Group	Year 2[a]	Year 2	Year 3	Year 4
Combustion	21688	21461	21461	21461
Steam	9707	9037	9037	9037
Utilities	2807[b]	433	433	433
Scheduling	262	260	260	262
Process Equipment	6035	6005	3106	3195
Buildings/Grounds	15413	13185	14069	14258
Total	55912	50383	48363	48646

(a) Annual savings rate at the end of the year.
(b) Two ECOs (with recommended annual savings of 2120 million Btu) forecasted to be implemented in the EADC callback were never implemented (PNL callback).

between the PNL annual savings results (year 2, 3, and 4) and the EADC annual savings in year 2 results from: 1) additional implementation of ECOs and 2) ECOs being taken out of service. Consequently, the energy savings reported by the Science Center on page A.2, Appendix A, will vary from the energy savings recorded by PNL. The aggregate energy conservation data provided by the Science Center on page A.3, Appendix A, will also vary from PNL findings for the reasons discussed above.

The number of years that a plant has had to implement or drop a specific ECO varies for plants audited in 1984 through 1987. In Figures 1 through 4 the energy savings information is broken out by year of audit. Figure 5 provides a summary of the energy savings associated with implemented ECOs at the 26 plants over the period 1984 through 1990.

PROGRAM ENHANCEMENTS

The reporting of ECO implementation and energy savings by the EADC program is generally accurate. For example, the analysis of 161 ECOs included in the assessment revealed that the status of 141 ECOs was as identified by the EADC Program. However, the following three areas for program enhancement were identified.

- First, funding could be provided to each Center for performing a survey approximately 4 to 7 years after the audit is complete. This would allow the EADCs to count the ECOs that had not been reported during the initial contacts and recalculate the energy savings for the ECOs which were later decommissioned or chosen for gradual implementation over a period of a few years. The information could also be used to enhance future auditing efforts. Knowing which ECOs are highly successful and why, and which ECOs are not as successful and why, would enable the Centers to capitalize on their successes and minimize recommendations which may be difficult for companies to implement.

- Second, the EADCs could account for the fact that some ECOs (i.e., light bulb or high-efficiency motor replacement) are generally implemented over a period of a few years as they burn out, as opposed to being completely implemented in 1 year's time. This would change slightly the total energy savings that are reported.

- Third, provisions could be made to account for companies that go out of business. Presently, energy savings calculations are based upon an assumption that all of the companies audited remain in business. Although this helps simplify

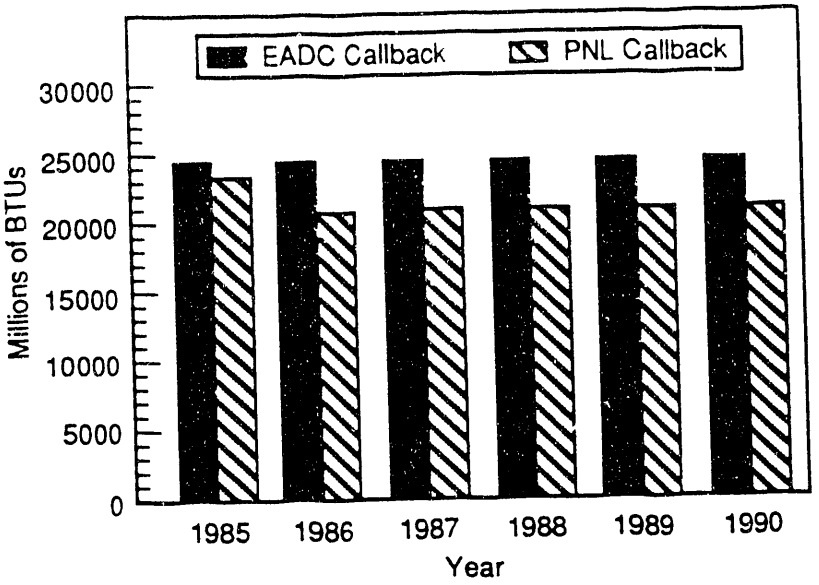

Figure 1. Annual Energy Savings Based on 11 Plant Audits (1984)

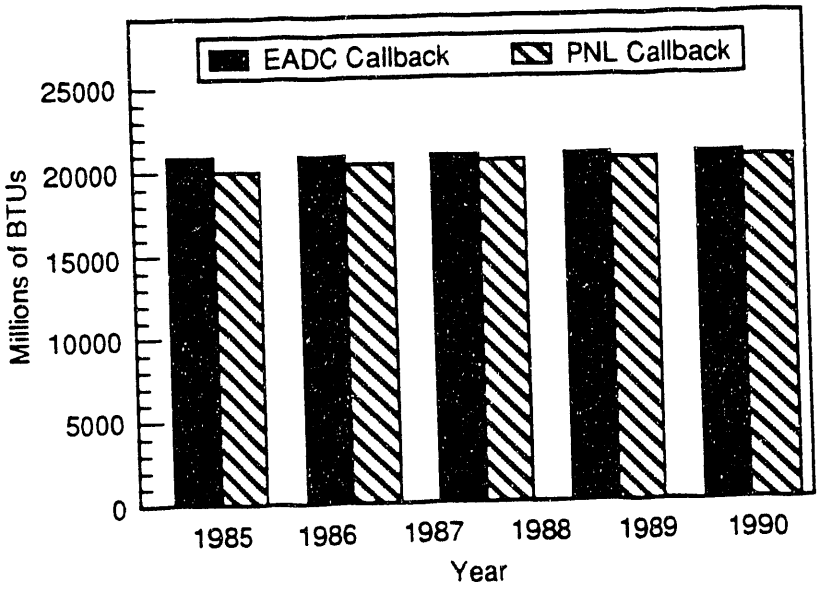

Figure 2. Annual Energy Savings Based on 6 Plant Audits (1985)

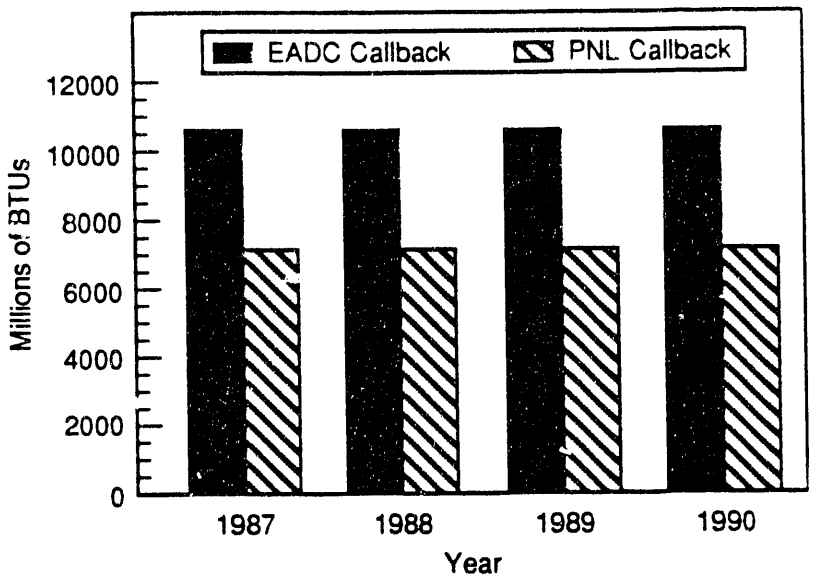

Figure 3. Annual Energy Savings Based on 6 Plant Audits (1986)

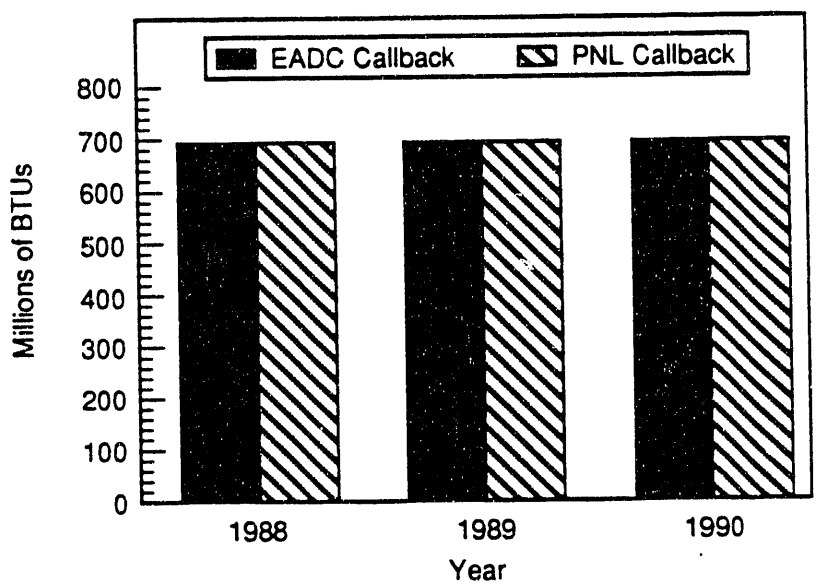

Figure 4. Annual Energy Savings Based on 3 Plant Audits (1987)

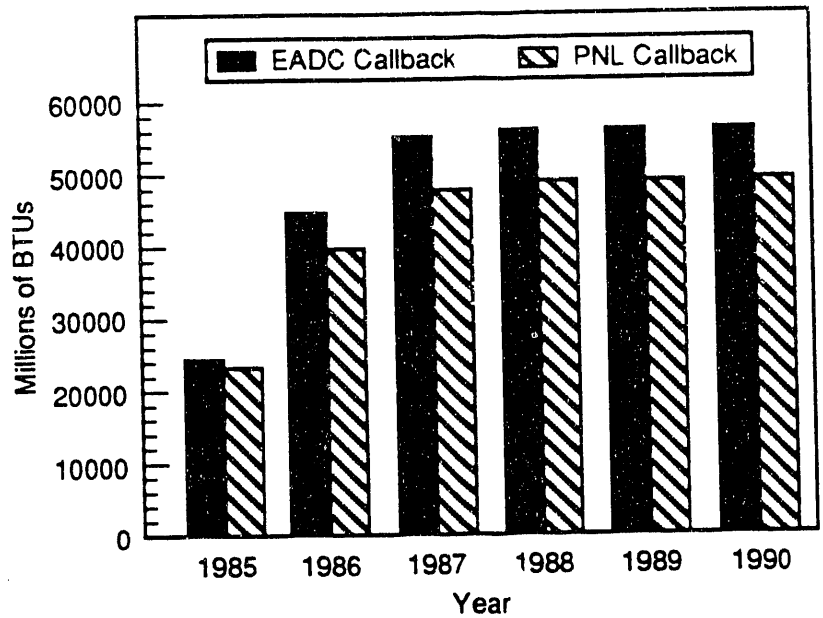

Figure 5. Summary of Annual Energy Savings Based on 26 Plant Audits (1984 - 1987)

calculating and reporting, total energy savings may change slightly as a result of plants going out of business. A callback 5 years later could help quantify the number of business failures. Provisions could also be made to identify ECO recommendations at Plant A, which have been used at other plants operated by the same firm.

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APPENDIX A

ANNUAL SUMMARY OF EADC ACTIVITIES

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January 30, 1991

Mr. Bruce Kinzey
Battelle - Pacific Northwest Laboratories
370 l'Enfant Promenade, Suite 900
Washington, D.C. 20024

Dear Mr. Kinzey:

The enclosed table, "Summary of Conservation and Savings Identified by EADCs", updates the progress of the Energy Analysis and Diagnostic Center (EADC) program. This table differs from the previous ones which have been sent to you in the following ways:

- All of the data for the 339 plants audited during the 1988-89 program period are now included; these data differ slightly from those estimated for this period in previous tables.

- The data for the 360 plants audited during the 1989-90 program period are included. These figures have been estimated using data from the 200 reports processed thus far by ITEM and my analysis of the remaining reports not yet processed. The estimates should be fairly accurate.

Also enclosed is an update of another table provided to you last year which shows aggregate figures of conservation and savings. Those total are the ones we use when giving results of the EADC program.

If you need further information or want to discuss the enclosures, please call me.

Sincerely,

Laura M. Deevy

Laura M. Deevy
Project Engineer
Industrial Technology and
Energy Management

lmd/gc

Enclosures

Summary of Conservation and Savings Identified by EADCs

EADC Program Period	1976-81	1981-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	Total
Number of Audits Reports	363	479	297	317	300	324	389	339	360**	3168
Energy Conservation (10^6 BTU/YR)										
Electricity	353575	430490	221823	341471	426937	478033	636037	481333	453836	3823535
Natural Gas	3195114	2152266	1120234	907221	1152348	822361	759896	1192724	979344	12281508
Fuel Oil	496618	138366	106582	107773	103785	73334	132912	167423	53307	1380100
Coal	749608	12936	2054	113314	79368	15200	558723	24622	0	1555825
Other	36149	92545	95546	581804	166725	385126	184105	54561	203767	1800328
Alternate	-364983	-384667	-201498	-274787	-571652	-676098	-816173	-200701	-217562	-3708121
Net	4466081	2441936	1344741	1776796	1357511	1097956	1455500	1719962	1472692	17133175
Cost Savings ($/YR)										
Electricity	3420950	5994664	4137017	6151015	8962208	7670038	9703735	7833451	8008492	61881570
Natural Gas	7466645	8663525	5273508	4322261	5125386	3467196	3119122	4910645	3455082	45803370
Fuel Oil	1722595	1015188	591559	635446	502104	267038	521491	589454	222505	6067380
Coal	1006245	21255	3915	139383	163258	21079	660361	44180	0	2059676
Other	86402	639724	471581	1150631	307620	311840	480437	533978	557959	4540172
Alternate	-660816	-807058	-426995	-1012352	-1585702	-1033659	-1187789	-310306	-555872	-7580549
Operating Cost	*	*	-5895	188834	326544	777053	309409	1241687	398077	3235709
Net	13042021	15527298	10044690	11575218	13801418	11480585	13606766	14843089	12086243	116007328

* Not Available

** Estimated based on the data for the 200 plants processed thus far.

Revised January 25, 1991

Aggregate energy conservation and savings to date if all measures identified by the EADC program were implemented since inception:

Energy Conservation (trillion btus)

	1976-81	1981-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90*
1977	0.893								
1978	1.786								
1979	2.680								
1980	3.573								
1981	4.466								
1982	4.466	1.220							
1983	4.466	2.441							
1984	4.466	2.441	1.345						
1985	4.466	2.441	1.345	1.777					
1986	4.466	2.441	1.345	1.777	1.358				
1987	4.466	2.441	1.345	1.777	1.358	1.098			
1988	4.466	2.441	1.345	1.777	1.358	1.098	1.456		
1989	4.466	2.441	1.345	1.777	1.358	1.098	1.456	1.720	
1990	4.466	2.441	1.345	1.777	1.358	1.098	1.456	1.720	1.473
	53.592	20.748	9.415	10.662	6.790	4.392	4.368	3.440	1.473

Total = 114.880 Trillion BTUs

Energy Savings (million dollars)

	1976-81	1981-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90*
1977	2.608								
1978	5.217								
1979	7.825								
1980	10.434								
1981	13.042								
1982	13.042	7.764							
1983	13.042	15.527							
1984	13.042	15.527	10.045						
1985	13.042	15.527	10.045	11.575					
1986	13.042	15.527	10.045	11.575	13.801				
1987	13.042	15.527	10.045	11.575	13.801	11.481			
1988	13.042	15.527	10.045	11.575	13.801	11.481	13.607		
1989	13.042	15.527	10.045	11.575	13.801	11.481	13.607	14.843	
1990	13.042	15.527	10.045	11.575	13.801	11.481	13.607	14.843	12.086
	156.504	131.981	70.313	69.451	69.006	45.924	40.821	29.686	12.086

Total = $625.772 Million

*estimated

Revised January, 1991

APPENDIX B

PLANT ECO INFORMATION

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PLANT ECO INFORMATION

The Energy Conservation Opportunities (ECOs) implemented by the 26 interviewed plants fall into six ECO categories: combustion, steam, utilities, scheduling and process equipment, and buildings and grounds. The definition for each category is described in the Findings section of this paper. The following information, by ECO category, was obtained during the PNL callback.

COMBUSTION

The most frequently recommended ECO in this category was adjusting the air/fuel ratio on boilers. The companies that received this recommendation generally implemented it within 1 year of the audit, primarily because of the relatively low cost of implementation. In fact, two firms contacted had not implemented any other ECO besides this one because of financial difficulties. Most companies incorporate this adjustment into a regular maintenance program in the facility on a monthly, quarterly, semiannual, or annual basis.

STEAM

Most of the companies that received recommendations pertaining to boiler operation and steam lines have implemented the ECOs. In addition, monitoring the systems to ensure continued savings is typical. One contact stated that insulating the previously bare steam pipes was the single largest contributor to the company's overall energy savings. This ECO was implemented within 1 year of the audit and the company continues to insulate steam pipes as new ones are added within the facility. Another contact determined that insulating the boiler feedwater holding tanks would be too expensive to implement immediately, but was able to implement the ECO during the third year after the audit was performed and has since found it to be very beneficial.

A few companies have found it impractical to continue implementing these recommendations. One company reduced steam pressure to the level recommended, but later determined this pressure to be insufficient for their needs. The pressure was subsequently returned to near the original operating level. The company still monitors the pressure and attempts to use only the minimum pressure necessary, however. Another company experienced cavitation problems with boiler feedwater that was preheated from recovered autoclave steam and discontinued this effort.

UTILITIES

No information about plant utilities was obtained in the PNL callback.

SCHEDULING

Most companies found that scheduling equipment operation to nonpeak hours was relatively easy and have been pleased with the results. Some companies have rescheduled the use of certain equipment to reduce demand charges, while others have decided to turn off equipment when not being used.

Companies choosing not to implement ECOs in this category have made this decision based on either impracticality (e.g., companies operating on a single-shift schedule have difficulty moving machine operations to after-hours) or subsequent events rendering the ECO irrelevant (e.g., discontinuing the relevant production line).

PROCESS EQUIPMENT

Replacing existing electrical motors with high-efficiency motors was a common recommendation made to companies because efficient motors appear to have achieved a high degree of market penetration and are accepted by industry. Without exception, all the firms surveyed who purchase motors now purchase high-efficiency motors when possible. A few firms who had not had "replacement of motors" as an audit recommendation have since undertaken the purchase of efficient motors as well.

The purchase of new motors only occurs at burnout of the old motors, however. This means that complete replacement of conventional motors may require a period of several years, particularly if a large number of conventional motors were new at the time of the audit. This fact conflicts with the EADC Program assumptions in two ways: 1) savings achieved from replacing motors actually requires several years to reach the full estimate given in the audit versus the EADC callback information which give full savings credit in the first year any motors were replaced; and 2) some firms had not replaced any motors at the time of the first callback so that EADC callback indicated zero savings from these ECOs; in all such cases some amount of motor replacement had occurred in the time since the first callback. No respondents indicated that they had returned to purchasing conventional motors once the move to high-efficiency motors had been made, although high-efficiency motors are not available (or may be exceedingly expensive) for particular applications.

BUILDINGS

The building and grounds ECO category includes discussions on both lighting as well as space heating, and ventilation cooling.

Lighting

The lighting recommendations made by the EADCs pertained to replacing conventional lighting with more energy-efficient lighting and eliminating nonessential lighting. Most of the companies surveyed agreed that these measures were good ways to save money on energy consumption, although most preferred to replace lighting on an as-needed basis (i.e., at burnout) or incrementally rather than in one sweeping effort.

Most companies believed it was too costly to immediately replace all existing light bulbs with energy-saving light bulbs. Generally, it takes companies an average of about 3 years to complete bulb and/or fixture replacement. This fact conflicts with the records kept by the EADC Program assumption that all replacement occurs in a single year; rather, the year indicated in EADC callback reflects only the initial year in which lighting replacement began. Many companies report that lighting replacement is ongoing.

Some recommendations were made to reduce lighting levels by simply removing nonessential bulbs or disconnecting unnecessary fixtures throughout the work-place. Generally, companies were able to successfully implement this suggestion in nonproduction areas (i.e., lunchrooms, office areas, and hallways). However, employees frequently resisted implementing these suggestions in production areas (i.e., machine rooms and shipping/receiving areas) because many found it too difficult to perform their required tasks in diminished lighting. Some companies have found that moving lights closer to the work space eliminates this problem.

Since the audit, a number of the companies have undergone expansion or facility remodeling. In virtually all cases, companies used efficient lighting and workplace design for minimizing lighting energy requirements in new buildings.

Space Heating, Ventilation, and Cooling

The majority of the HVAC opportunities noted by the EADCs involved modifying existing equipment to enhance cooling and heating, installing weatherstripping and plastic strip doors, and insulating rooms and exterior doors. Many of the

ECOs in this category have been implemented, especially when 1) implementation was easy, 2) capital requirements were small, and 3) adverse impacts on the work environment were anticipated as minimal.

Generally, companies quickly implement ECOs that require only minor capital investment. For example, most companies reported success in installing timers to optimize using their heating and air conditioning systems.

Companies agreed that many of the ECOs in these categories were excellent recommendations. However, most delayed implementation for a few years or carried them out over an extended period because of financial constraints or prior commitments to other projects. For example, the process of insulating walls and weatherstripping doors typically required 2 to 3 years to complete.

APPENDIX C

SINGLE PLANT INFORMATION

APPENDIX C

SINGLE PLANT INFORMATION

One firm (SIC 2013) experiencing financial constraints when their audit was performed in 1985 was able to implement only one of the ECOs that had been recommended to them. This required adjusting the air/fuel ratio on their boiler. The company was not in a position to implement the other ECOs because they would be too expensive, or the company would have to make changes in their production processes that they found unacceptable. The company has since been bought out by a larger corporation. However, they have not made any immediate plans to implement the remaining five ECOs.

One firm (SIC 2339) had undergone leveraged buyout soon after the first callback, with the result that none of the recommendations had been implemented except for an adjustment to the boiler air/fuel ratio (where no capital expense was required). This firm had previously reported their intention of carrying out some of the recommendations at the time of the first callback.

Another firm (SIC 2231) had abandoned two of the recommendations because of problems associated with using them and because of realizing smaller benefits than had been anticipated. This firm had at the same time implemented several additional conservation measures with a high degree of success that were not included in the recommendations.

A firm (SIC 2048) shifted a grinding operation to off-peak hours approximately 1 year after the first callback and reportedly began saving approximately $1000 per month in electricity.

One company reported that they had previously planned to alter their manufacturing process and remove the equipment that had been recommended for rescheduling. This company has since studied ways in which they could schedule the use of other pieces of equipment to reduce energy consumption.

Another company reported difficulty in implementing the suggestion to install timers on the plant HVAC system because of nonuniform production schedules, i.e., employees working overtime after controls had shut off the heat. Workers found their work environment uncomfortable and requested the company to return to their previous system.

One company that had originally decided not to insulate the walls in their shipping and receiving area after an audit in 1985 has since included the ECO in their 1992 Facility Improvement Plan.

END

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