

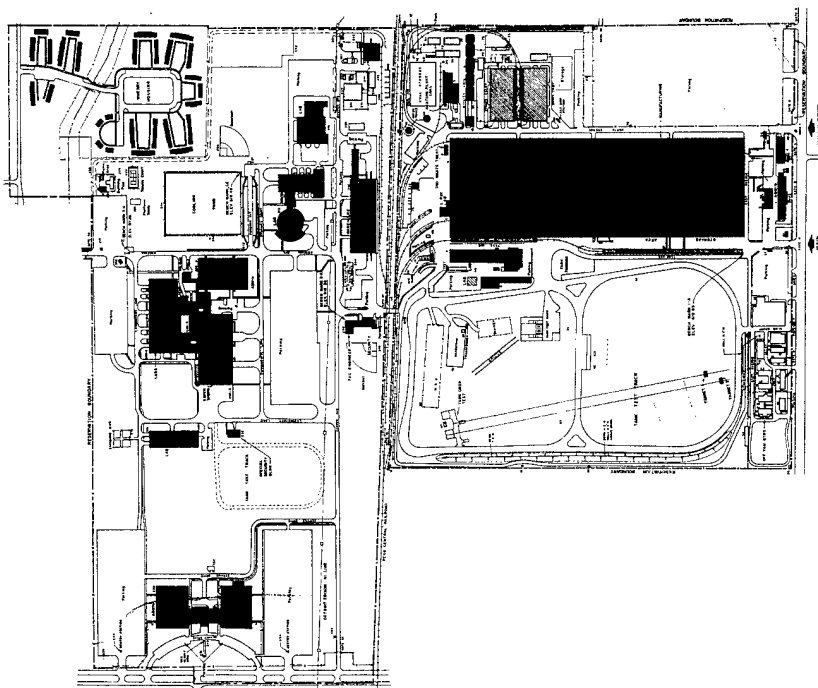
ENERGY ENGINEERING ANALYSIS PROGRAM

FINAL REPORT – INCREMENTS A, B, D, F AND G

VOLUME 1 – EXECUTIVE SUMMARY

U. S. ARMY

DETROIT ARSENAL, MICHIGAN



PREPARED FOR:
U. S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT

DIX QUALITY IMPROVEMENT

PROJECT A1-30-20
CONTRACT NO. DACA45-80-C-0091

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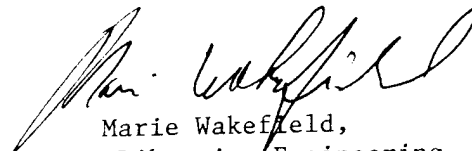


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A1-30-20
FINAL REPORT
VOLUME 1 - EXECUTIVE SUMMARY

ENERGY ENGINEERING ANALYSIS PROGRAM
INCREMENTS A, B, D, F AND G
DETROIT ARSENAL
AND
SATELLITES

CONTRACT NO. DACA45-80-C-0091

Prepared by
GARD, INC.
Niles, Illinois 60648

For
Department of the Army
Corps of Engineers
Omana District

September, 1983

PREFACE

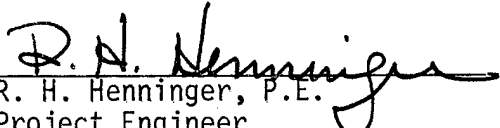
This Final Report summarizes all work accomplished under Increments A, B, D, F and G of the Energy Engineering Analysis Program conducted at the Detroit Arsenal (DA) in Warren, Michigan and Satellite Operations at Arsenal Acres, Pontiac Storage Facility and Keweenaw Field Station. The tasks assigned under these Increments have been completed and are documented within.

The study objective was to develop a systematic plan of projects that would result in the reduction of energy consumption in compliance with the Army Facilities Energy Plan (AFEP) and to prepare Project Development Brochures (PDB's), DD Forms 1391 and supporting documentation for those projects deemed feasible. The projects developed as a result of this study are described in this report. Project Development Brochures and DD Forms 1391 have been prepared in accordance with Army procedures and are bound separately.

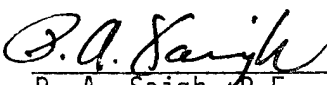
GARD has sincerely appreciated the cooperation that has been extended by members of the Omaha District, Corps of Engineers especially the Program Managers, Mr. S. Owens and Mr. E. Liu, and the Facilities Engineering staff of DA headed previously by Mr. R. Lang and currently by Mr. W. Chaudoin.

The GARD project team that conducted this study included K. Spaulding, M. Hormann, C. Schafer, N. Leslie, R. Hedrick and M. Hagen.

Respectfully submitted,


R. H. Henninger, P.E.
Project Engineer

Approved by:


P. A. Saigh, P.E.
Director, Government Programs

ADDENDUM TO FINAL REPORT

The reader's attention is directed to the following which has taken place since submittal of the Advanced Final Reports for Increments A, B, D, F and G.

1. In response to Revised ECIP Guidance issued 12/31/82, the Omaha District, Corps of Engineers has reviewed and revised all of the ECIP calculations for each of the five qualifying projects for which PDBs and DD 1391s have been prepared. Appropriate changes have been made in pertinent sections of the Project Development Brochures and DD Forms 1391 only. All of the ECOs that are part of ECIP Projects No. A-1, A-2, B-1, B-2 and D-1, still qualify when evaluated under the new ECIP guidelines. The Main Report as well as the Executive Summary have not been revised to include the new SIR calculations.
2. Recently, Modification 4 has been authorized. This new work will address Increments A, B, F and G for five additional buildings at DA, i.e., Buildings 229, 231, 249, 250 and 252. The results of this work will be covered by a separate Final Report.

EXECUTIVE SUMMARY
ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)
INCREMENTS A, B, D, F AND G
DETROIT ARSENAL AND SATELLITES

Authorization for Study

This Energy Engineering Analysis Program (EEAP) for Detroit Arsenal and supported satellites at Arsenal Acres, Pontiac Storage Facility and Keweenaw Field Station was conducted under Contract No. DACA45-80-C-0091 issued by the Omaha District, Corps of Engineers to GARD, INC., Niles, Illinois on the 13 August 1980. The Scope of Work was structured into work increments with Increments A and B authorized under the original contract, Increment G authorized under Modification 1 dated 3 March 1981 and Increments B (expanded EMCS), D and F authorized under Modification 2 dated 20 May 1982.

Objectives and Scope

As stated in the EEAP Scope of Work the overall objectives were:

- a) "Develop a systematic plan of projects that will result in the reduction of installation energy consumption in compliance with the Army Facilities Energy Plan."
- b) "Develop Coordinated Basewide Energy System Plans."
- c) "Prepare Project Development Brochures (PDBs), DD Forms 1391 and supporting documentation for all feasible energy conservation projects."

The Scope of Work further defined the objectives and scope of each work increment to be as follows:

Increment A - ECIP* Projects for Buildings and Processes

*ECIP - Energy Conservation Investment Program

Increment B - ECIP Projects for Utilities, Energy Distribution Systems
and Energy Monitoring and Control Systems (EMCS)

Increment C - Renewable Energy Systems Projects

Increment D - Cogeneration and Solid Waste Plants Projects

Increment E - Central Boiler Plant Projects

Increment F - Facilities Engineer Conservation Measures

Increment G - Projects Identified in Increments A and B that do not
qualify under ECIP criteria

This submittal presents the final results for Increments A, B, D, F
and G through a description of those energy conservation opportunities
(ECOs) and ECIP projects that were identified and evaluated as part of
these work increments. Increments C and E have not been authorized at
this time for Detroit Arsenal.

Approach

Numerous retrofit modifications referred to as energy conservation oppor-
tunities (ECOs) were identified for each building, system, and central plant
studied. Each ECO was evaluated separately using the life cycle costing
method described in the ECIP guidance included as Annex F of the AFEP. Energy
savings were determined for each ECO and life cycle benefits were calculated
using current mid FY82 fuel costs, which were escalated over the expected
life of the modification. Implementation or construction costs were also
determined using current FY82 cost data which were escalated to the midpoint
of construction assuming an FY86 project award date. Comparison of ECOs
was done on the basis of energy-to-cost (E/C), benefit-to-cost (B/C), and

simple amortization period (SAP) ratios in accordance with ECIP criteria. Qualifying ECOs were grouped into ECIP projects under the guidance of the Facilities Engineering Staff. Then, once adjustments were made for any interactive or synergistic ECO effects which were present within an ECIP project, the PDB and DD Form 1391 were prepared for each ECIP project. Non-qualifying ECOs became candidates for implementation as an Increment F or G project.

Facility Description

Detroit Arsenal (DA) is situated in Warren, Michigan just north of Detroit and is headquarters for the U.S. Army Tank-Automotive Command (TACOM). TACOM is responsible for the acquisition and readiness of combat and tactical vehicles. To this end, it supports government owned and contractor operated (GOCO) manufacturing plants at DA and Lima, Ohio, an extensive storage facility for DoD industrial mobilization equipment near Pontiac, Michigan, R&D laboratories at DA and a GOCO research and vehicle testing center at Keweenaw Field Station near Houghton, Michigan. In addition, officer's quarters and military housing are provided on the DA site and at Arsenal Acres, an off-post housing area located two miles south of DA.

The Detroit Arsenal installation is composed of 105 buildings on 341 acres of land. The size of the buildings range from a 24 square foot guardhouse to a 1,114,000 square foot tank production facility. The east site (Figure 1) contains the tank production and field testing facilities along with quarters buildings, food services, maintenance shops and central heating plant. The west site (Figure 2) houses administration buildings, R&D laboratories, and storage buildings. A total of 41 buildings (Table 1) at DA were identified for study under this contract representing some 2,437,240 gross square feet and constituting the majority of buildings actively occupied

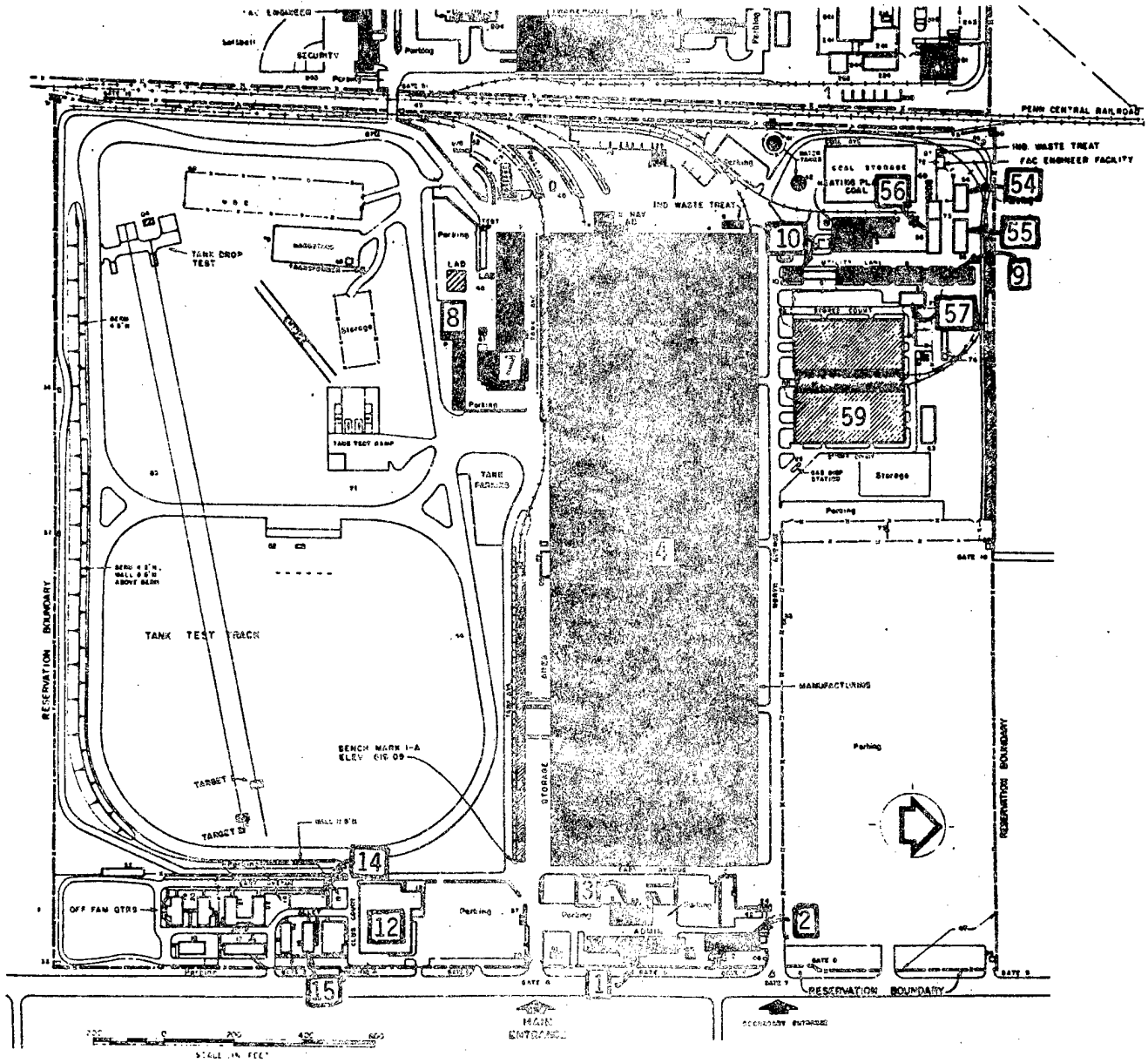


Figure 1 EAST SITE PLAN

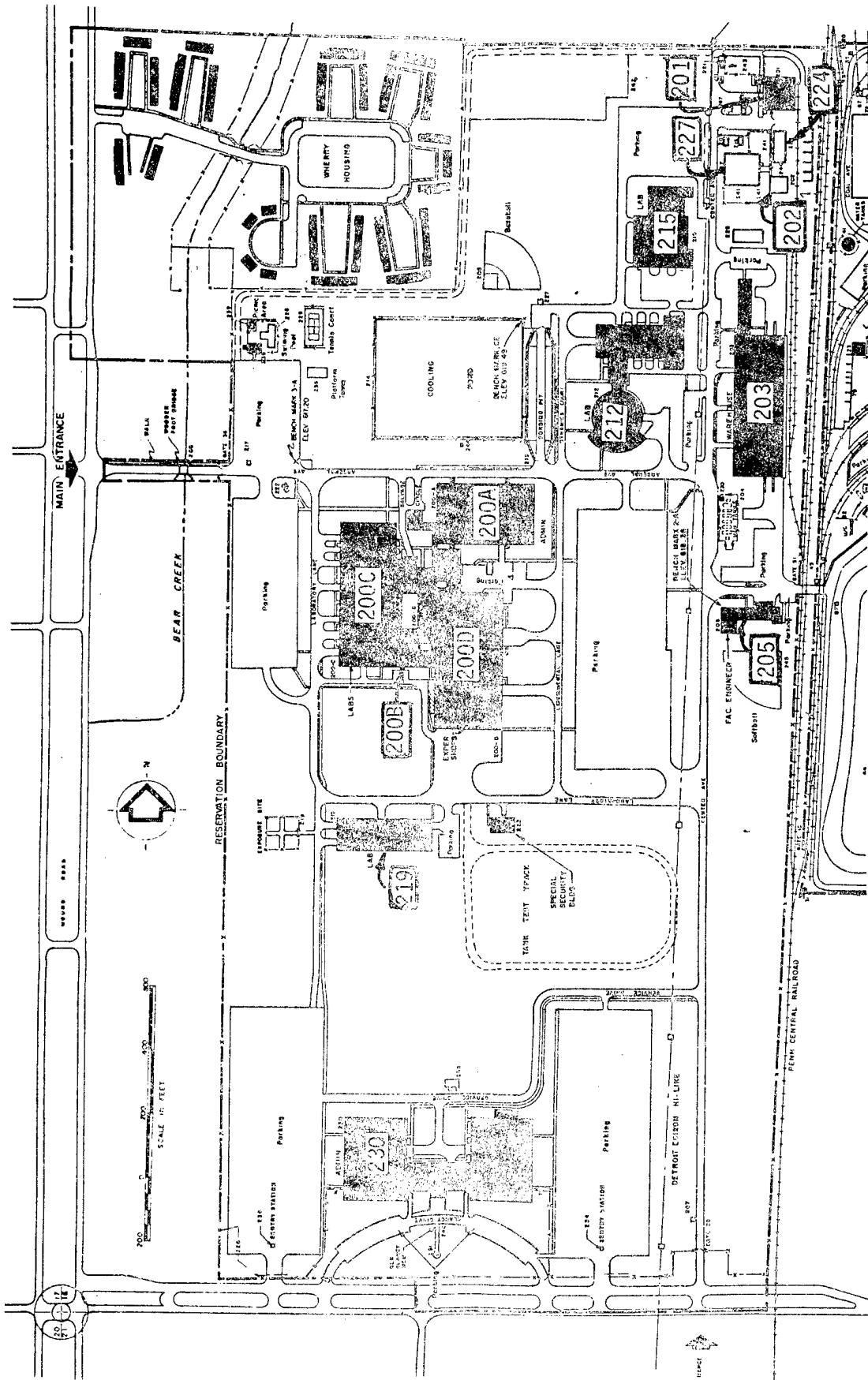


Figure 2 WEST SITE PLAN

TABLE 1
BUILDINGS DESIGNATED FOR STUDY AT
DETROIT ARSENAL

| Building Number | Title | Function | No. Floors | Gross Sq. Ft. |
|-----------------|---------------------------------|------------------------------------|------------|---------------|
| 1 | Administration | Administration/ General Purpose | 4 | 53,532 |
| 2 | Dispensary | Institutional | 1 | 7,540 |
| 3 | Telephone Exchange | Utility | 1 | 6,205 |
| 4 | Combat Vehicle Plant | Industrial | 1 | 1,114,381 |
| 5 | Central Heating Plant | Utility | 2 | 29,600 |
| 7 | Vehicle and Machine Repair | Industrial | 3 | 63,932 |
| 8 | Experimental Laboratory | Administration/ Research | 1 | 13,100 |
| 9 | Maintenance Shop | Service | 1 | 15,742 |
| 10 | FE Maintenance Shop | Service | 1 | 2,267 |
| 12 | Applied Instruction | Administration/ Training | 1 | 30,730 |
| 13 | Open Mess (Officer's Club) | Institutional | 1 | 5,369 |
| 14 | Open Mess (NCO) | Institutional | 1 | 4,172 |
| 15 | Bachelor's Enlisted Quarters | Housing | 2 | 4,478 |
| 17 | Family Housing | Housing | 1 | 2,879 |
| 18 | Post Exchange (PX) | Institutional | 2 | 4,500 |
| 40 | Track/Suspension Laboratory | Administration/ Research | 1 | 1,642 |
| 54 | FE Maintenance Shop | Service | 1 | 3,475 |
| 55 | FE Maintenance Shop | Service | 1 | 3,920 |
| 56 | FE Maintenance Shop | Service | 1 | 6,279 |
| 57 | Wash Rack/Storage | Service | 1 | 3,120 |
| 58 | General Storehouse | Storage | 1 | 49,960 |
| 59 | Lift Truck Repair | Service | 1 | 50,037 |
| 61 | FE Maintenance Shop | Service | 1 | 2,914 |

TABLE 1 (Con't.)
BUILDINGS DESIGNATED FOR STUDY AT
DETROIT ARSENAL

| Building Number | Title | Function | No. Floors | Gross Sq. Ft. |
|-----------------|---|------------------------------------|------------|---------------|
| 200A | Research & Development Activities | Administration/ General Purpose | 2 | 126,433 |
| 200B | Lecture Hall | Administration/ General Purpose | 2 | 49,544 |
| 200C | R & D Testing Laboratories | Administration/ Research | 1 | 82,265 |
| 200D | Experimental Shops | Administration/ Research | 1 | 112,461 |
| 201 | Printing Plant | Administration/ Communications | 1 | 10,466 |
| 202 | Roads and Grounds | Service | 1 | 2,450 |
| 203 | General Purpose Warehouse | Storage | 1 | 83,967 |
| 205 | FE Administration/ Fire/Security | Administration/ Special | 1 | 9,491 |
| 212 | Propulsion Systems Laboratory | Administration/ Research | 3 | 119,479 |
| 215 | Vehicle/Track and Suspension Laboratory | Administration/ Research | 1 | 45,268 |
| 219 | Model Shop | Administration/ Research | 1 | 30,400 |
| 224 | FE Maintenance Shop | Service | 1 | 3,920 |
| 225 | General Storehouse | Storage | 1 | 3,920 |
| 227 | Salvage and Surplus Storage | Storage | 1 | 12,000 |
| 228 | Swimming Pool | Institutional | 1 | - |
| 230 | TARCOM/TARADCOM Headquarters | Administration/ General Purpose | 2 | 264,474 |
| 232 | Cooling Tower | Utility | 1 | - |
| 238 | Bath House | Institutional | 1 | 968 |
| | | | | ----- |
| TOTAL | | | | 2,437,280 |

and presenting opportunities for saving energy.

The Arsenal Acres site covers 6.6 acres and has 7 family housing units, all of which were identified for study under this contract. Table 2 summarizes the general characteristics of each residence.

The Pontiac Storage Facility (PSF) includes 5 buildings totalling 607,633 square feet on a 31 acre site. Two buildings at PSF have been identified for study. These are listed in Table 3.

The Keweenaw Field Station (KFS) is an arrangement of 7 buildings located on a 27.3 acre tract of Houghton County Airport land in Michigan's upper peninsula leased by the Government. All KFS buildings were identified for study. Table 4 presents a summary of each building.

The current population for DA totals about 6,300 people. This level is not expected to vary significantly over the next five years. Population levels at the satellites have been steady at 6 to 7 families at Arsenal Acres, 5 people at PSF, and 15 people at KFS.

Energy Distribution Systems and Central Plants

The Detroit Arsenal utilizes three major forms of energy to support facilities operations: electricity, coal, and natural gas. Electricity is used for lighting, heating, cooling, ventilation, manufacturing, security, etc. systems. Coal and natural gas are utilized by the central heating plant to generate steam for heating, manufacturing and prime mover systems. Natural gas is also used as a source for heating and manufacturing systems. Table 5 summarizes the energy distribution systems that are in use at DA along with the central plants that supply these systems.

Electricity and natural gas are the only utilities distributed to Arsenal Acres. PSF utilizes fuel oil for heating as well as electricity. At KFS

TABLE 2
BUILDINGS DESIGNATED FOR STUDY AT
ARSENAL ACRES

| Building Number | Title | Function | No. Floors | Gross Sq. Ft. |
|-----------------|-------------------------------|----------|------------|-----------------|
| 301 | Commanding Officer's Quarters | Housing | 2 | 3,544 |
| 302 | Senior Officer's Quarters | Housing | 2 | 3,248 |
| 303 | Senior Officer's Quarters | Housing | 2 | 3,248 |
| 304 | Junior Officer's Quarters | Housing | 2 | 2,672 |
| 305 | Junior Officer's Quarters | Housing | 2 | 2,672 |
| 306 | Junior Officer's Quarters | Housing | 2 | 2,672 |
| 307 | Junior Officer's Quarters | Housing | 2 | 2,672 |
| TOTAL | | | | ----- 20,728 |

TABLE 3
BUILDINGS DESIGNATED FOR STUDY AT
PONTIAC STORAGE FACILITY

| Building Number | Title | Function | No. Floors | Gross Sq. Ft. |
|-----------------|-------------------------------|----------|------------|------------------|
| 1 | General Warehouse | Storage | 1 | 607,173 |
| 7 | Heating Plant and Water Tower | Utility | 1 | 363 |
| TOTAL | | | | ----- 607,536 |

TABLE 4
BUILDINGS DESIGNATED FOR STUDY AT
KEWEENAW FIELD STATION

| Building Number | Title | Function | No. Floors | Gross Sq. Ft. |
|-----------------|---------------------------------|------------------------------------|------------|-----------------|
| 1 | Research Facilities | Administration/ General Purpose | 1 | 8,971 |
| 2 | Vehicle Garage and Machine Shop | Service | 1 | 4,000 |
| 3 | Vehicle Storage | Storage | 1 | 5,600 |
| 4 | Vehicle Storage | Storage | 1 | 4,000 |
| 5 | Research & Testing Laboratory | Administration/ Research | 1 | 4,000 |
| 6 | Parts Storage | Storage | 1 | 1,000 |
| 7 | Parts Storage | Storage | 1 | 1,000 |
| TOTAL | | | | ----- 28,571 |

TABLE 5
DETROIT ARSENAL
DISTRIBUTION SYSTEMS AND CENTRAL PLANTS

| Energy Form | Source | Distribution System | End User |
|----------------|---|---|---|
| Electricity | Detroit Edison Co. | Primary Feeder @ 40 KV Secondary Feeders @ 4.8 KV | Substation A, Building 5 Specific Loads (Buildings, Perimeter Lighting, Tenants) |
| Electricity | Detroit Edison Co. | Primary Feeder @ 4.8 KV Secondary Feeders @ 240/ 120 V | Substation B, Building 12 Cantonment Area and Building 25 |
| Steam | Central Heating Plant Building 5 Capacity: 300,000 LB/HR Steam | Below Grade Pipes in Tunnels, Buried Pipes and Above Ground Pipes @ 175 psi | All buildings except sentry stations and Building 238 |
| Condensate | All buildings supplied with steam by Building 5 | Below Grade Pipes in Tunnels and Buried Pipes | Building 5 |
| Natural Gas | Consumers Power Co. | From Building 5 via Underground Pipes | East Site Buildings |
| Natural Gas | Consumers Power Co. | Underground Pipes | Buildings 200B, 200C, 200D, and 238 |
| Compressed Air | Compressor Plant - Building 5 | Below Grade Pipes in Tunnels and Buried Pipes 100 psi | Manufacturing and Administration Buildings |

electricity, natural gas, and fuel oil are used to support facility operations. Table 6 summarizes characteristics of each energy distribution system for the satellites.

Energy Conservation Actions Since FY75

DA recognized early the need for responsible energy management. When conservation goals were established in Executive Order No. 12003, DA responded by initiating several projects and programs.

The following list are examples of some of the energy conservation changes which have been made at DA, Arsenal Acres, and KFS.

Detroit Arsenal

- All thermostats for heating, air conditioning, and hot water systems were reset in accordance with Army standards.
- High efficiency lighting was installed in 2 manufacturing and service buildings.
- Thermostats and control valves were installed on steam radiators which were without existing individual controls.
- Two-step thermostats and valves were installed on unit heaters with only on/off controls in high bay areas.
- Outdoor weatherstats and valves were installed in the steam mains of 3 buildings to eliminate heating when outdoor temperature is above 45°F.
- Lighting levels were reduced to OSHA minimum where possible, e.g., stairwells, open office areas, and corridors.
- Overhead doors were replaced or removed and openings bricked up to reduce infiltration of 10 buildings.
- Roof insulation was installed on 5 buildings.

TABLE 6
ENERGY DISTRIBUTION SYSTEMS FOR SATELLITES

| | Energy Form | Source | Distribution System | End User |
|--------------------------|---|---|---|---|
| Arsenal Acres | Electricity Electricity Natural Gas | Detroit Edison Co. Detroit Edison Co. Consumers Power Co. | Primary Feeder @ 15.2 KVA Secondary Feeder @ 230/115 V Primary Feeder @ 15.2 KVA Secondary Feeder @ 230/115 V From Utility Bldg. via Underground Pipes | Buildings 301, 302, 303 Buildings 304, 305, 306, 307, Guardhouse, Streetlights All Buildings |
| Pontiac Storage Facility | Electricity Fuel Oil Hot Water Propane | Detroit Edison Co. Underground Storage Tanks Building 7 (BL-1) Capacity: 2512 LBS/HR Fuel: Fuel Oil | Primary Feeder @ 4800 V Aerial Line Buried Pipes Buried Pipes | Buildings 1, 2 and 7 Buildings 1 and 7 Building 6 Vehicles |
| Keweenaw Field Station | Electricity Natural Gas | Ontonago County Rural Electrification Association Michigan Power Co. | Aerial Lines Buried Pipes | Buildings 1, 2, 3, 5, 6 & 7 Buildings 1, 2 & 5 |

- Fiberglas insulation was installed on the walls of several metal buildings used for FE shops and storage.
- The window glazing and sash of 2 buildings were replaced with new insulating sash and thermopane windows.
- Sections of the steam supply and condensate return systems were replaced and/or insulated.
- Exterior walls were replaced with insulating panels in Buildings 200A and 215.
- The exterior windows of Building 4 were replaced with insulating panels.
- An EMCS system was installed to monitor, timeclock, and reset control points for the heating and cooling systems in 6 buildings.
- Load shedding controls were installed in 6 buildings.

Arsenal Acres

- Insulation was installed in attic of each residence.

Keweenaw Field Station

- Insulation was installed on the exterior walls and roof of all buildings.

Energy Conservation Studies

Since FY75, DA has contracted for one study that related to energy conservation: "Load Analysis for Building No. 4", AMC Project 4764565, 21 May 1976. As a result of this study the entire electrical distribution system of the Tank Plant (Building 4) was rehabilitated under Contract DACA45-77-C-0132, dated May 1977.

Historical Energy Data

Total annual facility-related energy consumption for DA and associated

satellites in terms of source energy for the years FY77 through FY80 is shown in Figure 3. Each form of energy has been converted to its heat energy equivalent to reflect source energy requirements. Comparison on an annual historical basis to FY75 consumption is shown in Table 7.

The historical energy consumption can also be expressed in terms of energy use per gross square foot floor area. This factor, i.e., energy use index (EUI), is a measurement of an installation's performance and can be used to compare energy usage of similar installations. Table 8 and Figure 4 summarizes the EUI for DA for FY75 through FY80. The trend indicates an increase in EUI for FY75 and FY77. Since FY77 the EUI has remained fairly steady. The percent change in EUI compares favorably with a percent change in heating degree days which indicates that weather related energy efficiency remained fairly constant.

Actual costs for purchased electricity, natural gas and coal were available from Detroit Arsenal prepared reports. Results for FY79 and FY80 were compiled and are presented in Table 9. Costs for electricity and natural gas are actual total costs incurred each period, i.e., they include taxes, fuel adjustment, surcharges, demand charges, etc. Demand charges for electricity which typically amount to about 35-40% of the total monthly electric bill are billed at a rate of \$5.80 per KW demand during onpeak periods. Energy charges are 2.95¢ per KWH (on peak) and 2.25¢ per KWH (off peak).

The billed utility costs for Arsenal Acres for FY77 through FY79 are summarized in Table 10 along with the average unit costs for each form of energy and total annual operating costs on a per square foot basis.

A breakdown of utility costs for PSF was unavailable.

A 12 month period of utility data was obtained for KFS from Michigan Technological University which is responsible for Site operations. Total

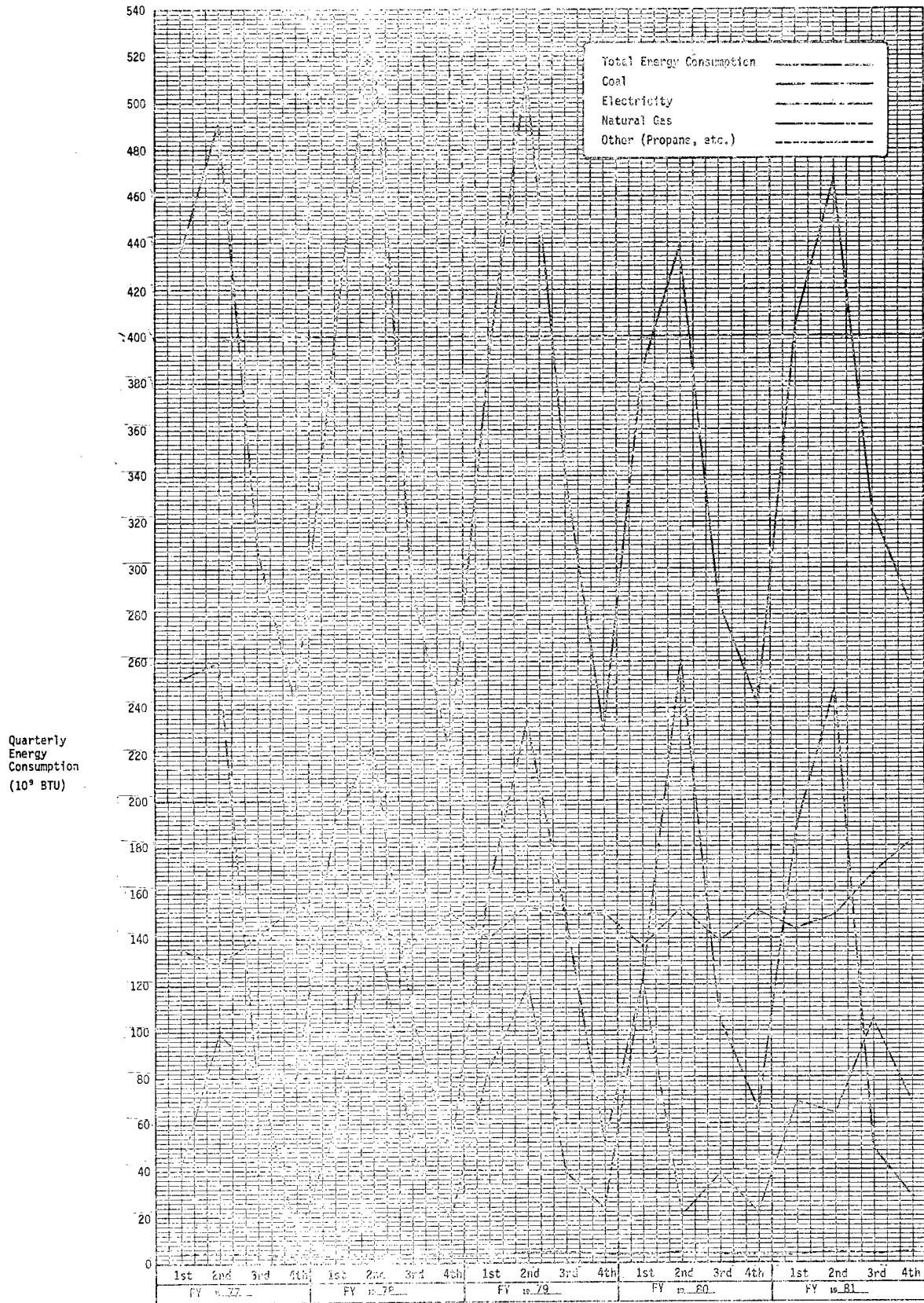


Figure 13 TOTAL ANNUAL ENERGY

TABLE 7
 DETROIT ARSENAL
 COMPARISON OF TOTAL ANNUAL
 FACILITY - RELATED PURCHASED ENERGY CONSUMPTION

| REPORTING PERIOD | ELECTRICITY | | NATURAL GAS | | COAL | | OTHER | | TOTAL | |
|------------------|-------------|--------|-------------|--------|---------|--------|--------|--------|-----------|--------|
| | MBTU | CHANGE | MBTU | CHANGE | MBTU | CHANGE | MBTU | CHANGE | MBTU | CHANGE |
| 75 | 495,006 | - | 234,799 | - | 572,138 | - | 12,312 | - | 1,305,255 | - |
| 76 | 524,990 | + 6.0% | 291,081 | +24.0% | 588,820 | + 2.9% | 13,608 | +20.3% | 1,419,599 | + 8.9% |
| 77 | 560,304 | +15.3% | 229,312 | - 2.3% | 572,049 | +17.5% | 15,510 | +26.0% | 1,477,174 | +13.2% |
| 78 | 561,009 | +19.5% | 297,050 | +22.3% | 569,175 | - 0.5% | 13,276 | + 7.8% | 1,450,510 | +11.1% |
| 79 | 534,663 | -22.4% | 265,589 | +13.1% | 595,675 | + 4.1% | 16,386 | +33.1% | 1,472,313 | +12.6% |
| 80 | 581,462 | +19.6% | 202,148 | -13.9% | 552,710 | - 3.4% | 14,789 | +20.1% | 1,351,109 | + 3.5% |

Notes

1. Source: DARCOM Energy Management Information System (DEIS) Reports
2. Includes consumption for Detroit Arsenal, Arsenal Acres and Keweenaw Field Station.
3. Results represent energy requirements at raw source energy point
4. FY75 used as base year. (-) change indicates saving, (+) change indicates increase

TABLE 8
DETROIT ARSENAL
HISTORICAL ENERGY CONSUMPTION
PER GROSS SQUARE FOOT

Assume Constant Real Property Inventory = 3,094,000 GSF
Includes Arsenal Acres, PSF and KSF

| Period | Purchased Energy (MBTU) | Energy Use Index (KBTU/GFS) | % Change Compared to FY75 |
|--------|-------------------------|-----------------------------|---------------------------|
| FY75 | 1,305,255 | 421,900 | - |
| FY76 | 1,419,589 | 458,000 | 8.7 |
| FY77 | 1,477,174 | 477,400 | 13.2 |
| FY78 | 1,450,510 | 468,800 | 11.1 |
| FY79 | 1,472,313 | 475,900 | 12.8 |
| FY80 | 1,351,109 | 436,700 | 3.5 |

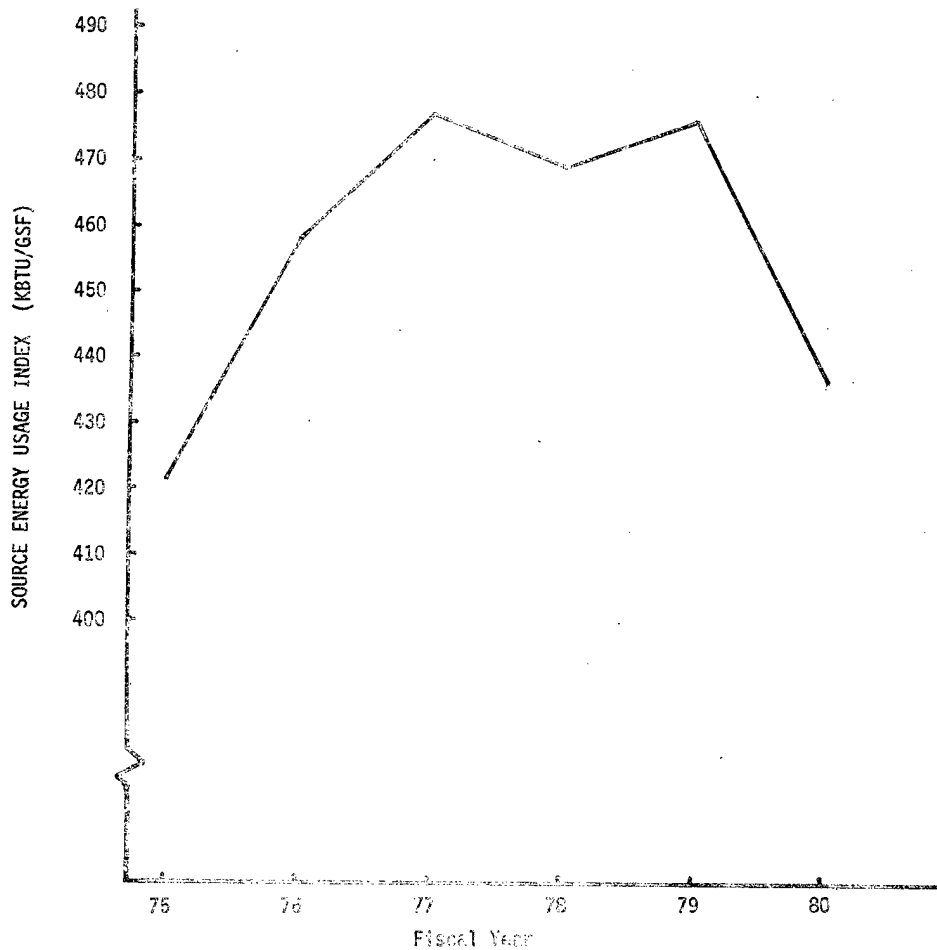


Figure 4 DETROIT ARSENAL AND SATELLITES
HISTORICAL SOURCE ENERGY USE INDEX

TABLE 9
 DETROIT ARSENAL
 SUMMARY OF OPERATING UTILITY COSTS
 FOR FY79 - FY80

| Period | Electricity (\$) | Natural Gas (\$) | Coal (\$) | Total | Estimated Operating Cost** (\$/SQ. FT.) |
|--------|---------------------|---------------------|--------------|-----------|--|
| FY79 | 1,726,425 | 634,212 | 1,029,548 | 3,390,192 | 1.388 |
| FY80 | 1,669,472 | 541,294 | 928,173 | 3,338,939 | 1.367 |

** Based upon 2,422,000 Sq. Ft. occupied

TABLE 10
 ARSENAL ACRES
 SUMMARY OF UNIT AND OPERATING
 UTILITY COSTS

| Period | Electricity | | Natural Gas | | Total | | Estimated Operating Cost \$/SQ.FT. |
|--------|------------------|---------------------|------------------|---------------------|------------------|----------------------|---------------------------------------|
| | TOTAL COST \$ | UNIT COST \$/KWH | TOTAL COST \$ | UNIT COST \$/CCF | TOTAL COST \$ | UNIT COST \$/MBTU | |
| FY77 | 5,879 | 0.0427 | 7,159 | 0.2571 | 13,038 | 3.90 | 0.629 |
| FY78 | 5,515 | 0.0446 | 6,116 | 0.2350 | 11,629 | 3.75 | 0.561 |
| FY79 | 5,817 | 0.0475 | 7,195 | 0.2677 | 13,012 | 4.08 | 0.627 |

energy usage at KFS was 3,012 MBTU for the reported period of July 1980 thru June 1981. Assuming only Buildings 1, 2 and 5 are used extensively, KFS had an EUI of 177.5 KBTU/SQ.FT. The cost for natural gas averaged \$0.357 per CCF or \$3.46 per MBTU. Electricity costs averaged \$0.073 per KWH or \$21.48 per MBTU.

Building Energy Consumption Analysis

At DA, utilities are metered only as they enter the site. Submetering is more prevalent at the satellites. Where metered data was available, this was used to establish a building's annual energy usage rate. Establishing annual energy usage rates for all other buildings was done using various analytical methods. Estimated annual energy consumption for all types of energy are summarized in Tables 11 through 14 on a building-by-building basis for those buildings under study. Total energy consumption was calculated for each building by converting all units to BTU's and summing them for each energy type. An energy usage index was then obtained for each building by dividing the total energy consumption by the occupied floor area.

Summary of Recommended Projects

A brief description for each of the projects identified and evaluated under this Energy Engineering Analysis Program study is provided in Table 15. The funding requirements and energy and cost savings for each of these are summarized in Table 16. The projects presented in this table are listed in order of descending energy-to-cost ratios.

Implementation of all of the ECIP qualifying projects will require over \$4.7 million in funding and yield a total annual energy savings of 194,000 MBTU. This energy savings figure is based upon each project being independent of the others, and is exclusive of the effects of interactions between

TABLE 11
 SUMMARY OF ESTIMATED ANNUAL BUILDING HEATING ENERGY CONSUMPTION
 DETROIT ARSENAL, WARREN, MICHIGAN

| BUILDING NUMBER AND TITLE | LOAD TYPE | ENERGY SOURCE | DESIGN LOAD (1000 B/H) | SEASONAL PLANT EFF. (PCT) | EQUIV. FULL-LOAD HOURS | ESTIMATED YEARLY LOAD (1000 BTU) |
|--|-----------|---------------|------------------------|---------------------------|------------------------|----------------------------------|
| 1 - ADMINISTRATION : GENERAL PURPOSE | HEAT | CHP | 800.3 | 100.0 | 2165.5 | 1,733,020. |
| 2 - DISPENSARY | HEAT | CHP | 250.1 | 100.0 | 2165.5 | 541,582. |
| 3 - TELEPHONE EXCHANGE | HEAT | CHP | 243.9 | 100.0 | 2165.5 | 528,156. |
| 4 - COMBAT VEHICLE PLANT | HEAT | CHP | 63916.9 | 100.0 | 2165.5 | 138,409,616. |
| 5 - HEATING PLANT | HEAT | CHP | 3216.0 | 100.0 | 2626.5 | 6,964,143. |
| 7 - VEHICLE AND MACHINE REPAIR | HEAT | CHP | 3926.4 | 100.0 | 2626.5 | 10,312,719. |
| 8 - EXPERIMENTAL LAB | HEAT | CHP | 991.0 | 100.0 | 2626.5 | 2,602,869. |
| 9 - FACILITIES ENGINEER MAINTENANCE SHOP | HEAT | CHP | 1063.1 | 100.0 | 2626.5 | 2,302,104. |
| 10 - FACILITIES ENGINEER MAINTENANCE SHOP | HEAT | CHP | 154.8 | 100.0 | 2626.5 | 406,583. |
| 12 - APPLIED INSTRUCTION | HEAT | CHP | 1353.1 | 100.0 | 2165.5 | 2,930,087. |
| 13 - OPEN MESS (OFFICERS CLUB) | HEAT | CHP | 192.1 | 100.0 | 2165.5 | 415,985. |
| 14 - OPEN MESS (NCO) | HEAT | CHP | 144.5 | 100.0 | 1962.1 | 283,520. |
| 15 - BACHELOR'S ENLISTED QUARTERS | HEAT | CHP | 125.2 | 100.0 | 2165.5 | 271,117. |
| 17 - FAMILY HOUSING | HEAT | CHP | 149.6 | 100.0 | 2165.5 | 323,954. |
| 18 - POST EXCHANGE AND COE OFFICE | HEAT | CHP | 150.3 | 100.0 | 2165.5 | 325,469. |
| 40 - TRACK/SUSPENSION LAB | HEAT | CHP | 157.0 | 100.0 | 1350.4 | 212,008. |
| 54 - FACILITIES ENGINEER MAINTENANCE SHOP | HEAT | CHP | 125.5 | 100.0 | 2165.5 | 271,765. |
| 55 - FACILITIES ENGINEER MAINTENANCE SHOP | HEAT | CHP | 152.5 | 100.0 | 2165.5 | 330,233. |
| 56 - FACILITIES ENGINEER MAINTENANCE SHOP | HEAT | CHP | 196.3 | 100.0 | 2165.5 | 425,080. |
| 57 - WASH RACK AND STORAGE | HEAT | CHP | 584.5 | 100.0 | 1350.4 | 789,292. |
| 58 - GENERAL STOREHOUSE | HEAT | CHP | 1185.9 | 100.0 | 1886.2 | 2,236,795. |
| 59 - LIFT TRUCK REPAIR | HEAT | CHP | 1216.9 | 100.0 | 1886.2 | 2,295,266. |
| 61 - FACILITIES ENGINEER MAINTENANCE SHOP | HEAT | CHP | 607.6 | 100.0 | 1350.4 | 820,485. |
| 200A - ADMINISTRATION : R&D ACTIVITIES | HEAT | CHP | 1787.9 | 100.0 | 1886.2 | 3,372,262. |
| 200B - ADMINISTRATION : GENERAL PURPOSE | HEAT | CHP | 1920.6 | 100.0 | 1886.2 | 3,622,556. |
| 200C - LAB & TEST : GENERAL PURPOSE | HEAT | CHP | 2720.9 | 100.0 | 1886.2 | 5,132,048. |
| 200D - EXPERIMENTAL SHOPS | HEAT | CHP | 12143.9 | 100.0 | 2626.5 | 31,896,032. |
| 201 - PRINTING PLANT | HEAT | CHP | 754.3 | 100.0 | 2626.5 | 1,981,174. |
| 202 - ROADS AND GROUNDS | HEAT | CHP | 116.2 | 100.0 | 2165.5 | 251,627. |
| 203 - GENERAL PURPOSE WAREHOUSE | HEAT | CHP | 4042.5 | 100.0 | 2626.5 | 10,617,656. |
| 205 - ENGINEERING ADMINISTRATION | HEAT | CHP | 394.5 | 100.0 | 2165.5 | 854,275. |
| 212 - PROPULSION SYSTEMS LABORATORY | HEAT | CHP | 5393.1 | 100.0 | 2165.5 | 11,678,565. |
| 215 - TRACK & SUSPENSION LAB | HEAT | CHP | 1907.2 | 100.0 | 2165.5 | 4,129,971. |
| 219 - MODEL SHOP | HEAT | CHP | 2553.1 | 100.0 | 2626.5 | 6,705,736. |
| 224 - FACILITIES ENGINEER MAINTENANCE SHOP | HEAT | CHP | 168.8 | 100.0 | 2165.5 | 365,530. |
| 225 - GENERAL STOREHOUSE | HEAT | CHP | 0.1 | 100.0 | 711.4 | 71. |
| 227 - SALVAGE & SURPLUS STORAGE | HEAT | CHP | 426.1 | 100.0 | 2165.5 | 922,704. |
| 230 - ADMINISTRATION : GENERAL PURPOSE | HEAT | CHP | 7227.2 | 100.0 | 1886.2 | 13,631,644. |
| 238 - BATH HOUSE | HEAT | GAS | 66.9 | 60.0 | 1350.4 | 150,566. |
| TOTAL ESTIMATED HEATING ENERGY | | | | | | 271,042,006. |

TABLE 12
SUMMARY OF ESTIMATED ANNUAL BUILDING HEATING ENERGY CONSUMPTION
ARSENAL ACRES, WARREN, MICHIGAN

| BUILDING NUMBER AND TITLE | LOAD TYPE | ENERGY SOURCE | DESIGN LOAD (1000 B/H) | SEASONAL PLANT EFF. (PCT) | EQUIV. FULL-LOAD HOURS | ESTIMATED YEARLY LOAD (1000 BTU) |
|--------------------------------------|-----------|---------------|------------------------|---------------------------|------------------------|----------------------------------|
| 301 - COMMANDING OFFICER'S QUARTERS | HEAT | GAS | 144.6 | 75.0 | 2165.5 | 417502. |
| 302, 303 - SENIOR OFFICER'S QUARTERS | HEAT | GAS | 135.6 | 75.0 | 2165.5 | 391517. |
| 304-307 - JUNIOR OFFICERS' QUARTERS | HEAT | GAS | 110.6 | 75.0 | 2165.5 | 319334. |
| TOTAL ESTIMATED HEATING ENERGY | | | | | | 2143083. |

TABLE 13
SUMMARY OF ESTIMATED ANNUAL BUILDING HEATING ENERGY CONSUMPTION
PONTIAC STORAGE FACILITY, PONTIAC, MICHIGAN

| BUILDING NUMBER AND TITLE | LOAD TYPE | ENERGY SOURCE | DESIGN LOAD (1000 B/H) | SEASONAL PLANT EFF. (PCT) | EQUIV. FULL-LOAD HOURS | ESTIMATED YEARLY LOAD (1000 BTU) |
|--------------------------------|-----------|---------------|------------------------|---------------------------|------------------------|----------------------------------|
| 1 - GENERAL WAREHOUSE | HEAT | GAS | 500.0 | 60.0 | 2165.5 | 1,804,551. |
| 7 - HEATING PLANT | HEAT | GAS | 2436.6 | 60.0 | 1350.4 | 5,483,855. |
| TOTAL ESTIMATED HEATING ENERGY | | | | | | 7,288,406. |

TABLE 14
SUMMARY OF ESTIMATED ANNUAL BUILDING HEATING ENERGY CONSUMPTION
KEWEENAW FIELD STATION, HOUGHTON, MICHIGAN

| BUILDING NUMBER AND TITLE | LOAD TYPE | ENERGY SOURCE | DESIGN LOAD (1000 B/H) | SEASONAL PLANT EFF. (PCT) | EQUIV. FULL-LOAD HOURS | ESTIMATED YEARLY LOAD (1000 BTU) |
|--------------------------------------|-----------|---------------|------------------------|---------------------------|------------------------|----------------------------------|
| 1 - ADMINISTRATION : GENERAL PURPOSE | HEAT | GAS | 253.7 | 75.0 | 2553.3 | 863,683. |
| 2 - VEHICLE GARAGE - MACHINE SHOP | HEAT | GAS | 160.9 | 75.0 | 2553.3 | 547,759. |
| 3 - VEHICLE STORAGE | HEAT | GAS | 218.3 | 80.0 | 303.0 | 82,681. |
| 5 - GENERAL LABORATORY | HEAT | GAS | 225.4 | 75.0 | 2112.0 | 634,719. |
| TOTAL ESTIMATED HEATING ENERGY | | | | | | 2,128,842. |

TABLE 15
DESCRIPTION OF EEAP GENERATED PROJECTS

| Project | Description |
|--|--|
| A-1/Reduce Window Area for Buildings 7, 212 and 219 | Removal of existing window systems and installation of translucent insulating panels in Buildings 7, 212 and 219. |
| A-2/ECOs for Buildings at DA and Satellites | Those ECOs identified under Increment A: <ul style="list-style-type: none"> ● Insulate Walls ● Upgrade Window Systems ● Install High Efficiency Lamps ● Convert to VAV |
| B-1/Modifications to Electrical and Steam Distribution Systems | Those ECOs identified under Increment B: <ul style="list-style-type: none"> ● Convert Street Lighting to HPS ● Insulate PRV Stations ● Insulate Aboveground Steam Lines ● Institute a Steam Trap Inspection and Replacement Program ● Replace Fire-Protection Water Heater at PSF |
| B-2/Energy Monitoring and Control System (EMCS) | Installation of an EMCS with ability for: <ul style="list-style-type: none"> ● Lighting Level Control ● Timeclock AHUs ● Timeclock EFs ● Reduce Ventilation Air ● Optimize Temperature Control ● Reset Hot Water Temperature ● Unoccupied Heating Shutdown ● Night Setback |
| D-1/Cogeneration System | Installation of a cogeneration system in Building 5 for production of electricity and steam. |
| F-1/Low Cost ECOs | Low cost ECOs identified for buildings throughout the site: <ul style="list-style-type: none"> ● Reduce Infiltration ● Install Door Seals ● Delamp ● Install DHW Controls ● Install Spark Ignition |
| F-2/ECOs for GOCO Buildings 4, 5, and 59 | Install lighting level controls in Building 4, reclaim heat generated by air compressors in Building 5, and reduce the ventilation air for Building 59. |

TABLE 15 (Cont'd.)
DESCRIPTION OF EEAP GENERATED PROJECTS

| Project | Description |
|---|---|
| F-3/ECOs for Housing at Arsenal Acres | Those low cost ECOs identified under Increment A for Arsenal Acres housing units: <ul style="list-style-type: none"> • Upgrade Window Systems • Weatherstrip and Caulk • Night Setback • Spark Ignition • Flue Dampers |
| F-4/Special Application ECOs | Those low cost ECOs identified under Increment A as a result of the observation of special operational procedures or environmental conditions during field surveys (e.g., install economizers for ADP AHUs in Building 230). |
| F-5/Building 4 Surface Treatment Tanks | Insulation of surface treatment tanks and installation of tank covers. |
| F-6/Building 229 and 231 Elevator Heat Recovery | Recovery of waste heat from elevator hydraulic systems to preheat domestic hot water. |
| G-1/Non-Qualifying Building ECOs | Those ECOs identified under Increment A which do not meet ECIP criteria for E/C or B/C ratios. |
| G-2A/Electrical Submetering of Selected Buildings | Installation of electric consumption meters in Buildings 1, 4, 5, 7, 12, 58, 59, 200A, 200B, 200C, 200D, 203, 205, 212, 215, 219 and 230. |
| G-2B/Steam Submetering of Selected Buildings | Installation of condensate meters in order to monitor steam usage in Buildings 1/2/3, 12-22/37, 7/8/11/40, 4/6/23, 9/10/57/61, 54/55/56/72, 58/59/63, 200A/200B/200C/200D, 201/202/224/227, 203/205, 212, 215, 219/233 and 230. |
| G-2C/Shutoff Little used Compressed Air Lines | Installing shutoff valves into existing compressed air lines. |
| G-3/EMCS for Keweenaw Field Station | Energy Monitoring and Control System for Buildings 1 and 5. |
| G-4/EMCS for Pontiac Storage Facility | Energy Monitoring and Control System for Building 1. |

TABLE 16

ENERGY ENGINEERING ANALYSIS PROGRAM
DETROIT ARSENAL AND SATELLITES

SUMMARY OF PROJECTS

| PROJECT TITLE | ANNUAL ENERGY SAVINGS | | | | TOTAL (MBTU) | DOLLAR SAVINGS (\$ 1000) | | COST (\$1000'S FY86) | | ECIP RATIOS | | |
|---|-----------------------|---------------|-------------|----------------|--------------|--------------------------|---------------|----------------------|--------|-------------|------|----------|
| | ELECT. (KWH) | NAT GAS (KCF) | COAL (TONS) | FUEL OIL (GAL) | | ANNUAL (FY86) | TOTAL BENEFIT | CWE | TIC | E/C | B/C | PAY BACK |
| <u>ECIP QUALIFYING PROJECTS:</u> | | | | | | | | | | | | |
| F-2 / ECOS FOR GOCO BLDGS 4, 5, 59 | 39417. | 0. | 549. | 0. | 13955. | 50.7 | 605.0 | 15.7 | 17.6 | 833.7 | 34.5 | 0.3 |
| F-5 / BLDG 4 SURFACE TREATMENT TANKS | 0. | 0. | 527. | 0. | 12950. | 43.9 | 218.8 | 18.7 | 19.7 | 690.8 | 11.1 | 0.4 |
| F-1 / LOW COST ECOS FOR DA & SATELLITES | 57755. | 1174. | 149. | 0. | 6020. | 34.7 | 423.1 | 9.3 | 9.8 | 645.4 | 43.2 | 0.3 |
| F-4 / SPECIAL APPLICATION ECOS FOR BLDGS AT-DA | 236948. | 0. | 115. | 0. | 5571. | 30.0 | 356.5 | 29.0 | 30.4 | 192.2 | 11.7 | 1.0 |
| D-1 / COGENERATION SYSTEM | 4278112. | 0. | -862. | 0. | 28420. | 329.2 | 6452.4 | 664.8 | 697.4 | 42.7 | 9.3 | 2.0 |
| F-3 / ECOS FOR HOUSING AT ARSENAL ACRES | 4609. | 1237. | 0. | 0. | 1330. | 9.0 | 189.8 | 35.1 | 36.8 | 37.9 | 5.2 | 3.9 |
| B-2 / EMCS FOR DA | 1203586. | 0. | 2654. | 0. | 79200. | 242.6 | 3102.0 | 2209.9 | 2318.3 | 35.8 | 1.3 | 9.1 |
| A-2 / RETROFIT MOD. FOR BLDGS AT DA & SATELLITES | 172338. | 45. | 319. | 0. | 9878. | 45.7 | 705.0 | 284.1 | 298.0 | 34.8 | 2.4 | 6.2 |
| B-1 / MODIFICATIONS TO ELECT. AND STEAM DIST. SYSTEMS | 131200. | 0. | 592. | 40090. | 21616. | 158.6 | 2070.6 | 685.2 | 689.0 | 31.6 | 3.0 | 4.1 |
| A-1 / REDUCE WINDOW AREA FOR BLDGS 7, 212, & 219 | 52586. | 0. | 594. | 0. | 15206. | 61.5 | 923.6 | 593.6 | 622.7 | 25.6 | 1.5 | 9.6 |

TABLE 16 (Cont'd)

ENERGY ENGINEERING ANALYSIS PROGRAM
DETROIT ARSENAL AND SATELLITES

SUMMARY OF PROJECTS

| PROJECT TITLE | ANNUAL ENERGY SAVINGS | | | | DOLLAR SAVINGS | | COST | | ECIP RATIOS | | | |
|--|-----------------------|---------------|-------------|----------------|----------------|---------------|---------------|----------------------------|-------------|------|-----|----------|
| | ELECT. (KWH) | NAT GAS (KCF) | COAL (TONS) | FUEL OIL (GAL) | TOTAL (MBTU) | ANNUAL (FY86) | TOTAL BENEFIT | (\$1000 'S. FY86) CWE | TIC | E/C | B/C | PAY BACK |
| NON-ECIP QUALIFYING PROJECTS: | | | | | | | | | | | | |
| F-5 / ELEVATOR HEAT RECOVERY BLDGS 229 & 231 | 12875. | 0. | 0. | 0. | 149. | 0.3 | 8.3 | 9.9 | 10.4 | 15.1 | 0.8 | 33.8 |
| G-4 / EMCS AT PSF | 513. | 0. | 0. | 3426. | 481. | 6.5 | 96.2 | 40.9 | 42.9 | 11.8 | 2.2 | 6.3 |
| G-3 / EMCS AT KFS | 399. | 339. | 0. | 0. | 354. | 0.4 | 14.7 | 37.6 | 39.4 | 9.4 | 0.4 | 107.1 |
| G-1 / NON-QUALIFYING BUILDING ECOS | -96343. | 271. | 524. | 0. | 12038. | 10.9 | 308.9 | 1708.2 | 1791.8 | 7.0 | 0.2 | 156.8 |
| G-2C / CLOSE OFF INFREQ. USED COMPRESSED AIR LINES | 1377. | 0. | 0. | 0. | 16. | 0.1 | 1.5 | 13.2 | 13.8 | 1.2 | 0.1 | 109.6 |
| G-2A / ELECTRICAL SUBMETERING | 0. | 0. | 0. | 0. | 0. | 0.0 | 0.0 | 30.0 | 30.0 | 0.0 | 0.0 | NONE |
| G-2B / CONDENSATE SUBMETERING | 0. | 0. | 0. | 0. | 0. | 0.0 | 0.0 | 35.5 | 35.5 | 0.0 | 0.0 | NONE |

projects. Figure 5 describes the degree to which interactions between projects will affect the energy savings credited to those projects. The projects listed as 'independent' are assumed to be implemented first. The effect on each of the other 'dependent' projects is then categorized as 'none', 'minimal' or 'significant'. All of the projects which presently qualify for ECIP funding would still meet ECIP criteria even if interactive effects on energy savings were taken into account.

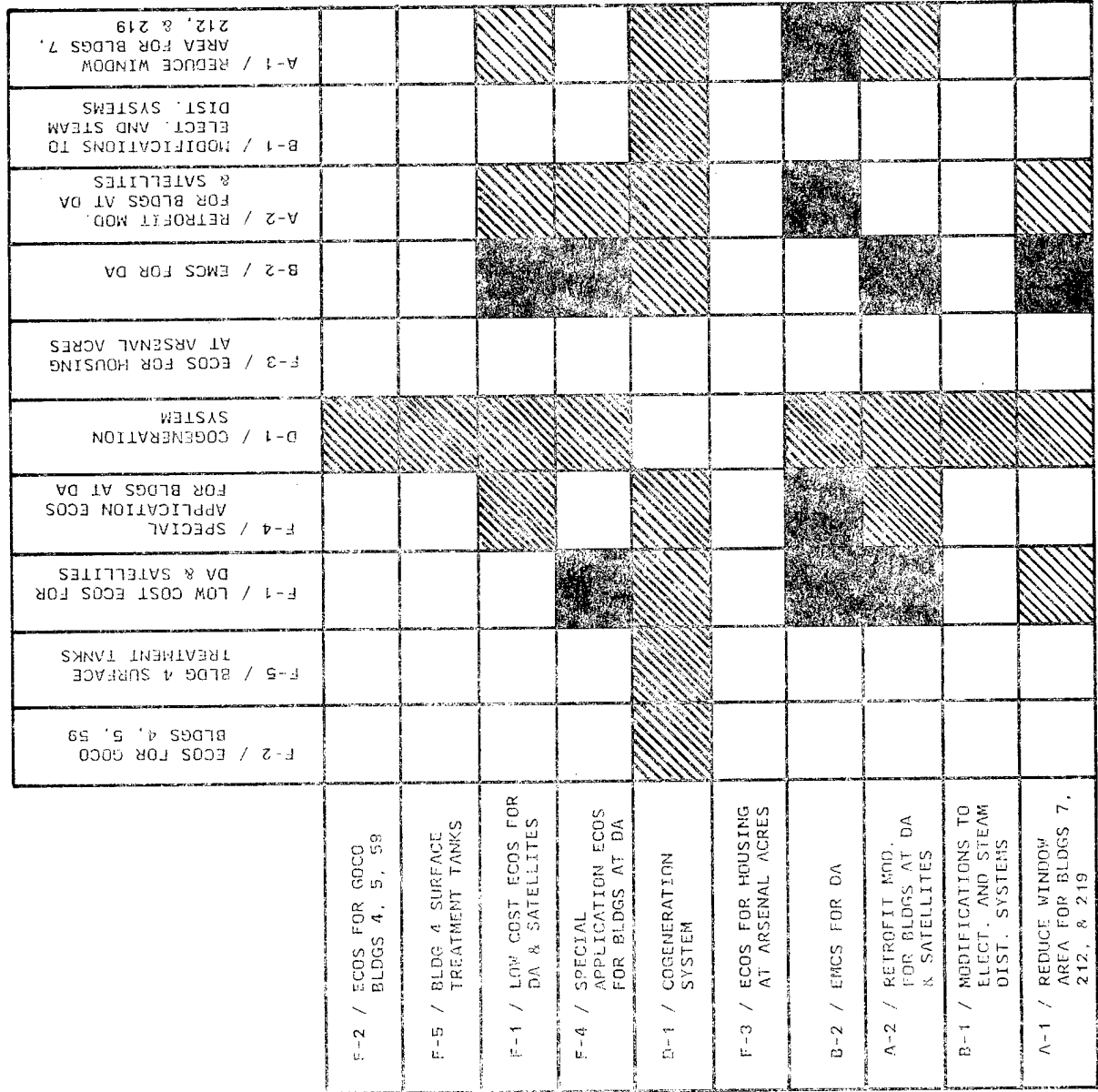
Energy Goals and Projected Site Energy Usage

According to the most recent DEIS reports, FY75 energy consumption at Detroit Arsenal (DA) totaled 1,305,255 MBTU. The Army Facilities Energy Plan (AFEP) established a goal of 25% reduction in energy consumption from FY75 to FY85. In order to meet this goal, the level of energy consumption at DA must be reduced to 978,941 MBTU/YR by October 1984.

Figure 6 depicts the DA energy consumption for the period FY75 through FY83 based upon the DEIS reports along with the AFEP FY85 goal. As can be seen, energy consumption at DA peaked in FY81 and since has decreased to a level of 1,234,911 MBTU (est.) in FY83, some 5.4% below the FY75 value.

Implementation of the 10 projects summarized in Table 16 which meet ECIP criteria would achieve a reduction in energy consumption of 194,000 MBTU/YR. This would bring the DA consumption level to 1,040,911 MBTU/YR, still above the target of 978,941 MBTU/YR. The projects developed for this EEAP do not recommend many ECOs for Building 4, the major user of energy. This was the direction agreed upon at prenegotiation meetings. The DA Facilities Engineering staff had already focused attention on Building 4 and identified several projects which are now being implemented. These projects include replacing the large window sections that made up most of the exterior

Dependent Project



Independent Project

Figure 5 EFFECT OF INTERACTIONS BETWEEN PROJECTS ON ENERGY SAVINGS

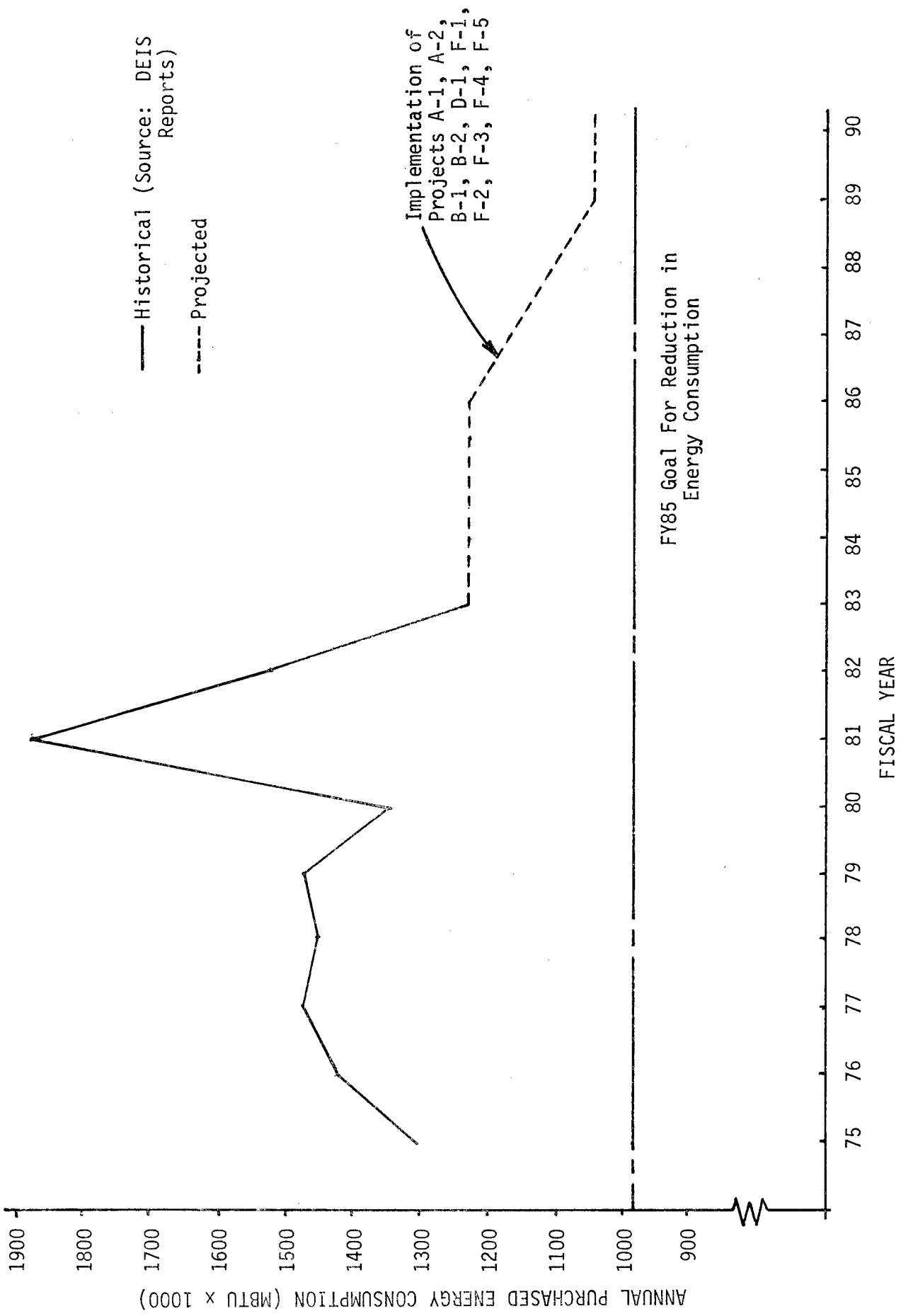


Figure 6 PROJECTED DETROIT ARSENAL ENERGY CONSUMPTION

skin with insulated panels, removing obsolete skylights, installing high efficiency lighting and installing an EMCS. Some of these projects have been recently completed and in fact have contributed to the drop in the energy consumption level in FY82 and FY83. Building 4 offers the best potential for achieving additional savings which would put the installation energy consumption below the FY85 goal.

ECIP funding for the projects generated under this study will not be available until FY86 and it will probably be three to four years after that time before all of the qualifying projects are funded and implemented. For this reason alone, DA may not be able to meet the AFEP goal by FY85. Even with complete and immediate funding, the goal is probably unattainable unless the energy consumption of production processes are addressed.