FINAL SUBMITTAL

ENERGY SURVEYS OF
ARMY INDUSTRIAL FACILITIES
ENERGY ENGINEERING ANALYSIS PROGRAM
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

EXECUTIVE SUMMARY

89
CONTRACT NO. DACA65-[redacted]-C-0154

PREPARED FOR:

U.S. ARMY CORPS OF ENGINEERS
NORFOLK, VIRGINIA

PREPARED BY:

ENERGY AND ENVIRONMENTAL SERVICES DEPARTMENT
REYNOLDS, SMITH AND HILLS, INC.
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MARCH 1991

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
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Marie Wakefield,
Librarian Engineering

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.1 Purpose

In October 1989, the Corps of Engineers, Norfolk District, issued Contract No. DACA65-89-C-0154 with Hunter Services, Inc. of Jacksonville, Florida. This contract called for the performance of Energy Engineering Analysis Program (EEAP) studies of Army Industrial Facilities at Radford Army Ammunition Plant (RAAP), Radford, Virginia. The objective of this study is to identify, evaluate and develop energy saving projects which meet the criteria of the army's many energy funding programs.

1.2 Report Organization

The report consists of an Executive Summary and four volumes. Volume I, the Narrative Report, contains the results of all of the site surveys, analysis and project development. All backup data and calculations are found in Volume II. The site survey notes are in Volume III, and project documentation forms necessary for receiving funding are in Volume IV.

2.0 INSTALLATION DESCRIPTION

Radford Army Ammunition Plant is located just north of I-81, 37 miles southwest of Roanoke and 108 miles northeast of Bristol, Tennessee. The facility was built in 1941 and was the first to produce gun powder in the U.S. Government's defense plant program. This was the first creation of the GOCO (government-owned, contractor-operated) plant, dedicated wholly to the production of war material. Since 1941, RAAP has produced over two billion pounds of military propellants in such areas as:

- Rockets
- Single-Base Propellants
- Solventless Propellants
- Double-Base Propellants
- Triple-Base Propellants
- Ignitors
- TNT
- Mortar Increments

Figure 2-1 contains a base materials flow diagram.

The RAAP installation includes approximately 7,000 acres and over 1,200 buildings. The employment level as in September 1989 was 5,350. Figure 2-2 is a site plan of RAAP and describes the basic production areas. Areas covered under this scope of work are:

Acid	Cast Propellant
Nitrocellulose B & C	Extruded Propellant
Solvent Recovery	Multibase Finishing
Finishing	Plant Air
Solventless	Plant Water
Increment 1	Powerhouses 1 & 2

BASE MATERIALS FLOW DIAGRAM
FOR PROPELLANTS MANUFACTURED AT RAAP

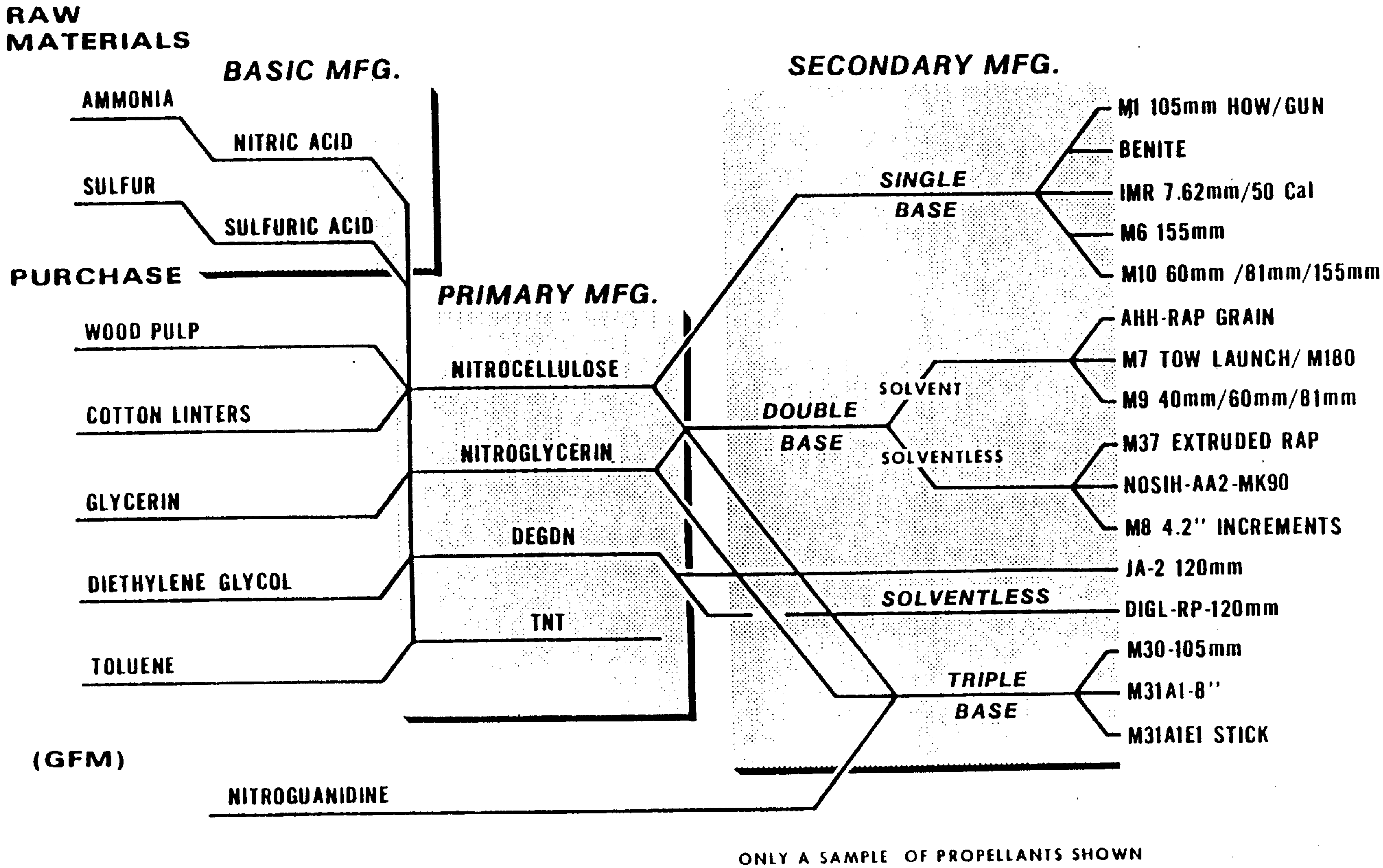
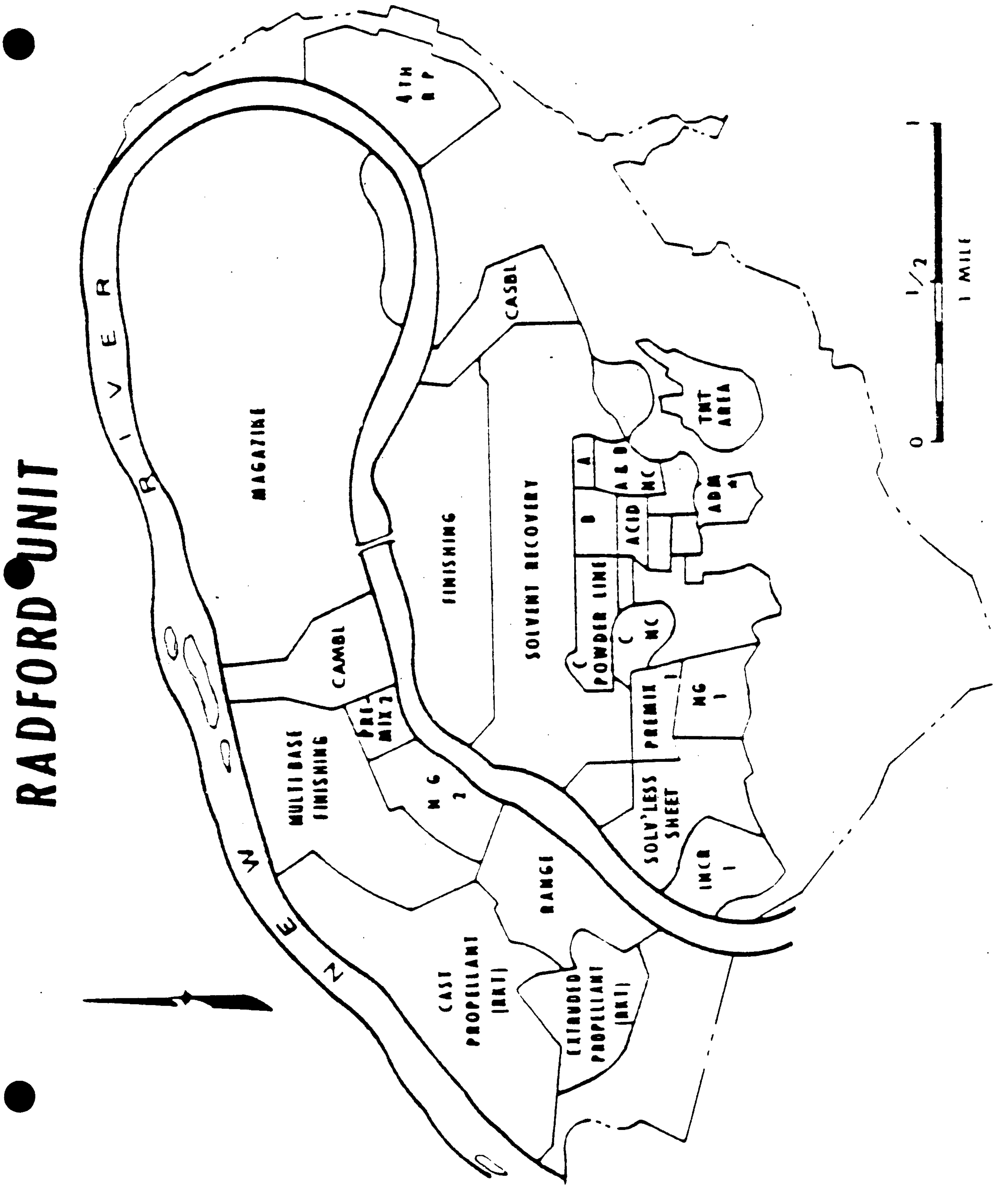


FIGURE 2-1

FIGURE 2-2


RADFORD UNIT
NEW RIVER
MAGAZINE
4TH RP
CASBL
CAMBL
PRE-MIX 2
MULTIBASE FINISHING
NG 2
RANGE
CAST PROPELLANT (RKT)
EXTRUDED PROPELLANT (RKT)
FINISHING
SOLVENT RECOVERY
A
B
A & B NC
ACID
ADM #1
TNT AREA
POWDER LINE
C
C NC
PREMIX 1
NG 1
SOLV'LESS SHEET
INCR 1
0
1/2
1 MILE

Nitroglycerin 1 & 2

Premix 1 & 2

4th Rolled Powder

Inert Gas

Incinerators

Areas not included in the scope of work are:

Magazine

CAMBL

CASBL

TNT

Administration

Nitrocellulose A

3.0 ENERGY CONSUMPTION AND PRODUCTION DATA

3.1 Historical Energy Use

Figure 3-1 shows the energy use and cost at RAAP from fiscal years 1985 to 1989. Both energy use and cost display a downward trend. This correlates well with decreased nitrocellulose production rates over the same time period (Figure 3-2).

Figures 3-3 and 3-4 show the distribution of energy use and cost, respectively, by fuel type. Coal dominates both pie charts at 87 percent on a Btu basis and 61 percent of the total utility bill. RAAP purchases over $4,500,000 in coal annually and is probably the single largest coal consumer among U.S. Army installations! RAAP is also one of the few installations that generates its own electricity. Typically, RAAP generates about one-half of its electricity. However, power house incidents in FY 89 have temporarily halted electrical power generation during CY-1989 and CY-1990. Current power generation levels are temporarily reduced until Power House modifications are completed.

Average energy prices are shown in Figure 3-5. RAAP is fortunate that their two largest energy sources, electricity and coal are relatively inexpensive. Electricity is about one-half the price of the average U.S. Army installation. Also, most installations pay more than twice the $1.61/MBtu price for heating fuel, usually in the form of fuel oil or natural gas.

RAAP also has an extensive metering program. There are more than 80 electricity meters and steam use meters throughout the installation. Plant personnel use these meter readings to allocate energy use in the different production areas and also to determine if energy consumption or energy costs can be reduced. An analysis of these data was performed to estimate where the energy is used at RAAP. Fuel use amounts were analyzed and assigned to one of

Radford Army Ammunition Plant

Historical Energy Use & Cost

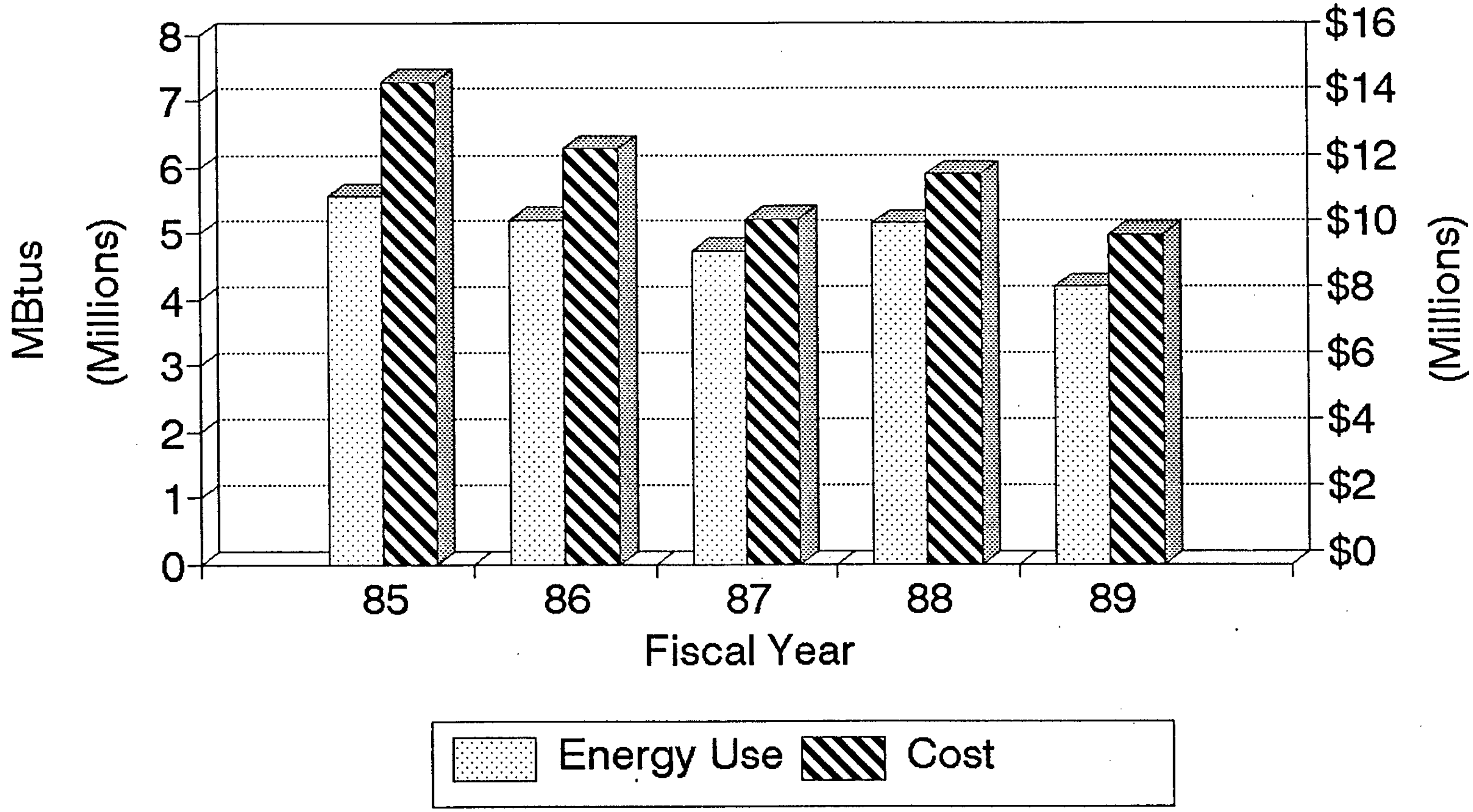


Figure 3-1

Radford Army Ammunition Plant
Historical NC Production

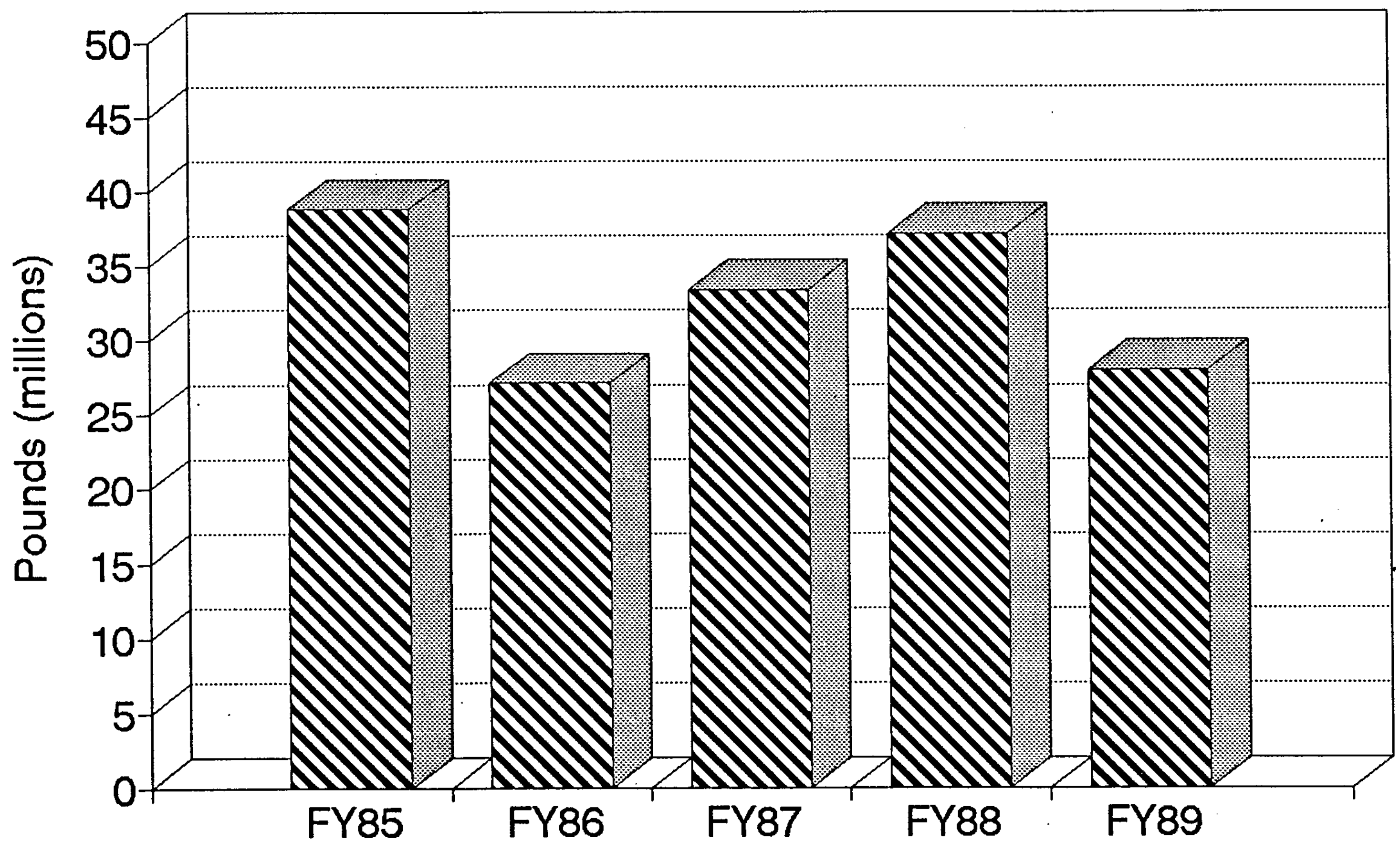
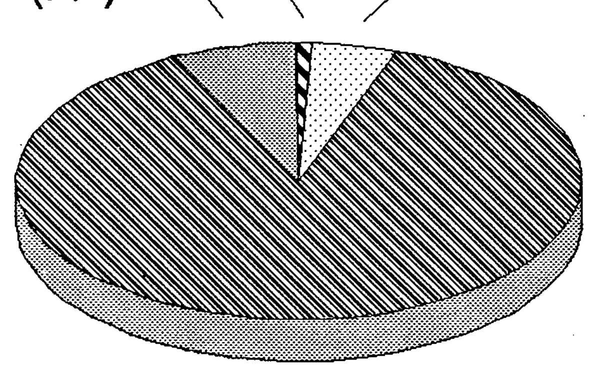


Figure 3-2

Radford Army Ammunition Plant

FY 89 Energy Use by Type



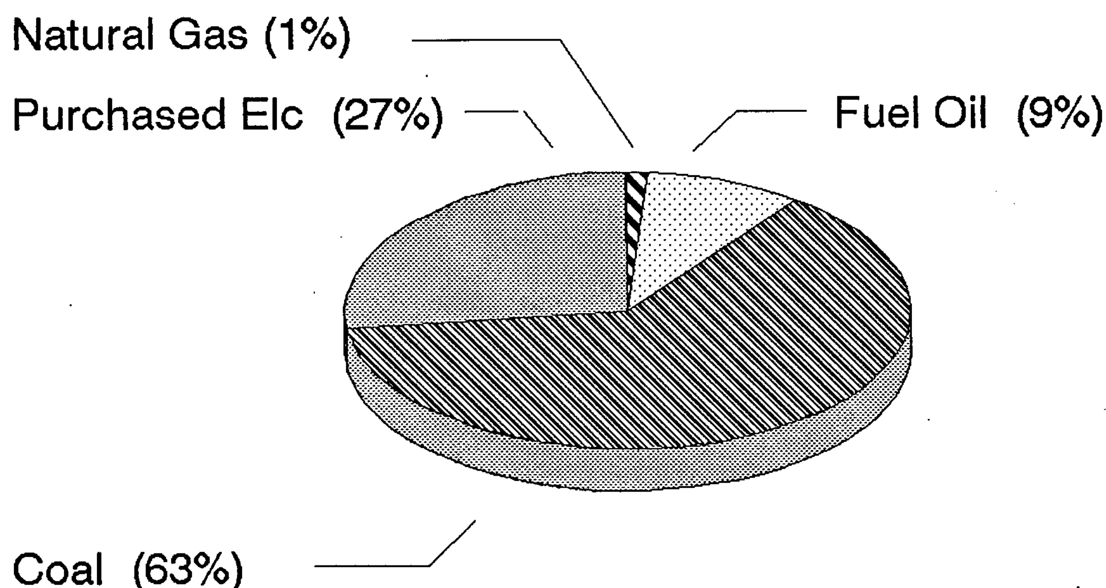
Total Use = 4,177,262 MBtu

Does not include mobility fuels.

Figure 3-3

Radford Army Ammunition Plant

FY 89 Energy Cost by Type



Total Cost = $ 9,652,835

Does not include mobility fuels.

Figure 3-4

Radford Army Ammunition Plant

FY 90 Average Energy Unit Prices

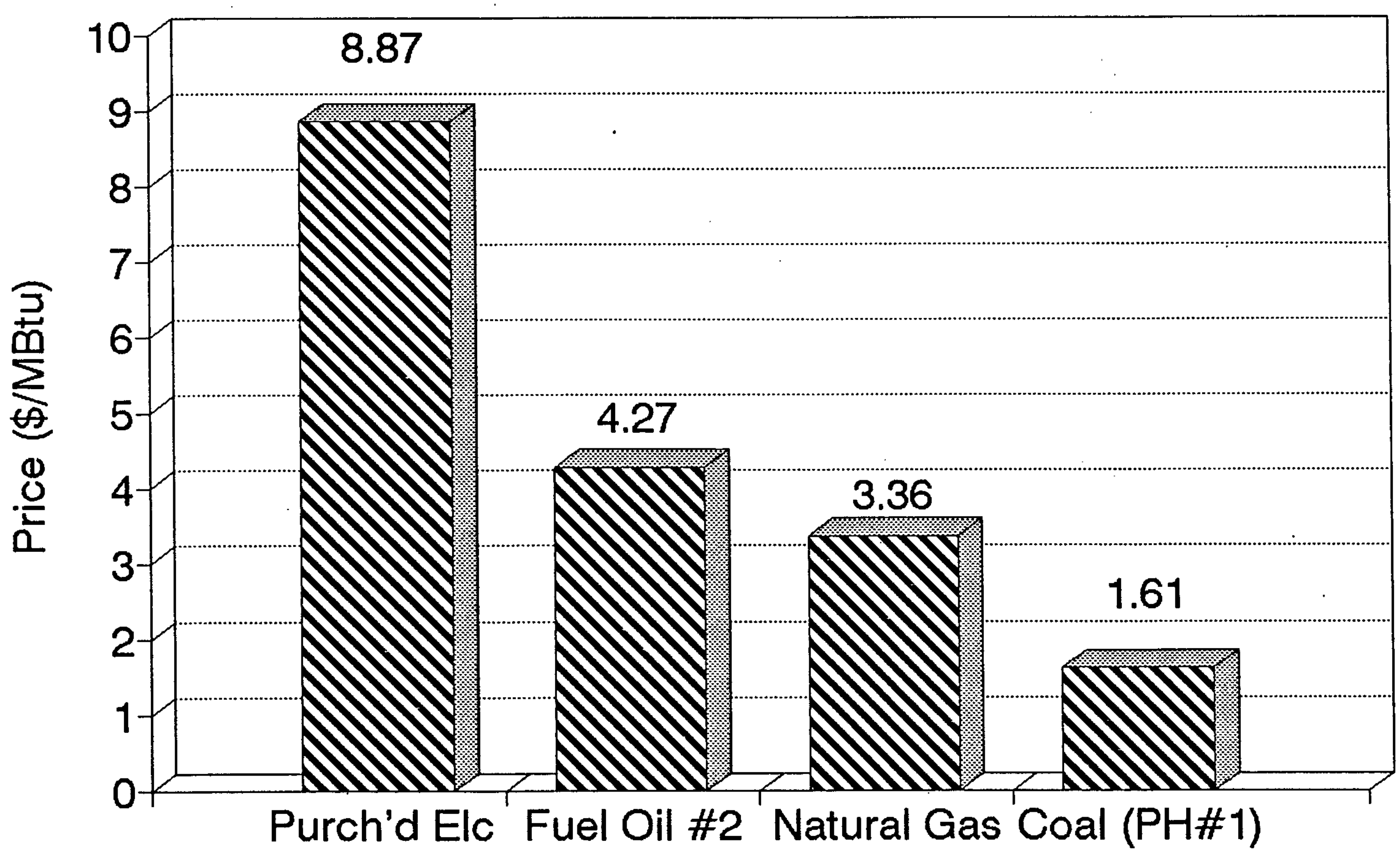


Figure 3-5

the six categories listed in Table 3-1. Plant utilities include Plant Water and Air and Cast Water and Air and the power houses. Steam consumption in Power House No. 1 is credited toward the generation of electricity (599,111 MBtu) based on power generation at 29 percent efficiency, and then allocated among the six categories. Table 3-1 shows the energy use breakdown by use and cost for FY 89.

The results show that about 87 percent of the energy on a Btu basis and 81 percent on a cost basis is directly used in production. The most energy intensive production areas are the acid and nitrocellulose areas.

3.2 Energy and Production Data Analysis

Historical energy consumption at Radford Army Ammunition Plant (RAAP) was analyzed using a linear regression analysis computer program to determine the dependency of primary energy use on variables that affect that use. In an industrial plant such as RAAP, these variables may be production end items, components of end-item production, number of employees, weather, or a combination of any of the above.

Analysis of RAAP energy data was done for the five fiscal years 1985 to 1989. Production for the five years of the four predominant quantities NC, AOP, NAC/SAC and NG is shown in Figure 3-6; percentages of the quantities for FY 89 are shown in Figure 3-7.

A linear regression analysis resulted in the following monthly five-year energy consumption equations:

Coal: $$\text{MBtu} = 95{,}000 + 220\ \text{HDD} + 0.061\ \text{NC} \qquad (1)$$

$$R^2\text{adj} = 0.802$$

Elec: $$\text{MBtu} = 26{,}880 + 0.00171\ (\text{AOP} + \text{NAC/SAC}) \qquad (2)$$

$$R^2\text{adj} = 0.603$$

TABLE 3-1. RADFORD AAP ENERGY USE - FY 89

FUEL TYPE	ENERGY USE MBTU	ENERGY USE $	END USERS: ADM & BLDG HEAT	END USERS: PLANT UTILITIES	END USERS: PROCESS: ACID & NC	END USERS: PROCESS: SOLVENT	END USERS: PROCESS: S'LESS	END USERS: PROCESS: OTHER
COAL (1)			111,700	-	1,050,083	705,066	1,033,875	139,111
Steam	3,039,835	$5,076,525	$186,539	-	$1,753,639	$1,177,460	$1,726,572	$232,315
Electricity	599,111	$1,000,515						
			78,144	214,451	232,580	158,211	161,668	54,272
PURCHASED ELECTRICITY	300,215	$2,602,864	$313,105	$859,251	$931,891	$633,913	$647,764	$217,456
			1,719	119,617	-	-	-	81,144
FUEL OIL #2	202,480	$857,843	$7,283	$506,781	-	-	-	$343,780
			-	-	8,507	23,608	-	2,986
NATURAL GAS	35,101	$115,131	-	-	$27,904	$77,433	-	$9,794
			-	-	-	-	-	534
PPG	534	$3,000	-	-	-	-	-	$3,000
TOTALS	4,177,276		191,563	334,068	1,291,170	886,885	1,195,543	278,047
			4.6%	8.0%	30.9%	21.2%	28.6%	6.7%
TOTALS		$9,655,878	$506,927	$1,366,032	$2,713,434	$1,888,806	$2,374,336	$806,345
			5.2%	14.1%	28.1%	19.6%	24.6%	8.4%

(1) Total coal = 3,638,946 MBtu and $6,077,040

Radford Army Ammunition Plant

FY85 - FY89 Production Quantities

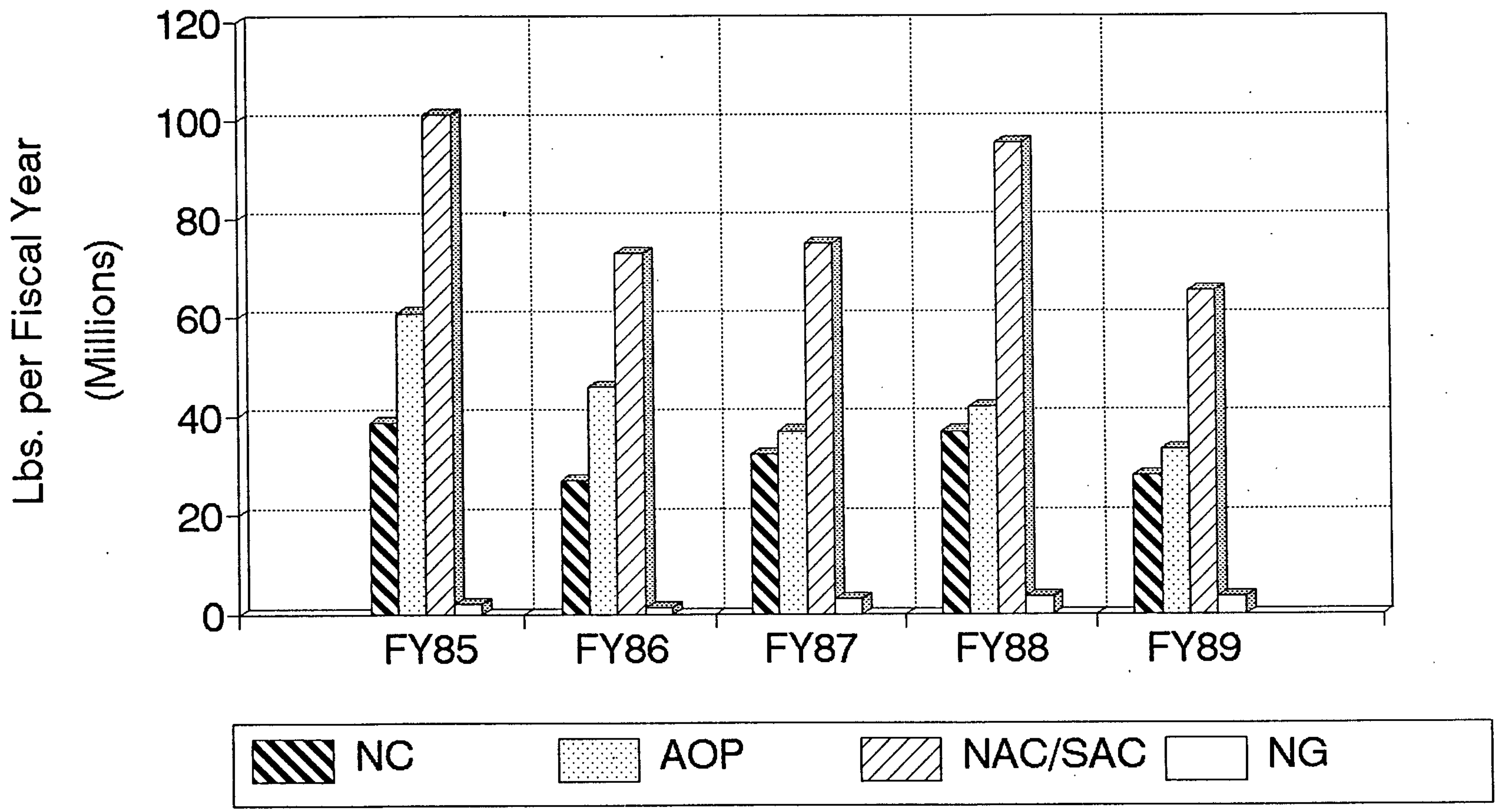


Figure 3-6

Radford Army Ammunition Plant
FY89 Production Quantities

Total = 129,941,696 lbs.

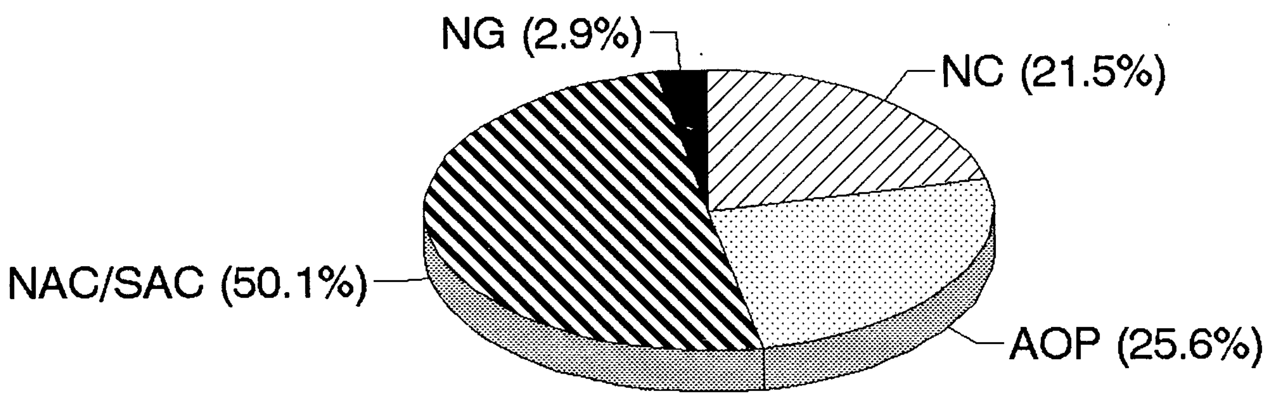


Figure 3-7

Where:

HDD	=	heating degree-days (base 65°F)
NC	=	nitrocellulose production (lbs)
AOP	=	ammonia oxidation production (lbs)
NAC/SAC	=	concentrated acid production (lbs)
R^2adj	=	R^2 adjusted for the number of variables and observations thereby providing an unbiased estimate

Figures 3-8 and 3-9 show the comparisons of the measured energy consumption to that calculated using the above equations.

The consumption of coal for the fiscal years 1985 to 1989 was most dependent on production, specifically that of NC. The total consumption of coal over the five-year period was approximately 21,172,000 MBtu; according to equation (1), approximately 5,505,000 MBtu, or 26 percent was due to weather; 9,955,300 MBtu, or 47 percent was related directly to production; and 5,711,700 MBtu, or 27 percent was not dependent on either (Figure 3-10).

The strongest correlation found for electricity was with the ammonia oxidation process (AOP) and the acid-concentration processes (Figure 3-9). There is no significant correlation of electricity use with weather.

Total electricity use at RAAP during the five-year period was 2,687,500 MBtu; equation (2) shows that 1,074,800 MBtu (40 percent) was related to AOP and NAC/SAC production, while 1,612,700 MBtu (60 percent) represents a yearly constant use (Figure 3-11).

When summarized, significant energy use at RAAP can be divided into three components, each of which offer opportunities for savings. The three components are:

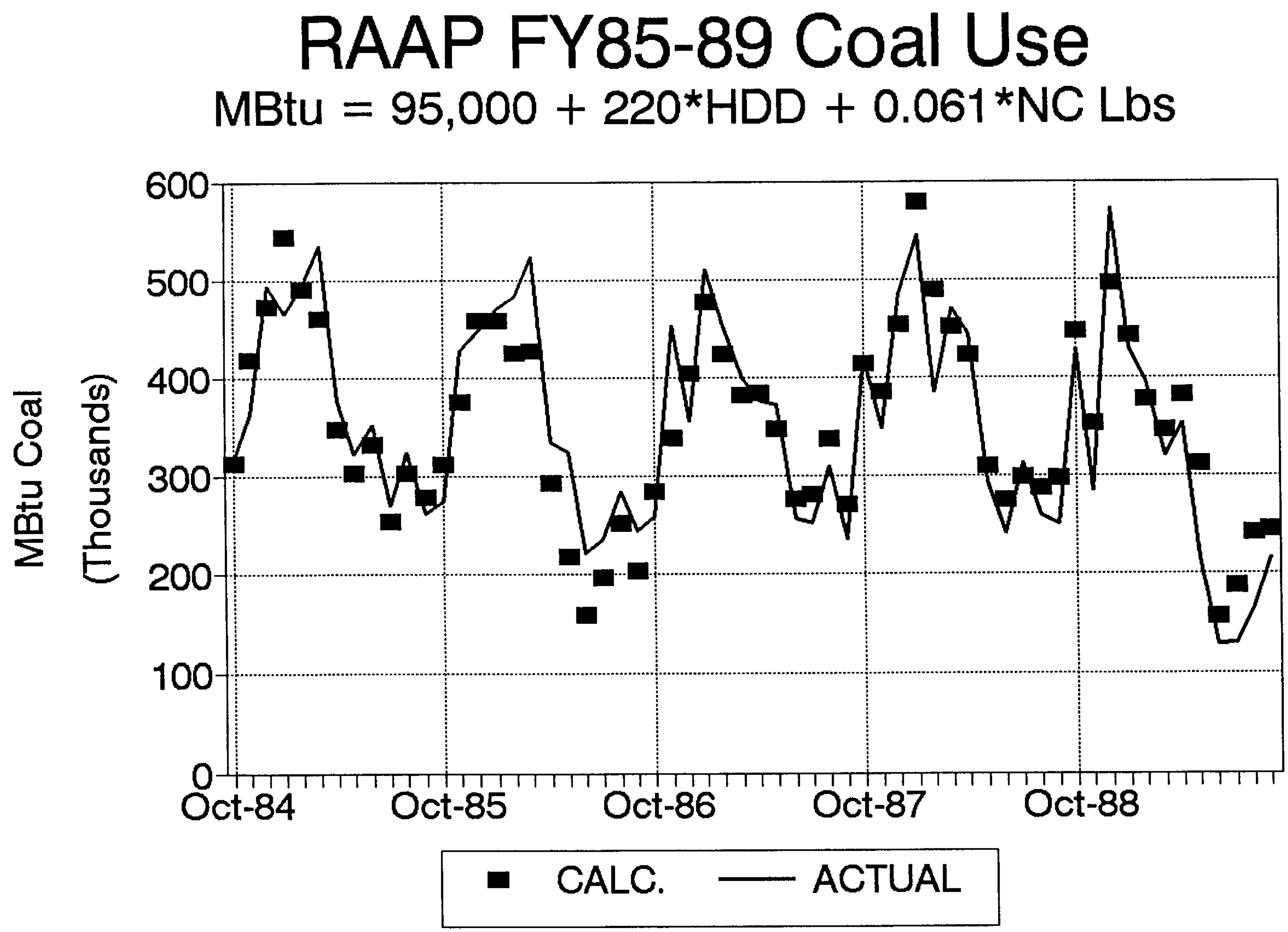

RAAP FY85-89 Coal Use
MBtu = 95,000 + 220*HDD + 0.061*NC Lbs
MBtu Coal
(Thousands)
600
500
400
300
200
100
0
Oct-84
Oct-85
Oct-86
Oct-87
Oct-88
CALC.
ACTUAL

Figure 3-8

RAAP FY85-89 Electricity Use

MBtu = 26800 + 0.00171*Lbs(AOP+NAC/SAC)

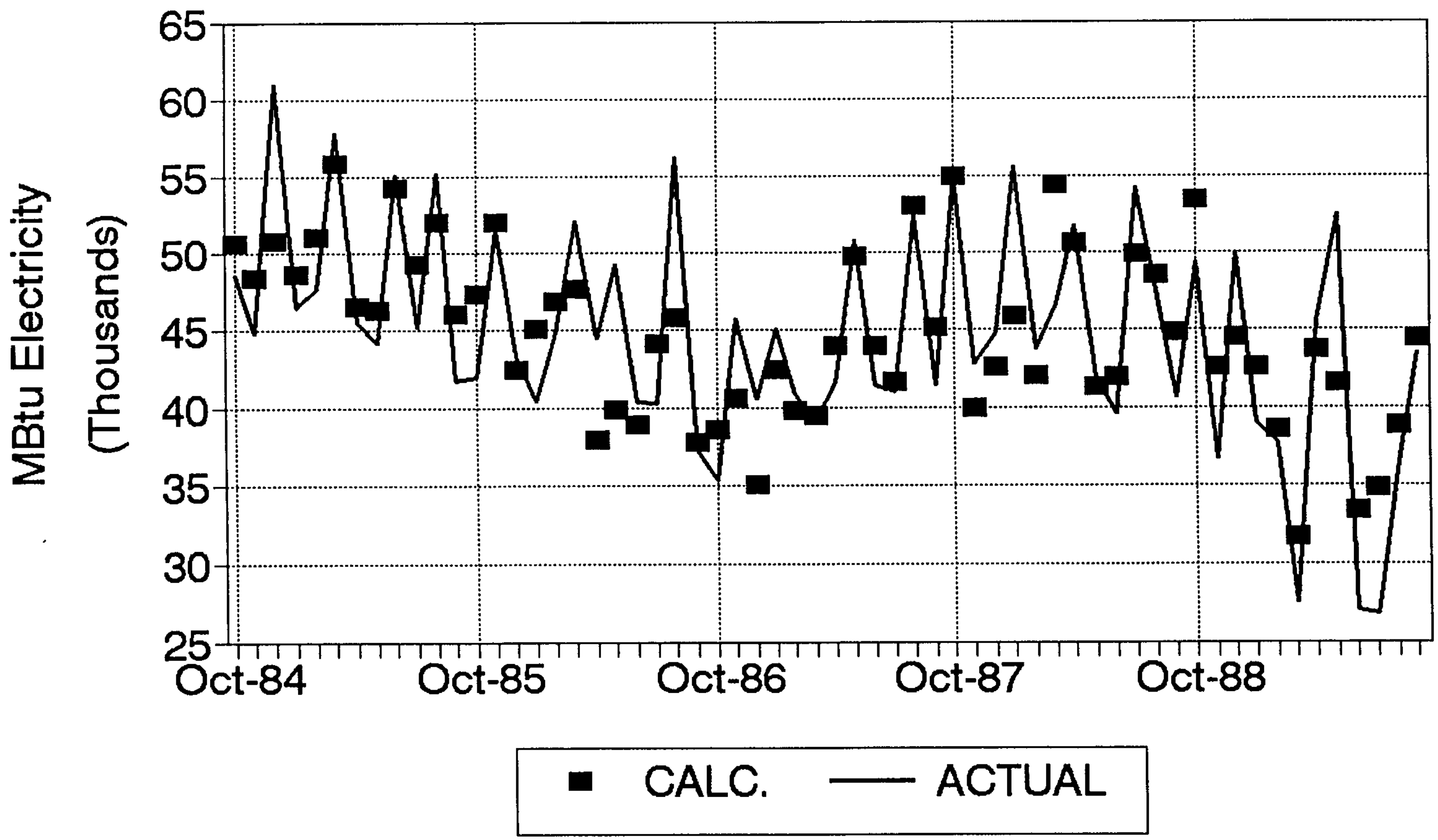


Figure 3-9

Radford Army Ammunition Plant

FY85-89 Coal Consumption Components

Total = 21,172,000 MBtu

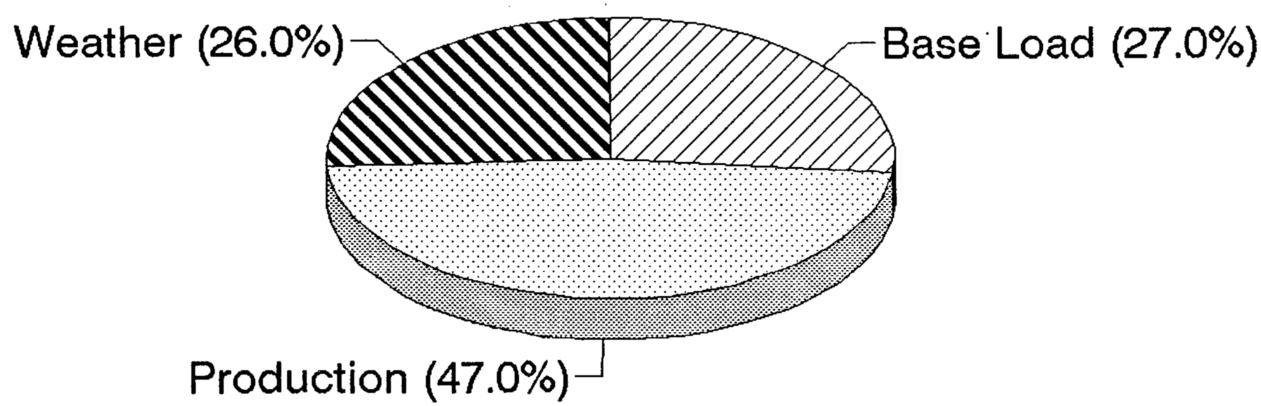


Figure 3-10

Radford Army Ammunition Plant

FY85-89 Elect. Consumption Components

Total = 2,687,500 MBtu

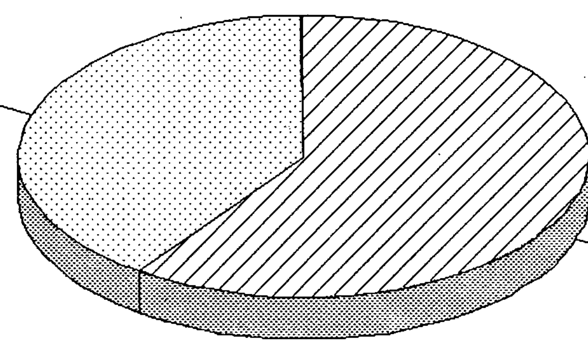


Figure 3-11

1. Production-related--over 40 percent of the variations in coal and electricity use at RAAP are directly related to changes in production. This is not a contradiction of the 86 percent process energy use fraction calculated in Section 2.3 using RAAP sub-metered data. Energy use was labelled process energy in Section 2.3 because it was used in production buildings. Therefore it included many uses that do not vary with production, such as, lighting and space heating.
2. Weather-related--over 26 percent of coal use is directly related to variances in cold weather. This is not surprising, since the use of building insulation is greatly restricted in an ammunition plant.
3. Constant energy use--the remainder of energy use, approximately 27 percent of coal and 60 percent of electricity, is more or less independent of any variations in weather or production. This represents such items as lighting and production standby heating and electrical requirements.

4.0 ENERGY CONSERVATION ANALYSIS

4.1 Energy Conservation Opportunity (ECO) Assessment

Each of the ECOs listed in the Scope of Work plus others were reviewed for their applicability and potential for significant energy savings and cost effectiveness for buildings representative of high energy consumption production areas at RAAP. The buildings actually surveyed vary from the list in the scope of work, but the intent of the survey was accomplished--to survey and investigate energy savings in the major energy users in all active production areas. The results of this assessment are contained in tables in Appendix B of Volume I.

For each of the ECOs that were chosen to be evaluated, energy savings were calculated, cost estimates made and life cycle cost analyses performed. A summary of the results are contained in Tables 4-1 and 4-2. The evaluated ECOs are described and listed alphabetically by process area in Table 4-1. Note that Net Cost Savings includes additional purchased electricity and all non-energy savings (costs). An alphabetical listing of evaluated ECOs along with a summary of the energy and cost savings analysis is shown in Table 4-2. Table 4-3 contains a listing prioritized by SIR. Table 4-4 contains a list prioritized by simple payback.

4.2 EEAP Study Update

An Energy Engineering Analysis Program (EEAP) was accomplished by Hayes, Seay, Mattern and Mattern and documented in a report dated January 1982. Three projects were recommended that are to be updated in this report:

- o T-102-G, Replacement and installation of gate valves
- o T-108, Change house modifications
- o WO-114G, Water dry tank covers

Table 4-1. ECOs Evaluated - Titles

#	ECO #	Description
1	FN-U-1	Cover water dry tank surface with insulating spheres
2	FN-U-2	Insulate fiberglass water dry tanks
3	GP-B-1	Install energy efficient motors
4	GP-B-2	Install energy efficient motors - upon failure
5	GP-B-3	Install energy efficient motors instead of rewind
6	GP-B-4	Install variable frequency drives on plant water pumps
7	GP-D-1	Replace existing IGG with heat recovery type
8	GP-D-2	Install condensing heat exchanger at Power House #1
9	GP-N-1	Replace incandescents with 35W HPS screw-ins
10	GP-N-2	Replace incandescents with Circline fluorescents
11	GP-N-3	Replace exterior incandescents with fluorescents
12	GP-N-4	Replace 40W fluorescents with 34W
13	GP-N-5	Replace lamps and ballasts with energy efficient types
14	GP-N-6	Replace incandescents with HPS fixtures
15	GP-N-7	Replace inefficient ballasts
16	GP-N-8	Replace incandescents with color-corrected HPS screw-ins
17	GP-N-9	Replace 40W fluorescents with 34W upon failure
18	GP-N-10	Replace inefficient ballasts upon failure
19	GP-W-1	Install vinyl strip door curtains
20	GP-X-1	Reduce exhaust gas temperature in incinerator
21	GP-X-2	Reduce water flow into incinerator
22	GP-X-3	Reduce incinerator excess air
23	GP-X-4	Install turning vanes in boiler ductwork
24	GP-X-5	Install thermostat control system in motor houses
25	GP-X-6	Change incinerator fuel to natural gas
26	MF-X-1	Install preheat coil controls in FADs
27	NC-U-1	Insulate boiling and poacher tubs
28	NC-X-1	Modify boiling tub heating method
29	SR-I-1	Remove steam coils in Activated Carbon Area

Table 4-2. ECO Evaluations - Results

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07
2	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75
3	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
4	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
5	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--
6	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
7	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
8	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
11	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
12	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
13	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
14	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
15	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
16	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
17	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
18	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
19	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00
20	GP-X-1	***		0	0	18,308	0	$78,175	***	***
21	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
22	GP-X-3	***		0	0	18,572	0	$79,300	***	***
23	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
24	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33
25	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
26	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16
27	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84
28	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97
29	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20

* On a per unit basis at time of failure.
** On a per unit basis.
*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 4-3. Results Of ECO Evaluations - Prioritized By SIR

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	GP-X-3	***		0	0	18,572	0	$79,300	***	***
2	GP-X-1	***		0	0	18,308	0	$78,175	***	***
3	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
4	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97
5	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20
6	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
7	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
8	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
11	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
12	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
13	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00
14	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07
15	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
16	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
17	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33
18	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
19	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84
20	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
21	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75
22	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
23	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
24	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
25	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16
26	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
27	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
28	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--
29	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--

* On a per unit basis at time of failure.
** On a per unit basis.
*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 4-4. Results Of ECO Evaluations - Prioritized By Simple Payback

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	GP-X-3	***		0	0	18,572	0	$79,300	***	***
2	GP-X-1	***		0	0	18,308	0	$78,175	***	***
3	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
4	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20
5	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97
6	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
7	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00
8	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
11	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
12	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
13	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
14	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
15	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07
16	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
17	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
18	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
19	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33
20	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84
21	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
22	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
23	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
24	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75
25	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16
26	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
27	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
28	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
29	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Replacement and Installation of Gate Valves

The project involves replacement of 137 gate valves and installation of one new valve in the "A" line powder area and four in the (Increment No. 1) first rolled powder area.

All known valves that were leaking have been either repaired or replaced by Hercules. Steam is now "valved off" to prevent flow to unneeded areas or buildings.

Change House Modifications

This project called for the installation of new fluorescent lighting to replace existing incandescent systems. This project has been accomplished.

Water Dry Tank Covers

Water dry tanks are open to the atmosphere, allowing heated water vapor and ether to escape during the drying cycles. This project would provide a fiberglass tank cover designed to collect the ether. Chilled water coils would condense the ether on the underside of the cover allowing the liquid ether to return to the tank.

This project has been rejected by RAAP engineering staff as not meeting existing safety requirements.

4.3 Operations and Maintenance Energy Savings

As a result of the site visits to Radford AAP, several operations and maintenance (O&M) energy savings ideas were identified. Energy and economic analyses were performed. The results of these analyses are presented below.

- Upon Failure, Rewind or Purchase a New Energy-Efficient Motor

The current practice is to rewind all motors unless the cost of the rewind is greater than 50 percent of the cost of a new motor. Analysis shows that this decision depends on the motor utilization. For one-shift operation, the cost of rewind would have to be greater than 75 percent of the cost of a new energy-efficient motor. For a two-shift operation, the 50-percent value is reasonable. For three-shift operation, it is economical to purchase new motors if the cost of rewind exceeds 25 percent for motors less than 200 horsepower.

- Upon Failure, Replace Standard Fluorescent Lamps with Energy-Efficient Types

Current practice is to replace failed fluorescent lamps with standard 40 W lamps. Replacing failed lamps with 34 W lamps saves about $1.13 per year for each lamp based on 6,240 hour/year operation. The incremental cost is the difference between the cost of the two lamps, which is $0.75 per lamp. This yields a payback of about 8-1/2 months.

- Upon Failure, Replace Standard Fluorescent Fixture Ballasts with Energy-Efficient Types

Currently, fluorescent fixtures use standard ballasts. By replacing these ballasts with energy efficient types when they fail, installation charges are avoided and a 20-percent reduction in energy use is accomplished.

Estimated savings are about 13 watts per two-lamp fixture or $2.45 per fixture per year based on 6,240 hour/year operation. The cost is the difference between energy-efficient and standard ballasts, which is about $6.67 per ballast. This yields a simple payback of 2.7 years.

- Upon Failure, Replace Standard Electric Motors with Energy-Efficient Types

The current policy is to replace a failed motor that cannot be economically repaired with a standard type. Energy-efficient motors offer efficiency improvements of three to nine percent and carry a cost premium of 50 to 60 percent over standard motors. The cost-effectiveness of this policy depends on the utilization of the motor. The results indicate that energy-efficient types should be purchased for all motors operating greater than one shift per day.

- Reduce the Exit Gas Temperatures on the Waste Propellant Incinerators

Waste propellant is carried to the incinerators mixed with water. Fuel oil is burned to evaporate this water and incinerate the waste propellant. The existing practice is to operate the incinerator at an exit gas temperature of about 1400°F. This temperature can be lowered by reducing the fuel oil flow to the burners. If the exit gas temperature is reduced to 500°F, the annual energy savings are $78,000. The existing permits may not allow this temperature reduction, but at $78,000 per year, it is worthwhile to pursue modifying the permit.

- Reduce the Amount of Oxygen in the Waste Propellant Incinerator Exit Gas

The waste propellant incinerator currently operates with an exit gas oxygen level of 15 percent. Efficient operation of #2 fuel oil combustion equipment requires about three percent oxygen. Reducing this level by a simple adjustment of the combustion controls will save about $80,000 per year.

- Power House #1 Operation

Power House #1 generates both steam and electricity for Radford AAP. It is the current practice to generate steam required to meet the plant demands. The resulting power generated by supplying steam turbines 400 psia steam is also utilized by the plant. The balance is purchased from the utility.

There are two types of turbines, backpressure (non-condensing) and condensing. The amount of steam sent to the condensing stage is minimized, since this is the least efficient stage of the turbine. Also, excess condensing during low power demand periods could cause Radford AAP purchases to fall below its contracted minimum of 7,800 kW.

However, an analysis of the turbine/generator performance curves supplied by Radford shows that if the flow to the condensing section is small enough, the efficiency of that stage drops rapidly. The shape of this curve indicates that flow to the condensing section should never drop below 15,000 pounds per hour and should probably remain around 20,000 pounds per hour. Operating at 10,000 pounds per flow to the condenser could cost up to $110,000 annually.

4.4 Low Cost/No Cost Projects

During the site survey, several low cost/no cost energy conservation opportunities were found. These were grouped by project type and evaluated for cost effectiveness. Each is analyzed separately and the results are contained in Table 4-5.

There are five basic project types:

LCNC 1: Repair Steam Leaks

LCNC 2: Turn Off Unneeded Lights

LCNC 3: Repair Steam Pipe Insulation

LCNC 4: Turn Off Steam When Not Needed

LCNC 5: Repair Leaking Compressed Air Valve

Table 4-5. Low Cost/No Cost Projects

Number	Cost	Energy Savings (MBtu/year) Coal	Electric	Energy Cost Savings
LCNC-1	$9,642	$7,260	--	$5,584
LCNC-2	--	--	150	1,325
LCNC-3	1,657	342	--	263
LCNC-4	--	384	--	296
LCNC-5	86	--	84	742
TOTALS	$11,385	$7,986	$234	$8,210

LCNC-1 = Repair steam leaks
LCNC-2 = Turn of unneeded lights
LCNC-3 = Repair steam pip insulation
LCNC-4 = Turn off steam when no needed
LCNC-5 = Repair leaking compressed air valve

5.0 ENERGY PLAN

5.1 Project Packaging

The ECOs listed in Table 4-2 were evaluated for appropriate funding category. The project scope of work listed the following guidelines on this subject.

	Project Cost	Simple Payback
QRIP	< $100,000	≤ 2 yrs.
OSD PIF	> $100,000	≤ 4 yrs.
PECIP	> $ 3,000	≤ 4 yrs.
ECAM	---	≤ 10 yrs., SIR > 1.0

AMCCOM provided the following changes for AMC installations in general and to be used for Radford AAP.

	Project Cost	Simple Payback
QRIP	$5,000-$100,000	≤ 2 yrs.
OSD PIF	> $100,000	≤ 4 yrs.
PECIP	> $100,000	≤ 4 yrs.
ECAM	---	≤ 10 yrs., SIR > 1.0

Form 1391 is required only for those ECAM projects costing greater than $200,000.

Table 5-1 contains the results of the analysis with the project funding category listed in the far right column. Projects GP-W-1 and NC-U-1 were not recommended because of safety concerns of RAAP Safety Division. Table 5-2 lists the ECOs by project funding category.

Based on guidance from Hercules Project Administration, the QRIP and OSD PIF forms were completed and are found in Volume IV. Those ECOs qualifying for ECAM funding are submitted by RAAP on an annual basis under the program named Production Support and Equipment Replacement. For ECAM projects, Radford requested that only the project discussion, economic analysis and calculations backup be provided.

Table 5-1. Results Of ECO Evaluations - Project Funding

#	ECO #	Construction Cost Plus SIOH	Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR	Project Funding
1	GP-X-3	***	0	0	18,572	0	$79,300	***	***	-
2	GP-X-1	***	0	0	18,308	0	$78,175	***	***	-
3	GP-X-2	$14,830	0	0	3,942	0	$16,832	0.84	20.36	QRIP
4	SR-I-1	$17,932	1,576	0	0	0	$13,979	1.22	7.20	QRIP
5	NC-X-1	$122,374	0	123,431	0	0	$94,927	1.23	8.97	QRIP
6	GP-N-3	$22,667	1,024	0	0	0	$15,770	1.37	6.52	QRIP
7	GP-W-1	$19,251	0	16,055	0	0	$12,348	1.48	3.00	NR
8	GP-X-4	$40,512	2,480	0	0	0	$21,998	1.67	6.83	QRIP
9	GP-N-1	$132,467	4,003	0	0	0	$65,833	1.91	4.67	OSD PIF
10	GP-B-4	$195,266	10,940	0	0	0	$96,994	1.91	4.59	OSD PIF
11	GP-N-2	$13,766	371	0	0	0	$6,416	2.04	4.38	ECAM
12	GP-X-6	$263,750	0	0	86,217	(86,217)	$78,457	3.20	4.80	OSD PIF
13	GP-D-2	$1,529,750	-695	215,204	0	0	$340,000	4.28	3.13	NR
14	GP-N-8	$155,150	2,354	0	0	0	$31,081	4.80	1.87	ECAM
15	FN-U-1	$52,643	0	12,258	0	0	$9,427	5.31	2.07	ECAM
16	GP-D-1	$289,627	0	24,475	0	0	$39,876	6.91	1.45	NR
17	GP-N-4	$8 **	0.13	0	0	0	$1	7.38	0.35	NR
18	GP-N-6	$533 **	2	0	0	0	$44	11.40	1.01	NR
19	GP-X-5	$42,488	0	4,602	0	0	$3,540	11.42	1.33	NR
20	NC-U-1	$70,271	0	6,674	0	0	$5,133	13.02	0.84	NR
21	GP-B-1	$1,737,092	12,827	0	0	0	$113,724	14.53	0.78	NR
22	GP-N-5	$87 **	0.58	0	0	0	$5	16.16	0.70	NR
23	GP-N-7	$59 **	0.39	0	0	0	$4	16.30	0.69	NR
24	FN-U-2	$45,905	0	2,822	0	0	$2,170	20.12	0.75	NR
25	MF-X-1	$64,219	0	706	0	0	$933	65.50	0.16	NR
26	GP-N-9	$1 *	0.13	0	0	0	$1	0.70	--	-
27	GP-N-10	$7 *	0.28	0	0	0	$2	2.70	--	-
28	GP-B-2	$369-$7,596 *	10-177	0	0	0	$85-$1600	2.9-5.8	--	-
29	GP-B-3	$580-$13,293 *	10-171	0	0	0	$85-$1513	5.2-9.0	--	-

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 5-2. Project Funding List

ORIP

- GP-X-2 - Reduce Water Flow to Incinerator (one unit only)
- SR-I-1 - Remove Steam Coils in Activated Carbon Area
- GP-N-3 - Replace Exterior Incandescents with Fluorescents
- GP-X-4 - Install Turning Vanes in Boiler Ductwork
- NC-X-1 - Modify Boiling Tub Heating Method (one tub only)

OSD PIF

- GP-B-4 - Install Variable Frequency Drives
- GP-N-1 - Replace Incandescents with 35W HPS Screw-Ins
- GP-X-6 - Change Incinerator Fuel to Natural Gas

ECAM

- FN-U-1 - Cover Water Dry Tanks with Insulating Spheres (one tank only)
- GP-N-8 - Replace Incandescents with Color-Corrected HPS Screw-Ins
- GP-N-2 - Replace Incandescents with Circline Fluorescents

5.2 Energy and Cost Savings

Energy and cost savings for the recommended project funding are listed in Table 5-3. The implementation of all projects yield a total annual energy savings of 160,023 MBtu and annual cost savings equal to $420,633. Low cost/no cost adjustments in the waste propellant incinerator (projects GP-X-1 and GP-X-3 in Table 4-4) yield another 36,880 MBtu and $157,475 annual energy and cost savings, respectively. This totals to 196,903 MBtu and $578,108 annual savings, which represents reductions of 4.7 percent and 6.0 percent, respectively. Figures 5-1 and 5-2 show energy use and cost, respectively, at Radford AAP before and after implementation of these projects.

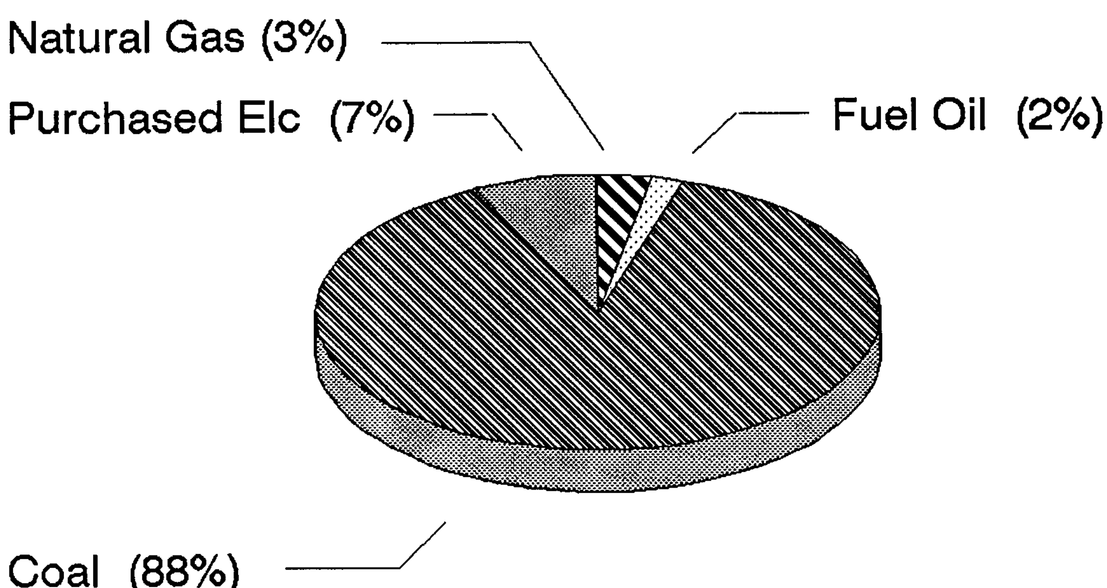
5.3 Project Schedule

Hercules Project Administration provided the following project implementation dates:

QRIP, OSD PIF and PECIP	FY92 (at earliest)
ECAM	FY95

Following this schedule, Figure 5-3 was developed to show the impact implementation the recommended projects would have on energy use at RAAP. QRIPs for one unit only would be implemented in FY92 with the remainder in FY95.

Radford Army Ammunition Plant
After Project Implementation



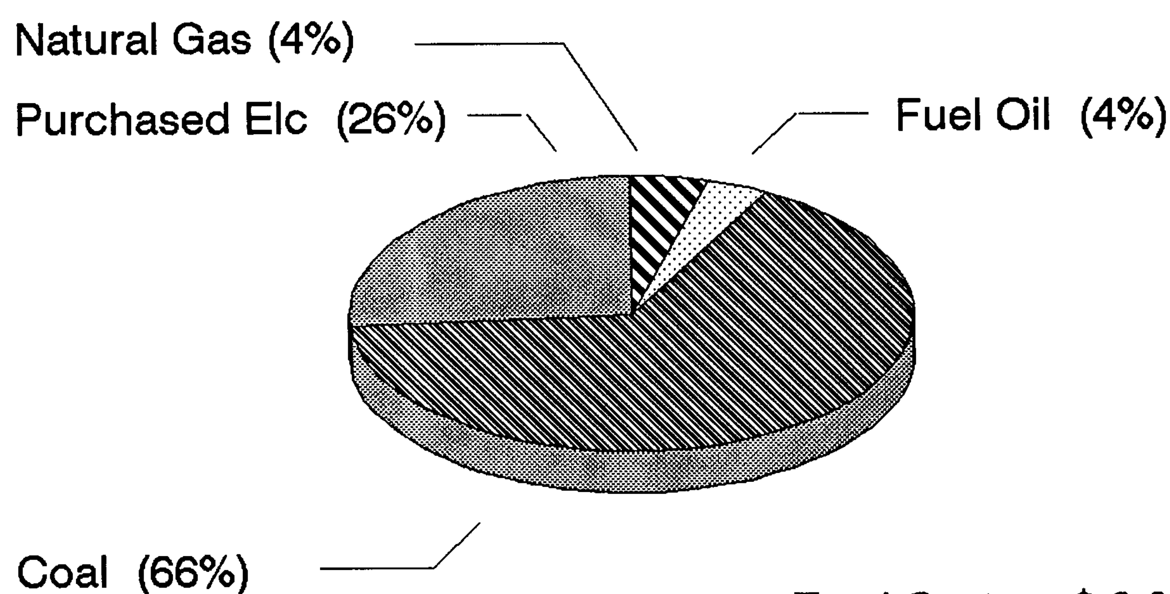
Total Use = 3,980,373 MBtu

Does not include mobility fuels.

Figure 5-1

3/91

Radford Army Ammunition Plant
After Project Implementation



Total Cost = $ 9,077,770

Does not include mobility fuels.

Figure 5-2

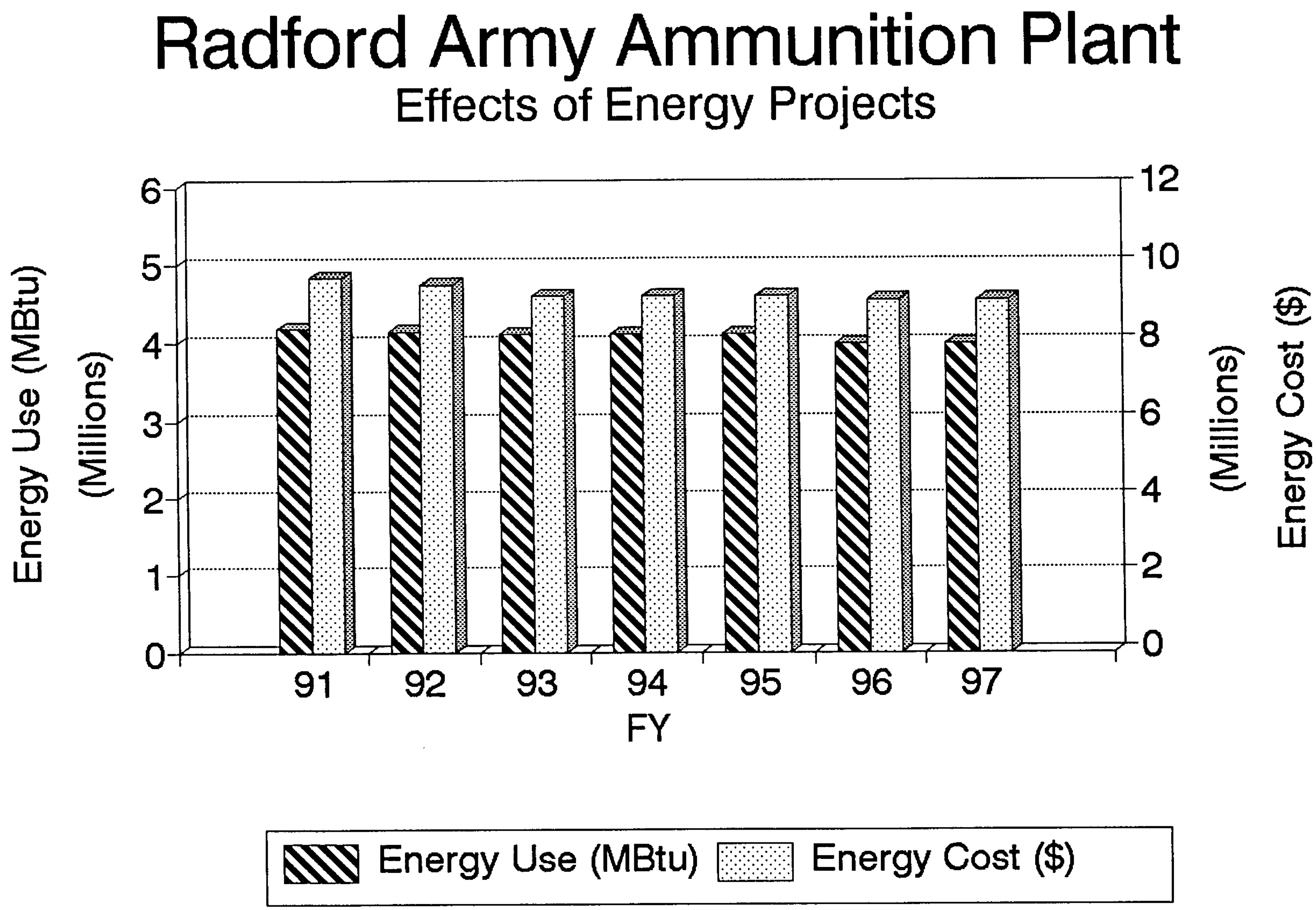

Radford Army Ammunition Plant
Effects of Energy Projects
Energy Use (MBtu)
(Millions)
0
1
2
3
4
5
6
Energy Cost ($)
(Millions)
0
2
4
6
8
10
12
91
92
93
94
95
96
97
FY
Energy Use (MBtu)
Energy Cost ($)

Figure 5-3