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ENERGY CONSERVED AND COSTS SAVED BY SMALL AND MEDIUM-SIZE MANUFACTURERS

1986-87 EADC PROGRAM PERIOD

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by

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EXECUTIVE SUMMARY

The Energy Analysis and Diagnostic Center (EADC) program provided energy-conserving and cost-saving assistance in 324 small and medium-size manufacturing plants during its 1986-87 operating period. This report presents the results produced by 13 EADCs which performed those 324 energy audits nationwide and then obtained additional data during 1988 from 322 manufacturers who had implemented at least some of the EADCs' recommendations or definitely scheduled implementation within two years.

The EADCs are located at accredited engineering departments of universities and staffed by faculty and students. Geographically they span the nation from Massachusetts to Oregon (east-west) and from Wisconsin to Texas (north-south). Their efforts are managed by University City Science Center through its Industrial Technology and Energy Management (ITEM) division. The U.S. Department of Energy sponsors the EADC program under its Office of Industrial Programs.

Implementation rates remained consistently high, even though four new EADCs came into the program and performed 60 energy audits during 1986-87. All together, 1406 energy conservation opportunities (ECOs) were implemented or definitely scheduled to be, and they represent a net implemented conservation of 842 billion BTU/year and an implemented cost saving of almost $5.73 million/year. Those degrees of implementation correspond to about 65% of the number found and to 76% of the BTUs and 51% of the dollars recommended.

Manufacturers continue to achieve exceptional returns from their investments in cost-saving ECOs, and the federal government also realizes attractive returns on its program support through revenues generated by income taxes levied upon manufacturers' incremental earnings, which are the measured results of cost savings derived from

implementing EADCs' recommendations.

During 1986-87 EADCs' manufacturers achieved internal rates of return (IRR) of 223 to 309% after taxes on their implementation investments, and the federal governments's IRR was 40 to 73%, depending on the tax rate and borrowing rate assumed. Similarly, manufacturers' profitability indices ranged from 1.43 to 1.80, and those of the federal government from 1.43 to 2.23. The profitability index (or leverage ratio) represents the number of constant dollars returned to investors for every dollar invested. Calculated by standard net present value method, it requires setting a discount rate on future cash flows; 10 and 15% were used in this report.

In general, the plants served during 1986-87 were a little smaller and used slightly less (0.4%) energy than the 300 plants assisted in 1985-86. Moreover, the 1986-87 plants paid 13% less for their energy, employed 8% fewer people, and had a sales total 4% smaller.

Some of the bigger decreases in energy cost savings from 1985-86 occurred in combustion efficiency and heat recovery and in heating, ventilating, and air conditioning improvements. A major increase occurred in switching to lower-priced energy sources.

Financial analyses of EADCs' implementation results reveal that energy price increases improve the economic incentives of energy conservation opportunities as long as the costs of implementation increase no faster than energy prices. But increases in the interest rates which manufacturers pay to borrow funds for implementation always decrease the profitability of these opportunities for the manufacturers and, therefore, for the federal government.

The high implementation rates and financial returns reflect the manufacturers' confidence in the EADCs' recommendations and their willingness to invest when the risks appear to be well-defined and manageable.

These results also convey an auspicious vision of how to improve the future competitiveness of the nation's small and medium-size manufacturers. Given practical and specific opportunities to lower costs without sacrificing output or quality, manufacturers as a group will take many of the actions needed to achieve the gains. When the federal government strengthens manufacturers' confidence by providing the information effectively, the results can be highly beneficial to the manufacturers, to the government, and to the nation as a whole.

FOREWORD

The Energy Analysis and Diagnostic Center (EADC) program provides energy-conserving and cost-saving assistance to small and medium-size manufacturers in 36 states. Engineering faculty from 13 universities, assisted by graduate and undergraduate students, analyze energy usage and manufacturing operations in each plant and then prepare an individualized report that recommends specific actions and estimates their costs and their benefits. Manufacturing plants are eligible if they meet the size criteria and are not more than 150 miles from an EADC.

The U.S. Department of Energy, Office of Industrial Programs, sponsors the EADC program, which is managed by University City Science Center, through its Industrial Technology and Energy Management (ITEM) division. This and similar reports are prepared from data which ITEM staff members extract as they review every energy audit report prepared by the EADCs. Eventually these data also include the results of manufacturers' implementation of EADCs' recommendations, together with costs and savings.

Manufacturers have as long as a year after an energy audit to decide which of the EADCs' recommendations they will implement. The 324 energy audits reported here were performed during the 1986-87 program period, and the results of implementing the EADCs' recommendations were obtained from the manufacturers throughout 1988.

The overall conservation and savings achieved by the EADCs while performing these 324 audits and the 1,756 energy audits which preceded them add up to some relatively large totals for small and medium-size manufacturers. All together, these audits have identified new opportunities to conserve about 12.4 trillion BTU/year and save almost $63.5 million/year in related costs, on the basis of period-by-period totals, as this table shows:

Time Period	Audits Performed	Net Energy Conservation Identified BTU x 10^{12}/yr	Cost Savings Identified $ x 10^3/yr	% Total Cost
1976-81	363	4.47	113,042	9.6
1981-83	479	2.44	15,492	12.2
1983-84	297	1.34	10,051	11.1
1984-85	317	1.77	11,399	11.1
1985-86	300	1.36	13,475	1.1
1986-87	324	1.10	10,704	9.9
Total	2,080	12.48	174,163	10.8

The total cost savings amount to about 11% of the total energy cost.

The EADCs' professional staff members who produced the results in this report are:

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A particular note of gratitude is expressed to Marilyn DeLoach, who edited and revised the computerized data from which the tables in this report were developed and to Clifford Maginn who manages the EADC datafiles and who rewrote numerous computer programs to generate the tables in this report.

Production, design and typography of this report were under the direction of Geraldine Clark and Russell Woodward.

CHAPTER ONE

ENERGY CONSUMPTION, CONSERVATION, AND COST SAVINGS

Manufacturers' Energy Use and Other Characteristics

The 324 manufacturing plants served by an EADC during 1986-87 were generally smaller and thus used a little less energy, paid 13% less for it, employed 8% fewer people, and had a sales total 4% smaller than the 300 plants served during 1985-86. The following comparison shows a definite shift toward smaller plants as four new EADCs came into the program and one of the older EADCs withdrew:

	1985-86	1986-87
Number of manufacturers served	300	324
Energy use, 10^6BTU/yr	18,086,902	18,007,237
Average use per plant, 10^6BTU/yr	60,290	55,578
Energy cost, $/yr	123,913,641	107,732,170
Average cost per plant, $/yr	413,045	332,507
Number of employees	53,924	49,745
Average number per plant	180	154
Gross sales, $ million/yr	6,617	6,343
Average sales per plant, $ million/yr	22.1	19.6

There were also major differences in the sources of energy responsible for the energy consumption during 1986-87 (Table 1). Relatively, overall energy consumption decreased by only 0.4%, but the size varied considerably from one energy source to another. For the first time, electricity became the largest source consumed on a BTU basis as well as in total cost, as it accounted for 35.8% of total energy consumption and 70.3% of total energy cost.

TABLE 1

ENERGY CONSUMPTION AND COST FOR PLANTS SERVED IN THE

1986-87 AND 1985-86 EADC PROGRAM PERIODS

ENERGY CONSUMPTION - MILLIONS OF BTU PER YEAR

	Usage		% Total Usage	
Energy Source	1985-86	1986-87	1985-86	1986-87
Electricity	5,135,134	6,449,328	28.4	35.8
Natural Gas	7,607,119	6,197,309	42.1	34.4
Fuel Oil	869,218	601,558	4.8	3.3
Coal	2,437,309	129,853	13.5	0.7
Wood	1,454,266	4,385,297	8.0	24.4
Other	583,856	243,892	3.2	1.4
Total	18,086,902	18,007,237	100.0	100.0

COST OF ENERGY CONSUMPTION - DOLLARS PER YEAR (current)

	Cost		% Total Cost	
Energy Source	1985-86	1986-87	1985-86	1986-87
Electricity	78,332,710	75,703,727	63.2	70.3
Natural Gas	34,174,577	25,227,607	27.6	23.4
Fuel Oil	3,940,800	1,974,677	3.2	1.8
Coal	3,309,702	430,563	2.7	0.4
Wood	1,964,289	3,651,622	1.6	3.4
Other	2,191,563	743,974	1.7	0.7
Total	123,913,641	107,732,170	100.0	100.0

Natural gas was responsible for almost as large a share of energy consumption (34.4%) as electricity, but its low unit price attributed only 23.4% of total cost to natural gas.

Fuel oil, coal, wood, and LPG were responsible for smaller quantities of total energy consumption and very small shares of total cost. Two shifts among them should be noted, however. During 1985-86 three plants consumed a total of more than 2.4 trillion BTU of coal, but the 1986-87 quantity was only 0.13 trillion BTU. On the other hand, wood consumption increased enough during 1986-87 to rank it third in size at 4.4 trillion BTU/year. All of this consumption was found in 14 plants served by four EADCs: Louisiana Tech, North Carolina A&T, Oregon State, and Tennessee. However, the average cost of wood was only $\$0.83/10^6$ BTU, and thus it accounted for just 3.4% of total energy cost.

EADCs continued to serve 19 different manufacturing industries during the year 1986-87, and Table 2 shows that the 324 plants employed 49,745 persons and sold over $6.34 billion in products and services. Those figures signify a 7.8% decrease in employment and a 4.1% decline in gross annual sales from the preceding year. Food processing (SIC 20) was again the industry served most often (38 plants), and it accounted for almost $1.3 billion in gross annual sales. Rubber and plastics (SIC 30) was the next most frequently served industry (36 plants). Only one of the 1986-87 plants was in the leather products industry (SIC 31), and that is consistent with EADCs' recent experience.

Recommended Conservation and Savings

Energy-conserving and cost-saving opportunities identified in the plants of 324 manufacturers during the 1986-87 EADC program period produced a variety of results, some of which represent significant departures from the results of earlier program periods.

TABLE 2

INDUSTRIES SERVED BY EADCs DURING 1986-87

SIC Code	Industry Description	Employment	Number of Plants Served	Gross Annual Sales (Thousands of Dollars)
20	Food and kindred products	5227	38	1,294,200
22	Textile mill products	2329	11	242,000
23	Apparel and other textile products	2187	11	236,700
24	Lumber and wood products	2527	16	244,400
25	Furniture and fixtures	2890	13	205,000
26	Paper and allied products	2054	15	281,600
27	Printing, publishing, and allied industries	2655	15	341,700
28	Chemical and allied products	842	12	158,250
29	Petroleum and coal products	140	3	22,880
30	Rubber and miscellaneous plastic products	4646	36	435,000
31	Leather and leather products	125	1	14,000
32	Stone, clay, glass, and concrete products	1591	12	162,500
33	Primary metal products	2948	26	509,700
34	Fabricated metal industries	5897	46	768,390
35	Machinery, except electrical	3574	20	367,800
36	Electrical equipment and supplies	4583	24	404,300
37	Transport equipment	2182	13	269,200
38	Measuring, analyzing, and controlling instruments	2653	9	275,400
39	Miscellaneous manufacturing industries	695	3	110,000
	TOTAL	49,745	324	6,343,020

During 1986-87, EADCs' recommendations to switch from one energy source to an alternate (and lower priced) fuel reached an all-time high total of over 676 billion BTU/year, which is equivalent to 38% of the gross conservation found for all energy sources (Table 3). The term "alternate fuel" applies to any energy source proposed as a substitute for another; for example, if natural gas is proposed as a less expensive substitute for electricity in a specific application, natural gas is considered an alternate fuel in that instance. Typically an energy source is recommended as an alternate fuel for economic reasons only, and in fact a lower priced alternate fuel is usually consumed in larger quantities than the energy source it replaced.

These observations acquire new meaning when the 1986-87 conservation data are examined closely and compared to results from the preceding program period (Table 3). Then the 1774 billion BTU/year of gross conservation identified during 1986-87 is reduced by 676 billion BTU/year of alternate fuel consumption, and the net conservation is reduced to 1098 billion BTU/year.

The gross conservation numbers represent 9.8% of energy consumption in 1986-87, which compares favorably with 10.7% for 1985-86. However, because of relatively large amounts of energy consumed as alternate fuel, the net amount of conservation was 6.1% in 1986-87 and 7.5% in 1985-86.

Cost savings present a similar but more revealing picture. Table 3 shows that the cost of alternate fuels consumed during 1986-87 was $1.034 million/year; during 1985-86 it had been $1.586 million/year even though the quantity of alternate fuels for 1985-86 was a little less than 85% of the 1986-87 amount. The low unit value put on alternate fuels ($1.53/$10^6$BTU) is the cause of the lower total cost of alternate fuels consumed.

TABLE 3

ENERGY CONSERVATION AND COST SAVINGS IDENTIFIED
FOR EACH ENERGY SOURCE

Energy Source	Energy Conservation Identified (10^6BTU/year) 1985-86	1986-87
Electricity	426,937	478,033
Natural Gas	1,152,348	822,361
Fuel Oil	103,785	73,334
Coal	79,368	15,200
Wood	120,371	378,708
Other	46,354	6,418
Total (Gross)	1,929,163	1,774,054
% Consumption	10.7	9.8
Alternates	-571,652	-676,098
Total (Net)	1,357,511	1,097,956
% Consumption	7.51	6.10

Savings Source	Cost Savings Identified ($/year) 1985-86	Unit Value ($/$10^6$BTU)	1986-87	Unit Value ($/$10^6$BTU)
Electricity	8,962,208	20.99	7,670,038	16.04
Natural Gas	5,125,386	4.45	3,467,196	4.22
Fuel Oil	502,104	4.84	267,038	3.64
Coal	163,258	2.06	21,079	1.39
Wood	154,043	1.28	255,486	0.67
Other	153,577	3.31	56,354	8.78
Total (Gross)	15,060,576		11,737,191	
Alternates	-1,585,702	2.77	-1,033,659	1.53
Total (Net)	13,474,874		10,703,532	
Oper. Cost	326,544		161,055	
Addnl. Inc.	-------		615,998	
Total	13,801,418		11,480,585	
% Cost	11.14%		10.66%	

In fact, all the unit values of energy sources listed for 1986-87 in Table 3 are low, and that exaggerates the difference in cost savings between the two program periods. The value of $\$0.67/10^6$BTU for wood conserved and the value of $\$1.39/10^6$BTU for coal are extremely low. The approximately 379 billion BTU/year of wood conserved ranks it just behind electricity as the third largest source of energy conserved, but the large gain in BTUs of wood conservation recommended was not large enough to offset the decreases in natural gas conservation recommended by the EADCs during 1986-87. These are the principal factors which, together with the switching to alternate fuels, account for most of the differences in energy conservation and cost savings between the two program periods.

The categories of energy use represented in the 1986-87 results continue to show the importance of manufacturing (Table 4), which is the sum of production and services. Of the 1774 billion BTU/year of conservation recommended, 16.6% was in production and 61.8%, in the services category; together they add up to 78.4% of the conservation in manufacturing operations. The balance was found in HVAC and housekeeping, which includes lighting.

Each of the categories of energy use can be described in these terms:

- **Production** — Energy consumed directly in manufacturing a product, e.g., gas used for heat treating steel.
- **Services** — Energy used to supply heat or power in an auxiliary manner to the process or product, e.g., steam, compressed air, refrigeration.
- **HVAC** — Energy used for personnel comfort or regulating environmental conditions for operating equipment, e.g., air conditioning.
- **Housekeeping** — Energy to be conserved by normal routine operations and maintenance, e.g., turning off unused lights and idle equipment, adjusting thermostats, shades, windows, and closing doors.

TABLE 4

ENERGY CONSERVATION AND COST SAVINGS IDENTIFIED
FOR EACH CATEGORY OF USE

1986-87

	Energy Conservation (10^6BTU/Year)			Cost Savings ($/year)				
	Gross	%	Net	Gross	%	Net	%	%
Production	293,840	16.6	-44,646	2,030,211	17.3	1,537,894	14.4	13.4
Services	1,095,615	61.8	769,537	6,738,499	57.4	6,282,253	58.7	54.7
HVAC	309,341	17.4	298,380	1,720,015	14.6	1,637,863	15.3	14.3
Housekeeping	75,258	4.2	74,685	1,248,466	10.7	1,245,522	11.6	10.8
Total	1,774,054	100.0	1,097,956	11,737,191	100.0	10,703,352	100.0	
Oper. Cost						161,055		1.4
Addnl. Inc.						615,998		5.4
Grand Total						11,480,585		100.0

Cost savings were also highly concentrated in manufacturing, as Table 4 also shows. Of the total savings, 73.1% occurred in production or services related to manufacturing.

For the first time, opportunities for the plants served to generate additional income from the EADCs' recommendations were tabulated during the 1986-87 program period. Though such opportunities had arisen before, there was no prior attempt to record them in the EADC data files. Table 4 reveals that they add up to almost $616,000/year and -- together with more than $161,000/year of operating cost savings -- increase the total savings found by the EADCs to $11,480,585/year, which equals 10.7% of energy cost. Virtually all of these savings occurred in manufacturing operations.

During 1986, four new EADCs were selected competitively and -- like all first-time participants in the program -- they were expected to perform only half the normal work-load during their initial year. Nevertheless, these four were collectively responsible for 18.5% of the 324 plants served during 1986-87. That means every fifth or sixth plant, on average, was analyzed and reported by a new EADC. This factor had an influence on the kind of plant chosen and, very probably, on the energy-conserving and cost-saving opportunities recommended. It is important to keep these points in perspective when 1986-87 results are reviewed.

Specific Industries' Conservation and Savings

Wide variations in identifiable energy conservation and cost savings occur among industries, and even within an industry (or 2-digit SIC code) considerable shifts can occur from one time period to another. It is important to acknowledge that any analysis or ranking of industries according to conservation and savings is for a particular time period and the plants served within that time; it is definitely not a generalization irrespective of time.

Table 5 presents the total and average energy conservation and cost savings for each industry served by any EADC during 1985-86. The rankings listed are based upon average values (per plant).

In all but two industries (SIC 20 and 28), the average conservation exceeded 1 billion BTU/year, and in all of them the average cost savings was larger than $10,000/year. Those are significant numbers when it is recalled that they come from small and medium-size manufacturers.

The two industries in which the average conservation did not exceed 1 billion BTU/year experienced enough switching to alternate fuels that their net conservation was negative. The three largest energy conservers were wood products (SIC 24), textiles (SIC 22), and primary metals (SIC 33), on the basis of average net conservation per plant.

The two industries with negative net conservation were among the leaders in average cost savings per plant (Table 5). The 12 chemical manufacturers (SIC 28) served by an EADC during 1986-87 had an average identified annual cost savings of $79,280 per plant. Food processors (SIC 20) ranked sixth in cost savings identified with an annual average of $37,167/per plant. These are the other industries among the top five, ranked according to the same basis:

SIC	Industry	Average Savings per Plant ($/year)
24	Lumber and Wood Products	$118,372
22	Textile Mill Products	$ 46,776
33	Primary Metal Products	$ 42,556
26	Paper and Allied Products	$ 38,763

TABLE 5

ENERGY CONSERVATION AND DOLLAR SAVINGS PER PLANT IN SPECIFIC INDUSTRIES

1986-87 EADC PROGRAM PERIOD

BASIS: 324 AUDIT REPORTS

SIC* Code	No. Plants	Net Conservation 10^6BTU/Year	Net Conservation Per Plant	Conservation Rank (Per Plant)	Net Savings $/Year	Net Savings (Per Plant)	Savings Rank (Per Plant)
20	38	-46,775	-1,231	19	1,412,352	37,167	6
22	11	78,391	7,126	2	514,541	46,776	3
23	11	12,892	1,172	17	113,958	10,360	19
24	16	321,003	20,063	1	1,893,946	118,372	1
25	13	60,708	4,670	4	256,891	19,761	15
26	15	45,622	3,041	9	581,439	38,763	5
27	15	36,979	2,465	12	377,976	25,198	11
28	12	-14,476	-1,206	18	951,357	79,280	2
29	3	9,052	3,017	10	61,902	20,634	14
30	36	81,028	2,251	13	912,965	25,360	10
31	1	1,284	1,284	16	14,187	14,187	18
32	12	38,540	3,212	7	276,076	23,006	13
33	26	146,625	5,639	3	1,106,447	42,556	14
34	46	146,520	3,185	8	1,185,844	25,779	9
35	20	54,646	2,732	11	376,062	18,803	16
36	24	33,426	1,393	15	599,501	24,979	12
37	13	50,873	3,913	6	408,812	31,447	7
38	9	35,407	3,934	5	232,034	25,782	8
39	3	6,202	2,067	14	43,240	14,413	17

*Table 2 presents the name of each industry.

CHAPTER TWO

IMPLEMENTATION OF EADCs' RECOMMENDATIONS TO CONSERVE ENERGY AND REDUCE COSTS

Categories of Energy Use

Implementation offers an ultimate test of EADCs' recommendations, because manufacturers will adopt only recommendations based on good engineering judgment and an unbiased assessment of their cost-effective usefulness. However, a rejection by the manufacturer does not imply the recommendation embodies technological errors; on the contrary, it may just be impractical (or appear to be), or too theoretical, or too costly, or just poorly presented. It is also possible that the manufacturer is facing a cash flow problem or that the current business climate is too uncertain to justify the risk that accompanies every implementation cost. There are numerous reasons for a manufacturer to reject or indefinitely postpone an EADC's recommendations, and they may have little to do with the intrinsic quality of the recommendations.

All together, 1406 ECOs were implemented or definitely scheduled to be by 322 manufacturers, and they represent a net energy conservation of about 842 billion BTU/year and a total cost saving of almost $5.73 million/year. Those degrees of implementation correspond to about 65% of the number found and to 76% of the BTUs and 51% of the dollars recommended (Table 6). In the preceding chapter, negative energy conservation was shown to be the result of switching to alternate fuels which are lower priced than the original fuel but which are consumed in larger quantities. Relatively few of these measures were implemented, and thus the implemented net conservation is numerically larger than it would have otherwise been. Of course aggregate percentages based upon all the

TABLE 6

IMPLEMENTATION OF EADCs' RECOMMENDATIONS
ACCORDING TO CATEGORY OF ENERGY USE

1986-87

	Net Conservation (10^6BTU/year)	%	Net Cost Savings ($/year)	%
Production				
Implemented	122,533	11.0	731,061	6.5
Services				
Implemented	491,366	44.3	3,236,726	28.8
HVAC				
Implemented	179,620	16.2	968,944	8.6
Housekeeping				
Implemented	44,463	4.0	794,999	7.1
All Categories				
Implemented	837,982	75.5	5,731,730	51.0

opportunities identified do not imply that every manufacturer implemented those percentages of conservation and savings recommended by the EADCs. Nevertheless, these numbers reflect a continuing high degree of acceptance of EADCs' recommendations by the manufacturers, who know they have no obligation to implement whatever is recommended -- unless it makes good sense and offers an economic incentive.

Manufacturing (production plus services) represents the largest use category of implemented energy conservation and cost savings, just as it does for recommended measures. Of the 75.5% of recommended conservation which was implemented, 56.0% was in manufacturing (11.2% in production plus 44.8% in services). That means almost three-fourths of the implemented conservation occurred in measures related to manufacturing operations. Of the 51.0% of recommended cost savings which was implemented, 35.3% was in manufacturing, which represents almost 70% of all the cost savings implemented. The dominance of manufacturing among implemented and recommended ECOs has been a characteristic of the EADC program from the beginning, and there is no indication of any directional change.

Specific Industries and Implementation

Quantities of implemented energy conservation and cost savings for 1986-87, expressed also as a percentage of the recommended amount, are summarized for each of 19 industries in Table 7. Because of the accounting problem which occurs with negative net energy conservation, ranking and comparisons of industries are preferably made on a cost-saving basis.

It is obvious that the miscellaneous manufactured products industry (SIC 39) ranked first with 99.45% implementation of the recommended cost savings. However, only 3 plants were served in this industry, and that is not a very large sample. In the electrical equipment

TABLE 7

IMPLEMENTED ENERGY CONSERVATION AND COST SAVINGS

IN EACH INDUSTRY

1986-1987

SIC* Code	Net Conservation Implemented: Total (10^6BTU/yr.)	Net Conservation Implemented: As % Recommended	Net Savings Implemented: Total ($/yr.)	Net Savings Implemented: As % Recommended	Relative Rank
20	125,686	**	754,916	53.45	14
22	38,746	49.43	308,631	59.98	9
23	10,800	84.77	81,058	71.13	6
24	168,657	52.54	499,511	26.37	19
25	25,593	42.16	190,538	74.17	5
26	29,114	63.82	182,932	31.46	18
27	30,311	81.97	285,270	75.47	4
28	55,429	**	305,918	32.16	17
29	7,561	83.53	48,306	78.04	3
30	42,939	52.99	488,031	53.46	13
31	977	76.09	7,563	53.31	15
32	28,794	74.71	182,070	65.95	8
33	86,638	59.09	617,093	55.77	11
34	69,605	47.51	666,446	56.20	10
35	27,212	49.80	203,686	54.16	12
36	25,944	77.62	493,373	82.30	2
37	29,802	58.58	209,224	51.18	16
38	27,130	76.62	164,160	70.75	7
39	7,044	113.58	43,004	99.45	1

* See Table 2 for the name of each industry (SIC code).

** The net conservation figures recommended for SIC 20 and 28 are negative because of proposed switching to alternate fuels in those industries.

industry (SIC 36), 24 plants were served, and it ranks second with 82.30% of the recommended cost savings implemented.

A relatively large number of industries had implementation percentages of 50-60%, and only three (SIC 24, 26, and 28) were below that level.

In dollar amounts, these are the industries where the largest implementation totals were found:

SIC Code	Industry Name	Total Cost Savings Implemented, $/year
20	Food and kindred products	754,916
34	Fabricated metal products	666,446
33	Primary metal products	617,093
24	Lumber and wood products	499,511
36	Electrical equipment and supplies	493,373

Each of these ways of ranking and comparing industries where implementation occurred is less than fully satisfactory. A preferable approach is to examine each industry according to the average cost savings implemented per plant. Table 8 presents that figure, together with the rank of each industry on that basis for implemented and recommended net savings.

The lumber and wood products industry (SIC 24) had the largest average cost savings implemented per plant: $31,215/year, and the textile products industry (SIC 22) was next at $28,056/year per plant. Only two industries -- apparel (SIC 23) and leather products (SIC 31) -- had average implemented savings smaller than $10,000/year. In three others -- chemicals (SIC 28), primary metals (SIC 33), and electrical equipment (SIC 36) -- the average cost savings per plant exceeded $20,000/year.

TABLE 8

COMPARISON OF SAVINGS PER PLANT

IMPLEMENTED AND RECOMMENDED FOR 1986-1987

SIC Code	Implemented Net Savings Per Plant ($/year)	Implemented Net Savings Rank	Recommended Net Savings Rank
20	19,866	6	6
22	28,056	2	3
23	7,369	19	19
24	31,215	1	1
25	14,657	12	15
26	12,195	16	5
27	19,017	7	11
28	25,480	3	2
29	16,103	9	14
30	13,557	15	10
31	7,563	18	18
32	15,172	11	13
33	23,733	4	4
34	14,488	13	9
35	10,184	17	16
36	20,558	5	12
37	16,095	10	7
38	18,241	8	8
39	14,334	14	17

It is also interesting to compare industry rankings according to whether the cost savings are recommended or implemented. Table 8 reveals that six industries had the same rank (or the same plus or minus one) on both bases, that five were higher on the basis of implementation, and that the other nine ranked higher on the basis of recommended measures.

Principal Types of ECOs Implemented

The results presented in Table 9 for certain types of ECOs are consistent with the previously noted trend toward smaller plants and lower cost savings in 1986-87, relative to the 1985-86 program period. Moreover, they show that decreased savings occurred with each of the three major types of ECOs (DIECO groups): combustion, process changes, and buildings and grounds (covering HVAC and lighting), but the most notable shifts occurred with the combustion type (DIECO Group 10), in both total and average savings. Collectively these three major types of ECOs were responsible for 62.9% of the total implemented cost savings in 1986-87.

To understand these developments better it is necessary to examine them at the next level of detail, which in Table 10 reveals that combustion efficiency improvements (DIECO 11) and combustion heat recovery (DIECO 13) are still responsible for most of the implemented cost savings related to combustion. However, the 1986-87 implemented savings value for DIECO 11 was only 69% as large as it had been during 1985-86, and for DIECO 13, only 39%.

Among process measures, the leading implemented cost savings are attributable to equipment maintenance and replacement (DIECO 51), changes in techniques specific to certain processes (DIECO 53), and process heat confinement (DIECO 55). They account for 77% of the process-change type of savings.

TABLE 9

COMPARISONS OF IMPLEMENTED ENERGY CONSERVATION AND COST SAVINGS 1985-86 and 1986-87

MAJOR DIECO GROUP	CONSERVATION			SAVINGS	
	Frequency	(10^6BTU/yr)	Average	$/yr	Average
		1985-86 (300 Plants)			
10 (Combustion)	147	270,266	1,839	1,046,363	7,118
50 ((Processes)	325	235,922	726	1,455,621	4,479
60 (Bldg. & Grd.)	401	176,622	440	1,821,737	4,543
				4,323,721	
		1986-87 (324 Plants)			
10 (Combustion)	128	239,619	1,872	615,336	4,807
50 (Processes)	387	215,697	557	1,430,627	3,697
60 (Bldb. & Grd.)	465	177,604	382	1,559,633	3,354
				3,605,596	

TABLE 10

TYPES OF MAJOR ECOs IMPLEMENTED

1986-87 EADC PROGRAM PERIOD

DIECO SUBGROUP NUMBER	DESCRIPTION	FREQUENCY	CONSERVATION, 10^6BTU/YR Total	CONSERVATION, 10^6BTU/YR Average	SAVINGS, $/YR Total	SAVINGS, $/YR Average
11	Equipment efficiency: operational	90	151,477	1,683	374,889	4,165
12	Equipment maintenance and replacement	2	26,619	13,309	21,879	10,940
13	Combustion heat recovery	20	46,242	2,312	183,795	9,190
14	Combustion heat confinement	16	15,281	955	34,773	2,173
	TOTAL DIECO 10	128	239,619		615,336	
51	Equipment maintenance repairs, replacement	120	43,117	359	393,288	3,277
52	Process operations & design	6	27,368	4,561	86,426	14,404
53	Techniques specific to certain processes	151	23,846	158	367,363	2,432
54	Process heat recovery	30	48,358	1,612	240,575	8,019
55	Process heat confinement	80	73,008	913	342,975	4,287
	TOTAL DIECO 50	387	215,697		1,430,627	
61	Lighting	285	42,757	150	775,153	2,720
62	Space heating and cooling	180	134,847	749	784,480	4,358
	TOTAL DIECO 60	465	177,604		1,559,633	

During 1986-87 the implemented cost savings in buildings and grounds were almost equally divided between lighting (DIECO 61) and space heating/cooling (DIECO 62), which was only abut two-thirds of its 1985-86 value.

Table 11 presents similar detail on implemented cost savings for the three other types of ECOs. Those related to utility supply (electricity, compressed air, water, and fossil fuels) generated the most cost savings ($780,404/year = 36.7% of the total for DIECO 20, 30, 40, and 90). Alternate-fuel measures were responsible for implementation of $538,199/year cost savings, including $171,576/year of implemented cogeneration savings. However, implemented savings in alternate fuels were only about half as large in 1986-87 as they had been in 1985-86.

Among these types of implemented ECOs, those next in responsibility for cost savings are steam system maintenance ($407,929/year) and changes in equipment scheduling ($348,121/year).

This kind of analysis can be useful in pinpointing the types of ECOs statistically responsible for trends in conservation and cost savings among manufacturers. For that reason, they can be useful in focusing the attention of program management and audit teams on the types of ECOs which have been productive and on those which indicate a potential for more energy conservation and cost savings.

TABLE 11

OTHER TYPES OF ECOs IMPLEMENTED

1986-87 EADC PROGRAM PERIOD

DIECO Subgroup Number and Description		Frequency	Conservation (10^6BTU/yr) Total	Avg.	Savings ($/yr) Total	Avg.
21	Steam system maintenance	78	137,147	1,758	407,929	5,230
22	Steam system	15	41,445	2,763	45,083	3,006
	TOTAL DIECO 20	93	178,592		453,012	
31	Electricity supply	45	1,254	28	377,474	8,388
32	Compressed air supply	169	17,390	103	270,114	1,598
33	Water usage	8	685	86	45,305	5,663
34	Fossil fuels	2	0	0	22,359	11,180
36	Misc. utility changes	10	0	0	65,152	6,515
	TOTAL DIECO 30	234	19,329		780,404	
41	Equipment scheduling	76	36,321	478	348,121	4,581
42	Plant scheduling	1	0	0	4,028	4,028
43	Packing, shipping, handling, transportation	1	66	66	372	372
	TOTAL DIECO 40	78	36,387		352,521	
92	Conversion to more economical fuel	18	5,491	305	366,623	20,368
93	Cogeneration	2	-34,737	-17,374	171,576	85,788
	TOTAL DIECO 90	20	-29,246		538,199	

CHAPTER THREE

FINANCIAL ANALYSES OF ECOs IMPLEMENTED

Manufacturers are continuing to achieve exceptional returns from their investments in cost-saving ECOs recommended by EADCs that carried out energy analyses in their manufacturing plants during 1986-87. The federal government is also realizing attractive returns from its support for the EADC program. The government's returns are revenues generated by income taxes levied upon manufacturers' incremental earnings, which are the results of cost savings derived from implementing EADCs' recommendations.

During 1986-87, manufacturers achieved internal rates of return (IRR) of 223 to 309% on their investments and the federal government's IRR was 40 to 73%, depending on the tax rate and borrowing rate assumed. Similarly, manufacturers' leverage ratios ranged from 1.43 to 1.90 and those of the federal government from 1.43 to 2.23.

This chapter offers an account and an analysis of the financial returns to the federal government and to manufacturers who implemented cost-saving measures which EADCs had recommended. The implementation data were gathered individually from each manufacturer by the EADC staff who had served the plant.

The results in this chapter reveal the effects of several factors upon manufacturers' financial returns from implementing ECOs' recommendations, but they also help in understanding the impacts of macroeconomic policies (e.g., borrowing rates and price escalations) upon manufacturers' investment returns.

All the financial analyses reported here were carried out under the following conditions:

- Implementation costs are capitalized by the manufacturers and all the funds are borrowed.

- Borrowing rates are fixed for the duration of a loan, and all loans are made for 5 years with the understanding that they will be repaid (interest and principal) in equal annual installments at the end of each year.

- Implementation costs depend upon price escalation rates, which are stated for each analysis. Basic costs (before escalation) were estimated and their timing specified for each measure in every plant by the EADCs and then aggregated for analysis according to the year of implementation. Only ECOs scheduled for implementation within two years were counted.

- Energy prices can be escalated at specified rates for analytical purposes, and their effects are seen in the cost savings which manufacturers realize from implementation. (Experience suggests that modest increases in energy prices and implementation costs do not affect implementation rate per se.)

- All rates of return and other measures of profitability are calculated after taxes (rate specified) unless otherwise stated.

To evaluate how cost-effective implementation can be, we subject results to standard financial analyses and calculate internal rates of return (IRR) and net present values, based upon specified discount rates for future earnings. The net present value method is used to calculate leverage ratios for these implementation results. The leverage ratio is the ratio of all cash flows (discounted at a specified rate to a first-year time period) to the sum of the capital investments needed to implement the ECOs. Some sources designate the leverage ratio as a profitability index.

One simplified interpretation of the leverage ratio considers it to represent the number of (constant) dollars returned to the investors for every dollar invested. For example, LR_{10}

= 2.50 implies that $2.50 is returned in constant dollars to the investors (discounted from future cash flows at 10%/year) for every dollar invested.

The IRR is the rate of return at which the sum of discounted future cash flows equals the initial investment, or the rate at which net present value is zero. Mathematically, IRR is expressed by this equation:

$$0 = CF_0 + \{CF_1 / (1 + i)\} + \{CF_2 / (1 + i)^2\} + \ldots + \{CF_n / (1 + i)^n\}$$

in which CF = cash flow

$CF_{subscript}$ = the year in which the cash flow occurs

i = IRR

The loan interest rates that manufacturers pay for the funds they borrow to implement cost-saving ECOs have definite effects upon the manufacturers' financial positions. Table 12 shows the negative effects upon pre-tax cash flows when borrowing rates increase from 9 to 15% per year. For the 322 manufacturers (from the 1986-87 period) who are implementing ECOs, there is a projected decrease in cash flow of almost $800,000 if the borrowing rate is allowed to go from 9 to 12% and of almost $1.62 million for an increase from 9 to 15%. Those numbers represent a decline of 3 to 7% in projected cash flow for increases in borrowing rates without any other changes in the implementation conditions.

Calculation of the internal rates of return (IRRs) and the leverage ratios (or profitability indices) which accompany increases in the manufacturers' borrowing rates reveals adverse impacts upon financial returns to the federal government as well as the private sector.

TABLE 12

EFFECTS OF BORROWING RATES
UPON MANUFACTURERS' CASH FLOWS
AFTER IMPLEMENTING ENERGY CONSERVATION OPPORTUNITIES

(1986-87 EADC Program)

Year	Borrowing Rate		
	9% Net Cash Flow*	12% Change in Net Cash Flow	15% Change in Net Cash Flow
	Dollars	Dollars	Dollars
1987	-394,270	-35,214	-71,027
1988	530,782	-201,971	-404,685
1989	3,023,890	-203,575	-410,938
1990	4,213,608	-165,766	-337,832
1991	4,451,680	-119,444	-246,007
1992	5,124,804	-63,550	-131,957
1993	6,604,023	-8,247	-17,166
Total	23,644,517	-797,767	-1,619,612
% Change	0	-3.37%	-6.85%

*Net cash flow is the difference in current dollars between manufacturers' savings and costs for implementing energy conservation opportunities (ECOs). First-year costs are negative because savings are not credited until one year after ECOs are implemented. Each year's costs is the sum of depreciation and interest paid on funds borrowed to implement the ECOs.

Low borrowing rates produce a larger IRR and a higher leverage ratio for the government and the manufacturers (Table 13). For example, the leverage ratios (at a 10% discount rate) show that the federal government, within 5 years, collects $2.23 (in constant dollars) for every federal dollar invested if the manufacturer can borrow implementation funds at 9% interest, instead of only $2.01 at 15% interest. Similarly, the manufacturers' leverage ratio drops from $1.90 to $1.77. For the same range of interest rates, the federal government's IRR goes from 44.1 to 39.8%, and the manufacturers' IRR, from 309.2 to 223.2%.

On the other hand, increasing energy prices improve the financial returns to the federal government and the manufacturers as long as implementation costs do not increase at a higher rate. When energy prices and implementation costs increase at 6% per year instead of 3%, the IRR goes from 44.1% to 49.0% for the federal government and from 309.2% to 324.2% for manufacturers (Table 14). The same shifts in energy prices and implementation costs produce changes from 2.23 to 2.76 in the federal government's leverage ratio (10% discount rate) and from 1.90 to 2.21 in the manufacturers' leverage ratio.

However, if implementation costs increase at 6% instead of 3% per year, but energy price increases remain at a 3% level, there are small but definite decreases in IRR and leverage ratio for the federal government and the manufacturers (Table 14).

From a policy perspective it is apparent that energy price increases improve the economic incentives of energy conservation opportunities as long as the costs of implementation increase no faster than energy prices. But increases in the interest rates which manufacturers pay to borrow funds to implement energy conservation always decrease the profitability of these opportunities.

TABLE 13

EFFECTS OF BORROWING RATES AND INCOME TAX RATES

UPON RETURNS FROM MANUFACTURERS' INVESTMENTS

IN ENERGY CONSERVATION

(1986-87 EADC Program)

BORROWING RATES

	15%		12%		9%	
	Fed. G.	Mfr.	Fed. G.	Mfr.	Fed. G.	Mfr.
IRR						
25% Tax Rate	39.8	223.2	41.9	261.8	44.1	309.2
50% Tax Rate	64.5	223.2	68.4	261.8	73.2	309.2
Leverage Ratio at 25% Tax Rate						
10% Discount	2.01	1.77	2.12	1.83	2.23	1.90
15% Discount	1.43	1.43	1.53	1.49	1.63	1.54

TABLE 14

EFFECTS OF GROWTH IN ENERGY PRICES

UPON RETURNS FROM MANUFACTURERS' INVESTMENTS

IN ENERGY CONSERVATION

(1986-87 EADC PROGRAM)

Growth Rates		Returns to Federal* Government			Returns to* Manufacturers		
Energy Prices	Implementation Costs	LR_{10}	LR_{15}	IRR	LR_{10}	LR_{15}	IRR
6%	6%	2.76	2.05	49.0%	2.21	1.79	324.2%
3%	3%	2.23	1.63	44.1%	1.90	1.54	309.2%
3%	6%	2.19	1.59	43.4%	1.87	1.52	299.1%

LR_{10} = leverage ratio for five-year cash flows discounted at 10% to first-year time period and compared to sum of capital investments to implement ECOs.

LR_{15} = leverage ratio for five-year cash flows discounted at 15% to first-year time period and compared to sum of capital investments to implement ECOs.

IRR = Internal rate of return.

*These are after-tax returns for an income tax of 25% levied against manufacturers' cost savings (incremental earnings) and for a borrowing rate of 9% applied to the capital investment funds needed to implement the ECO.

Earlier in this chapter the IRR was described as the rate of return which equates the sum of discounted future cash flows to the initial investment which produces the cash flows. It is reasonable, therefore, to expect that the size of the initial investment will influence the value of the IRR. To test this expectation, a hypothetical case was developed, and its results compared to the actual implementation results reported by the manufacturers.

Manufacturers report implementation according to the year in which it occurs. They borrow implementation funds on the same schedule. To create the hypothetical test case, half the second year's investment was assumed to occur during the first year, and half the second year's savings were similarly assumed to occur one year earlier. The results in Table 14 show that the leverage ratios of the federal government and the manufacturers went up slightly when these events occurred. In other words, a dramatic shift from second year toward first year implementation and investment had a small beneficial effect upon leverage ratio. The impacts upon IRR were mixed; for the federal government it went up slightly (49.0 to 50.1%); for the manufacturers, IRR decreased from 324.1% to 204.1%.

The explanation for this turn of events is chiefly mathematical, but it can be simplified somewhat by examining the relative sizes of the first-year cash flows of the government and the private sector. These are the results:

1st year Manufacturers' Investment	1st year Cash Flows	
	Federal Government	Manufacturers
$1,183,789	-$1,598,568	-$295,702
$4,132,339	-$1,812,337	-$937,012

The federal government's first year cost went up only from $1.6 million to $1.8 million (factor of 1.12). But the manufacturers' first year cost went from about $0.30 million to $0.94

million (factor of 3.13). The change is relatively much larger among manufacturers.

These results illustrate the possible volatility of IRRs derived from a series of unequal cash flows. It is risky to conclude from IRR data alone the size of the effect which a financial parameter has upon financial returns. Unless the influence of all other factors is clearly understood or controlled, the apparent effect could be misleading when comparing one parameter against another. In contrast, profitability index or leverage ratio appears to be less ambiguous.

In summary, the financial returns earned by manufacturers who implement EADCs' recommendations continue to be very attractive. Even though the federal government earns a smaller rate of return than manufacturers, it is still very profitable for the government to support the EADCs' efforts. In part, these returns offer supporting testimony to the practicality and effectiveness of the EADCs' recommendations, derived from proven technologies.

At the same time, the high implementation rates and financial returns provide a tribute to the manufacturers' confidence in the EADCs' recommendations and to their willingness to invest when the risks appear to be well-defined and manageable.

These results also indicate an auspicious vision of how to improve the future competitiveness of the nation's small and medium-size manufacturers. Given practical and specific opportunities to lower costs without sacrificing output or product quality, manufacturers as a group will take many of the actions needed to achieve the gains. When the government strengthens manufacturers' confidence by providing the information effectively, the results can be highly beneficial to the manufacturers, to the government, and to the nation as a whole.