Table of Contents

List of Tables

List of Figures

List of Figures (continued)

I. Introduction

Energy Analysis and Diagnostic Centers (EADCs) conducted 585 industrial energy audits for small to medium sized manufacturers in Fiscal Year 1993 through funding provided by the Office of Industrial Technologies (OIT) of the U.S. Department of Energy. EADC audits consist of faculty led teams from accredited engineering universities performing a one day visit to a manufacturing plant following an extensive data gathering function. Manufacturers qualified for audits if employment was under 500 persons at the site, sales were less than $75 million, annual energy bills totaled under $1.75 million, and no professional staff were on hand to do the energy analyses. The resulting report produced for the manufacturer includes information about the plant's energy use, processes and other information. In addition, several assessment recommendations are written up with sufficient detail to provide anticipated energy cost savings, as well as implementation costs and simple paybacks. Within one year the staff of each EADC conducts a survey of the audited manufacturers to determine which recommended conservation measures were adopted.

Established in 1976 as a result of oil shortages and the increased awareness of the importance of energy conservation, the EADC Program has grown from the original four schools to 18 in Fiscal Year 1992. In FY93, operations increased from 18 to 22 Centers with the acquisition of the University of Arkansas at Little Rock, the University of Maine, North Carolina State University, San Francisco State University, and West Virginia University and the departure of Rutgers, The State University of New Jersey to field management duties. First year centers perform fifteen audits while established universities double that workload.

This net growth in participating universities provided the opportunity for significant changes in the Program's operational makeup. Management duties were divided into two regions beginning in Fiscal Year 1993 - Rutgers University assumed control for the Eastern Region while the University City Science Center continued management of those EADCs in the West.

This report contains sections on general program statistics, assessment recommendations with related implementation results, and field management reports by region. Program statistics analysis, and graphics were generated by the database managers at Rutgers University. Section III., Standard Financial Calculations, was produced by the University City Science Center. Field management reports were contributed by each respective management organization.

II. Program Statistics

A. General

In FY93, 585 energy audits were performed bringing the program total to 5,037 audits from inception. Since only fifteen audits were performed in FY81, the data shown in this report dates back to 1982, the second year for which data was available . The number of audits in this data set is 4,361. Unless otherwise noted, figures are for fiscal year 1993. Table 1 shows the number of audits performed by fiscal year.

Fiscal Year	No. of Audits Performed
82	253
83	211
84	248
85	368
86	298
87	324
88	388
89	340
90	360
91	455
92	531
93	585
Total	4,361

Table 1. Audits Performed by Fiscal Year

The total amount of recommended energy conservation measures in FY93 was approximately 2,400,000 Million British Thermal Units (MMBTU) with a dollar value of over $27 million. The oil consumption that would be avoided was 417,000 barrels, measured in barrels of oil equivalent (BOE), and the carbon avoided was 56,000 metric tons, measured in carbon equivalent (CE).[1] Non-energy recommendations, such as administrative cost savings and waste reduction savings, amounted to $2.6 million. The resultant total recommended savings were $29.6 million.

[1] Carbon avoidance is a generally accepted method of quantifying the production of Carbon Dioxide (CO_2), a known "greenhouse" gas, by the combustion of fossil fuels.

The FY93 implementation survey conducted by the centers revealed that the amount of energy saved by manufacturers through implementation of recommendations contained in reports resulting from audits, as reported by the clients, was 1,150,000 MMBTU, with a dollar value of almost $9.4 million. This equates to 198,000 barrels of oil and 26,600 metric tons of carbon avoided. The implemented non-energy measures resulted in a savings of $1.6 million. This brings the total implemented savings in FY93 to almost $11 million.

B. Client Profile

i. Geographic Distribution of Audits

Each center operates in a geographic area of approximately 150 miles from the site of the university. The distribution of audits in FY93 is shown in the following table by state.

STATE	No. of Audits Performed in Each State	EADC/IAC	No. of Audits Performed by Each EADC/IAC	Percent of Audits Performed in Each State
Alabama	1	Georgia Institute of Technology	1	100%
Arkansas	16	U. of Arkansas - Little Rock	13	81%
		Oklahoma State University	3	19%
Arizona	30	Arizona State University	30	100%
California	45	San Diego State University	30	67%
		San Francisco State University	15	33%
Colorado	30	Colorado State University	30	100%
Connecticut	8	University of Massachusetts	8	100%
Florida	29	University of Florida	29	100%
Georgia	23	Georgia Institute of Technology	22	96%
		University of Florida	1	4%
Iowa	23	Iowa State University	23	100%

Table 2. Geographic Distribution of Audits by State

STATE	No. of Audits Performed in Each State	EADC/IAC	No. of Audits Performed by EADC/IAC	Percent of Audits in Each State
Illinois	35	Iowa State University	2	6%
		U. of Missouri - Rolla	3	9%
		University of Notre Dame	5	14%
		U. of Wisconsin - Milwaukee	25	71%
Indiana	16	University of Notre Dame	15	94%
		University of Dayton	1	6%
Kansas	18	University of Kansas	15	83%
		Oklahoma State University	3	17%
Kentucky	9	University of Tennessee	8	89%
		University of Dayton	1	11%
Louisiana	2	U. of Arkansas - Little Rock	2	100%
Massachusetts	17	University of Massachusetts	17	100%
Maryland	1	West Virginia University	1	100%
Maine	15	University of Maine	15	100%
Michigan	8	University of Notre Dame	8	100%
Minnesota	3	Iowa State University	3	100%
Missouri	36	University of Kansas	9	25%
		U. of Missouri - Rolla	27	75%
North Carolina	14	North Carolina State U.	14	100%
Nebraska	8	Iowa State University	2	25%
		University of Kansas	6	75%
New Hampshire	2	University of Massachusetts	2	100%
New York	6	Hofstra University	6	100%

Table 2. Geographic Distribution of Audits by State (continued)

STATE	No. of Audits Performed in Each State	EADC/IAC	No. of Audits Performed by EADC/IAC	Percent of Audits in Each State
Ohio	34	University of Notre Dame	2	6%
		University of Dayton	28	82%
		West Virginia University	4	12%
Oklahoma	24	Oklahoma State University	24	100%
Oregon	19	Oregon State University	19	100%
Pennsylvania	26	Hofstra University	24	92%
		West Virginia University	2	8%
Tennessee	15	University of Tennessee	15	100%
Texas	30	Texas A&M - College Station	30	100%
Virginia	8	North Carolina State U.	1	13%
		University of Tennessee	7	87%
Vermont	3	University of Massachusetts	3	100%
Washington	11	Oregon State University	11	100%
Wisconsin	5	U. of Wisconsin - Milwaukee	5	100%
West Virginia	8	West Virginia University	8	100%

Table 2. Geographic Distribution of Audits by State (continued)

The following table shows the state breakdown of audits performed by each center.

EADC/IAC	No. of Audits Performed by Each EADC/IAC	STATE	No. of Audits Performed in Each State	Percent Audits Performed by Each EADC/IAC in a State
Arizona State University	30	Arizona	30	100%
Colorado State University	30	Colorado	30	100%
Georgia Institute of Technology	30	Alabama	1	3%
		Georgia	22	73%
		South Carolina	7	24%
Hofstra University	30	New York	6	20%
		Pennsylvania	24	80%

Table 3. Geographic Distribution of Audits by Center

EADC/IAC	No. of Audits Performed by Each EADC/IAC	STATE	No. of Audits Performed in Each State	Percent Audits Performed by Each EADC/IAC in a State
Iowa State University	30	Iowa	23	76%
		Illinois	2	7%
		Minnesota	3	10%
		Nebraska	2	7%
North Carolina State U.	15	North Carolina	14	93%
		Virginia	1	7%
University of Notre Dame	30	Illinois	5	17%
		Indiana	15	50%
		Michigan	8	26%
		Ohio	2	7%
Oklahoma State University	30	Arkansas	3	10%
		Kansas	3	10%
		Oklahoma	24	80%
Oregon State University	30	Oregon	19	63%
		Washington	11	37%
San Diego State University	30	California	30	100%
San Francisco State University	15	California	15	100%
Texas A&M - College Station	30	Texas	30	100%
U. of Arkansas - Little Rock	15	Arkansas	13	87%
		Louisiana	2	13%
University of Dayton	30	Indiana	1	3%
		Kentucky	1	3%
		Ohio	28	94%
University of Florida	30	Florida	29	97%
		Georgia	1	3%

Table 3. Geographic Distribution of Audits by Center (continued)

EADC/IAC	No. of Audits Performed by Each EADC/IAC	STATE	No. of Audits Performed in Each State	Percent Audits Performed by Each EADC/IAC in a State
University of Kansas	30	Kansas	15	50%
		Missouri	9	30%
		Nebraska	6	20%
University of Maine	15	Maine	15	100%
University of Massachusetts	30	Connecticut	8	27%
		Massachusetts	17	57%
		New Hampshire	2	6%
		Vermont	3	10%
U. of Missouri - Rolla	30	Illinois	3	10%
		Missouri	27	90%
University of Tennessee	30	Kentucky	8	27%
		Tennessee	15	50%
		Virginia	7	23%
U. of Wisconsin - Milwaukee	30	Illinois	25	83%
		Wisconsin	5	17%
West Virginia University	15	Maryland	1	7%
		Ohio	4	27%
		Pennsylvania	2	13%
		West Virginia	8	53%

Table 3. Geographic Distribution by Center (continued)

ii. SIC Code

The EADC program serves manufacturers with a two digit Standard Industrial Classification (SIC) from 20 to 39 inclusive (Table 4). Figure 1 shows the number of audits performed in each classification. Note that no audits were performed in SIC 21 (Tobacco Products) in FY93.

SIC	Industry
20	Food and Kindred Products
21	Tobacco Products
22	Textile Mill Products
23	Apparel and Other Textile Products
24	Lumber and Wood Products
25	Furniture and Fixtures
26	Paper and Allied Products
27	Printing and Publishing
28	Chemical and Allied Products
29	Petroleum and Coal Products
30	Rubber and Misc. Plastic Products
31	Leather and Leather Products
32	Stone, Clay, and Glass Products
33	Primary Metals Industries
34	Fabricated Metal Products
35	Industrial Machinery and Equipment
36	Electronic and Other Electric Equipment
37	Transportation Equipment
38	Instruments and Other Related Products
39	Miscellaneous Manufacturing Industries

Table 4. Standard Industrial Classification

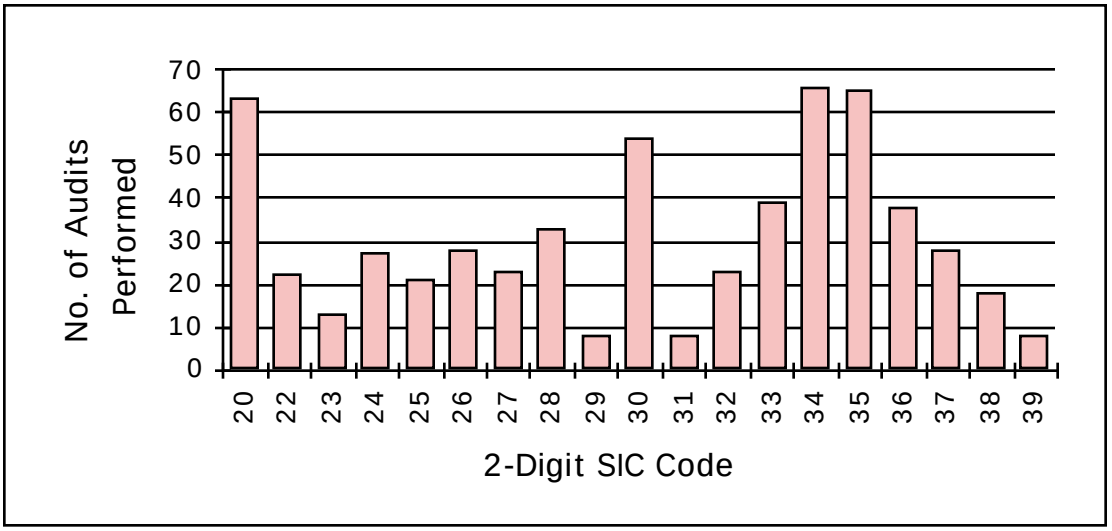

Figure 1. Plants Served in FY93 by Industry Type

iii. Company Size

Audits are available for small to medium size businesses which meet three of the following requirements:

- Gross sales below $75 million
- A maximum of 500 employees at the site
- Annual energy bills below $1.75 million
- Lack of professional staff to do energy analyses

In fiscal year 1993, the total energy usage of the clients was 45 million MMBTU, costing $ 292 million. There was an average of 172 employees at each location. The companies had a total sales of almost $16 billion. The average sales of the clients by fiscal year is shown in figure 2.

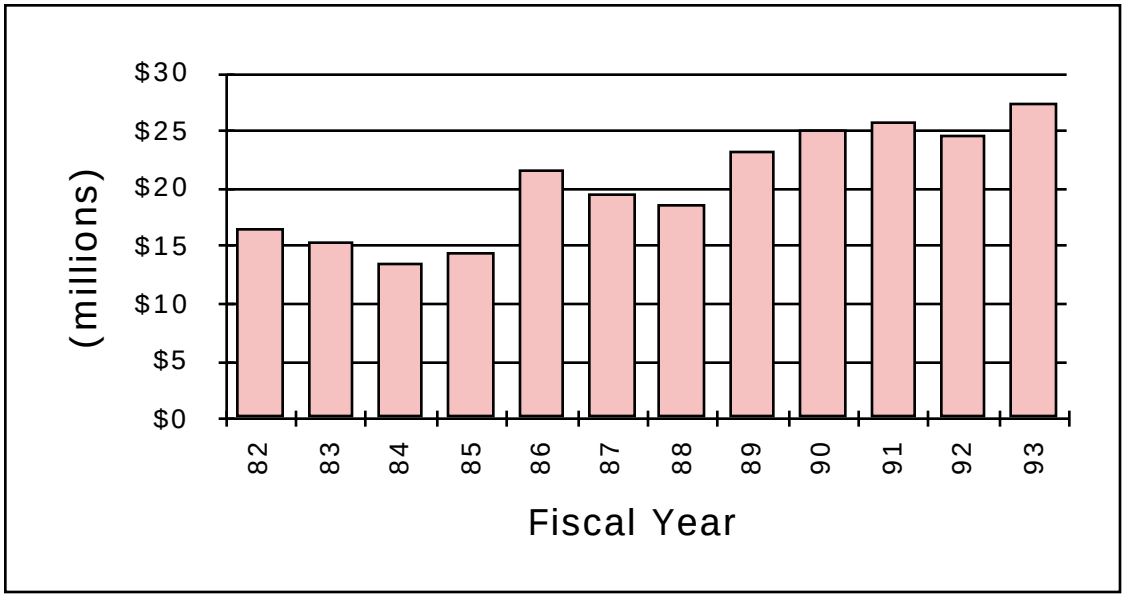

Figure 2. Average Client Sales by Fiscal Year

iv. Client Energy Consumption

The average plant served in FY93 had purchased energy use of 67,000 MMBTU with an associated cost of $483,000. Electricity cost the typical client $20.38 / MMBTU and natural gas cost $4.30 / MMBTU. The average sales of an audited plant was $27 million. The make-up of manufacturer fuel types is shown in figures 3 and 4.

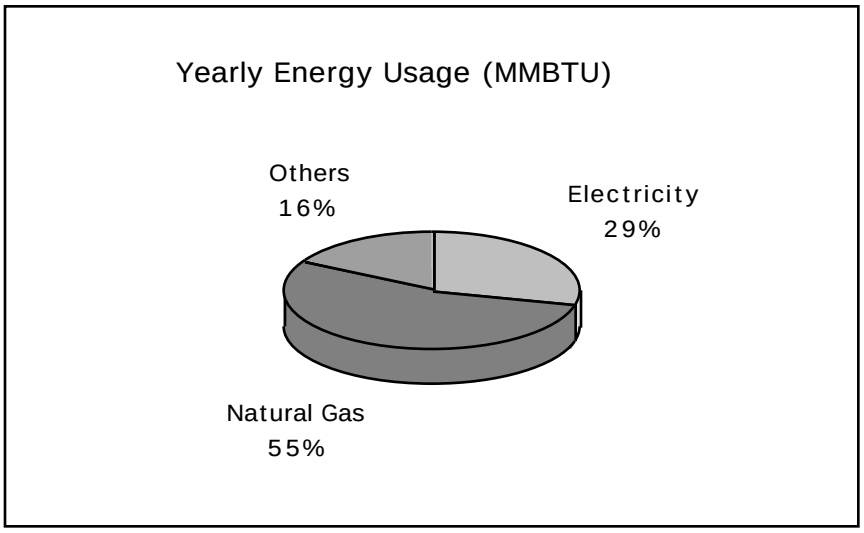

Figure 3. Energy Use of Plants Served in FY93 by Energy Type

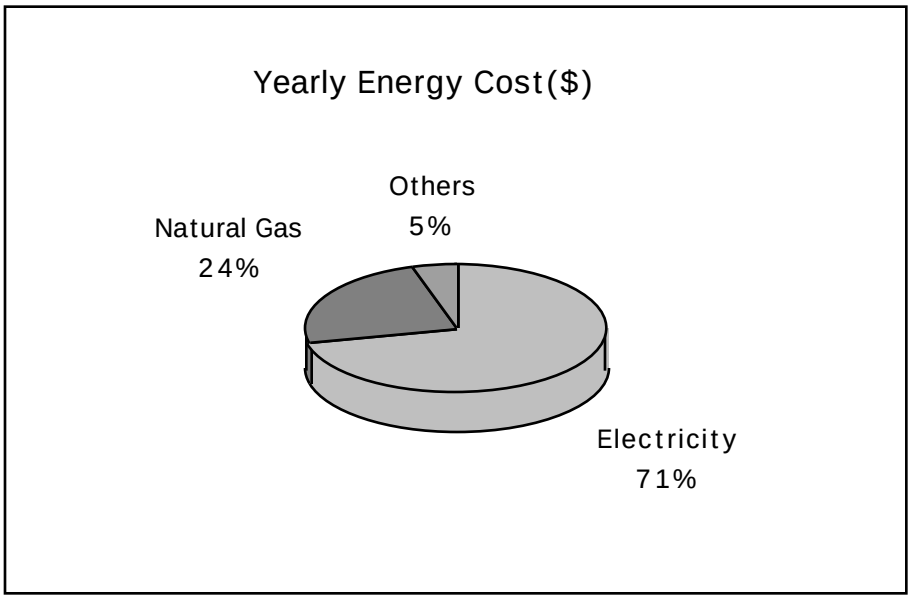

Figure 4. Energy Costs of Plants Served in FY93 by Energy Type

The average client energy usage and associated energy cost by fiscal year is shown in the following figures.

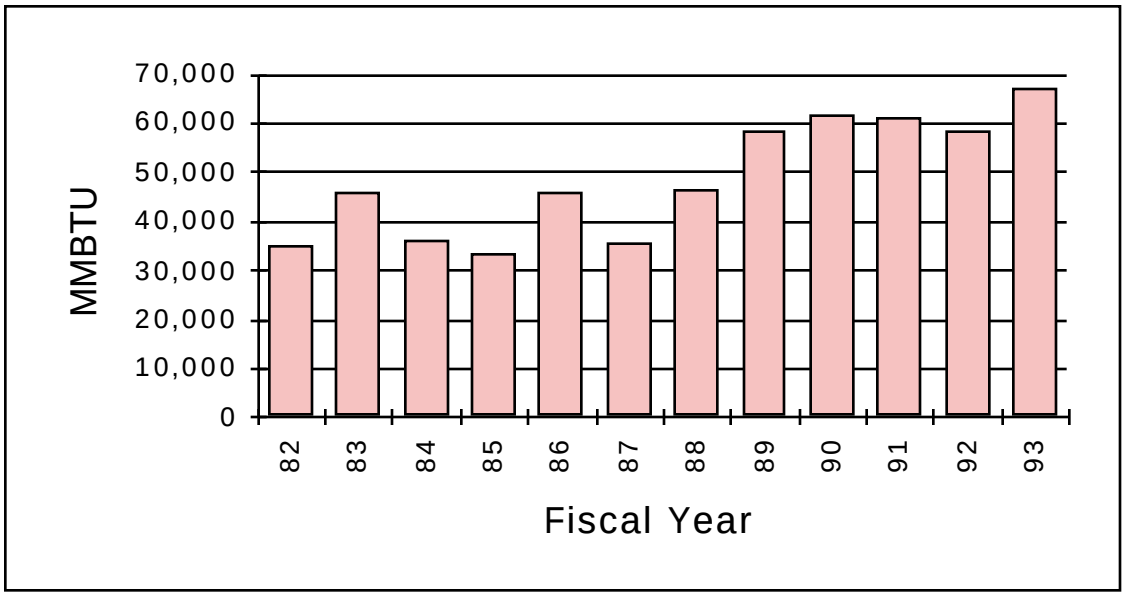

Figure 5. Average Client Energy Usage by Fiscal Year

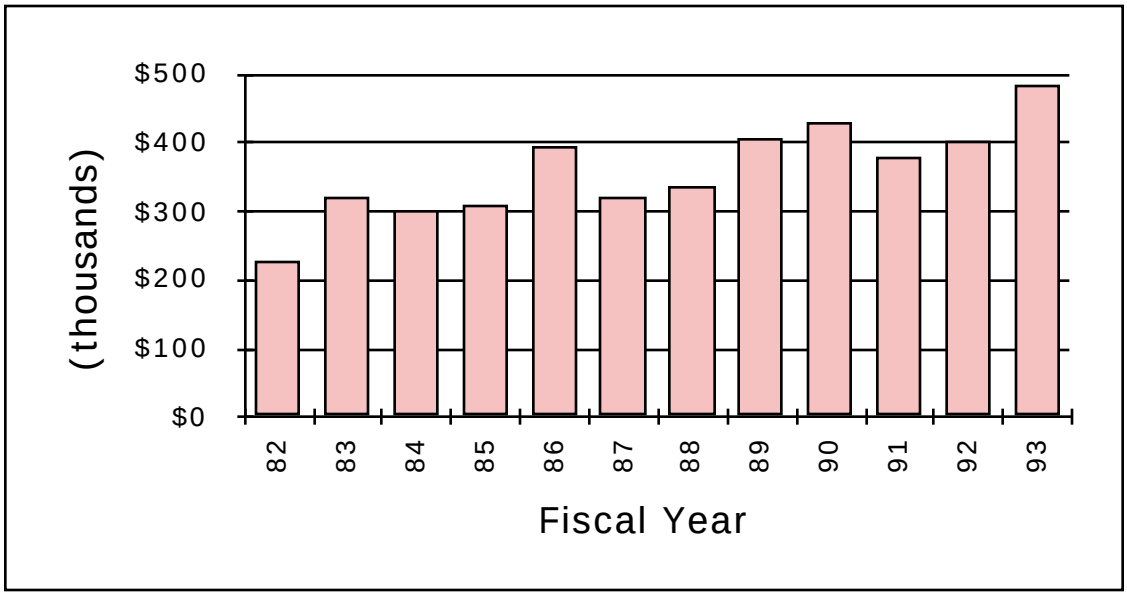

Figure 6. Average Client Energy Costs by Fiscal Year

C. Assessment Recommendations

i. General

Table 5 indicates the recommended energy saved in millions of BTUs, dollars, barrels of oil equivalent, and carbon equivalent, for fiscal year 1993 and previous years. Due to the anticipated growth of the program into Industrial Assessments in FY94, non-energy savings (water, waste, administrative savings, etc.) were recorded separately in the database beginning in FY93.

Fiscal Year	Recommended Energy Conserved (MMBTU)	Recommended Energy Saved ($)	Recommended Energy Conserved B.O.E.	Recommended Energy Conserved C.E. (mt)	Recommended Non-Energy Saved ($)
82	1,106,843	$6,699,741	190,016	25,600	n/a
83	1,520,973	$8,712,422	261,111	35,179	n/a
84	1,278,278	$8,979,598	219,447	29,566	n/a
85	2,186,558	$13,917,967	375,375	50,573	n/a
86	1,663,618	$13,640,445	285,600	38,478	n/a
87	1,101,577	$10,751,519	189,112	25,479	n/a
88	1,503,026	$13,603,630	258,030	34,764	n/a
89	1,780,449	$13,081,589	305,656	41,180	n/a
90	1,568,225	$14,028,351	269,223	36,272	n/a
91	1,290,537	$17,373,265	221,551	29,849	n/a
92	2,035,676	$21,804,001	349,472	47,084	n/a
93	2,429,267	$27,042,250	417,042	56,187	$2,596,381

Table 5. Recommended Energy Conservation by Fiscal Year

The figures 7 through 10 show average recommended energy conservation per audit by fiscal year.

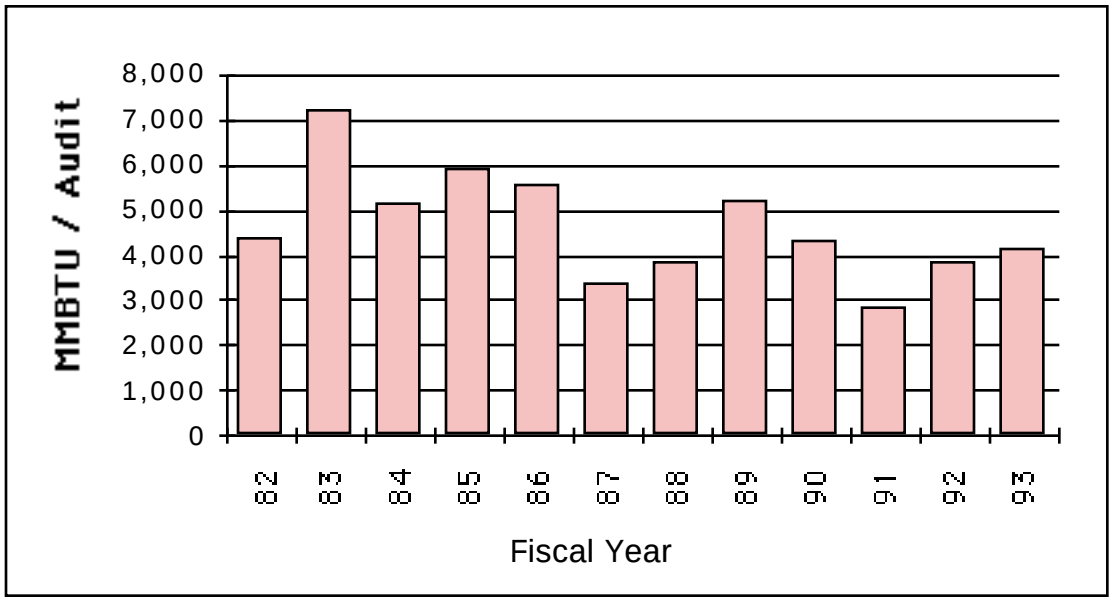

Figure 7. Average Recommended Energy Conserved Per Audit by Fiscal Year

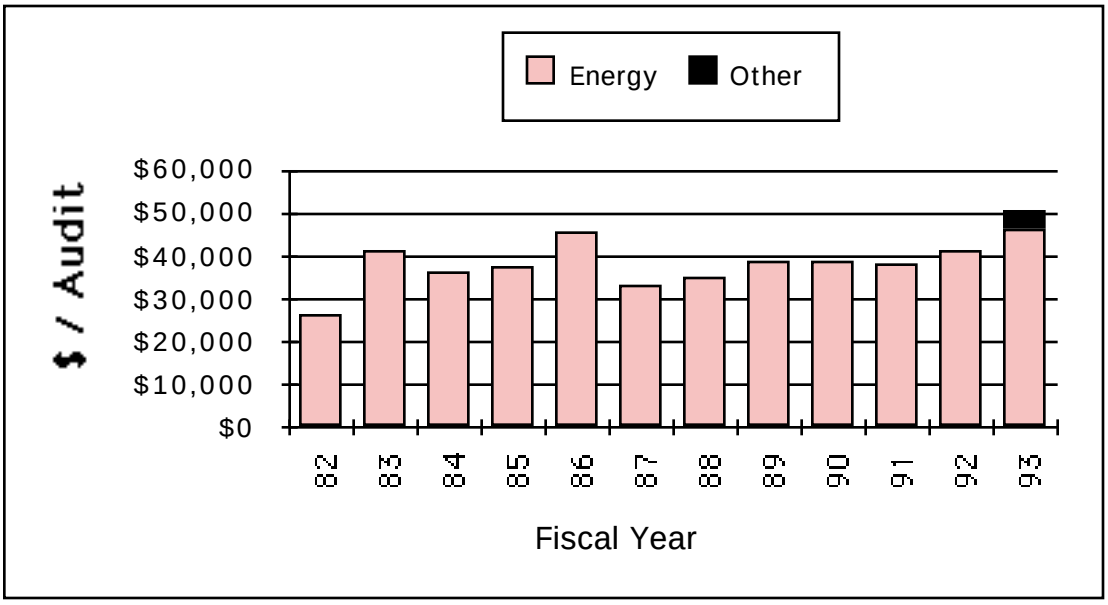

Figure 8. Average Recommended Cost Savings Per Audit by Fiscal Year

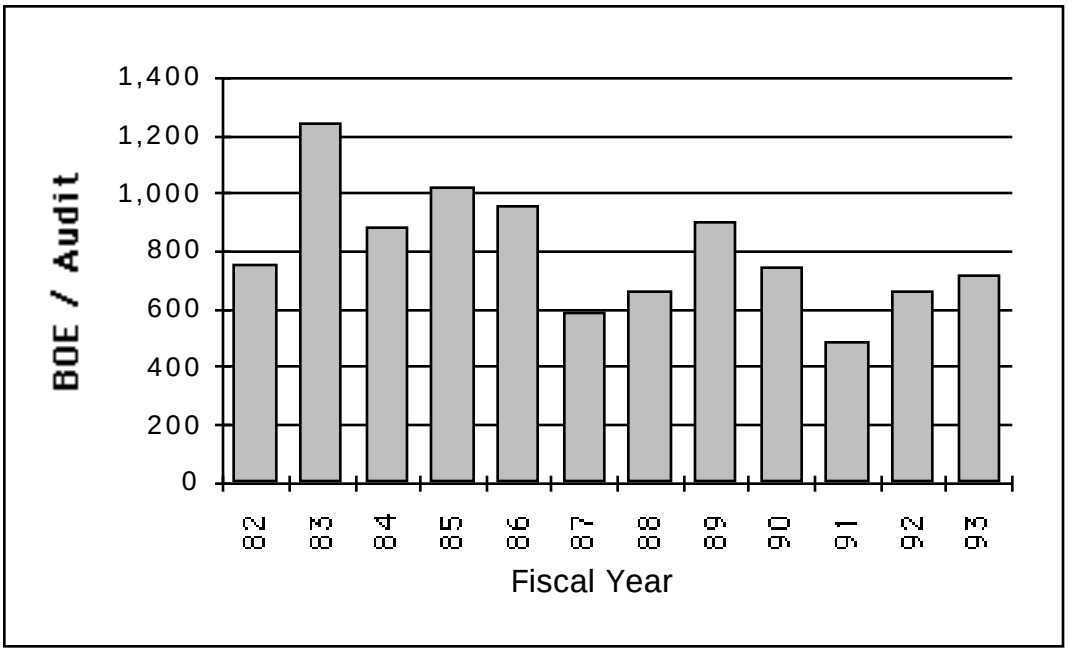

Figure 9. Average Recommended Barrels of Oil Avoided Per Audit by Fiscal Year

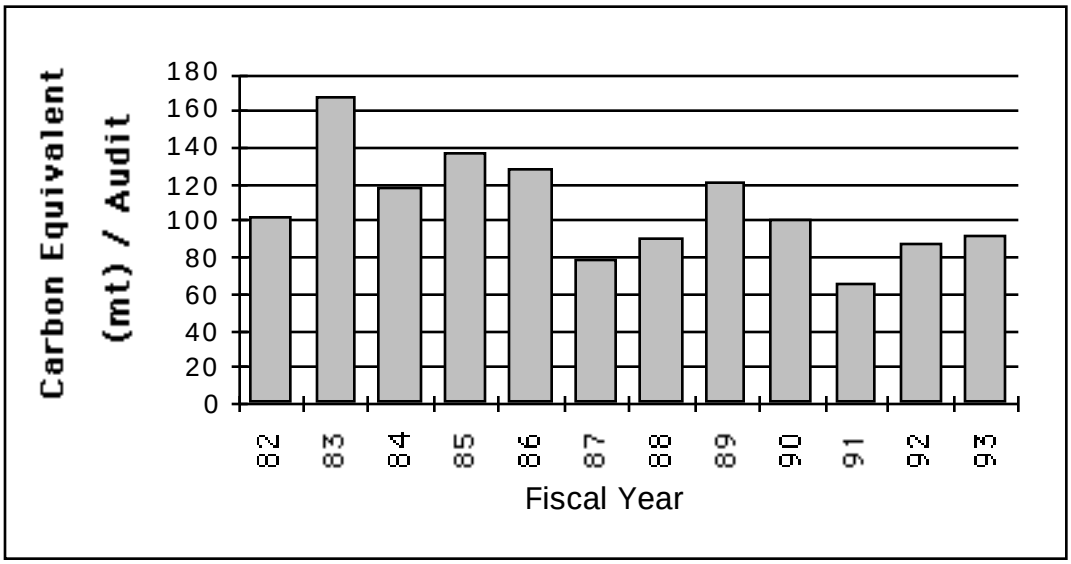

Figure 10. Average Recommended Carbon Avoided Per Audit by Fiscal Year

Figures 11 and 12 indicate energy conserved per audit on a three year average basis:

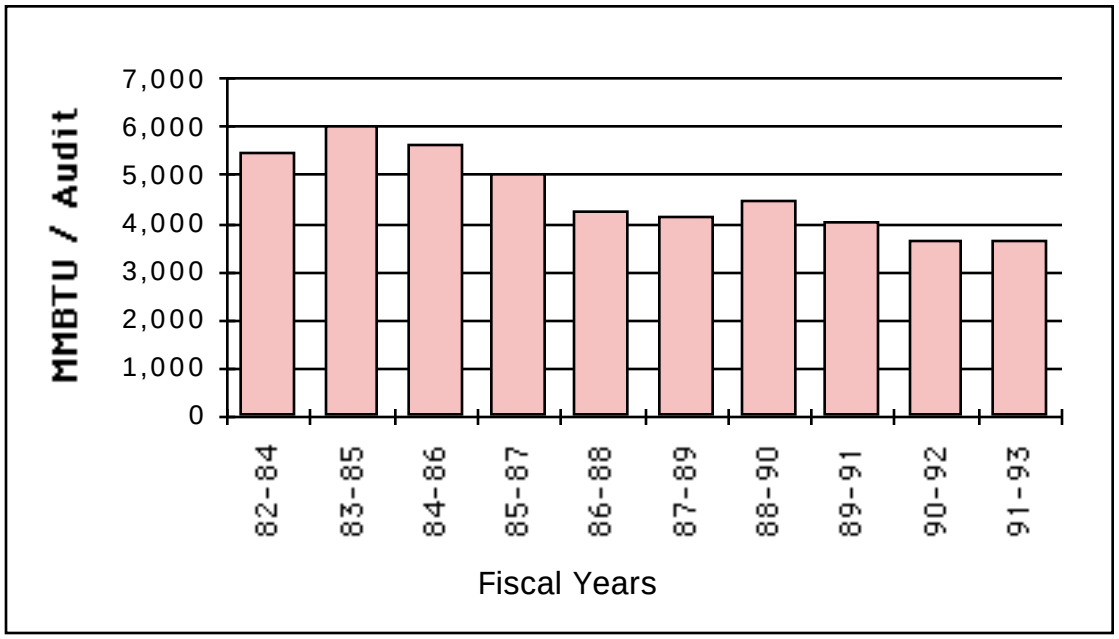

Figure 11. Recommended Energy Conserved Per Audit (3 Year Average)

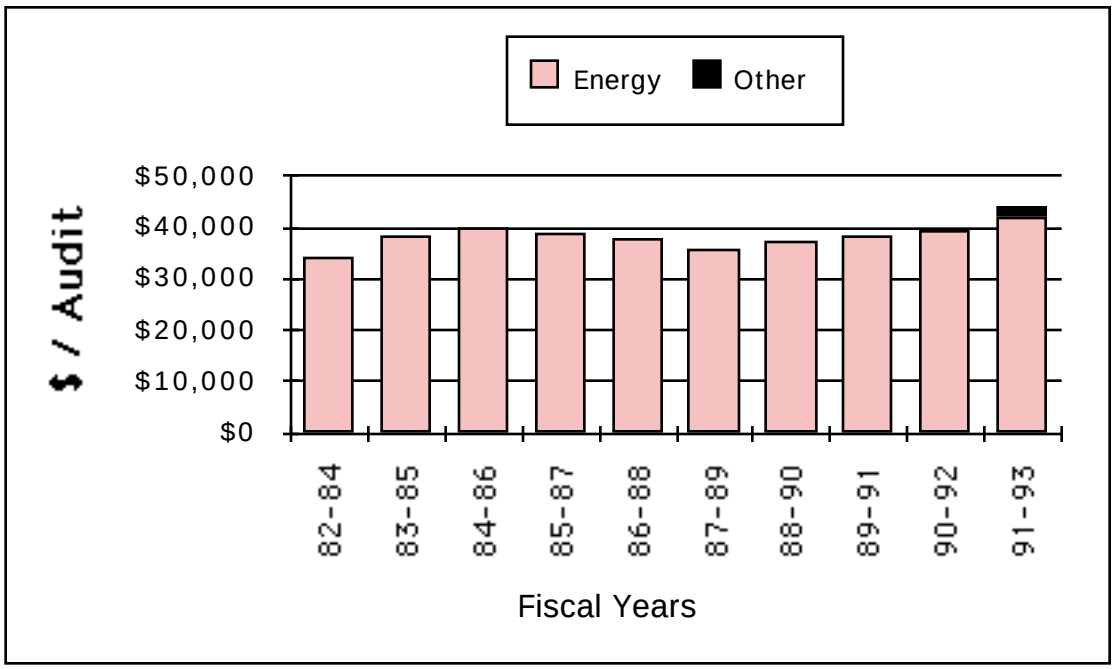

Figure 12. Recommended Cost Savings Per Audit (3 Year Average)

The three year average of recommended barrels of oil saved and carbon avoided is indicated in figures 13 and 14.

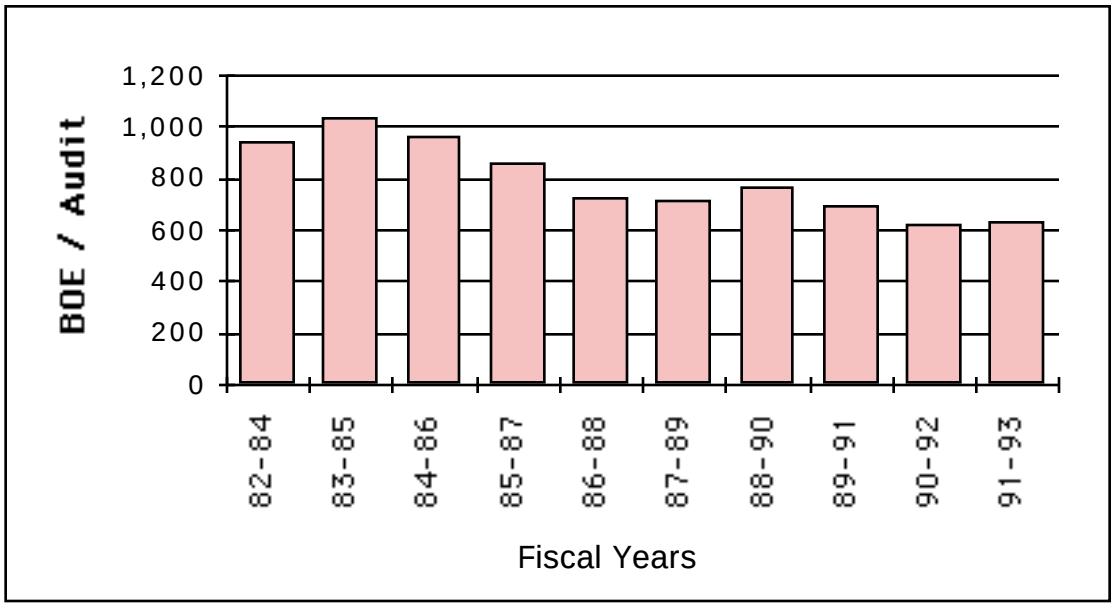

Figure 13. Barrels of Oil Avoided Per Audit (3 Year Average)

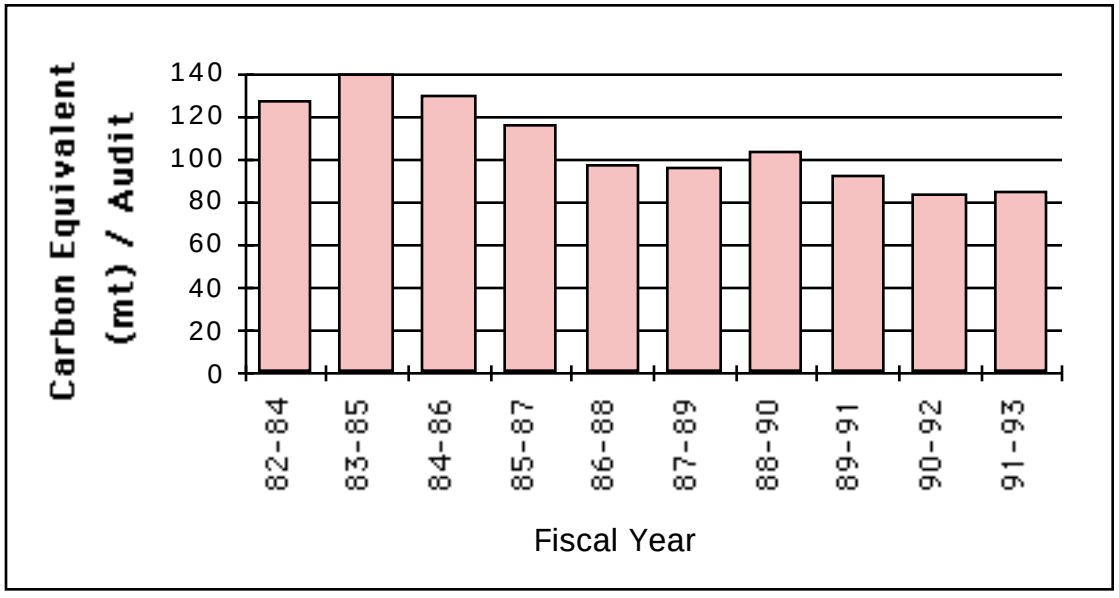

Figure 14. Carbon Avoided Per Audit (3 Year Average)

The cost of electricity and natural gas is averaged over a three year period, and shown in figures 15 and 16.

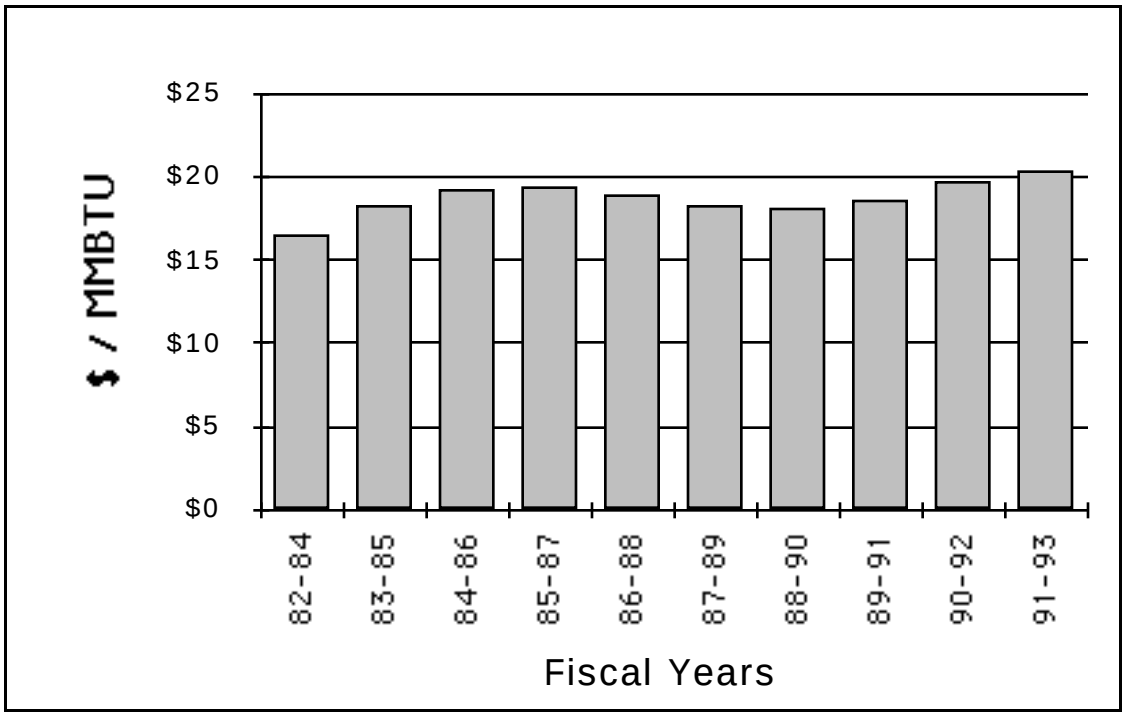

Figure 15. Electricity Cost (3 Year Average)

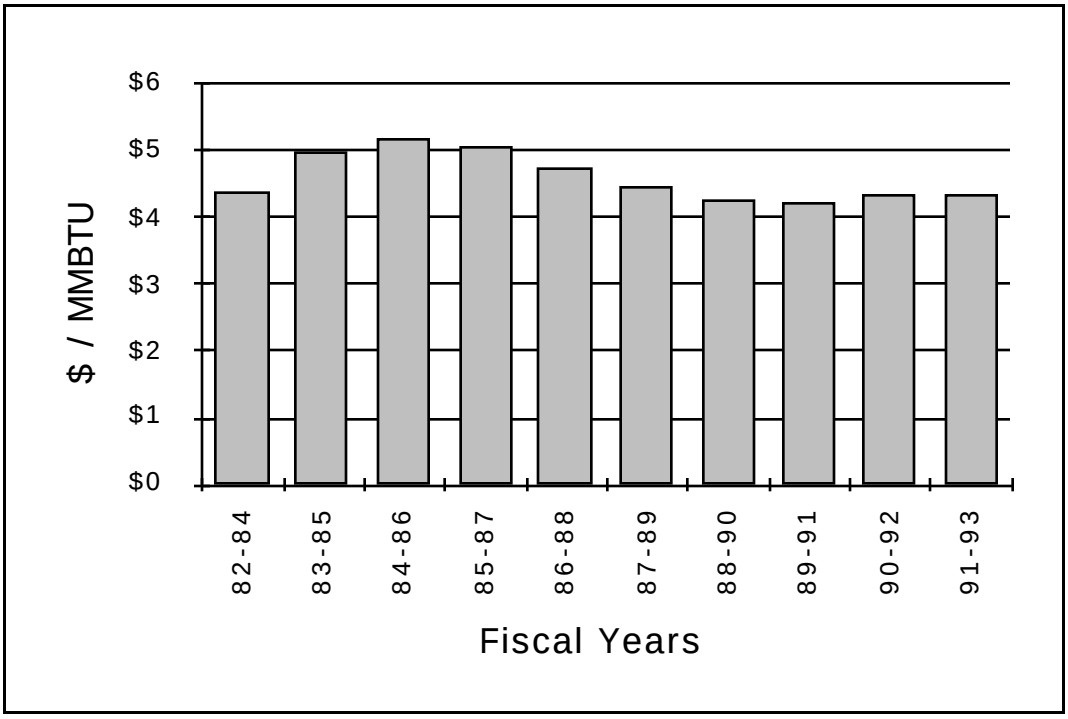

Figure 16. Natural Gas Cost (3 Year Average)

In some cases, immediate implementation of a measure is not recommended due to financial restrictions, time constraints, or other considerations. In order that these recommendations (called incremental) do not skew the database, these recommendations were flagged, starting in FY93. Figures 17 - 20 show the average first year energy conserved per audit.

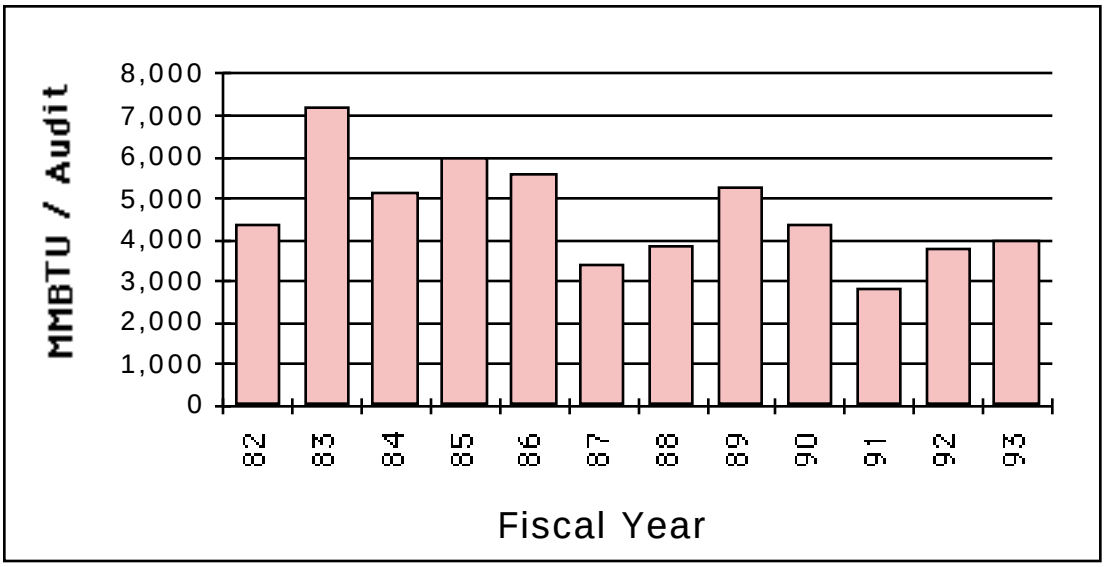

Figure 17. Average First Year Recommended Energy Conserved Per Audit by Fiscal Year

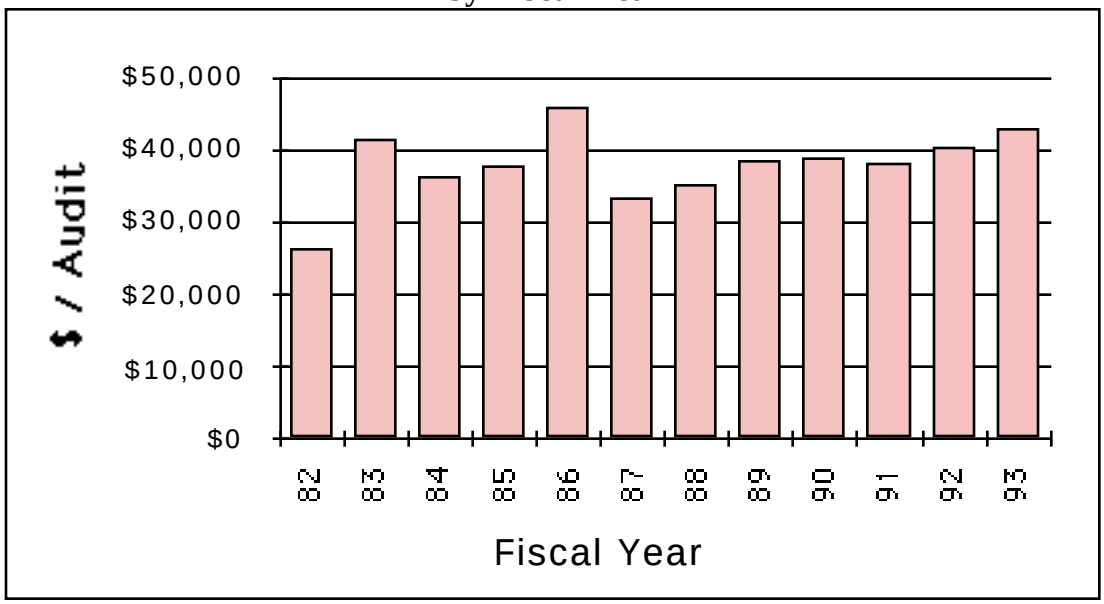

Figure 18. Average First Year Recommended Cost Savings Per Audit by Fiscal Year

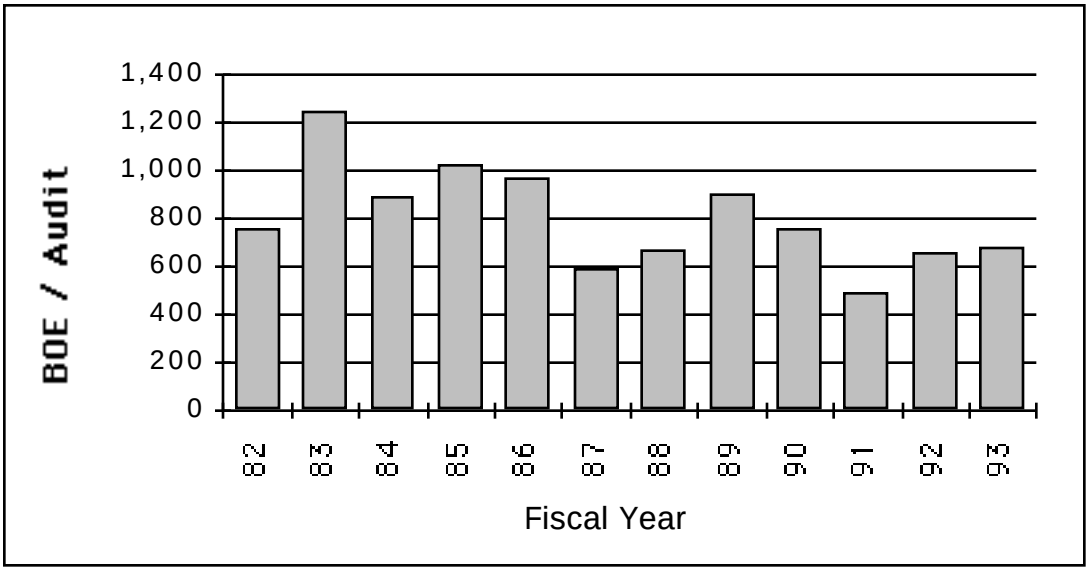

Figure 19. Average First Year Recommended Barrels of Oil Avoided Per Audit by Fiscal Year

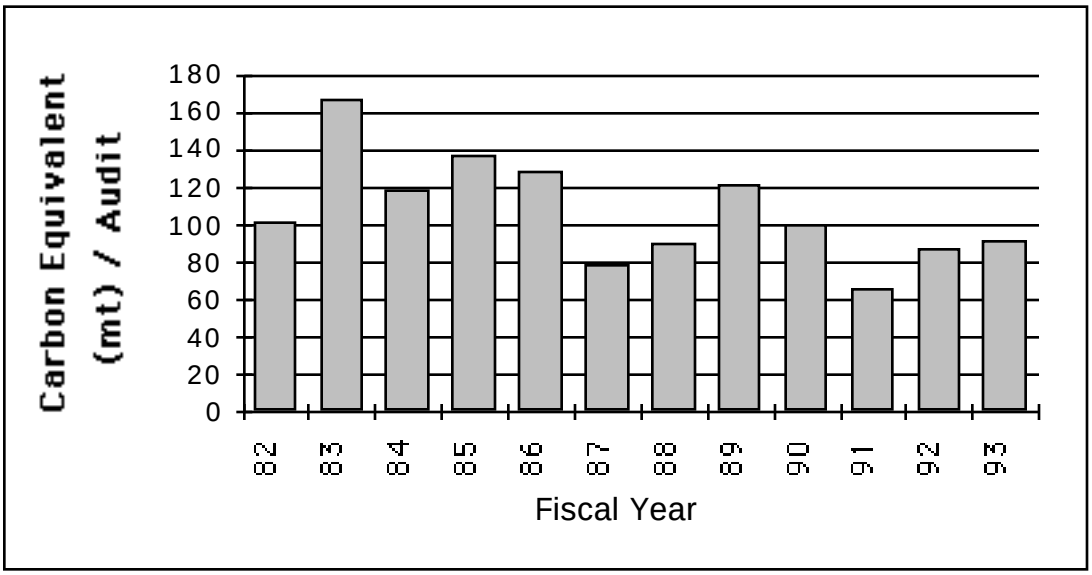

Figure 20. Average First Year Recommended Carbon Avoided Per Audit by Fiscal Year

ii. Recommended Conservation by Industry Type

Energy conservation recommended in fiscal year 1993 is shown in figures 21 through 24. The largest amount of recommended savings by a substantial margin both in BTUs and dollars was SIC 32 (Stone, Clay, and Glass Products), due to three large recommendations regarding furnaces, dryers, and co-generation. The lowest savings in energy was SIC 23 (Apparel and Other Textile Products), and in dollars was SIC 31 (Leather and Leather Products), however the margin was not substantially lower than some other industry types.

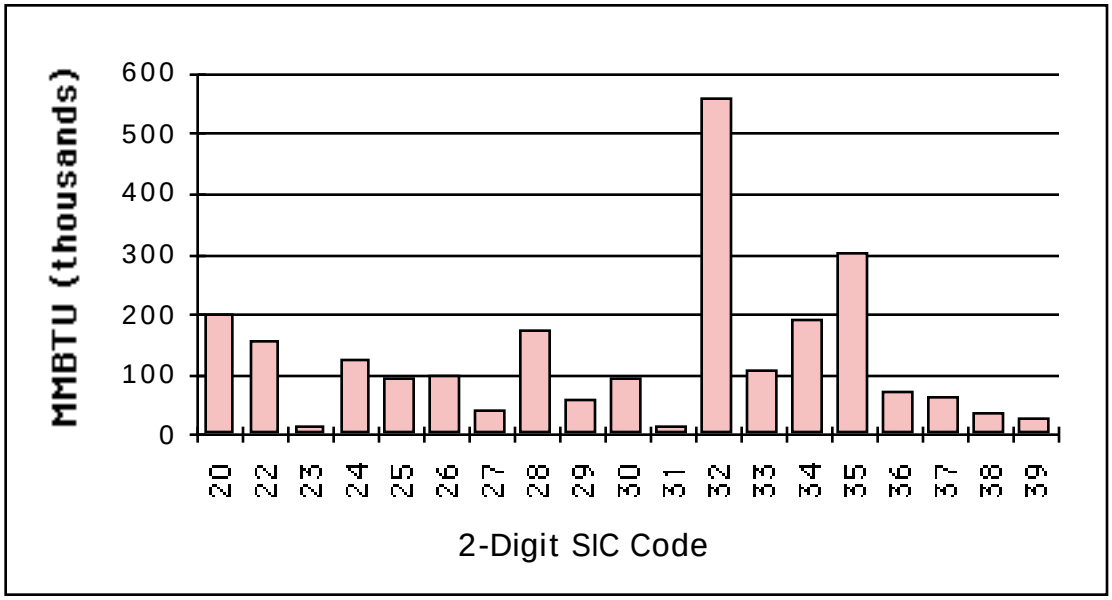

Figure 21. Recommended Energy Conserved by Industry Type

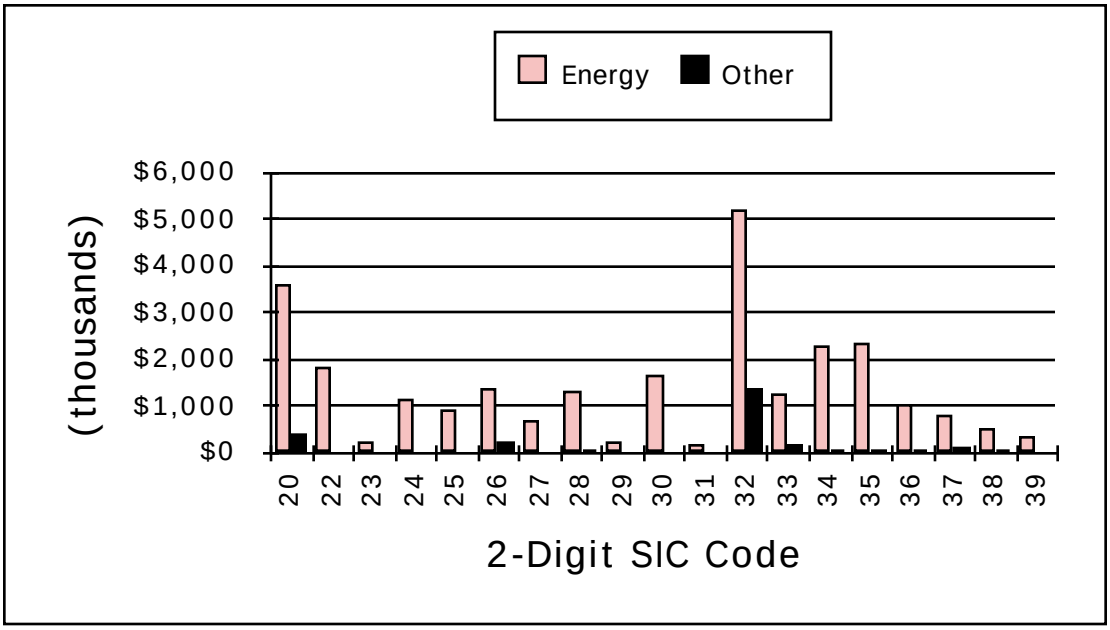

Figure 22. Recommended Cost Savings by Industry Type

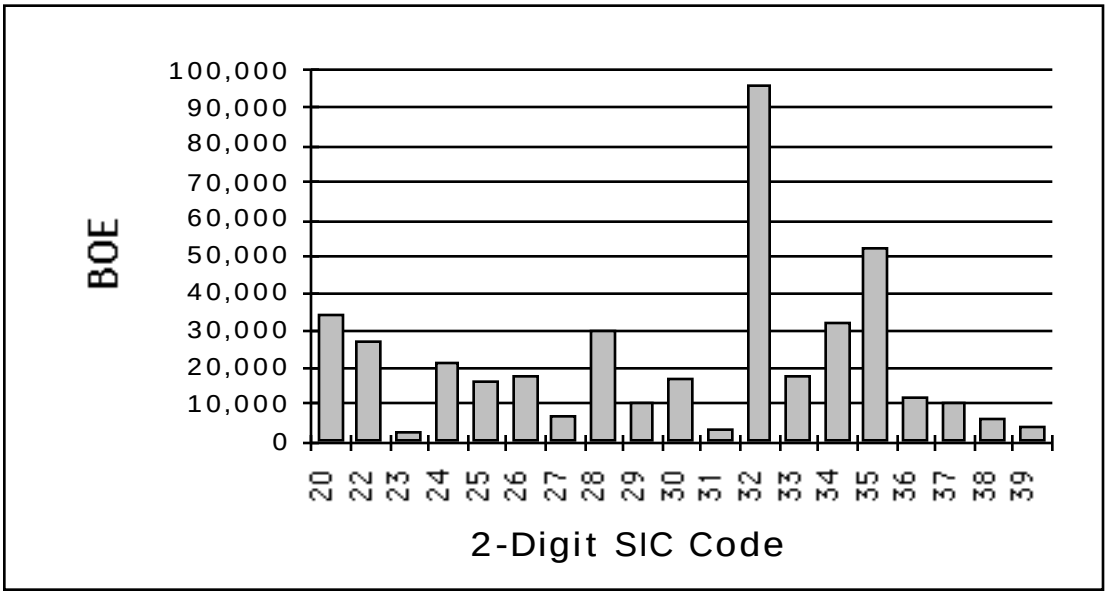

Figure 23. Recommended Barrels of Oil Avoided by Industry Type

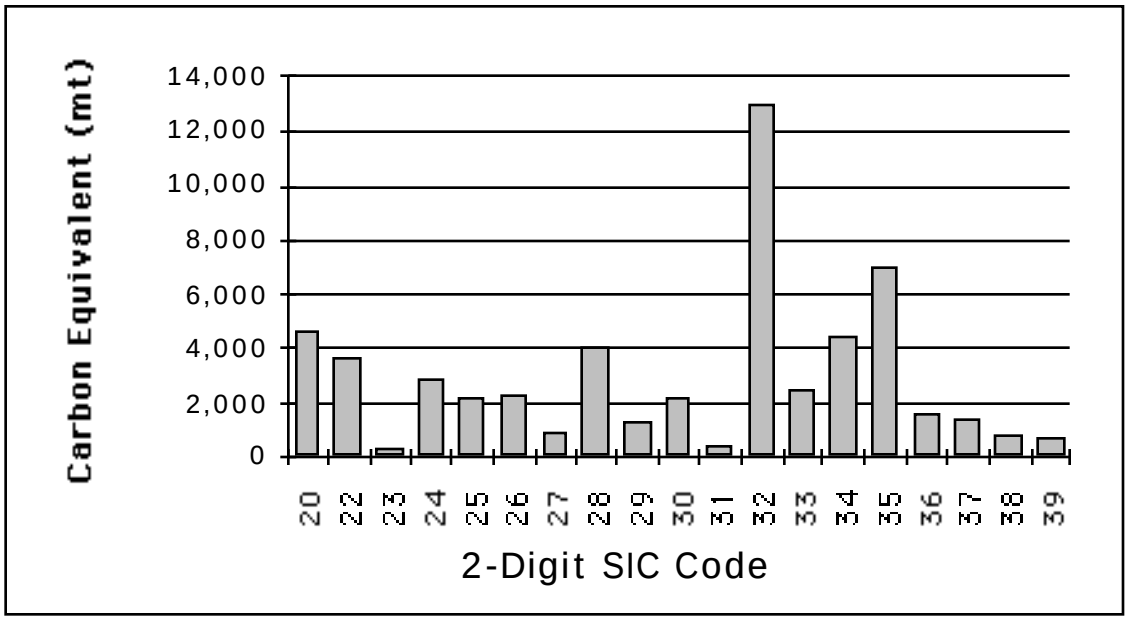

Figure 24. Recommended Carbon Avoided by Industry Type

iii. Recommended Conservation by Energy Type

Energy recommendations are broken into 12 different fuel types: Electricity, Natural Gas, Liquid Petroleum Gas, Fuel Oil (#1,#2, #4, #6), Coal, Wood, Paper, Other Gas, and a general category for "Other Energy". Again, in FY93, non-energy savings were separately tracked. The amount of energy savings recommended in FY93 was almost 2.5 million MMBTU, with a dollar amount of just over $27 Million. This data is shown in table 6, with the percentages by energy type in figures 25 and 26. For the sake of clarity, it should be pointed out that some recommendations, such as co-generation and fuel switching result in increased energy consumption (negative savings).

Energy Stream	Total Conserved (MMBTU)	Total Saved ($)
Electricity	1,166,771	22,502,529
Natural Gas	1,135,020	4,553,619
L. P. G.	13,018	86,740
Fuel Oil #2	-55,203	-480,952
Fuel Oil #4	1,518	5,858
Fuel Oil #6	48,167	105,624
Coal	348	2,501
Wood	83,538	80,533
Paper	1,338	186
Other Gas	1,844	4,620
Other Energy	32,908	180,992
Non-Energy	n/a	2,596,381
Total:	2,429,267	29,638,631

Table 6. Recommended Conservation and Cost Savings by Energy Type

Examination of the data shows that electricity and natural gas comprise the vast majority of energy and dollar savings.

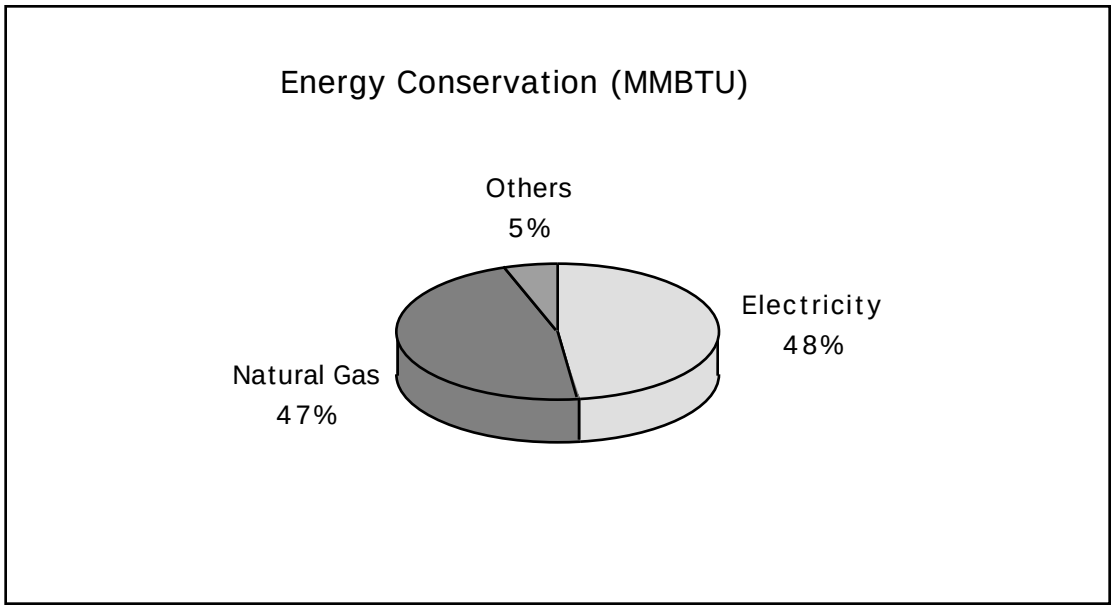

Figure 25. Composition of Recommended Energy Conserved by Energy Type

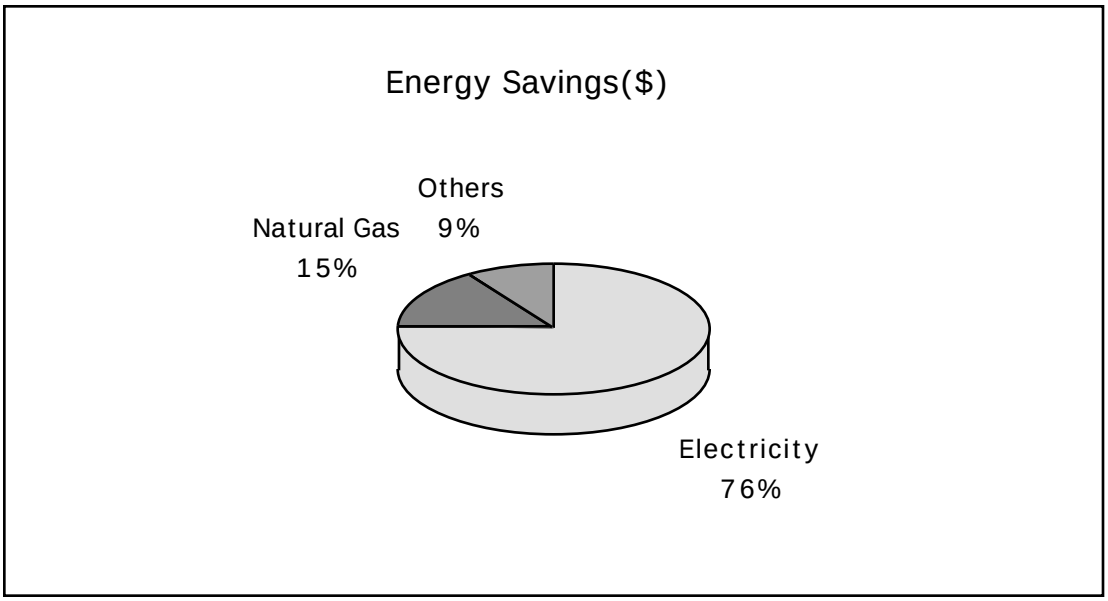

Figure 26. Composition of Recommended Cost Savings by Energy Type

iv. Recommended Conservation by Recommendation Type

Energy conservation recommendations are categorized by use of a detailed numbering system called the Assessment Recommendation Code (ARC). There are more than 300 coded recommendations broken into nine major 2-digit categories.

2.1 Combustion Systems
2.2 Thermal Systems
2.3 Electrical Power
2.4 Motor Systems
2.5 Industrial Design
2.6 Operations
2.7 Buildings and Grounds
2.8 Ancillary Costs
2.9 Alternate Energy Use

Figure 27 shows the frequency of the recommendations according to their 2-digit ARC number. One category, Alternate Energy Use was not recommended in FY93.

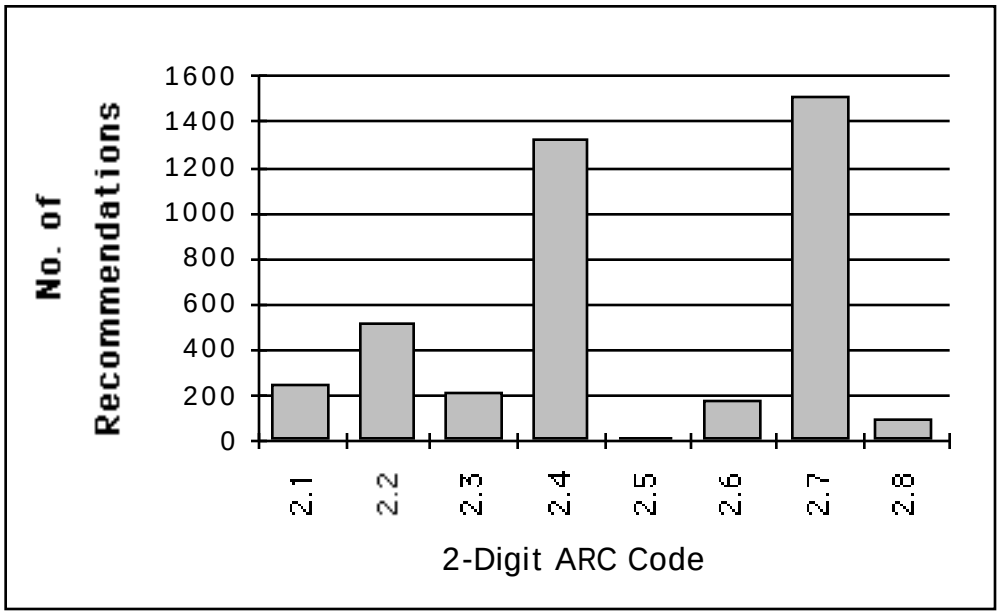

Figure 27. Number of Recommendations by Recommendation Type

D. Implementation Results

i. General

The EADC program has historically enjoyed a high rate of implementation of recommendations. The results of the 1993 program year, showed an implementation rate of over 49%. This rate represents the ratio of the number of recommendations that are adopted, as reported by the clients, to the number of recommendations made by the centers. The implementation rate as defined as the amount of energy (MMBTU) saved compared to the amount recommended was 47%, and as cost ($) saved to recommended was 34%. Table 7 and figures 28 through 31 are all related to implementation results.

Fiscal Year	Energy Conserved (MMBTU)	Implemented Energy Saved ($)	Energy Conserved B.O.E.	Energy Conserved C.E. (mt)	Implemented Non-Energy Saved ($)
82	354,008	$1,839,122	60,774	8,188	n/a
83	351,431	$1,923,834	60,332	8,128	n/a
84	655,636	$4,591,834	112,556	15,164	n/a
85	1,125,751	$7,007,105	193,262	26,038	n/a
86	904,243	$6,677,381	155,235	20,914	n/a
87	827,032	$5,866,384	141,980	19,129	n/a
88	1,047,382	$6,149,840	179,808	24,225	n/a
89	995,477	$7,509,294	170,897	23,025	n/a
90	859,421	$6,628,891	147,540	19,878	n/a
91	791,924	$8,464,119	135,953	18,317	n/a
92	1,174,662	$10,185,850	201,659	27,169	n/a
93	1,153,099	$9,363,870	197,957	26,670	$1,607,717

Table 7. Implemented Energy Conserved by Fiscal Year

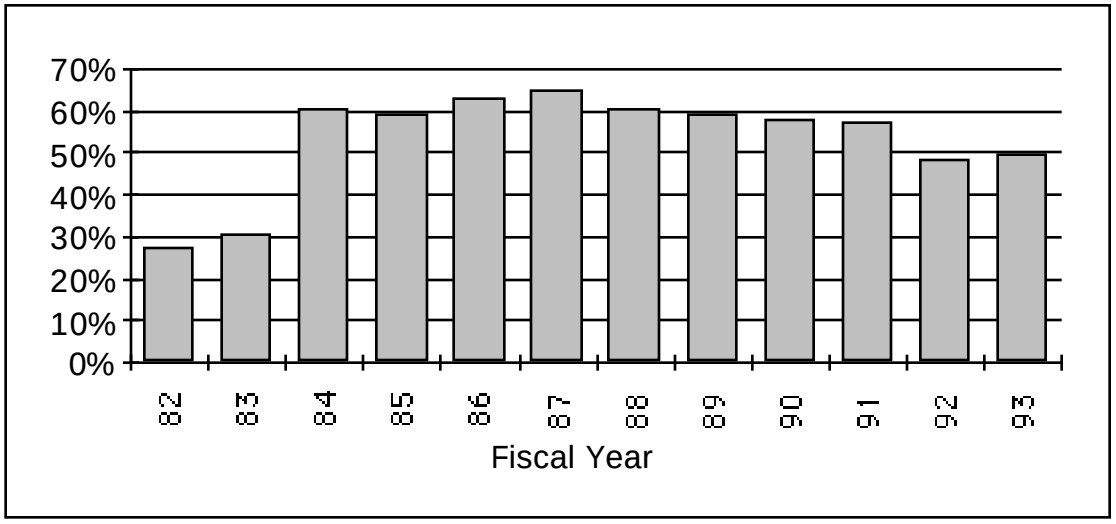

Figure 28. Percent of Recommendations Implemented by Fiscal Year

Assuming that the useful life of any one implemented energy conservation measure is not indefinite, figures 29 through 32 show the cumulative effect of these measures over a ten year time frame.

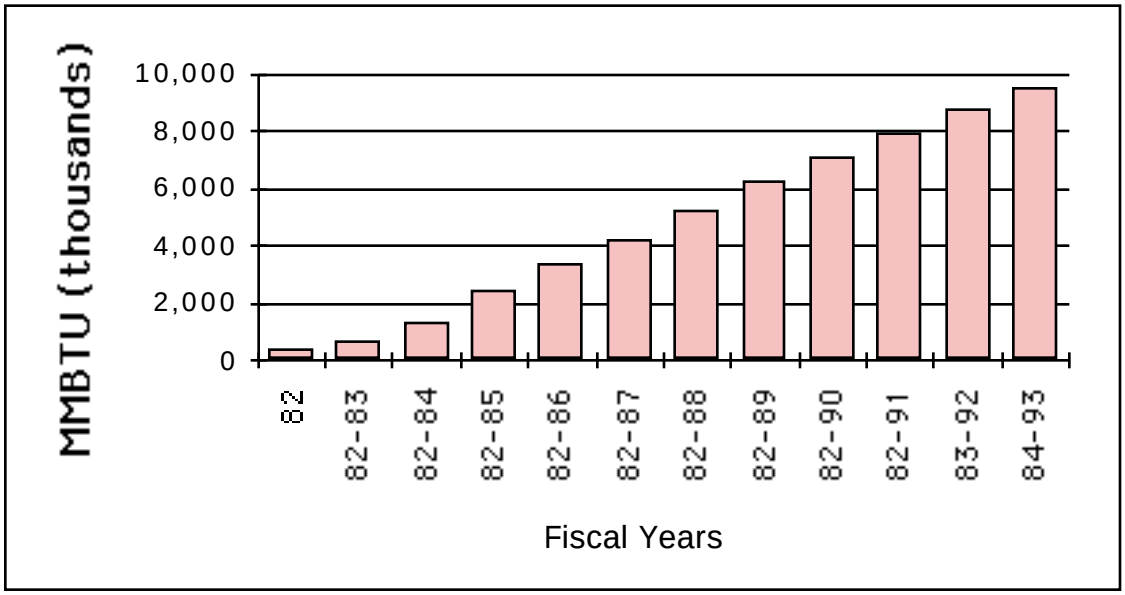

Figure 29. 10 Year Cumulative Energy Savings

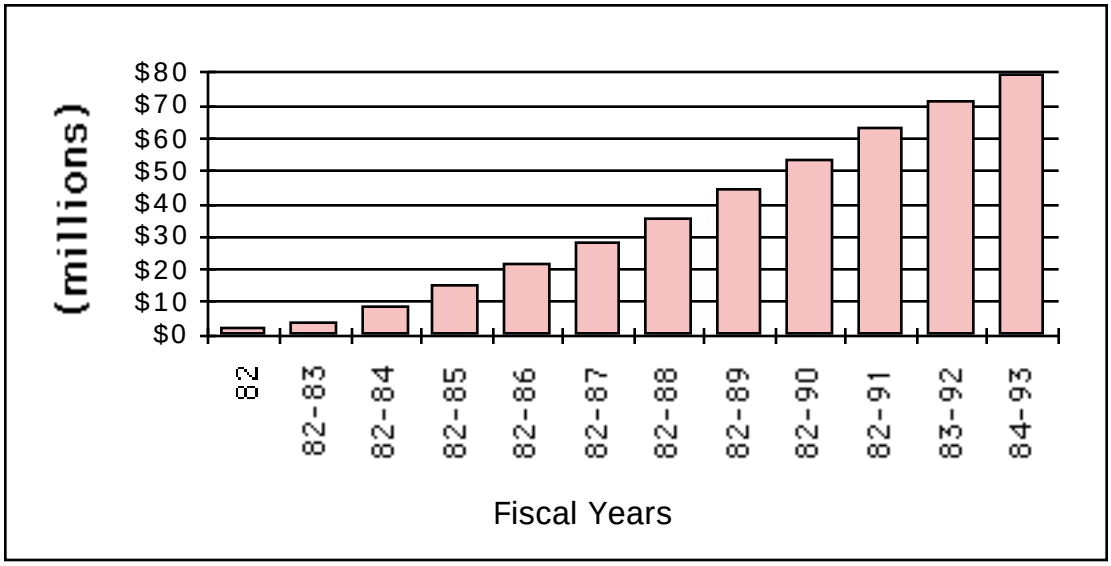

Figure 30. 10 Year Cumulative Cost Savings

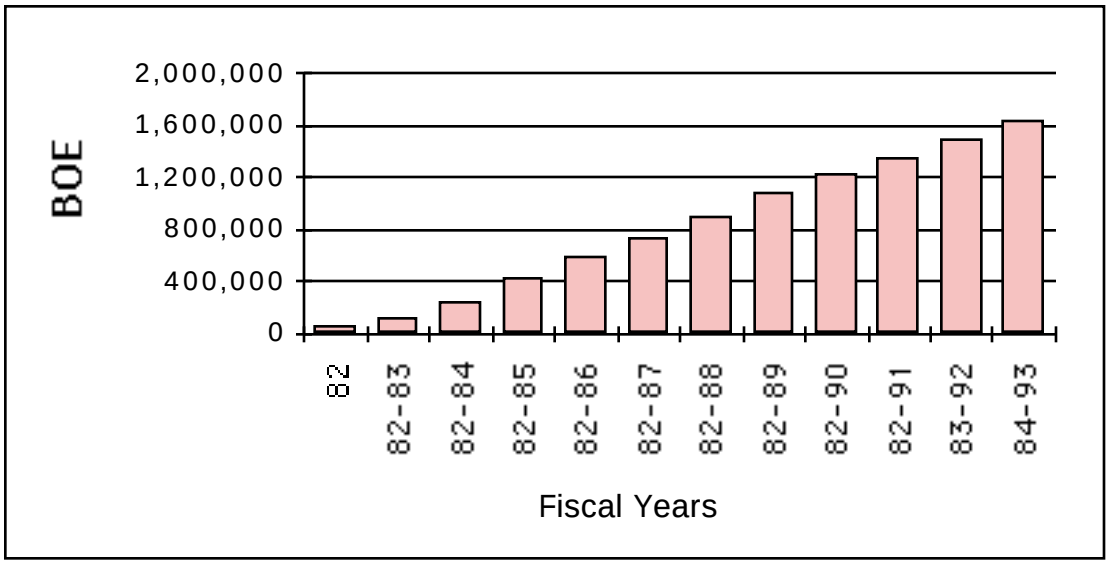

Figure 31. 10 Year Cumulative Barrels of Oil Avoided

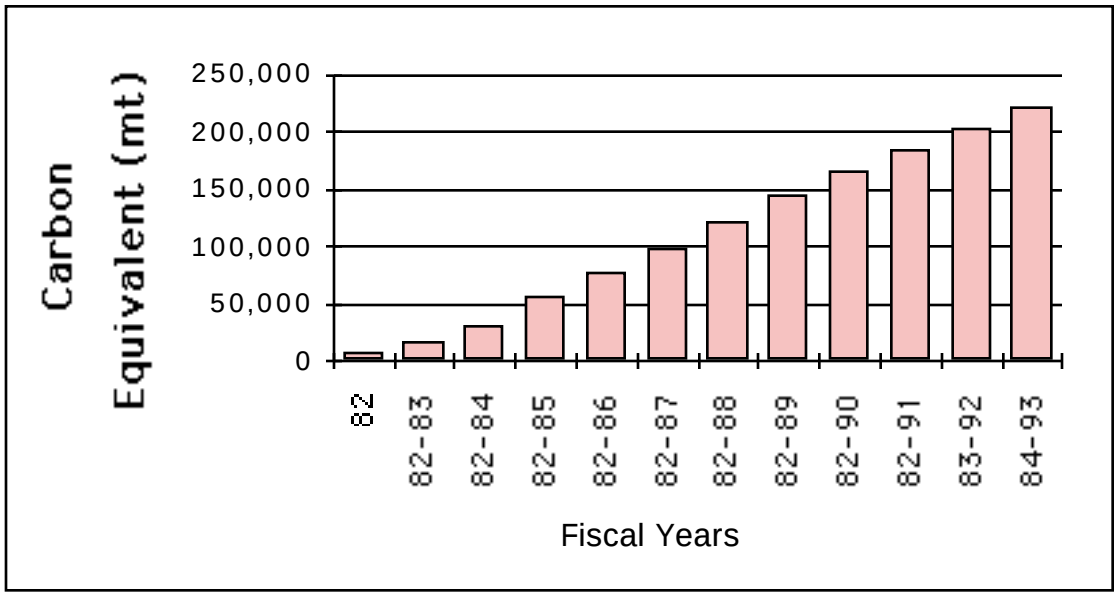

Figure 32. 10 Year Cumulative Carbon Avoided

Similar to the charts showing recommended savings, the average energy saved due to the implementation of recommended measures is shown per audit for FY93 and as a three year average. This can be seen in figures 33 through 40.

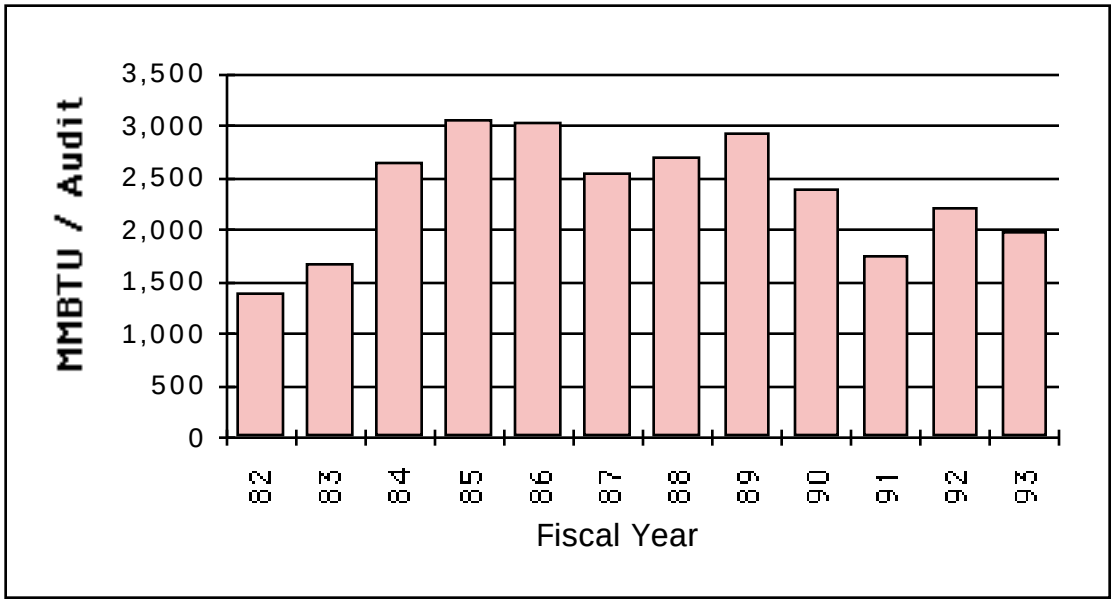

Figure 33. Average Implemented Energy Conserved Per Audit by Fiscal Year

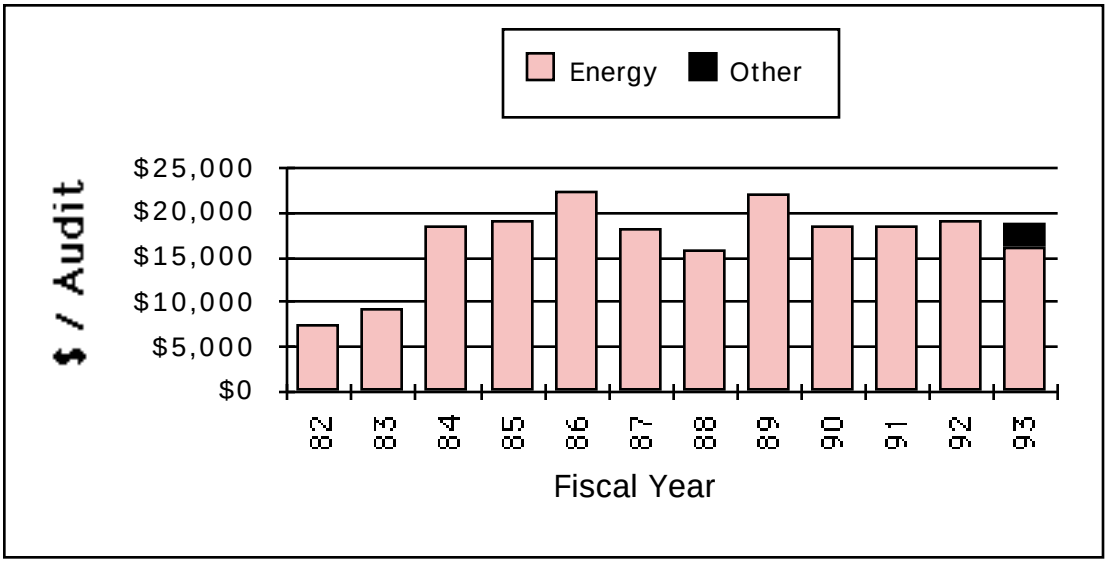

Figure 34. Average Implemented Cost Savings Per Audit by Fiscal Year

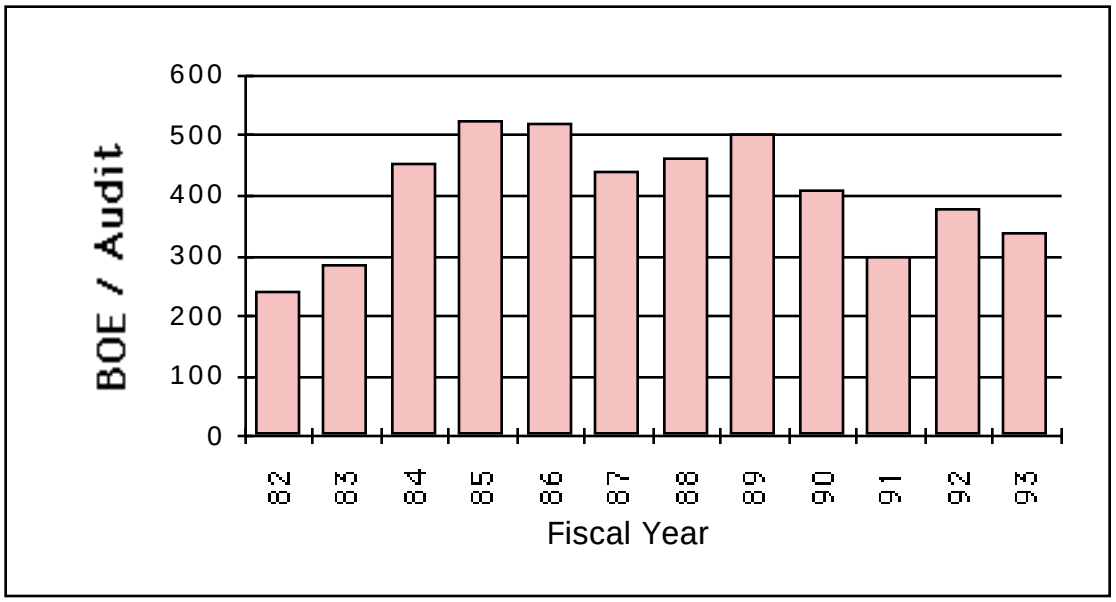

Figure 35. Average Implemented Barrels of Oil Avoided by Fiscal Year

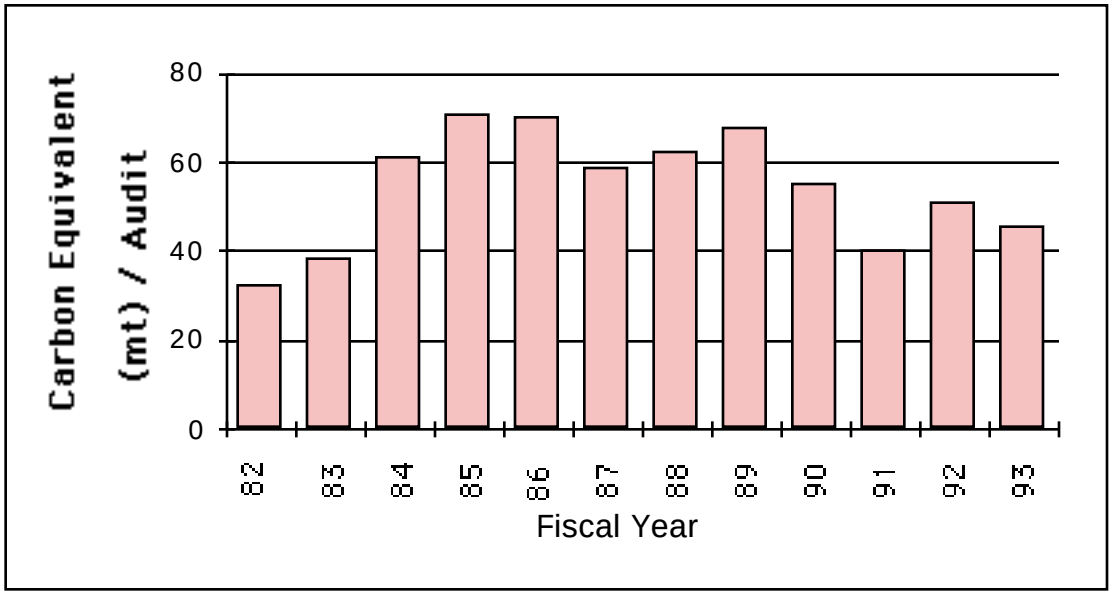

Figure 36. Average Implemented Carbon Avoided by Fiscal Year

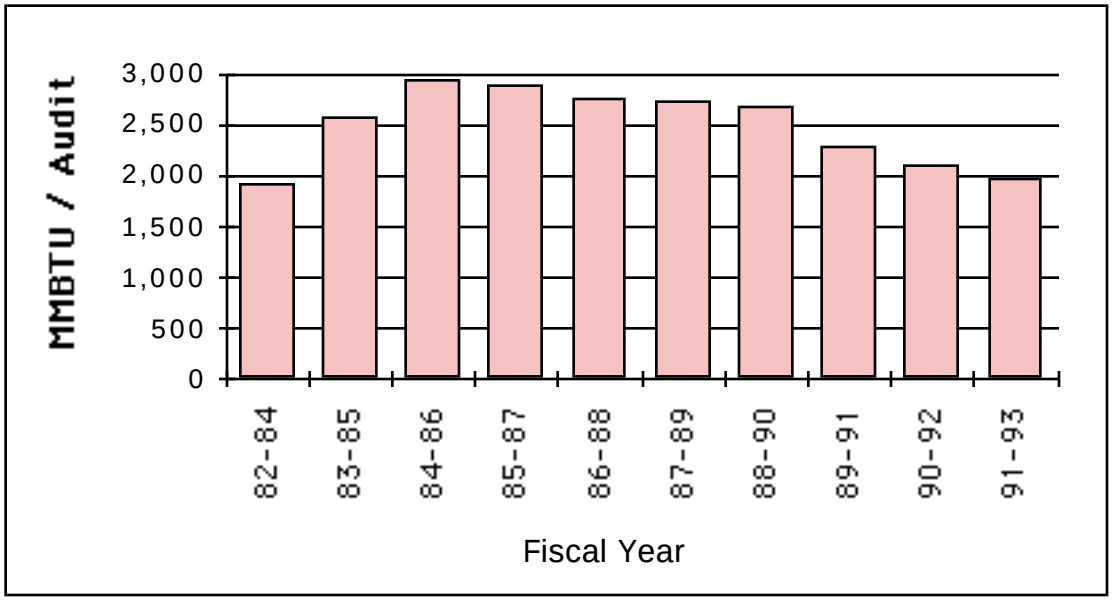

Figure 37. Implemented Energy Conserved Per Audit (3 Year Average)

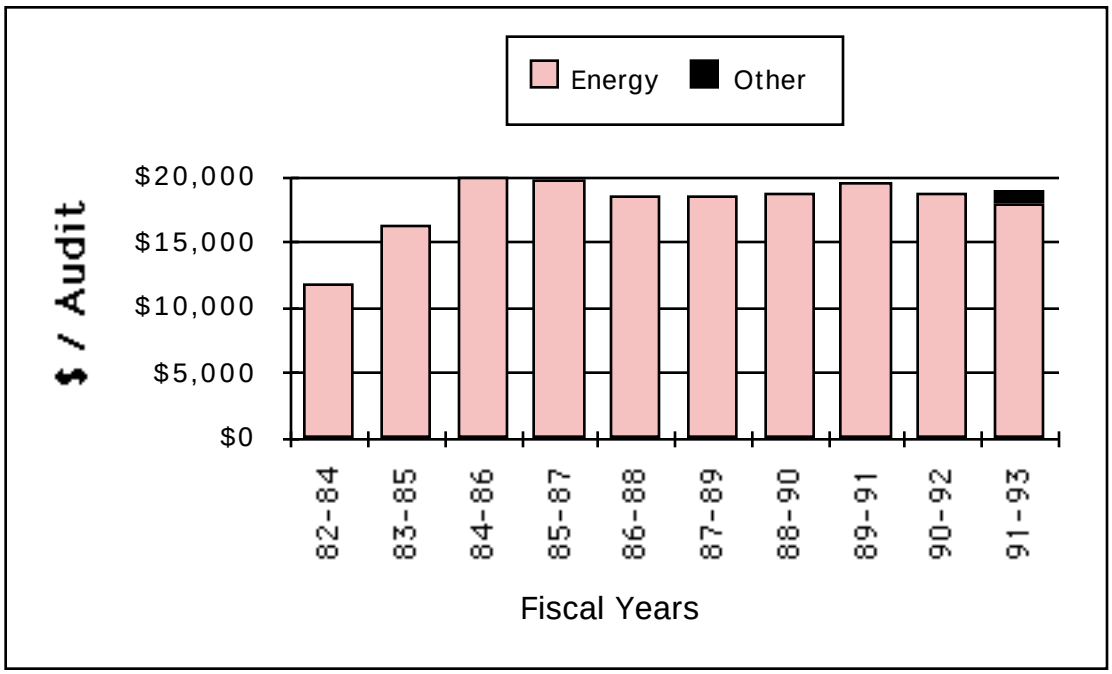

Figure 38. Implemented Cost Savings Per Audit (3 Year Average)

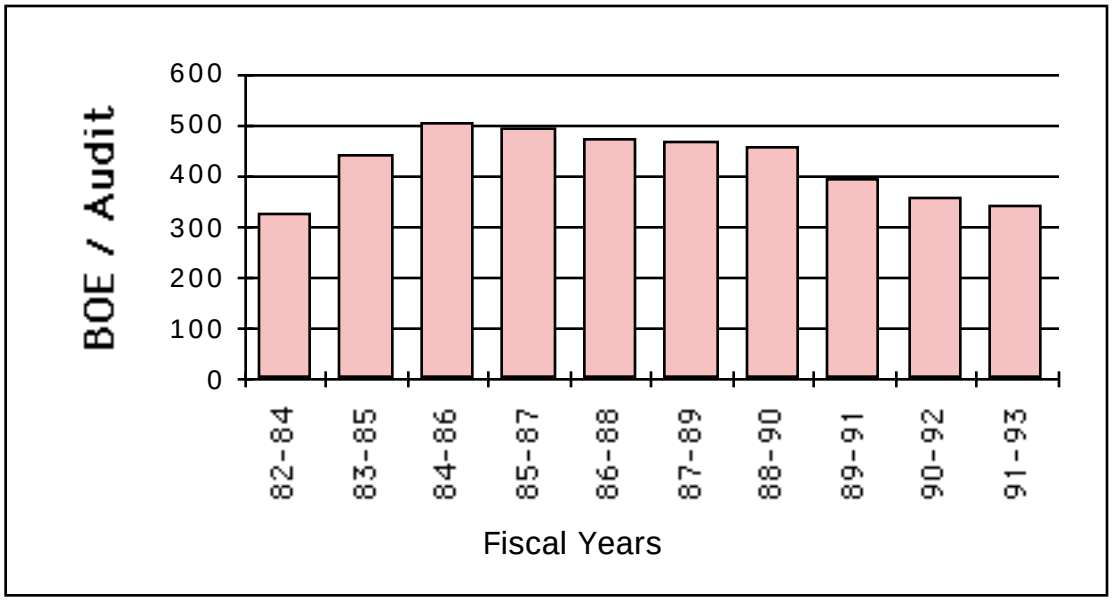

Figure 39. Implemented Barrels of Oil Avoided Per Audit (3 Year Average)

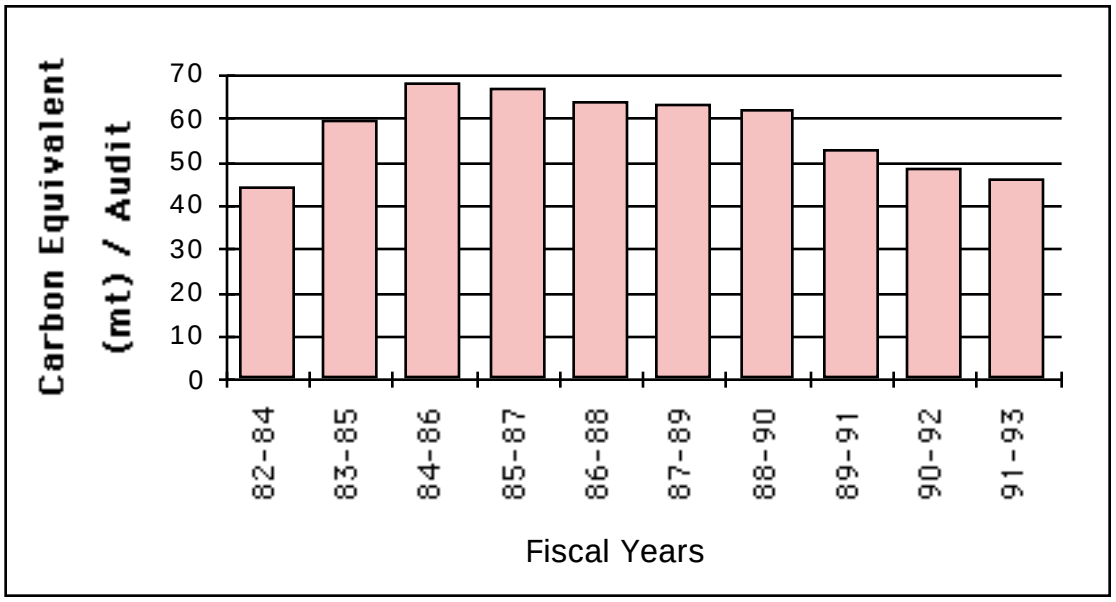

Figure 40. Implemented Carbon Avoided Per Audit (3 Year Average)

ii. Implemented Conservation by Industry Type

Energy conservation resulting from implemented recommendations in FY93 is shown on figures 41 through 44. The greatest amount of energy conserved was in SIC 35 (industrial machinery and equipment). In energy cost savings the largest savings was in SIC 20 (food and kindred products) followed closely by SIC 34 (fabricated metal) and SIC 35. One recommendation regarding switching fuels from natural gas to coal produced a large non-energy savings in SIC 32 (Stone, Clay, and Glass Products).

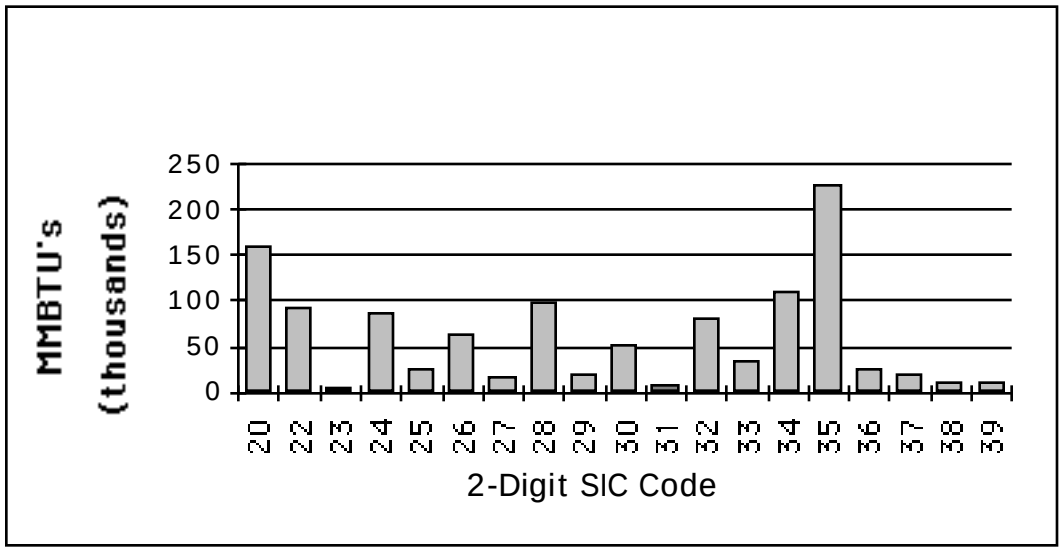

Figure 41. Implemented Energy Conserved by Industry Type

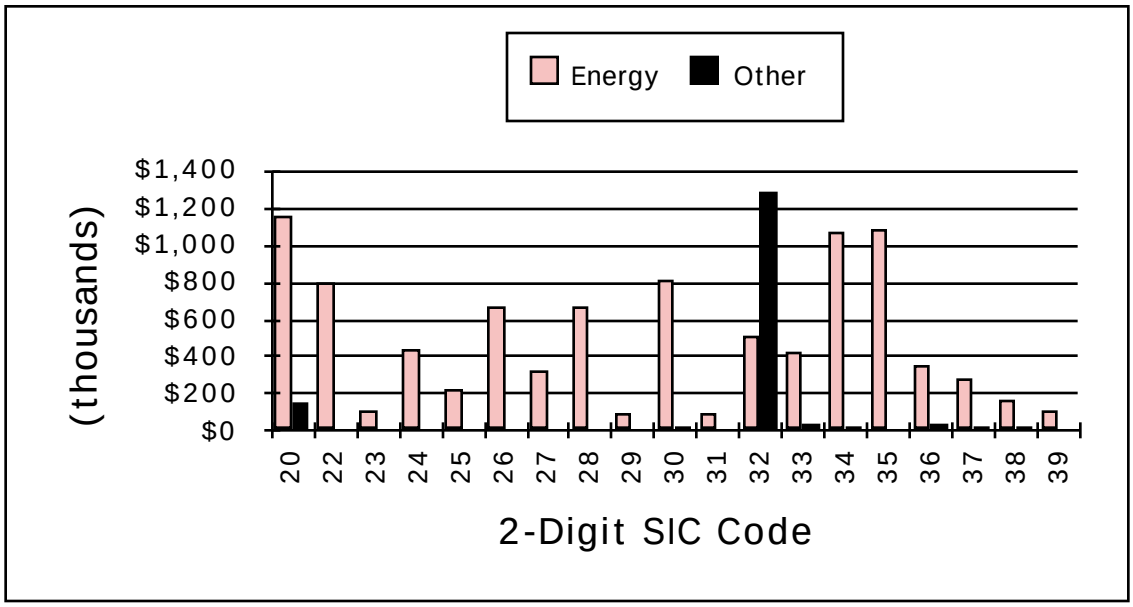

Figure 42. Implemented Cost Savings by Industry Type

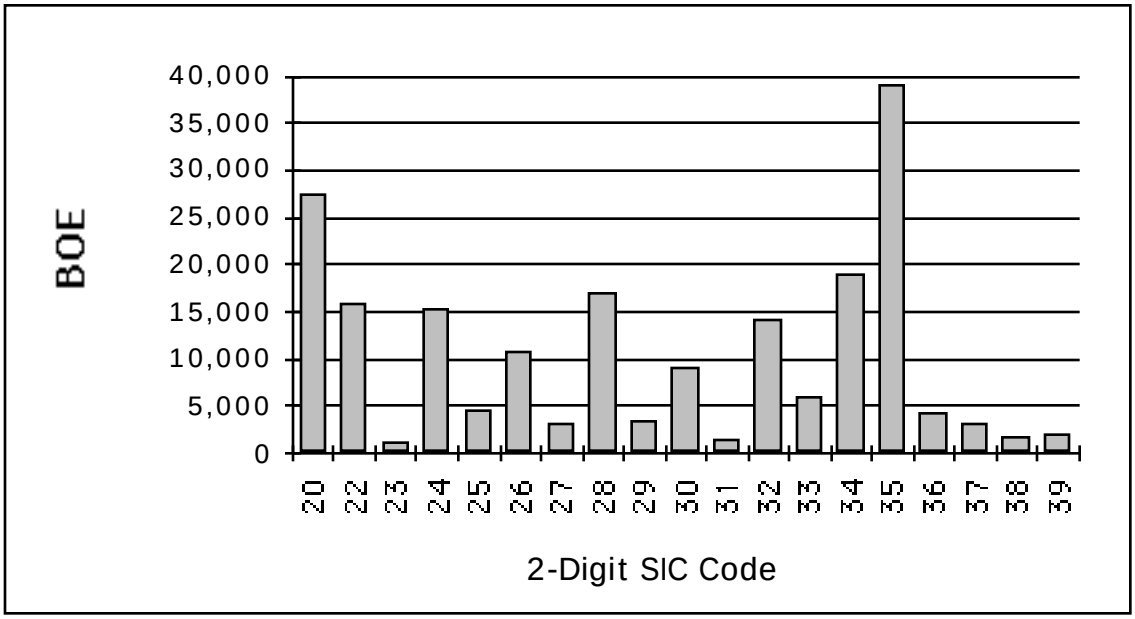

Figure 43. Implemented Barrels of Oil Avoided by Industry Type

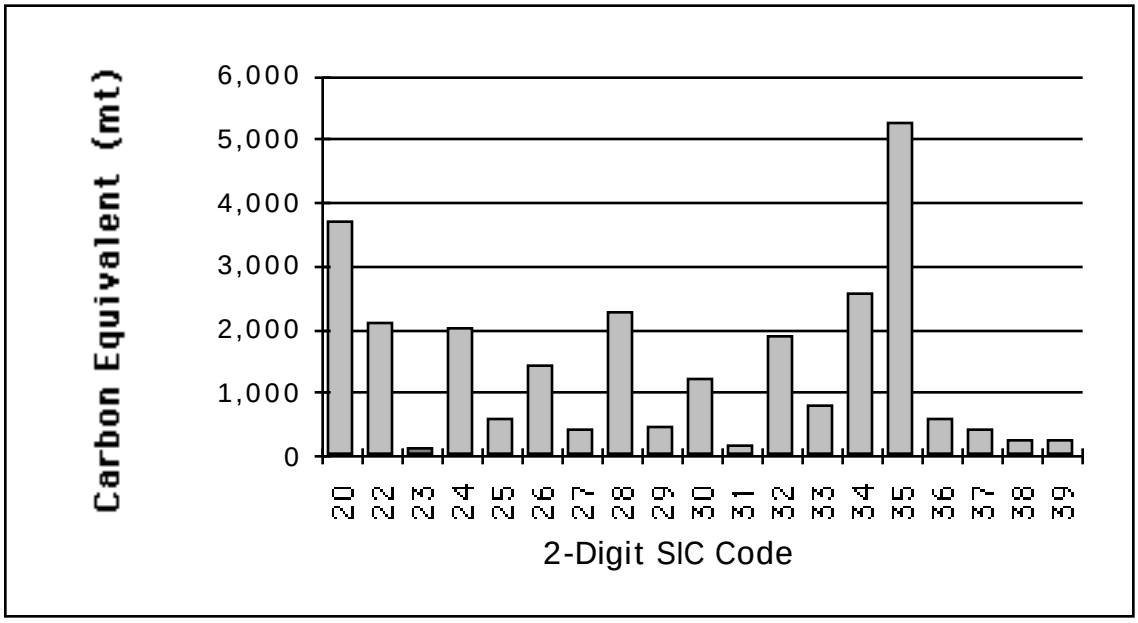

Figure 44. Implemented Carbon Avoided by Industry Type

iii. Implemented Conservation by Energy Type

Table 8, and figures 45 and 46 reflect implemented energy and cost savings broken down by energy type. A large number of fuel switching and electricity generating recommendations were not implemented. This is why the recommended energy and cost saved for #2 fuel oil was negative (see table 6), yet the implemented values shown here are positive.

Energy Stream	Implemented Energy Conserved (MMBTU)	Implemented Energy Savings ($)
Electricity	367,015	$6,866,821
Natural Gas	656,121	$2,241,191
L. P. G.	1,920	$12,586
Fuel Oil #2	44,014	$102,316
Fuel Oil #4	0	$0
Fuel Oil #6	1,211	$2,446
Coal	348	$2,501
Wood	68,261	$44,842
Paper	0	$0
Other Gas	1,520	$3,670
Other Energy	12,689	$87,497
Non-Energy	n/a	$1,607,717
Total:	1,153,099	$10,971,587

Table 8. Energy Conserved and Cost Savings by Energy Type

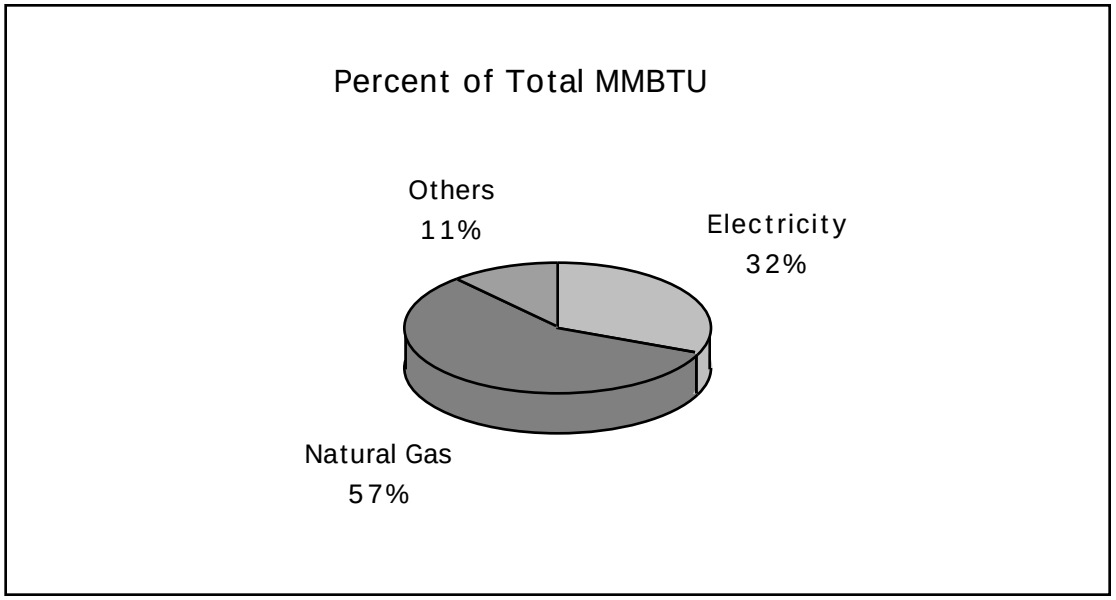

Figure 45. Composition of Implemented Energy Conserved

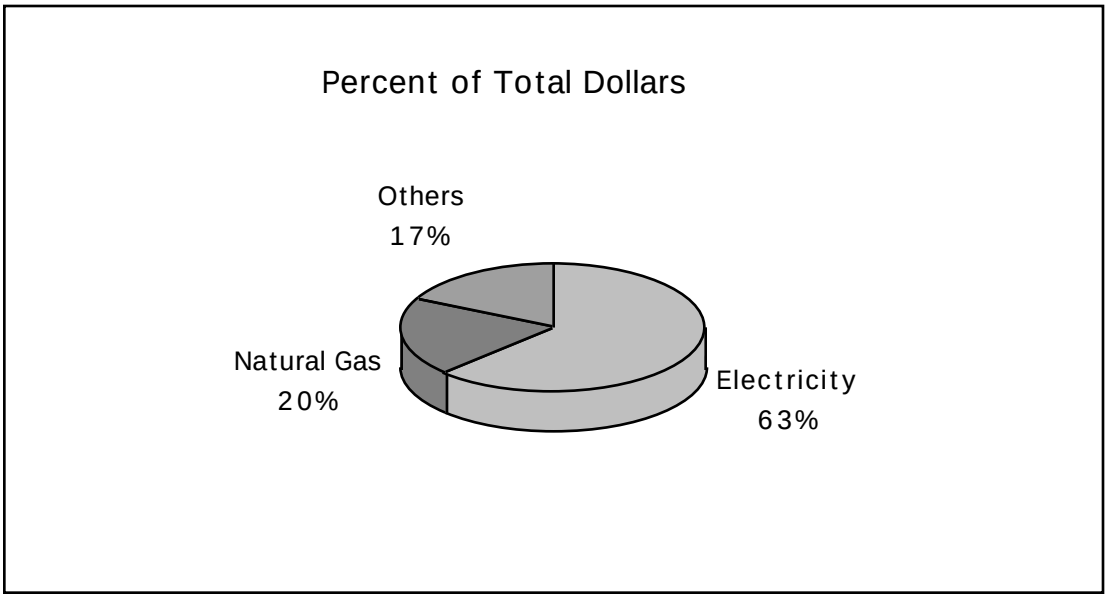

Figure 46. Composition of Implemented Cost Savings_

iv. Implemented Conservation by Recommendation Type

Finally, the number of implemented recommendations by type for fiscal year 1993 is shown in figure 47.

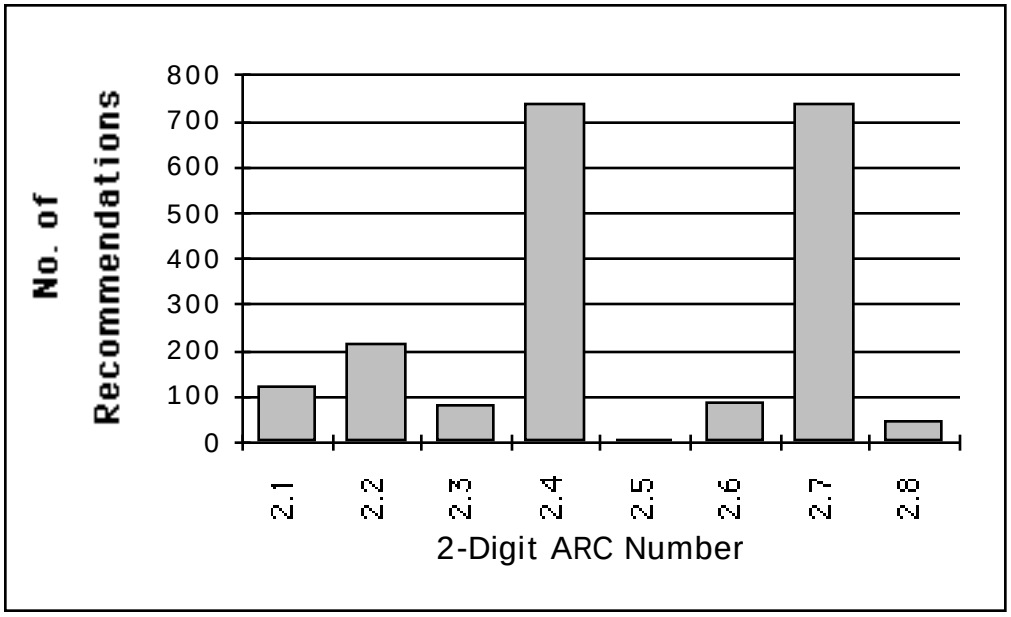

Figure 47. Number of Implemented Recommendations by Type

III. Standard Financial Calculations

Standard financial calculations of the EADC program results have been made by ITEM staff on the basis of data obtained from the EADC database maintained by Rutgers University.

These calculations show financial returns to the federal government and to manufacturers from their investments in generating and implementing energy-conserving and cost-saving recommendations.

Results are summarized in the attached table for a variety of parameters: growth rate of implementation costs, growth rate of cost savings, and borrowing rate.

These 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 (until all loans have been amortized) 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

A similar net present value method was used to calculate leverage ratios or profitability indices. For the same series of annual cash flows (until all loans have been amortized) based upon actual implementation, a rate (for example, 10%) is assumed in order to discount these future cash flows to the initial period of the investment. The leverage ratio is the ratio of the sum of discounted future cash flows to the sum of all capital investment needed to implement the ECOs.

Standard Financial Calculations of EADC Results 1992-1993

IMP COST GROWTH %	ENSAV GROWTH %	BORR RATE %	FEDERAL GOVERNMENT IRR	FEDERAL GOVERNMENT LR_{10}	FEDERAL GOVERNMENT LR_{15}	MANUFACTURERS IRR	MANUFACTURERS LR_{10}	MANUFACTURERS LR_{15}
3	3	3	48.8	2.31	1.73	375	3.53	2.92
3	3	6	47.4	2.26	1.68	330	3.47	2.86
3	3	9	45.9	2.20	1.63	294	3.41	2.80
3	3	6	47.4	2.26	1.68	330	3.47	2.86
6	3	6	47.1	2.24	1.67	328	3.46	2.85
6	0	6	42.0	1.80	1.31	310	2.90	2.47
6	3	6	47.1	2.24	1.67	328	3.46	2.85
6	6	6	52.1	2.74	2.07	346	3.99	3.27
12	6	6	51.7	2.71	2.05	341	3.96	3.25

Table 9. Standard Financial Calculations of EADC Results 1992-1993

GLOSSARY

IMPCOST GROWTH = annual growth rate of the cost of implementing EADCs' recommendations.

ENSAV GROWTH = annual growth rate of cost savings from implementation of EADCs' recommendations.

BORR RATE = annual borrowing rate for debt service on funds borrowed to implement EADCs' recommendations.

IRR = internal rate of return.

LR_{10}, LR_{15} = leverage ratio for five-year cash flows discounted at 10 or 15% to the initial time period and compared to the program investment by the manufacturers.

IV. Regional Reports

A. Western Region

i. Major Activities and Highlights for FY93

The 1992-1993 period of the Energy Analysis and Diagnostic Center program marked the first time that two field managers were responsible for managing the activities of the EADC's. University City Science Center (UCSC), designated as the western region field manager, became responsible for the following 11 EADCs during 1992-1993:

(AS)	Arizona State University	Mr. Robert Peltier
(AR)	University of Arkansas-Little Rock	Mr. Burton Henderson
(CO)	Colorado State University	Dr. C. Byron Winn
(IA)	Iowa State University	Dr. Howard N. Shapiro
(KU)	University of Kansas	Dr. M. Clay Belcher
(MO)	University of Missouri-Rolla	Dr. Burns E. Hegler
(OK)	Oklahoma State University	Dr. Wayne C. Turner
(OR)	Oregon State University	Dr. George M. Wheeler
(SD)	San Diego State University	Dr. Halil M. Guven
(SF)	San Francisco State University	Dr. Ahmad Ganji
(AM)	Texas A & M University (College Station)	Dr. Warren M. Heffington

ii. Centers Supervised

The history of the western centers is shown in the following table.

Center	Date Entered Program	93 Audits Completed	Director's Years in Program	Student Participation	
				Graduate	Under Grad.
AS	FY90	30	4		10
AR	FY93	15	1	1	5
CO	FY84	30	10	7	9
IA	FY91	30	3	5	22
KU	FY81	30	3	2	6
MO	FY90	30	4	5	12
OK	FY81	30	12	10	18
OR	FY87	30	7	4	13
SD	FY91	30	2	8	6
SF	FY93	15	1	4	5
AM	FY87	30	7	7	15

Table 10. History of Western Centers

Two of those EADCs, the University of Arkansas-Little Rock and San Francisco State University, were new to the program in 1992-1993 and were each responsible for completing 15 energy audits. The other nine each completed a full load of 30 energy audits, so that the total was 300 for the Western region.

Many outstanding results were generated during those audits, but the following examples of what manufactures implemented illustrate their variety and scope:

- A cement producer in Colorado saves over $1.2 million/yr. by converting a natural gas-burning kiln to coal. The plant realizes additional savings of nearly $88,000/yr. by reducing air infiltration to a preheater.

- An Oklahoma refiner and producer of natural and synthetic waxes saves nearly $366,000/yr. by improving the plant's steam system. Steam leaks and faulty steam traps were repaired; modifications were made to return condensate to the boiler; and steam and condensate lines were insulated. An additional $5,200/yr. in savings is also realized by replacing incandescent lamps with high-pressure sodium lamps.

- A manufacturer of pre-fabricated steel buildings and components in Texas saves $24,00/yr. by using capacitors to improve power factor. Implementation of a recommendation to change electric rate schedules produces another $10,900/yr. of savings. Repairing compressed air leaks yields $1,000/yr. savings.

- A producer of dimensional lumber in Oregon saves over $28,000/yr. by reducing the air / fuel ratio of its wood-fired boiler. Controlling fan speeds to the dry kilns saves another $22,000/yr. Improving lighting efficiency saves $12,400/yr. and repairing compressed air leaks saves another $3,600/yr. Increasing the efficiency of selected motor systems by measures such as replacing standard motors with high-efficiency motors at burn-out, using notched V-belts, and installing high torque drive belts and sheaves leads to savings of nearly $3,600/yr.

- A manufacturer of anodized and plated metal parts in Arizona saves $60,000/yr. by replacing electric resistance heating in plating and anodizing tanks with steam. Improving the lighting efficiency of the plant saves over $1,100/yr. Installing shades over air conditioner condensers saves over $400/yr. and using synthetic lubricants adds $360/yr. in savings.

A solicitation package for expansion of the program was prepared and disseminated by UCSC during the Spring of 1993. Proposals received from prospective EADCs were reviewed by a selection panel composed of DOE and field management staff. During the summer of 1993, representatives of the election panel made site visits to nine finalists. As a result, eight new EADCs were selected to begin operation during FY94, including these four in the West: Bradley University, the University of Nevada-Reno, South Dakota State University, and Texas A&M University-Kingsville. Provisions were made for training all eight at Colorado State University during FY94.

The annual directors' meeting was held during August of 1993. The meeting was managed by Energetics, Inc., under subcontract to UCSC. Discussions at the meeting centered on a variety of administrative and technological topics.

Plans to incorporate waste assessments into the EADCs' services were begun during FY93. This aspect of the EADCs' activities were intended to build upon the success of the EPA-sponsored Waste Minimization Assessment Center program, which was managed by UCSC. Colorado State University also participated in a study for DOE to assess the viability of performing joint waste minimization/energy conservation assessments for manufacturing plants.

B. Eastern Region

i. Introduction

Field Management for the Eastern EADC region is the responsibility of the Office of Industrial Productivity and Energy Assessment (OIPEA) at Rutgers, the State University of New Jersey. OIPEA is an office of the department of Mechanical and Aerospace Engineering at Rutgers. In addition to the field management responsibilities, in FY93, Rutgers was tasked with the responsibility of maintaining the EADC database for the entire program. Electronic transfer of data from the EADCs to OIPEA was initiated, and the database was made available to the public at no cost for the first time.

ii. Centers Supervised

The Eastern Region was comprised of eight experienced centers performing 30 audits each, and three new centers performing 15 audits each. The addresses and phone numbers of all centers is given in the appendix. The schools and directors participation in FY93 is shown below.

(GT)	Georgia Institute of Technology	Mr. William A. Meffert
(HO)	Hofstra University	Dr. Charles Forsberg
(MA)	University of Massachusetts	Dr. Lawrence A. Ambs
(ME)	University of Maine	Mr. Scott C. Dunning
(NC)	North Carolina State University	Dr. Hebert Eckerlin
(ND)	University of Notre Dame	Dr. John W. Lucey
(TN)	University of Tennessee	Dr. Richard J. Jendrucko
(UD)	University of Dayton	Dr. Henry N. Chuang
(UF)	University of Florida	Dr. Barney L. Capehart
(WI)	University of Wisconsin	Dr. Umesh Saxena
(WV)	University of West Virginia	Dr. Ralph Plummer

The history of the centers, the directors experience, and the student participation is shown in Table 11.

Center	Date Entered Program	93 Audits Completed	Director's Years in Program	Student Participation	
				Graduate	Under Grad.
GT	FY82	30	3		4
HO	FY92	30	2		8
MA	FY84	30	10	5	1
ME	FY93	15	1		7
NC	FY93	15	1	4	5
ND	FY91	30	3	3	23
TN	FY76	30	18	9	2
UD	FY76	30	18	1	2
UF	FY91	30	3	4	14
WI	FY87	30	7	4	5
WV	FY93	15	1		8

Table 11. History of Eastern Centers

iii Simple Payback

The EADC program has had a traditionally high implementation rate (defined as the ratio of implemented measures to recommended measures) of close to 50%[2] (see Figure 28). This has led to some skepticism regarding the reasons for such a success rate.

In many types of energy audits offered by utility or government agencies, the expert in the energy field designs a so-called "boilerplate" audit, that is a rigid set of calculations based on modeling of an "average" facility. The auditor goes into the field, collects the necessary data, and plugs the information into the boilerplate program. The auditors, in these cases, are inexperienced and have very little input to the final recommendations.

By contrast, the EADC program puts experienced professors in the field with paid, engineering students. This produces a more insightful and practical audit. The director spends a significant amount of time interviewing the client. When they arrive at the plant, questions are answered such as; how purchasing decisions are made in the company, and

[2] We are proud of the fact that all five of the new centers in FY93 had implementation rates of at least 50% of the average.

who makes them? Are these decisions made locally, or at the corporate headquarters? What is considered a large amount of money, and what is an acceptable payback? During the exit interview, the audit team discusses their ideas with their contact and discovers which of the ideas will be seriously considered, and which ones will not.

Many of the most successful ideas come directly from the plant manager or engineer. He or she has an idea, but either does not know how to quantify the results, or needs support in selling the idea to management. Typically, the plant manager has a solid idea of the implementation costs in involved, but not the potential savings. The following chart shows how the simple payback of improvements recommended and implemented has changed over the years.

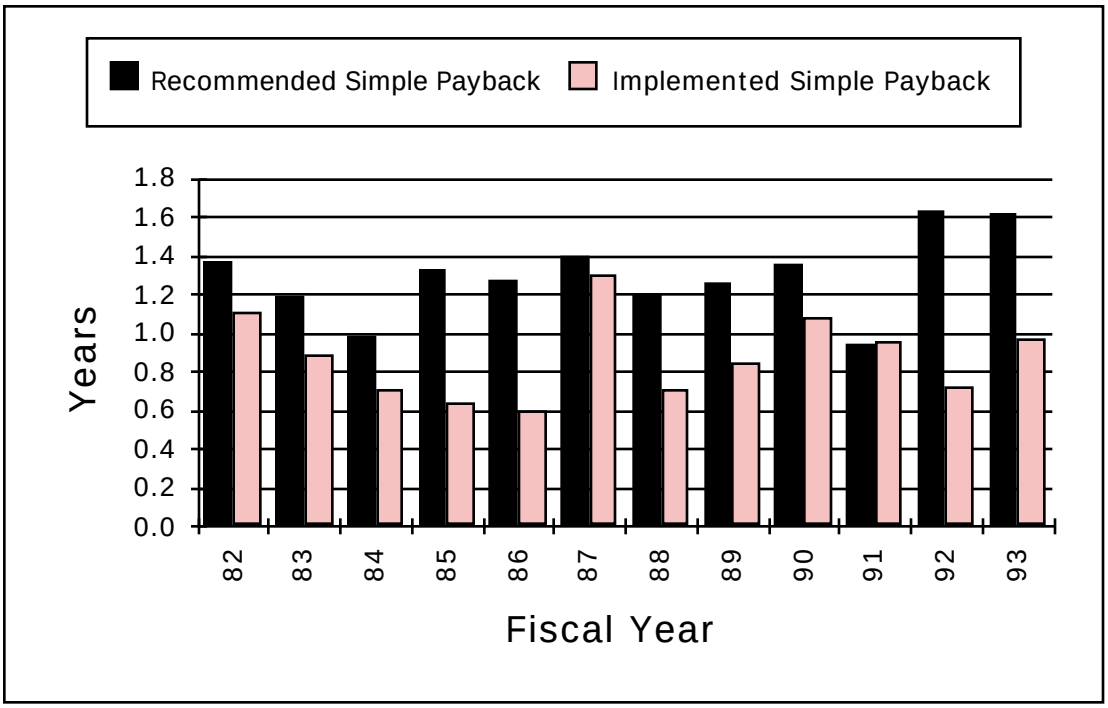

Figure 48. Average Recommended and Implemented Simple Payback

Directors are encouraged to be creative in their recommendations and this is proven by the large number of different recommendations used. Many of these recommendations are used only once or twice during the year, indicating the level to which this style of auditing is tailored to a particular client. As mentioned earlier, the Assessment Recommendation Code Manual has over 300 energy conservation opportunities. In FY93, the directors used 231 different recommendations.

As shown in Figure 27, most recommendations are process oriented. In FY93, thirty-seven new AR numbers were used and seventy different ARs were recommended only once. The average number of recommendations has grown from five per report in the initial years to seven per report in FY93. This shows that the EADC program is definitely not a "canned" program of a few frequently used recommendations. An example of some of the more creative recommendations recommended in fiscal year 1993 in this category include:

- Install a Natural Gas Driven Generator
- Operate Bracing Furnace Off Shift
- Replace Motor Generator Set
- Install Wood Cogeneration System
- Purchase Electrical Transformer
- Replace Convection Oven with Infra-red Oven
- Install Ozone Water Treatment System
- Install Uninteruptable Power System and Line Conditioner

Appendix I.

EADC Program Contact List

Appendix II.

EADC Territory Maps

List of Figures

List of Figures (continued)