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

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**1988-89 EADC PROGRAM PERIOD**

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by

*F. William Kirsch*

**UNIVERSITY CITY SCIENCE CENTER**  
*Industrial Technology and Energy Management Division*  
*F. William Kirsch, Ph.D., Vice President*  
3624 Market Street  
Philadelphia, PA 19104  
(215) 387-2255

**MASTER**

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## TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY .....	1
INTRODUCTION .....	4
I. ENERGY CONSUMPTION, CONSERVATION, AND COST SAVINGS .....	9
II. IMPLEMENTATION OF EADCs' RECOMMENDATIONS TO CONSERVE ENERGY AND REDUCE COSTS .....	25
III. FINANCIAL ANALYSES OF ECOs IMPLEMENTED .....	34

APPENDIX

## EXECUTIVE SUMMARY

Energy Analysis and Diagnostic Centers (EADCs) provided energy-conserving and cost saving assistance in 339 small and medium-size manufacturing plants nationwide during 1988-89. This report presents the results of what was recommended to those manufacturers, the record of what was implemented by them, and an analysis of the financial rewards gained by them. It also includes an accounting of the financial returns to the federal government, derived from taxes upon the cost savings, or incremental income, of the manufacturers who implement the EADCs' recommendations. EADCs collect implementation data within a year of the energy audit, and for these results that time period extended through 1990.

The EADCs are located at accredited engineering departments of universities and staffed by faculty and students. At present there are 18 EADCs serving manufacturers in 37 states; of these, two were established as a result of the 1989 competition, and five more were chosen competitively in 1990. Most of the results in this report were generated by 11 EADCs (named in the Appendix); two others withdrew voluntarily after completing only 10 energy audits during 1988-89.

Primary responsibility for selecting, training, evaluating, and managing the EADCs belongs to the Industrial Technology and Energy Management (ITEM) division of University City Science Center (UCSC). The Department of Energy's Office of Industrial Technologies sponsors the EADC program through an agreement with UCSC.

Since its inception in 1976, the EADC program has identified an aggregate conservation of about 115 trillion BTU and a combined cost saving of almost \$626 million through 1990. The cumulative cost to the federal government has been about \$13 million.

Approximately \$7.9 million per year in new cost savings has either been implemented by the manufacturers served during 1988-89 or is definitely scheduled to be within two years. That figure of \$7.9 million per year represents about 53% of the cost savings recommended to manufacturers and is one of several changes found among results from the 1988-89 program

period. For instance, a saving as large as \$831,745 per year is now being achieved through implemented cogeneration opportunities first recommended within this time frame.

The two industries with the largest implemented savings are food products (SIC 20) and chemicals (SIC 28). About 74% of the overall implementation was associated with manufacturing operations rather than building and grounds measures. Most of the implemented cost savings occurred with types of energy conservation opportunities (ECOs) classified as utility supply, process and equipment, or building and grounds. Collectively, these groups add up to about 65% of the total implemented savings, and within these groups implementation was as high as 84% of the savings recommended.

The internal rate of return (IRR) to the manufacturers served during 1988-89 was between 377 and 464% per year after taxes, based on their investments in the EADCs' recommendations. The federal government's IRR was 59 to 62% per year at the same 25% tax rate. The leverage ratios, or profitability indices, for these earning rates were between 2.80 and 3.84 for the federal government. That means the federal government, within five years of manufacturers' investments resulting from the 1988-89 program, will realize in constant dollars \$2.80 to \$3.84 (discounted to the first year) for every federal dollar invested in support of the program. For the manufacturers as a group, this measure of return was between \$3.05 and \$3.89. (The precise value depends on the borrowing rate for the capital investment, the escalation rate for energy prices and implementation costs, the implementation rate itself, and the discount rate applied to future cash flows.)

The same standard financial analyses of implemented cost-saving ECOs were utilized to explore certain issues, such as the effect on profitability as a result of implementation cost increases and higher interest rates for borrowing money. These analyses revealed:

- A small negative shift of 3.89 to 3.75 in the manufacturers' leverage ratio when interest rate increased from 9 to 15%/year. The corresponding shift for the federal government was from 3.84 to 3.67.
- Favorable effects on leverage ratio for energy prices increasing 6% per year even though implementation costs escalate more rapidly -- up to 24% per year.

- No combinations of financial parameters have been found which portray EADCs' recommended investments to conserve industrial energy as being less than extremely profitable.

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 demonstrate one means 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.

## INTRODUCTION

An additional 339 small and medium-size manufacturers will be able to save more than \$14.73 million/year in energy and operating costs as a result of opportunities identified in their plants by Energy Analysis and Diagnostic Centers during 1988-89. About \$1.34 million of that total is due to reductions in operating costs proposed by the EADCs. This report describes and analyzes those results, presents the record of their implementation, and offers financial analyses of their value to the manufacturers and the return on program investment which these implemented opportunities give to the federal government.

This report is organized into these three chapters:

- Energy Consumption, Conservation, and Cost Savings
- Implementation of EADCs' Recommendations to Conserve Energy and Reduce Costs
- Financial Analyses of ECOs Implemented

To appreciate more completely the scope and importance of results presented in those chapters, it is helpful to examine some of the accomplishments which preceded the work reported here.

### Cumulative Results of the EADC Program

The eleven EADCs which served 339 manufactures during 1988-89 benefited from the collective information established by them and their predecessors over 13 years. (Two of the EADCs which began to operate during 1988-89 withdrew voluntarily during the first quarter of the period for institutional reasons related to their own campuses; collectively they performed ten audits during this program period.)

A statistical compilation of all EADC accomplishments through 1990 (Table 1) reveals that cumulative values of almost \$626 million in cost savings and 115 trillion BTU have been

TABLE 1  
 AGGREGATE ENERGY CONSERVATION AND COST SAVINGS RECOMMENDED BY EADCS

	E A D C Program Period										Total
	1976-81	1981-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90*		
No. Audits Performed	363	479	297	317	300	324	389	339	360		
Energy Conservation (trillion BTU)											
During period	4.466	2.441	1.345	1.777	1.358	1.098	1.456	1.776	1.473		
Cumulative	53.592	20.748	9.415	10.662	6.790	4.392	4.368	3.440	1.473	114.880	
Cost Savings (\$ million)											
During Period	13.042	15.527	10.045	11.575	13.801	11.481	13.607	14.843	12.086		
Cumulative	156.504	131.985	70.313	69.451	69.006	43.924	40.821	29.686	12.086	625.772	

\*Estimated

recommended to manufacturers over the years. The federal government's contractual support for this work adds up to almost \$13 million through 1990.

This report focuses on the 1988-89 program period because it is the most recent one for which we have complete implementation data. Manufacturers have as long as a year after an energy audit to decide which of the EADCs' recommendations they will implement. Therefore the implemented results from 1988-89 were obtained from the manufacturers throughout 1990.

### Spectrum of Industries Served

The 339 plants served by an EADC during 1988-89 were distributed among 19 major industries (2-digit SIC codes); only one was represented by a single plant (SIC 29: petroleum products) and one other (SIC 31: leather products) was represented by two plants. None of these plants was typical of its industry, and the plant which manufactures petroleum products was not a refinery. Hardly any petroleum refineries are small enough to meet EADC criteria for small and medium-size plants. Also, domestic makers of leather products are so few that it is not surprising only two were among the 339 served.

The complete distribution of plants served during 1988-89 is presented in Table 2, together with their total employment and gross annual sales on an industry-specific basis (two-digit SIC code). Once again, the food products industry was represented by the most plants (60 plants in SIC 20), but the second largest number (43) occurred in the fabricated metals industry (SIC 34). This change in rank is due to a much smaller number of plants served during 1988-89 in the non-electrical machinery industry (SIC 35), which had been the second largest.

Table 3 shows the industries where the major shifts occurred between the two most recently reported periods of the EADC program. One trait suggested by these data is a trend toward plants with larger average sales figures. That trend is apparent for each industry but two: SIC 32 (about even) and SIC 36 (smaller). More will be said about plant size in the first chapter of this report.

TABLE 2  
INDUSTRIES SERVED BY EADCs DURING 1988-89

SIC Code	I n d u s t r y	Employment	Number of Plants Served	Gross Annual Sales Thousands of Dollars
20	Food and kindred products	11,475	60	1,940,215
22	Textile mill products	5,288	17	426,200
23	Apparel and other textile products	2,008	9	201,500
24	Lumber and wood products	1,774	16	285,500
25	Furniture and fixtures	861	6	95,500
26	Paper and allied products	2,833	21	500,600
27	Printing, publishing, and allied industries	2,877	18	304,600
28	Chemical and allied products	2,842	17	634,000
29	Petroleum and coal products	75	1	15,000
30	Rubber and miscellaneous plastics products	5,126	30	570,400
31	Leather and leather products	330	2	25,000
32	Stone, clay, glass, and concrete products	1,914	14	214,600
33	Primary metal products	2,619	15	276,300
34	Fabricated metal industries	6,446	43	828,200
35	Machinery, except electrical	5,254	26	618,600
36	Electrical equipment and supplies	3,280	16	295,000
37	Transport equipment	2,014	13	257,500
38	Measuring, analyzing, and controlling instruments	2,242	9	213,000
39	Miscellaneous manufacturing industries	1,540	6	184,000
	T o t a l	60,798	339	7,885,715
	Means	179		23,262

TABLE 3  
 PRINCIPAL CHANGES AMONG INDUSTRIES SERVED

SIC Code	Number of Plants Served			Average Gross Annual Sales \$ Million/Plant	
	1987-88	1988-89	1987-88	1988-89	
22	10	17	29.30	32.34	
24	24	16	13.19	17.84	
25	12	6	10.08	15.92	
30	45	30	12.76	19.01	
32	10	14	14.69	15.33	
33	20	15	13.90	18.42	
35	51	26	18.10	23.79	
36	23	16	24.67	18.44	
39	10	6	19.22	30.67	
All	389	339	18.53	23.26	

## CHAPTER ONE

# ENERGY CONSUMPTION, CONSERVATION, AND COST SAVINGS

### Manufacturers' Energy Use and Other Characteristics

The trend toward larger sales figures for the plants served by an EADC during 1988-89 was also found for employment data (Table 4). Average sales per plant went from \$18.5 to \$23.3 million in a year, and the average employment per plant increased from 159 to 179.

Similarly, average energy cost per plant was \$403,669/year in 1988-89 versus \$361,265 for the preceding program period. However, average energy consumed per plant was significantly smaller during 1988-89 (63.4 billion BTU/year) than during 1987-88 (72.7 billion BTU/year). Many factors can bring about these kinds of changes at individual plants (geographic location, industry mix, energy or labor intensiveness, history of conservation efforts). At this broad level of consideration, firm attribution of causes is not possible; it is more important to be aware of the year-to-year differences and then to look at more detailed information within the context of these parameters.

For example, energy costs can be analyzed on a specific basis, such as energy cost per employe. Doing that for plants served in each industry reveals a mixed pattern (Table 5). In 11 industries, specific energy cost per employe was larger during 1988-89 than it had been during 1987-88. But for seven other industries, the opposite was found. That kind of behavior is consistent with the small difference in this parameter for all plants served in 1987-88 and 1988-89 and illustrates the difficulty often encountered in treating industrial energy consumption and conservation on a macro basis, because the controlling factors are operative at a micro level -- even at times on a single plant basis.

Year-to-year differences and similarities in energy consumption and cost by energy source are evident in Table 6. Fluctuations in overall consumption and cost were discussed previously from the data in Table 4. What Table 6 reveals are the relative mixes of energy sources within a

TABLE 4  
 MANUFACTURERS' ENERGY USE AND OTHER CHARACTERISTICS

	1986-87	1987-88	1988-89
Number of manufacturers served	324	389	339
Energy use, 10 <sup>6</sup> BTU/yr	18,007,237	28,274,230	21,497,078
Average use per plant, 10 <sup>6</sup> BTU/yr	55,578	72,684	63,413
Energy cost, \$/yr	107,732,170	140,532,000	136,843,900
Average cost per plant, \$/yr	332,507	361,265	403,669
Number of employees	49,745	62,028	60,798
Average number per plant	154	159	179
Gross sales, \$ million/yr	6,343	7,209	7,886
Average sales per plant, \$ million/yr	19.6	18.5	23.3

TABLE 5  
COMPARISON OF SPECIFIC ENERGY COSTS

SIC Code	Industry	Specific Energy Cost (\$/YR/EMP)	
		1987-88	1988-89
All		2,263	2,319
20	Food and kindred products	2,697	2,159
22	Textile mill products	3,823	2,369
23	Apparel and other textile products	463	558
24	Lumber and wood products	3,377	4,355
25	Furniture and fixtures	827	1,550
26	Paper and allied products	3,017	3,265
27	Printing, publishing, and allied industries	1,152	854
28	Chemical and allied products	5,373	3,191
29	Petroleum and coal products	*	*
30	Rubber and miscellaneous plastics products	2,365	2,967
31	Leather and leather products	*	*
32	Stone, clay, glass, and concrete products	10,643	6,985
33	Primary metal products	3,547	3,009
34	Fabricated metal industries	1,966	2,014
35	Machinery, except electrical	1,264	1,409
36	Electrical equipment and supplies	1,127	2,132
37	Transport equipment	974	1,206
38	Measuring, analyzing, and controlling instruments	1,225	2,152
39	Miscellaneous manufacturing industries	1,002	2,368

\*The number of plants is too small for these data to be significant

TABLE 6  
ENERGY CONSUMPTION AND COST FOR PLANTS SERVED IN THE  
EADC PROGRAM, 1986-87 TO 1988-89

ENERGY CONSUMPTION - MILLIONS OF BTU PER YEAR

	U s a g e			% T o t a l U s a g e		
	1986-87	1987-88	1988-89	1986-87	1987-88	1988-89
Number of Plants	324	389	339			
<u>Energy Source</u>						
Electricity	6,499,328	6,084,061	6,404,777	36.0	21.5	29.8
Natural Gas	6,197,309	11,004,442	11,437,256	34.3	38.9	53.2
Fuel Oil	601,558	774,409	1,109,914	3.3	2.8	5.2
Coal	129,853	6,154,796	32,192	0.7	21.8	0.2
Wood	4,385,297	3,967,329	1,683,533	24.3	14.0	7.8
Other	243,892	289,193	829,406	1.4	1.0	3.8
Total	18,057,237	28,274,230	21,497,078	100.0	100.0	100.0

COST OF ENERGY CONSUMPTION - DOLLARS PER YEAR (current)

	U s a g e			% T o t a l U s a g e		
	1986-87	1987-88	1988-89	1986-87	1987-88	1988-89
Number of Plants	324	389	339			
<u>Energy Source</u>						
Electricity	75,703,727	93,281,048	93,822,339	70.3	66.4	68.6
Natural Gas	25,227,607	33,282,299	36,561,612	23.4	23.7	26.7
Fuel Oil	1,974,677	2,876,571	3,206,729	1.8	2.0	2.3
Coal	430,563	8,251,626	54,050	0.4	5.9	0.04
Wood	3,651,622	1,524,714	1,285,908	3.4	1.1	1.0
Other	743,974	1,315,742	1,913,262	0.7	0.9	1.4
Total	107,732,170	140,532,000	136,843,900	100.0	100.0	100.0

particular period of the EADC program. During the 1988-89 period, natural gas and electricity resumed their more important roles in energy usage and cost. Coal had accounted for 21.8% of the energy used by manufacturers during 1987-88, but that share dropped to only 0.2% in 1988-89. Similarly, the role of wood as an energy source among EADCs' manufacturers has declined by 40-50% in each program period since 1986-87 to a level of 7.8% of the total in 1988-89. On a cost basis, electricity remained dominant (68.6% of total) and natural gas was second (26.7%) during 1988-89. Together they were responsible for more than 95% of what manufacturers spent for energy during 1988-89.

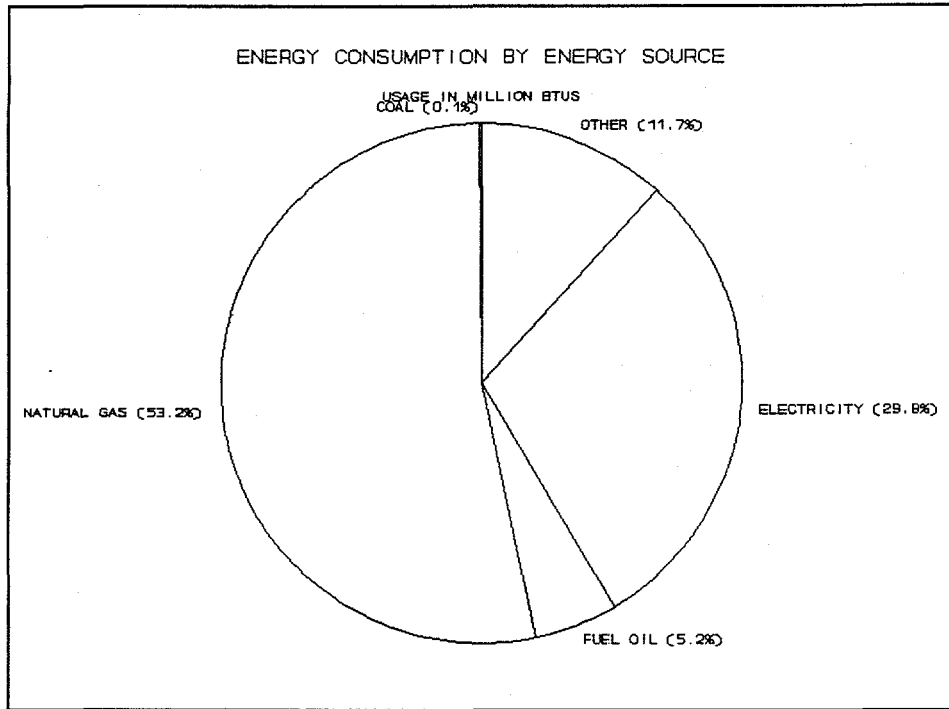
Figures 1 and 2 graphically present energy consumption and cost during 1988-89 according to energy sources. They obviously reflect the dominance of electricity and natural gas.

#### Recommended Conservation and Savings

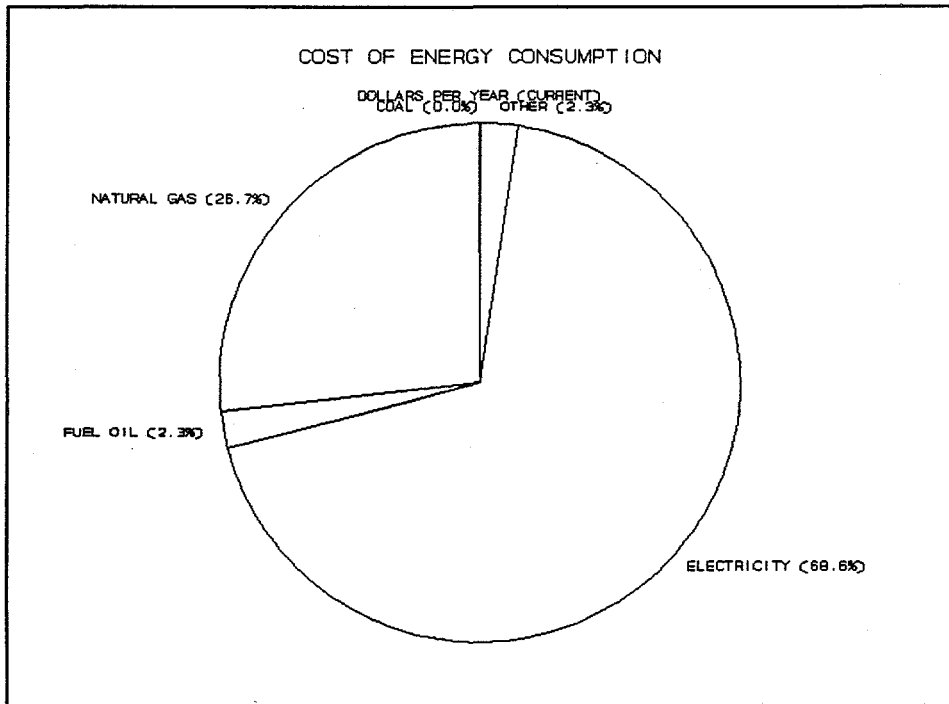
EADCs recommended 2,384 ECOs to 339 small and medium-size manufacturers during 1988-89. Collectively they represent a gross energy conservation of 1,921 billion BTU/year, or 9.0% of total consumption. The corresponding savings figure is more than \$13.5 million/year, or 9.9% of total cost (Table 7). Figures 3 and 4 show the portions of energy conservation and cost savings attributable to each energy source. Expectedly, electricity offers the largest recommended cost saving among all energy sources, and natural gas is next in rank, even though natural gas is clearly the largest source of energy conservation.

The quantity of alternate fuel purchased for ECOs during 1988-89 was only about 43% as large as it had been during the preceding period of the EADC program. These ECOs save money under the individual circumstances where they are recommended, but collectively they represent the purchase of more than \$0.518 million/year of alternate fuels. Therefore, the net energy cost saving found is about \$13.00 million/year for 1988-89.

EADCs also identify operating cost savings and opportunities for generating additional income while performing energy audits. During 1988-89, those totaled almost \$1.74 million/year (Table 7). When added to the \$13.00 million/year of energy cost savings, this factor brings the



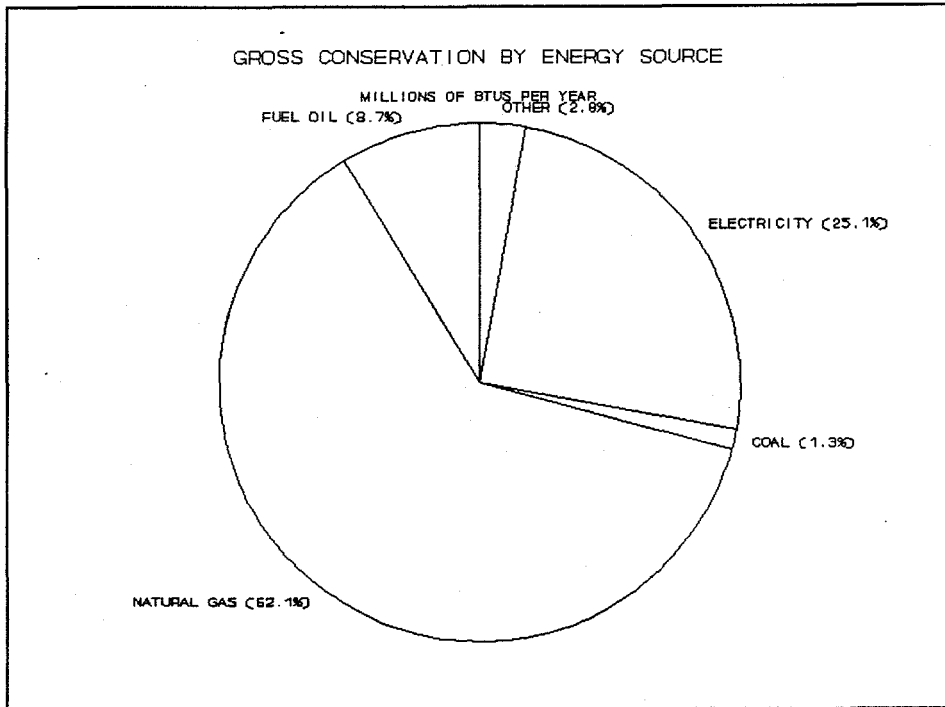
**Figure 1**



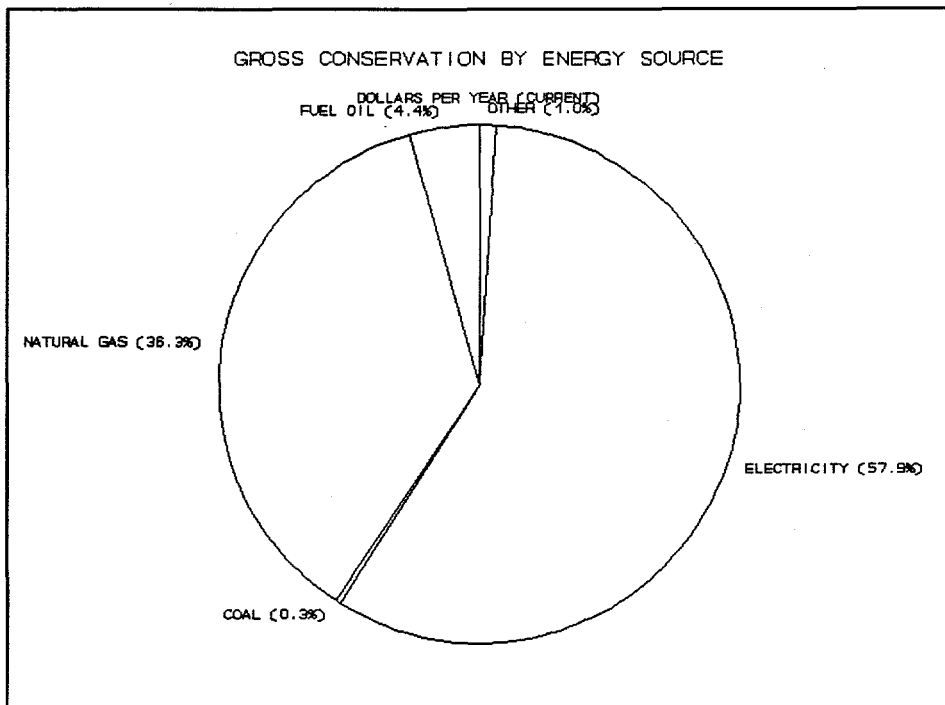
**Figure 2**

TABLE 7  
ENERGY CONSERVATION AND COST SAVINGS IDENTIFIED FOR EACH ENERGY SOURCE

Energy Source	Energy Conservation Identified (10 <sup>6</sup> BTU/yr)				Cost Savings Identified (\$/yr)				
	1986-87	1987-88	1988-89	1986-87	1987-88	1988-89	1986-87	1987-88	1988-89
Electricity	478,033	636,415	481,331	7,670,038	9,735,588	7,833,399			
Natural Gas	822,361	759,896	1,193,045	3,467,196	3,119,302	4,912,515			
Fuel Oil	73,334	132,912	167,423	267,038	521,491	589,454			
Coal	15,200	558,723	24,622	21,079	660,361	44,180			
Wood	378,708	126,600	27,784	255,486	37,497	28,141			
Other	6,418	57,505	26,777	56,354	421,363	110,763			
Total (gross)	1,774,054	2,272,051	1,920,982	11,737,191	14,495,602	13,518,452			
% Consumption	9.8	8.0	9.0	10.9	10.3	9.9			
Alternates	-676,098	-816,173	-200,701	-1,033,659	-1,194,338	-518,364			
Total (net)	1,097,956	1,455,878	1,720,281	10,703,532	13,301,264	13,000,088			
% Consumption	6.1	5.2	8.0						
Oper. Cost Saving				161,055	308,547	1,340,237			
Additional Income				615,998	21,577	395,074			
Total				11,480,585	13,631,388	14,735,399			
% Cost				10.7	9.7	10.8			



**Figure 3**



**Figure 4**

overall net cost savings identified to \$14.74 million/year, or 10.8% of total cost. Opportunities for generating additional income do not occur often but can be relatively large. For example, the sale of electricity (from cogeneration) offered the potential to produce \$170,165 per year. At a plywood plant, installing a radio-frequency veneer re-dryer could bring about \$224,909 per year of additional income from increased production and reduced losses.

#### Types of ECOs and Industries

EADCs find and recommend a variety of energy conservation opportunities (ECOs) throughout the 19 industries (2-digit SIC codes) which they serve. Our purpose here is to examine briefly the kinds of ECOs recommended and to analyze the industries where they were found. It is obvious that during 1988-89 certain industries generated more energy cost-saving than others (Figure 5 and Table 8).

To conduct this kind of examination and analyze the variety of ECOs and the industries where they occur, we will focus on energy cost saving as the major parameter rather than energy conservation itself. The chief reason for this choice is the statistical ambiguity created when energy conservation is considered, and the recommendation of alternate energy sources is the factor which creates the ambiguity. An EADC's recommendation to a manufacturer may involve substitution of one energy source for another, usually for reasons of cost. The alternate source may even be consumed in slightly larger quantities but at a lower overall cost. This larger consumption represents a negative conservation. As a result, comparisons of energy conserved become ambiguous and require more detailed information if they are to be understood correctly.

Moreover, manufacturers decide to accept or reject EADCs' recommendations chiefly for their cost-saving value, although other factors like convenience and ease of control can influence the decision. For all of these reasons, this comparison of industries and energy conservation potential will focus upon cost saving.

It is obvious that food processing (SIC 20), chemicals (SIC 28), and fabricated metal products (SIC 34) were responsible for recommendations of more total cost savings than any other

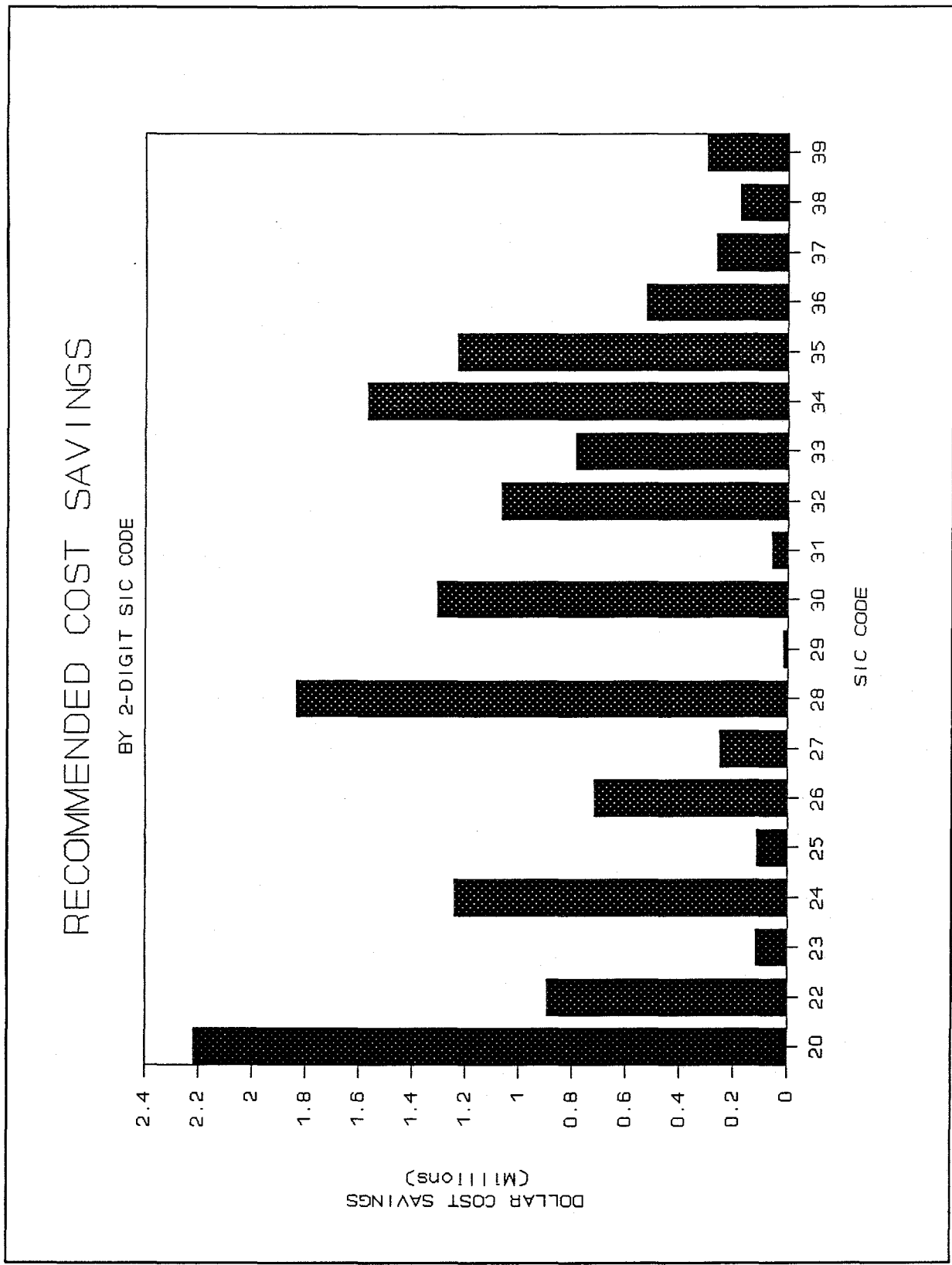


Figure 5

TABLE 8  
 COST SAVINGS RECOMMENDED AND IMPLEMENTED BY EACH INDUSTRY

1988-89 EADC Program

SIC Code	I n d u s t r y	C o s t S a v i n g s , \$ / y r		
		Recommended	Implemented	% Implementation
20	Food and kindred products	2,219,981	1,341,795	60.4
22	Textile mill products	894,689	630,556	70.5
23	Apparel and other textile products	117,719	59,522	50.6
24	Lumber and wood products	1,244,633	285,413	22.9
25	Furniture and fixtures	112,873	62,934	55.8
26	Paper and allied products	720,796	296,934	41.2
27	Printing, publishing, and allied industries	252,849	153,120	60.6
28	Chemical and allied products	1,836,055	1,307,492	71.2
29	Petroleum and coal products	15,502	8,973	57.9
30	Rubber and miscellaneous plastics products	1,312,277	635,397	48.4
31	Leather and leather products	60,359	14,278	23.7
32	Stone, clay, glass, and concrete products	1,072,325	702,739	65.5
33	Primary metal products	791,103	438,637	55.4
34	Fabricated metal industries	1,572,108	1,003,630	63.8
35	Machinery, except electrical	1,235,669	327,505	26.5
36	Electrical equipment and supplies	529,291	206,385	39.0
37	Transport equipment	266,568	146,415	54.9
38	Measuring, analyzing, and controlling instruments	179,384	91,665	51.1
39	Miscellaneous manufacturing industries	302,730	166,001	54.8
	T o t a l	14,736,911	7,879,391	53.5

during 1988-89. Together they account for about 38% of the total cost savings recommended in 19 industries.

Seven other industries were individually prominent for their cost-saving potential from the EADCs' energy audits, as this summary shows:

<u>SIC</u>	<u>% Total</u>	<u>SIC</u>	<u>% Total</u>
22	6.1	30	8.9
24	8.4	32	7.3
26	4.9	33	5.4
		35	8.4

Collectively these ten industries represent more than 87% of the total \$14.7 million recommended in net energy cost savings.

Finding and recommending cost-saving ECOs in a given industry depend upon the pattern of energy use, climate, age of equipment, and level of profitable activity at the plant. Generalizations are difficult to make and subject to change. One common factor among many plants, whether in the same or different industries, is the type of ECO recommended. To examine ECOs on this basis we used ITEM's numerical Directory of Industrial Energy Conservation Opportunities (DIECO). The result appears in Table 9 where savings are reported by the DIECO major group into which they were classified.

These data show that ECOs classified as process and equipment changes (DIECO 50), building and grounds measures (DIECO 60), and utility supply (DIECO 30) were responsible for almost 64% of the cost savings recommended to 339 manufacturers. Virtually all ECOs outside the building and grounds categories are related to manufacturing operations.

One advantage of the DIECO system is the capability it gives to examine ECOs at various levels of detail. Grouping the EADCs' recommendations at a 2-digit level enables us to learn more about the kinds of actions proposed to the manufacturers (Figure 6 and Table 10).

This level of detail obviously reflects what had been said earlier about the kinds of ECOs recommended. They cover a broad range and focus strongly upon manufacturing operations. The

TABLE 9  
 COST SAVINGS RECOMMENDED IN MAJOR DIECO GROUPS

1988-89 EADC Program

DIECO Major Group	Description	Cost Savings Recommended (\$/year)	% Total
10	Combustion	1,702,370	11.6
20	Steam System	469,468	3.2
30	Utility Supply	2,737,690	18.6
40	Scheduling	594,025	4.0
50	Process and Equipment	3,528,972	23.9
60	Building and Grounds	3,126,664	21.2
70	Non-energy Cost Savings	730,275	5.0
90	Alternate Sources	1,847,447	12.5
	Total	14,736,911	100.0

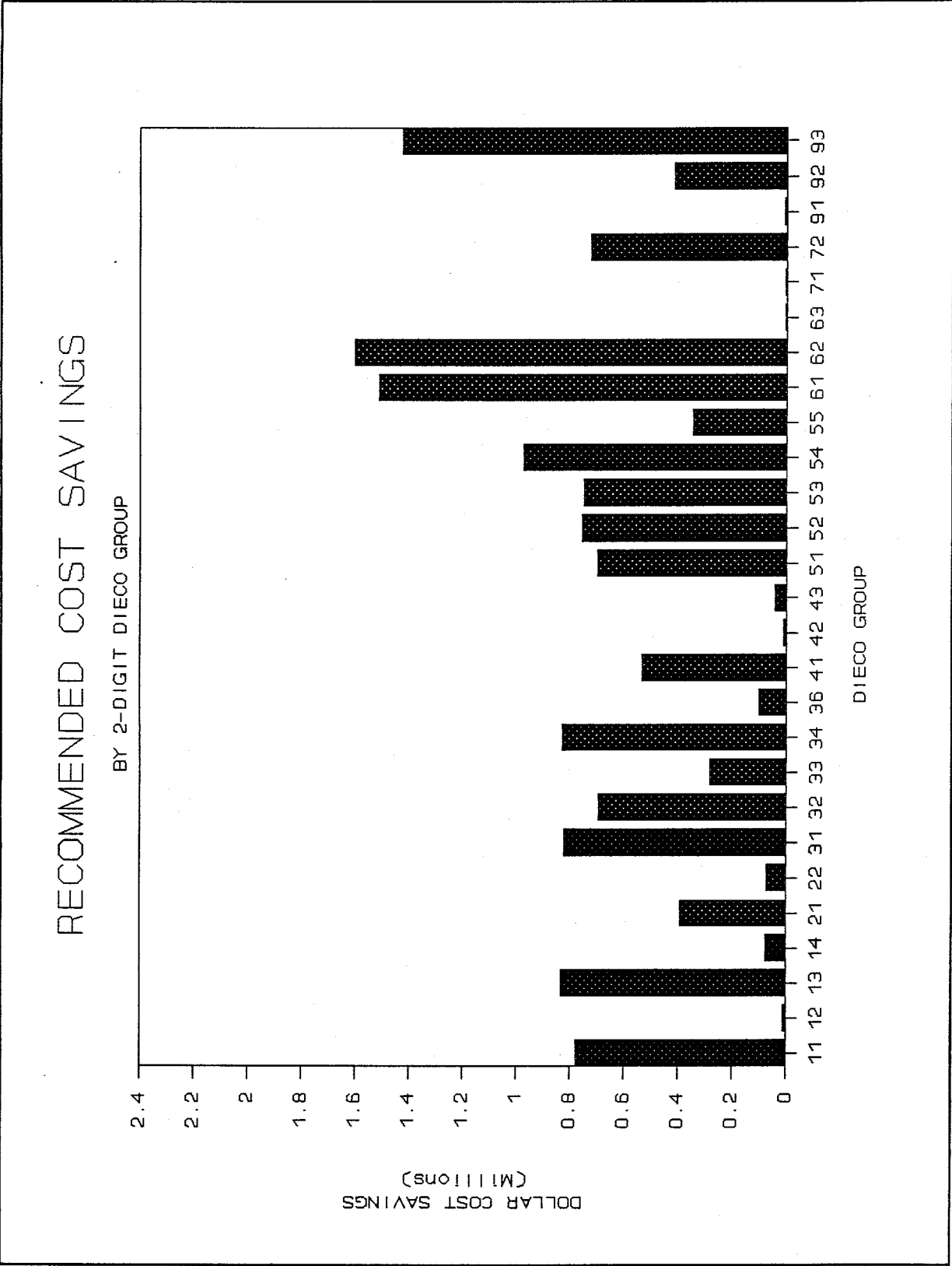


Figure 6

TABLE 10

## COST SAVINGS RECOMMENDED AND IMPLEMENTED BY EACH DIECO SUBGROUP

1988-89 EADC Program

DIECO Subgroup	Description	C o s t   S a v i n g s		
		Recommended	Implemented	% Imp.
11	Combustion equipment efficiency	778,026	670,438	86.2
12	Combustion equipment maintenance and replacement	11,532	11,532	100.0
13	Combustion heat recovery	834,288	237,149	28.4
14	Combustion heat confinement	78,524	38,338	48.8
21	Steam equipment repair and upgrading	393,309	345,633	87.9
22	Steam system changes	76,159	31,670	41.6
31	Electricity supply	823,538	413,366	50.2
32	Compressed air supply	696,185	513,614	73.8
33	Water supply	285,209	26,553	79.4
34	Fossil fuel supply	831,516	673,959	81.1
36	Miscellaneous utility changes	101,242	85,349	84.3
41	Equipment scheduling	536,932	311,466	58.0
42	Plant scheduling	10,634	2,368	22.3
43	Packaging, handling, shipping	46,459	2,074	4.5
51	Process equipment maintenance and repair	698,305	318,127	45.6
52	Process operation and design	757,907	123,068	16.2
53	Process-specific techniques	751,146	467,643	62.3
54	Process heat recovery	976,546	276,629	28.3
55	Process heat confinement	345,068	156,598	45.4
61	Lighting efficiency	1,514,949	1,024,695	67.6
62	HVAC efficiency	1,606,008	862,412	53.7
63	Miscellaneous buildings and grounds	5,707	5,550	97.2
71	Equipment cost savings	5,300	5,300	100.0
72	Material cost savings	724,975	38,006	5.2
91	Waste and byproducts as fuel	7,900	0	0.0
92	Conversion to more economical fuel	413,408	206,129	49.9
93	Cogeneration	1,426,139	831,745	58.3
	Total	14,736,911	7,879,391	53.5

cogeneration ECOs (DIECO 93) also explain why the alternate fuel major group (DIECO 90) is so large.

Many of these ECOs require capital investments for implementation, and the decision to invest depends upon numerous factors, some of which are obvious (like payback time) and others which are more subjective (like the size of the investment). The next chapter of this report deals with the implemented results from the EADCs' recommendations, and the third chapter analyzes the financial returns to the manufacturers and to the federal government according to criteria like internal rate of return (IRR) and leverage ratio (LR) or profitability index.

## CHAPTER TWO

### **IMPLEMENTATION OF EADCs' RECOMMENDATIONS TO CONSERVE ENERGY AND REDUCE COSTS**

Implementation offers an ultimate test of EADCs' recommendations, because manufacturers will adopt only recommendations based on good engineering judgment and objective 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. This chapter presents a record of what the manufacturers served by an EADC during 1988-89 decided to implement.

#### Types of ECOs Implemented

Most of the implemented cost savings occurred in the utility supply, process and equipment, and building and grounds major DIECO groups (Table 11). Implemented ECOs within these three groups add up to 65.3% of the whole \$7.9 million/year savings. Comparing that figure to the total \$14.7 million/year of recommended savings reveals an overall implementation rate of 53.5%.

The data in Table 11 represent some significant changes from the 1987-88 program period, especially in the overall implementation rate, which increased from 49.1 to 53.5 of the cost savings recommended. In addition, the share of implemented savings attributable to process and

TABLE 11  
 COST SAVINGS IMPLEMENTED IN MAJOR DIECO GROUPS

1988-89 EADC Program

DIECO Major Group	Description	Cost Savings Implemented (\$/yr)	% Total Implemented	Implementation as % of Recommended Value
10	Combustion	957,457	12.1	56.2
20	Steam System	377,303	4.8	80.4
30	Utility Supply	1,912,821	24.3	69.9
40	Scheduling	315,908	4.0	53.2
50	Process and Equipment	1,342,065	17.0	38.0
60	Buildings and Grounds	1,892,657	24.0	60.5
70	Non-energy Cost Savings	43,306	0.6	5.9
90	Alternate Sources	1,037,874	13.2	56.2
Total		7,879,391	100.0	53.5

equipment changes (DIECO 50) decreased to 17.0% of the 1988-89 total (from 28.9% in 1987-88) while the alternate source category went from 2.2% in the preceding period to 13.2% in 1988-89. More will be said later about how these shifts occurred.

From another perspective, the highest implementation rate was found among the steam system changes (DIECO 20), where 80.4% of the cost savings recommended was in fact implemented. As has been discussed, implementation percentage varies widely from one DIECO major group to another but it was almost as high (69.9%) for the utility supply group (DIECO 30), which accounted for the largest quantity of implemented costs savings, more than \$1.9 million/year.

It is even more interesting to look at the implemented conservation measures at the next higher level of detail (Table 10, page 23 and Figure 7, page 28). For example, cogeneration was responsible for over 80% of the implemented cost savings in the alternate fuels group (DIECO 90). About 58.3% of the cogeneration cost savings recommended was in fact implemented.

Within each major DIECO group, a wide range of implementation rates occurs. For utility supply, the largest DIECO major group implemented, the components varied from an implementation rate of 50.2% (electricity supply) to 84.3% for miscellaneous utility changes. However, the biggest implemented utility savings was realized in fossil fuel supply (\$673,939/year) and compressed air supply (\$513,614/year). These include recommendations such as switching to direct purchase of natural gas, as well as more mundane matters such as fixing leaks on the compressed air system and reducing the air supply pressure or downsizing the compressor to match needs.

# IMPLEMENTED COST SAVINGS BY 2-DIGIT DIECO

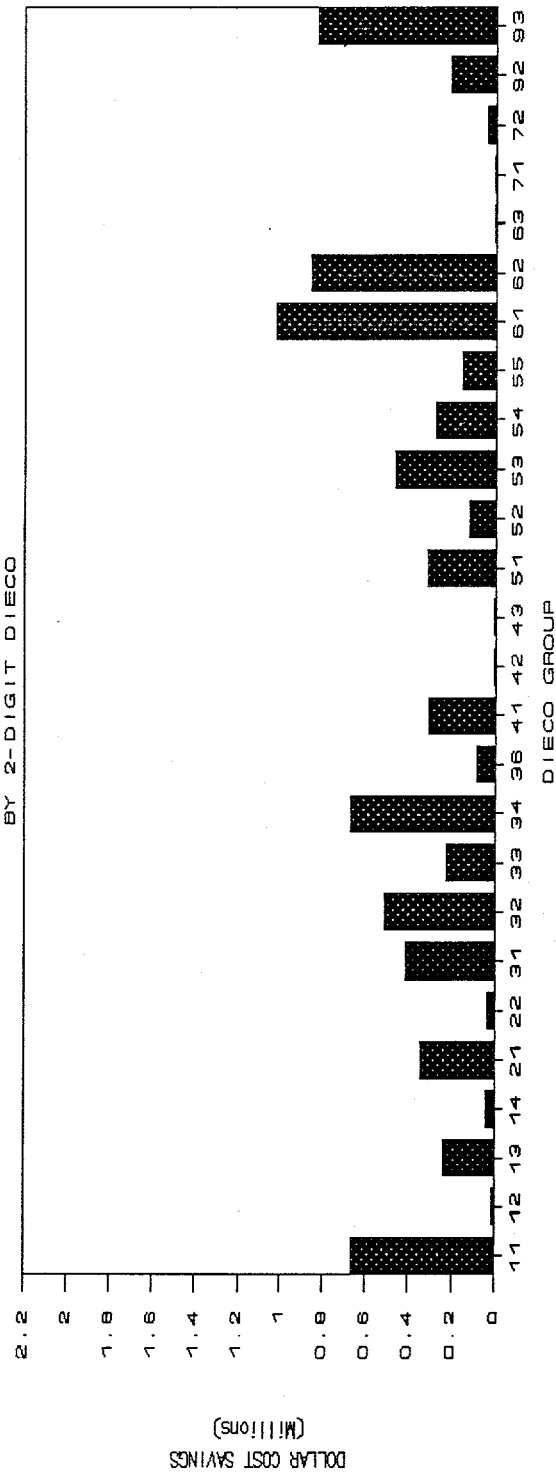


Figure 7

The subgroup data in Table 10 and Figure 7 also reveal relatively large implemented dollar savings and/or a high implemented percentage of the recommended value for a variety of other measures. These include:

DIECO Subgroup		Implemented Savings (\$/year)	% Implemented
11	Combustion equipment efficiency	670,438	86.2
12	Combustion equipment maintenance and replacement	11,532	100.0
21	Steam equipment repair and upgrading	345,633	87.9
31	Electricity supply	413,366	50.2
32	Compressed air supply	513,614	73.8
34	Fossil fuel supply	673,959	81.1
41	Equipment scheduling	311,466	58.0
51	Process equipment maintenance and repair	318,127	45.6
53	Process-specific techniques	467,643	62.3
61	Lighting efficiency	1,024,695	67.6
62	HVAC efficiency	862,412	53.7
93	Cogeneration	831,745	58.3

Traditionally manufacturers are said to resist any process change, but these results in DIECO 51 and 53 indicate a willingness to overcome that resistance when recommendations make their point clearly and effectively.

Not every facet of the data on specific ECO types can be discussed in this report, but Table 10 and Figure 7 enable the reader to have the information readily accessible for future comparison and analysis.

#### Implementation in Specific Industries

Plants in all industries implemented some of the EADCs' recommendations, but the extent varied a great deal from one to another. Table 8 (page 19) and Figure 8 offer a comparative

# IMPLEMENTED COST SAVINGS

BY 2-DIGIT SIC CODE

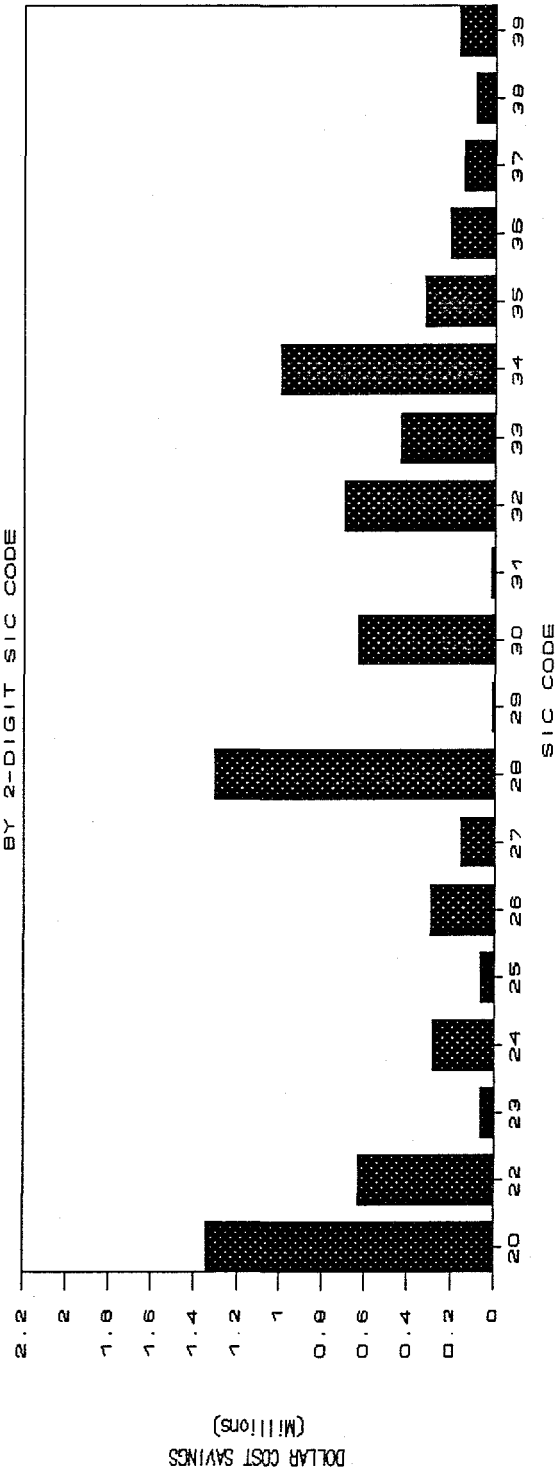


Figure 8

distribution of recommended and implemented cost savings, together with a figure for the per cent implementation in each industry. Food processing (SIC 20) and chemicals (SIC 28) are the industries responsible for more recommended and implemented cost savings than any others. However, the quantity of cost savings is very high in these four other industries:

SIC	Implemented Cost Savings (\$/yr)
22	630,556
30	635,397
32	702,739
34	1,003,630

In eleven industries (SIC 20, 22, 25, 27, 28, 29, 32, 33, 34, 37, 39), the degree of implementation was higher than the overall average of 53.5%, but in six others (SIC 24, 26, 30, 31, 35, 36) manufacturers implemented less than 50% of the cost savings recommended by the EADCs. With the exception of the food products industry, the amount of savings and the per cent of recommended savings implemented varies considerably from one program period to another.

This variability emphasizes the individuality of manufacturing plants and the decisions made by their managers and owners to implement EADCs' recommendations. For that reason, the implementation reported is strictly applicable only to the plants served and the ECOs recommended to them during the 1988-89 program period. It is wrong to try to generalize from these data without examining results from other time periods and exploring the reasons for the results obtained.

#### Implementation and Categories of Energy Use

Implemented cost savings have also been analyzed according to the category of the plant's energy use in which they occurred. As listed in Table 12, the data continue to reflect the dominance of ECOs in the manufacturing category (production plus services), which accounts for 74% of the implemented cost savings. The remaining 26% is divided almost evenly between the

TABLE 12

## IMPLEMENTATION OF EADCs' RECOMMENDATIONS ACCORDING TO CATEGORY OF ENERGY USE

1988-89 EADC Program

	Net Cost Savings (\$/year)	% Implemented
Production		
Implemented	643,715	19
Services		
Implemented	5,218,778	58
HVAC		
Implemented	985,192	53
Housekeeping		
Implemented	1,031,706	69
Total	7,879,391	--

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, heating, adjusting thermostats.
- Housekeeping   Energy to be conserved by normal routine operations and maintenance, e.g., lighting changes, domestic service water.

HVAC and the housekeeping category. The percentages shown in the table reveal the degree to which EADCs' recommendations in a specific category were implemented. It is important to keep in mind that the services category is for energy used to supply heat or power to the process or product and is, therefore, related to manufacturing operations. As defined among EADCs, production is a very narrowly defined category.

The next chapter of this report presents financial analyses of the implemented cost savings and shows their profitability to manufacturers and to the federal government, which sponsors the EADC program.

## CHAPTER THREE

### FINANCIAL ANALYSES OF ECOs IMPLEMENTED

#### General Considerations and Public Policy Implications

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.

It is also possible from these analyses to assess the effects of financial policies and parameters upon the profitability of implementing EADCs' recommendations. Among the parameters examined are the escalation rates of manufacturers' implementation costs and of energy prices and their costs of borrowing the funds required for implementation. Previously, the effects of accelerating the implementation rate and of counting savings beyond the five years needed to repay the loans have been reported. These points will be discussed in detail later in this chapter, but it can be stated with confidence that no combinations of financial parameters have been found which portray EADCs' recommended investments to conserve industrial energy as being less than extremely profitable. The key ingredient for implementation appears to be the manufacturers' decisions to make the capital investments; once that point has been reached, none of the financial parameters makes the investment unattractive -- and that includes implementation cost escalations as high as 24% per year (while energy prices and savings increase at only 6% per year) and borrowing rates up to 15% per year.

In terms of public policy, whatever truly encourages manufacturers to invest in sound opportunities (such as EADCs' recommendations) to reduce energy consumption and cost is likely to be successful even though the costs of implementation and borrowing money increase dramatically. The key elements are the quality of the recommendations and the confidence to invest.

### Internal Rate of Return and Leverage Ratio

Manufacturers' financial returns from investment in cost-saving energy conservation opportunities (ECOs) continue to be exceptionally high, according to results from the 1988-89 period of the EADC program. 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 1988-89, manufacturers achieved internal rates of return (IRR) of 377 to 464% on their investments after taxes of 25% had been levied against their earnings; the federal government's IRR was 59 to 62% at the same tax rate. Similarly, manufacturers' leverage ratios ranged from 3.05 to 3.89, and those of the federal government, from 2.80 to 3.84. A detailed presentation of these and other financial data is given in Tables 13 and 14.

These highly favorable results were calculated according to standard financial methods, which specify IRR as 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:

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

in which CF = cash flow

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

$i$  = IRR

A similar net present value method was used to calculate leverage ratios, which some sources designate as profitability indices. For the same series of annual cash flows based upon actual implementation, a rate (10 or 15% in this report) is assumed in order to discount these future cash flows to the initial time period of the investment. The leverage ratio is the ratio of the sum of

TABLE 13  
EFFECTS OF BORROWING RATES UPON RETURNS FROM INVESTMENTS IN ENERGY CONSERVATION

1988-89 EADC Program

Leverage Ratio at 25% Tax Rate*	B o r r o w i n g     R a t e s					
	15%		12%		9%	
	Federal Government	Manufacturers	Federal Government	Manufacturers	Federal Government	Manufacturers
10% Discount	3.67	3.75	3.74	3.81	3.84	3.89
15% Discount	2.80	3.05	2.86	3.10	2.95	3.17
IRR at 25% Tax Rate	58.6	377	59.9	417	61.6	464

\* These numbers are based on the assumption that costs of energy and of implementation are growing at 6% per year. Leverage ratio is for five-year cash flows discounted at the stated per cent to the first-year time period and compared to the program investment by the federal government and the capital investment by the manufacturers.

TABLE 14

## EFFECTS OF GROWTH IN ENERGY AND IMPLEMENTATION COSTS UPON RETURNS FROM INVESTMENTS IN ENERGY CONSERVATION

1988-89 EADC Program

Growth Rates		Borrowing Rate	Returns to Federal Government*		Returns to Manufacturers*	
Energy Costs	Implementation Costs		LR <sub>10</sub>	LR <sub>15</sub>	LR <sub>10</sub>	LR <sub>15</sub>
6	6	9	3.84	2.95	3.89	3.17
6	12	9	3.75	2.87	3.81	3.11
6	6	12	3.74	2.86	3.81	3.10
6	12	12	3.67	2.80	3.75	3.05
6	24	15	3.39	2.56	3.52	2.86
				IRR		IRR
				61.6		464
				60.5		455
				59.9		417
				58.9		408
				54.8		348

\*These are after-tax returns for a tax rate of 25% assumed to be levied against manufacturers' cost savings.

LR<sub>10</sub>, LR<sub>15</sub> = Leverage ratio for five-year cash flows discounted at the stated per cent (10 or 15) to the first-year time period and compared to the program investment by the federal government and the capital investment by the manufacturers.

IRR = Internal rate of return.

discounted future cash flows during five years to the sum of all the capital investments needed to implement the ECOs.

One simplified interpretation of the leverage ratio considers it to represent the number of (constant) dollars returned to the investors during five years after each investment for every dollar invested. For example,  $LR_{10} = 2.50$  implies that \$2.50 is returned in constant dollars to the investors during five years (discounted from future cash flows at 10% per year) for every dollar invested.

In this report, when the LR lies between 2.80 and 3.84, it means that the federal government will realize \$2.80 to \$3.84 for every federal dollar invested in the EADC program for 1988-89. The government will reap this return from taxes levied at a 25% rate upon manufacturers' incremental earnings (cost savings). The exact value depends upon the manufacturers' cost of borrowing money and the rate of inflation during the life of the loans.

All of these financial analyses were carried out under the following conditions:

- Implementation costs are capitalized by the manufacturers and the funds are borrowed at one of three time periods: immediately or after one year or after two years following the energy audit.
- 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. Capital investments are depreciated linearly to a value of zero within five years.
- 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.
- All rates of return and other measures of profitability are calculated after taxes (rate specified).

#### Parameters with Effects on Profitability

Two sets of parameters were examined for their effects upon the profitability of investments in energy conservation by manufacturers and the federal government.

The first of these is the interest rate which manufacturers pay to borrow the funds to implement the EADCs' recommendations (Table 13). Comparatively small negative effects were the result of raising interest rates from 9 to 15%. For example, the federal government's leverage ratio (Table 13,  $LR_{10}$ ) decreased from 3.84 to 3.67 as a result of raising the interest rate paid by manufacturers from 9 to 15%. Similarly, the manufacturers'  $LR_{10}$  went from 3.89 to 3.75 for the same shift of interest rates. However, a manufacturer who recovers \$3.75 after five years for every dollar invested will not have many complaints about a shift in borrowing rate from 9 to 15%.

The second set of parameters examined is the growth rate of energy costs and of implementation costs. Whether these growth rates are 6% or 12% per year, the financial returns to the federal government and the manufacturers are extremely attractive (Table 14) even though energy costs (and cost savings) were kept at 6% per year. Previously, EADC results showed that allowing energy costs to rise at the same rate as implementation costs improved the profitability of investments in industrial energy conservation.

As a severe test of the profitability of manufacturers' investing in energy conservation opportunities identified by the EADCs, financial returns were calculated with assumptions that implementation costs escalated at 24% per year, that energy costs rose at 6% per year, and that the borrowing rate for capital funds was 15% per year.

Table 14 shows that, even under these stringent conditions, manufacturers would realize an IRR of 348% and a leverage ratio of 3.52 at a 10% discount rate. Similarly, the federal government's IRR was 54.8% and its leverage ratio was 3.39.

All of these results suggest that the large IRR values are very auspicious but are not sufficient to be reliable investment criteria. Leverage ratio (or profitability index) appears to be far more sensitive and understandable.

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 demonstrate one means 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.

APPENDIX

## EADCs RESPONSIBLE FOR ENERGY AUDIT RESULTS IN THIS REPORT

---

### Colorado State University

C. Byron Winn, Director  
John R. Bleem

### University of Dayton

Henry N. Chuang, Director  
Norman L. Hecht

### Georgia Institute of Technology

P. Alan Pashkevich, Director  
William A. Meffert  
Douglas M. Moore

### University of Kansas

Peter W. TenPas, Director  
Donald Gyorog

### Louisiana Tech University\*

Norman F. Marsolan, Director  
Robert T. Havard  
Bruce G. Wilson

### University of Massachusetts

Lawrence L. Ambs, Director  
James F. Manwell  
Barry Simon

### North Carolina A&T State University\*\*

Arup K. Mallik, Director  
Harmohindar Singh

### Oklahoma State University

Carl B. Estes, Director  
Wayne C. Turner

### Oregon State University

George M. Wheeler, Director  
Dwight J. Bushnell

### Rutgers University

Michael R. Muller, Director  
David G. Briggs

### University of Tennessee

Richard J. Jendrucko, Director  
Phylissa S. Miller

### Texas A&M University

Warren M. Heffington, Director  
W.D. Turner  
Melvin G. Glass

### University of Wisconsin (Milwaukee)

Umesh Saxena, Director  
Arun Garg

\*Performed three energy audits in 1988-89

\*\*Performed 7 energy audits in 1988-89

## ITEM STAFF

ITEM professionals responsible for program management, the results reported and interpreted, and the conclusions expressed are:

F. William Kirsch, Director of ITEM

Henry C. Beck, Consulting Engineer

Laura M. Deevy, Assistant Manager, Technology Assessment and Evaluation

Marilyn DeLoach, Data Analyst

Christopher J. Law, Staff Engineer

Gwen P. Looby, Assistant Manager, Manufacturing Technology Applications

J. Clifford Maginn, Manager, Information Systems and Database Development

Kirsten M. Reeder, Project Engineer

Production, design, and typography were under the direction of Mariela G.

Andrews; editing and revising the report were carried out by Gwen P. Looby. Their efforts are sincerely appreciated and acknowledged.

\* \* \*

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