

**VOLUME I**

**EXECUTIVE SUMMARY**

**ENERGY SAVINGS OPPORTUNITY SURVEY**

**ENERGY ENGINEERING ANALYSIS PROGRAM**

**FORT BUCHANAN, PUERTO RICO**

**FINAL REPORT**

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July 28, 1989

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**Replacement**

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GLOSSARY OF ABBREVIATIONS  
(FOR ALL VOLUMES)

AHU	air handling unit
ARC	Army Reserve Center
ASHRAE	American Society of Heating, Refrigerant, and Air-Conditioning Engineers
BEQ	Bachelor Enlisted Quarters
BEA	Building Energy Analysis
Btu	British thermal unit
btuh	British thermal unit per hour
CAP	Civil Air Patrol
cfm	cubic feet per minute
CHW	chilled water
CID	Criminal Investigation Division
COE	Corps of Engineers
DB	dry-bulb
DEA	Drug Enforcement Agency
DEH	Director of Engineering and Housing
DHW	domestic hot water
DLA	Defence Logistics Agency
DOD	Department of Defense
DX	direct expansion
ECIP	Energy Conservation Investment Program
ECO	Energy Conservation Opportunity
EEAP	Energy Engineering Analysis Program
EPRI	Electric Power Research Institute
ESOS	Energy Savings Opportunity Survey
fc	footcandle
FOQ	Field Officer Quarters
FY	fiscal year
gpd	gallons per day
HID	high-intensity discharge
HQ or HQS	Headquarters
HVAC	heating, ventilating, and air-conditioning
kVA	kilovoltampere
kW	kilowatt
kWh	kilowatthour
LAO	Legal Assistance Office
LCCA	Life Cycle Cost Analysis
MBtu	Millions of British thermal units
mtc	Maneuver Training Command
MWh	megawatthour
NOAA	National Oceanographic and Atmospheric Agency
NCO	Non-Commissioned Officer
NCOW	NCO Wherry Housing
O.A.	outside air
OAC	Oneirus Aerospace Corporation
OSD	Office of the Secretary of Defense
OSD PIF	OSD Productivity Improvement Funding
OWH	Officers' Wherry Housing
PDB	Program Development Brochure

## GLOSSARY OF ABBREVIATIONS

PECIP	Productivity Enhancing Capital Investment Program
PIF	Productivity Improvement Funding
PRC	Planning Research Corporation
PX	Post Exchange
QRIP	Quick Return on Investment Program
R	resistance (to heat conduction)
RH	relative humidity
RIF	Site consumption (1 kW = 3,412 Btu's)
RUF	Source consumption (1 kW = 11,600 Btu's)
SEAD	Systems Engineering and Analysis Division
SIR	Savings-to-Investment Ratio
SOW	Statement of Work
SSS	Selective Service System
TASC	Training and Audio-Visual Support Center
u	thermal transmissivity
USAR(C)	U.S. Army Reserve (Center)
VAV	variable air volume
WB	wet-bulb
WHR	waste heat recovery

## EXECUTIVE SUMMARY

### 1. INTRODUCTION

This is the Executive Summary of the Final Report required under Contract No. DACA 21-87-C-0508 between the Savannah District Corps of Engineers (COE) and the Systems Engineering and Analysis Division (SEAD), Planning Research Corporation (PRC). The contract calls for an Energy Savings Opportunity Survey (ESOS) [Energy Engineering Analysis Program (EEAP)] at Fort Buchanan and its associated U.S. Army Reserve (USAR) Centers, Puerto Rico (see figure 1-1).

The complete report also includes Volume II, Narrative Report; Volume III, documentation of recommended Energy Conservation Opportunities (ECO's); Volume IV, Field Notes; Volume V, Building Descriptions and Special Studies; and Volume VI, an appendix containing ECO's not recommended, minutes of review meetings, the Statement of Work, and the electric utility's rate schedule.

PRC was selected to perform the contract in Spring 1986; the Pre-Negotiation Conference took place on 15 July 1986; and the Notice to Proceed was issued 5 January 1987. The field survey was conducted 17 to 27 February 1987. Also in February 1987, a newly formed company, Oneirus Aerospace Corporation (OAC), negotiated a leveraged buyout of PRC's Aerospace Systems Division, including this contract. In July 1987, OAC submitted the Interim Report, which was rejected by the COE Review Board. In April 1988, OAC filed for bankruptcy, PRC repossessed its assets and, in August 1988, the contract was novated back to PRC. The Interim Report was rewritten, resubmitted in November 1988, and accepted in February 1989. At the February Review Meeting, the date of 10 April 1989 was set for submittal of the Pre-Final Report, 23 May 1989 for the Review Meeting, and 23 June 1989 for Final Report submittal. Because of scheduling difficulties by the reviewing agencies, these dates were later changed to 28 June 1989 and 28 July 1989.

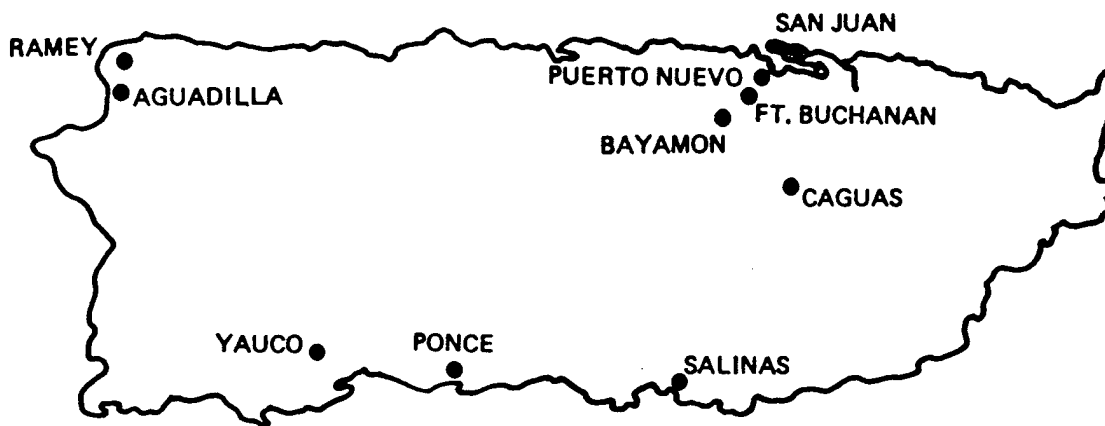


Figure 1-1. General Location of Facilities

2. SUMMARY OF COSTS, SAVINGS

The ECO's identified and recommended in this survey are listed in section 4.

In summary, for the total program, 19 projects, if implemented, will save:

11,101 MBtu's of electrical energy or

3,252,622 kilowatt-hours, annually, saving

\$260,321 per year for an investment of

\$957,143. The projects will pay for themselves in

3.7 years and the Savings-to-Investment Ratio (SIR) will be

7.6.

### 3. GENERAL RECOMMENDATIONS

In addition to the individual energy-saving projects that are the primary results of this study, four general recommendations are called for.

#### 3.1 METERING

Fort Buchanan is billed for electric power through two primary meters known as Main and 600 Area. Of the 15 submeters on the post (none of which is regularly read and recorded), two are on the Commissary and one each on the Post Exchange (PX) and Community Club. These three buildings are the largest and most wasteful consumers on the post, such that the energy analysis can account for only a little over one-third of the billed 600 Area consumption (see BLAST-Analyzed Buildings, Volume V). These meters, at least, should be used and brought to the attention of all interested parties. Accurate data at the building level would support greater accountability and conservation efforts at these facilities.

#### 3.2 MAINTENANCE

Each of these three largest energy users is operating its air-conditioning systems with disabled or bypassed controls and some chillers and air handling units are in very poor condition. The Director of Engineering and Housing (DEH) is woefully short-handed for competent heating, ventilating, and air-conditioning (HVAC) and controls technicians due to budget and salary limitations. Investment in qualified personnel would result in a widespread reduction in electricity costs.

#### 3.3 WASTE HEAT RECOVERY

There is a NAVFAC project now in the approval cycle for installing central air-conditioning in family housing at Fort Buchanan. ECO-7, recommended herein, would add waste heat recovery to provide energy for domestic hot water (DHW) for these units. Costs for the waste heat recovery will be substantially less if the two projects are implemented as one - \$278,000 if the projects are coordinated versus \$393,000 if done separately.

### 3.4 INDOOR LIGHTING

Several buildings at Fort Buchanan are grossly overlighted and many others use substantially more energy than necessary for lighting. The following actions are urged for immediate and significant reductions in the consumption of electrical energy.

- a. The PX, Club, and Commissary managers should survey their respective buildings accompanied by the DEH, who should point out the many high-wattage incandescent lamps left on unnecessarily, dirty reflectors, and overlighted offices and corridors.
- b. Screw-in fluorescent lamps should universally replace incandescent lamps, giving the same illumination for one-tenth the power consumption.
- c. Standard fluorescent tubes and ballasts should be replaced by those of more modern technology. Savings of 30 percent can be realized with low wattage tubes and electronic ballasts.
- d. The DEH should walk through all office buildings and, where called for, delamp two of all four-tube fluorescent fixtures and each alternate two-tube fixture. Also, DEH should check unnecessary use of high-bay lighting at ARC's.

#### 4. ENERGY CONSERVATION OPPORTUNITIES

Thirty-one projects have been analyzed and written up in the course of this survey. Nineteen projects are recommended and fully documented as Energy Conservation Investment Program (ECIP), Productivity Enhancing Capital Investment Program (PECIP), Quick Return on Investment Program (QRIP), ECO, or Work Order in Volume III. The remaining 12 are not recommended, either because they have been combined into, or replaced by, other recommended ECO's or because their SIR's are less than 1.0. Complete descriptions of these ECO's are included in Volume VI.

##### 4.1 RECOMMENDED ECO's

The following table gives the major parameters for recommended ECO's.

<u>ECO No.</u>	<u>Title</u>	<u>Buildings</u>	<u>Cost, \$</u>	<u>Savings, MBtu</u>	<u>SIR</u>	<u>Document</u>	<u>Payback Years</u>
1	Seal plastic windows	21, 200 Series	3,084	205.3	6.8	Work Order	0.8
7	Air-conditioning heat recovery	All family housing	278,000	1,750.0	3.4	ECIP	3.4
8	Lower DHW temperature	All family housing	3,150	573.0	42.5	Work Order	0.2
9	Attic insulation	200 Series	10,000	127.2	4.0	PECIP	3.2
13	Programmable controls	200 Series	2,900	9.8	5.0	Work Order	2.1
14	Skylighting	509, 512	1,300	61.6	6.5	Work Order	1.8
15	Reduce lighting levels	613	300	15.3	19.5	Work Order	0.6
16	Timers for electrical appliances	ARC's	2,100	128.1	16.8	Work Order	0.7
19	Roof insulation	Family housing	505,600	4,862.0	2.6	ECIP	4.4
21	Air-conditioning zone control	ARC's	6,400	555.3	29.0	QRIP	0.5
22	Reduce infiltration	Puerto Nuevo	4,300	41.4	2.6	Work Order	4.4
24	Window replacement	214	11,458	112.2	2.7	ECO	4.4
25	Energy conservation	390	18,960	768.1	3.4	PECIP	3.4
26	Lighting controls	200, 1300	21,370	575.5	5.7	QRIP	1.6
27	Reduce infiltration	PX	2,250	90.7	48.0	Work Order	0.1
28	Photocell controls	External lights	38,815	467.6	3.5	PECIP	3.5
29	Fluorescent EXIT lamps	All	31,956	299.0	14.2	QRIP	0.7
30	Air-conditioning waste heat recovery	607	1,100	5.2	1.3	Work Order	9.0
31	Fluorescent entry lighting	All family housing	<u>14,100</u>	<u>453.9</u>	4.7	QRIP	1.3
			957,143	11,101.0			

#### 4.2 ECO's NOT RECOMMENDED

The following ECO's have either been combined into more comprehensive ECO's or do not meet the standard of SIR > 1.0.

<u>ECO No.</u>	<u>Title</u>	<u>Buildings</u>	<u>Disposition</u>
2	Enthalpy economizer	21	SIR = 0.0
3	Sliding glass windows	21, 200, 1300	See ECO-24
4	Replace fan coil thermostat	390	See ECO-25
5	Thermostat for CHW valve	390	See ECO-25
6	Air-conditioning waste heat recovery	390	See ECO-25
10	Daylighting/photocells	200 Series	See ECO-26
11	Daylighting/photocells	1300 Series	See ECO-26
12	Lighting efficiency	612, ARC's, AMSA	SIR = 0.6
17	Bypass thermostat settings	1316, 1320	Savings negligible
18	Solar heating, DHW	All family housing	See ECO-7
20	Floor insulation	FOQ	SIR < 1.0
23	Decentralize DHW	390	Negative SIR

## 5. BASE DESCRIPTION

Fort Buchanan, Puerto Rico is located on 728 acres in the southwestern portion of the San Juan municipal area. It was established in 1923 and has served a variety of military purposes. Since 1977, it has been a subpost of Fort MacPherson, Georgia. The mission of Fort Buchanan is to provide:

1. Administrative and logistical support to the active and Reserve component units in Puerto Rico and the U.S. Virgin Islands
2. Family housing and community support facilities for service personnel and authorized Federal employees
3. Personnel services and community support facilities for retirees, service personnel, and dependents of deceased military personnel

Set in a tropical marine climate, Fort Buchanan provides housing for approximately 2,000 residents. The average annual temperature is 78°F. The base includes approximately 1,466,513 sq ft of building floorspace. Included in this area are:

- |                          |                       |
|--------------------------|-----------------------|
| o Family housing         | o Administration      |
| o Educational facilities | o Community Club      |
| o Warehouses             | o Exchange facilities |
| o Transient housing      | o Commissary          |

Housing consists of:

- o 141 Wherry Housing units for officers, 70 of which are 2-bedroom and 71 of which are 3-bedroom
- o 27 Capehart Housing units that are two-story buildings for enlisted personnel
- o Wherry duplexes containing 91 apartments for non-commissioned officers, consisting of 3 4-bedroom, 48 3-bedroom, and 40 2-bedroom units

- o 31 Field Officers' Quarters (FOQ), including 3 4-bedroom, 19 3-bedroom, and 9 2-bedroom units
- o A Sergeant Major Quarters
- o 3 Bachelor Enlisted Quarters (BEQ), consisting of 8 2-bedroom apartments each

There are 22 former BEQ facilities in the 1300 Area that are now used by a variety of tenants. They include numerous Reserve components, which have both administrative and storage areas in the buildings. Tenants include other agencies on a reimbursable basis such as the Drug Enforcement Agency (DEA), Selective Service System (SSS), and others. One of the buildings is occupied by the base Fire Department.

A total of 21 warehouses are located on the site. Some are used for equipment storage for the various Reserve components while others support the Commissary and PX. Other uses for converted warehouse facilities are toy store/auto sales, furniture sales, and package store. There are two basic types of warehouses. The 500 Area warehouses are concrete with wood or metal roofs while the larger 600 Area buildings are entirely concrete.

A large (80,350 sq ft), modern Commissary serves military personnel in the San Juan area, providing a complete line of provisions. Attached to the Commissary is a cold storage warehouse containing both refrigerated and frozen food areas. Nearby is a modern PX with a department store type outlet as its focus and with several specialty shops under the same roof. The third large, newer facility is the Community Club, which houses both the Officers' and Non-Commissioned Officers' (NCO) Clubs as well as a large ballroom.

An elementary school and a high school provide residents with educational facilities. In addition, Building 21 is a U.S. Army Reserve School with classroom facilities.

Administrative and support facilities are presently located at various sites throughout the base. The 200 Area buildings provide a variety of administrative facilities in 18 very similar buildings. A new building houses the DEH offices, with shops in older facilities to its rear. A new Headquarters Building at the former PX site houses several administrative departments.

Fort Buchanan is also responsible for the facilities at USAR Centers "out on the island" and in the San Juan area. In addition to the Fort Buchanan Reserve Center located in the 1300 Area of the base proper are USAR Centers at:

- o Aguadilla
- o Ramey
- o AMSA
- o Bayamon
- o Puerto Nuevo
- o Caguas
- o Ponce
- o Salinas
- o Yauco

6. ENERGY CONSUMPTION

Building 390 has a fuel oil-fired hot water heater and the Community Club has a propane-fired hot water heater. All other energy consumed at Fort Buchanan is electrical.

6.1 HISTORICAL

Electrical energy consumption over the past 5 years has been as follows:

<u>FY</u>	<u>Main (MWh)</u>	<u>600 (MWh)</u>	<u>ARC's (MWh)</u>	<u>Total (MWh)</u>	<u>Site (MBtu)</u>	<u>Source (MBtu)</u>
1984	15,684	6,414	1,251	23,349	79,689	270,844
1985	14,374	7,676	1,572	23,622	80,621	274,012
1986	13,911	8,197	1,477	23,585	80,495	273,584
1987	24,212	3,876	1,553	29,641	101,164	343,836
1988	24,260	3,612	1,700	29,572	100,929	343,035

From fiscal year (FY) 82 through FY 86, consumption remained fairly consistent. Several new and large consumers came online at that time, however, and consumption since FY 86 has been almost 30-percent higher (see figure 6-1).

6.2 CURRENT

Detailed surveys of electricity consumption for each building (or typical building) were made in 1987. The following table shows the major users. (These numbers have been adjusted upward to account for consumption not identified and for consumption by buildings not included in the survey, so that they can be compared directly with the metered FY 86 totals).

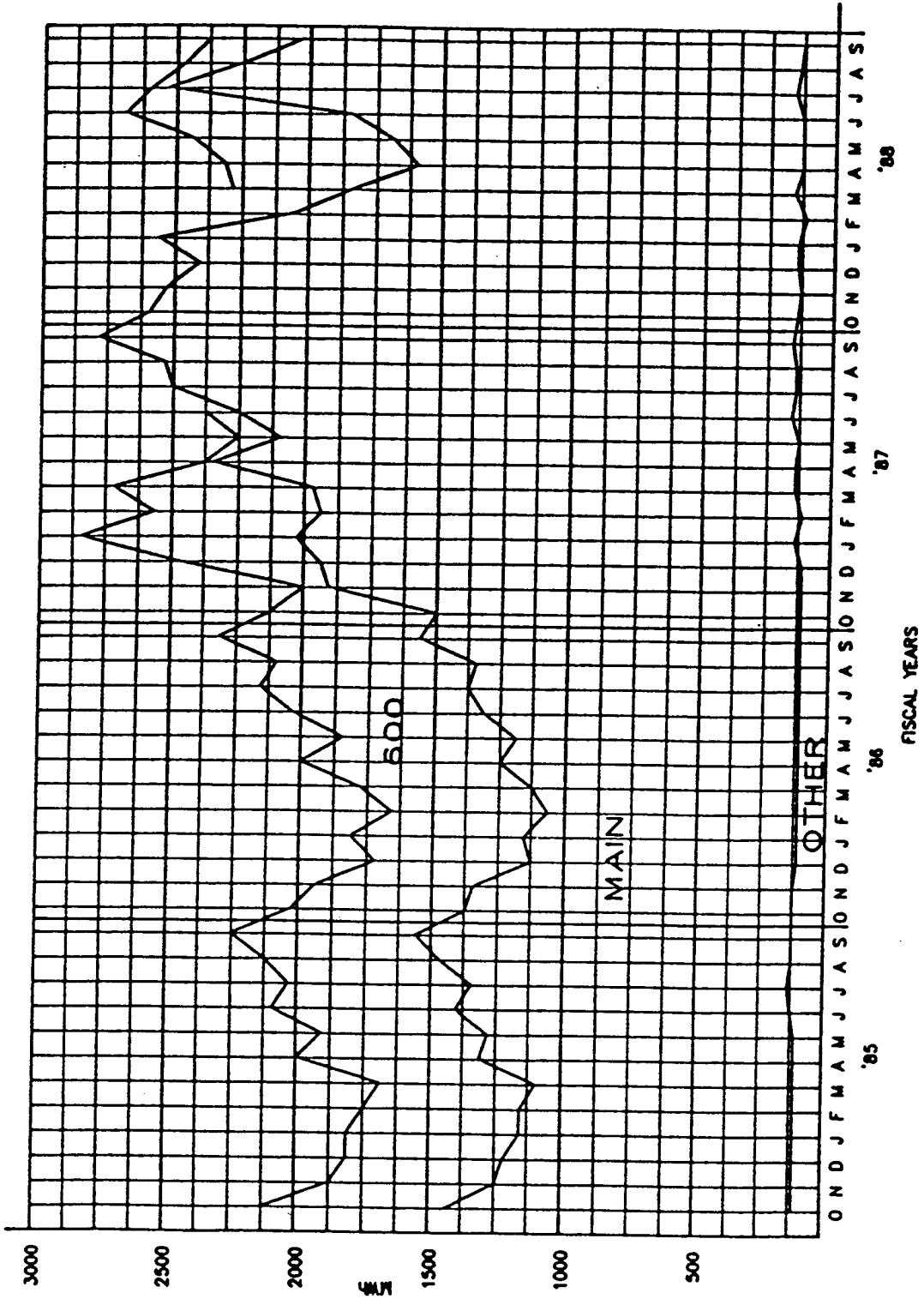


Figure 6-1. Electrical Energy Consumption (FY 85 through FY 88)

	<u>MBtu</u>	<u>1,000's of kWh</u>	<u>Cost, \$</u>
Post Exchange	10,245	3,002	240,160
Commissary	4,242	1,243	99,440
Community Club	11,392	3,338	267,040
Family housing	44,234	12,961	1,036,880
1300 Series	2,737	802	64,160
Reserve Centers	5,091	1,492	134,280
All other	<u>2,550</u>	<u>747</u>	<u>59,760</u>
	80,497	23,585	1,901,720

### 6.3 PROJECTED

From FY 82 through FY 86, electricity consumption grew at an average rate of 620,000 kWh per year. Between FY 86 and FY 87, there was an increase of 6 million kWh. Assuming no new quantum jumps, an increase of about 600,000 kWh per year, due to anticipated growth, can be expected. This would lead to a projected consumption of 32 million kWh in 1992. If all of the recommended ECO's were to be implemented before the end of FY 92, projected consumption would be decreased by 11,101 MBtu (3,253 MWh), or slightly less than 15 percent of the FY 86 consumption (see figure 6-2).

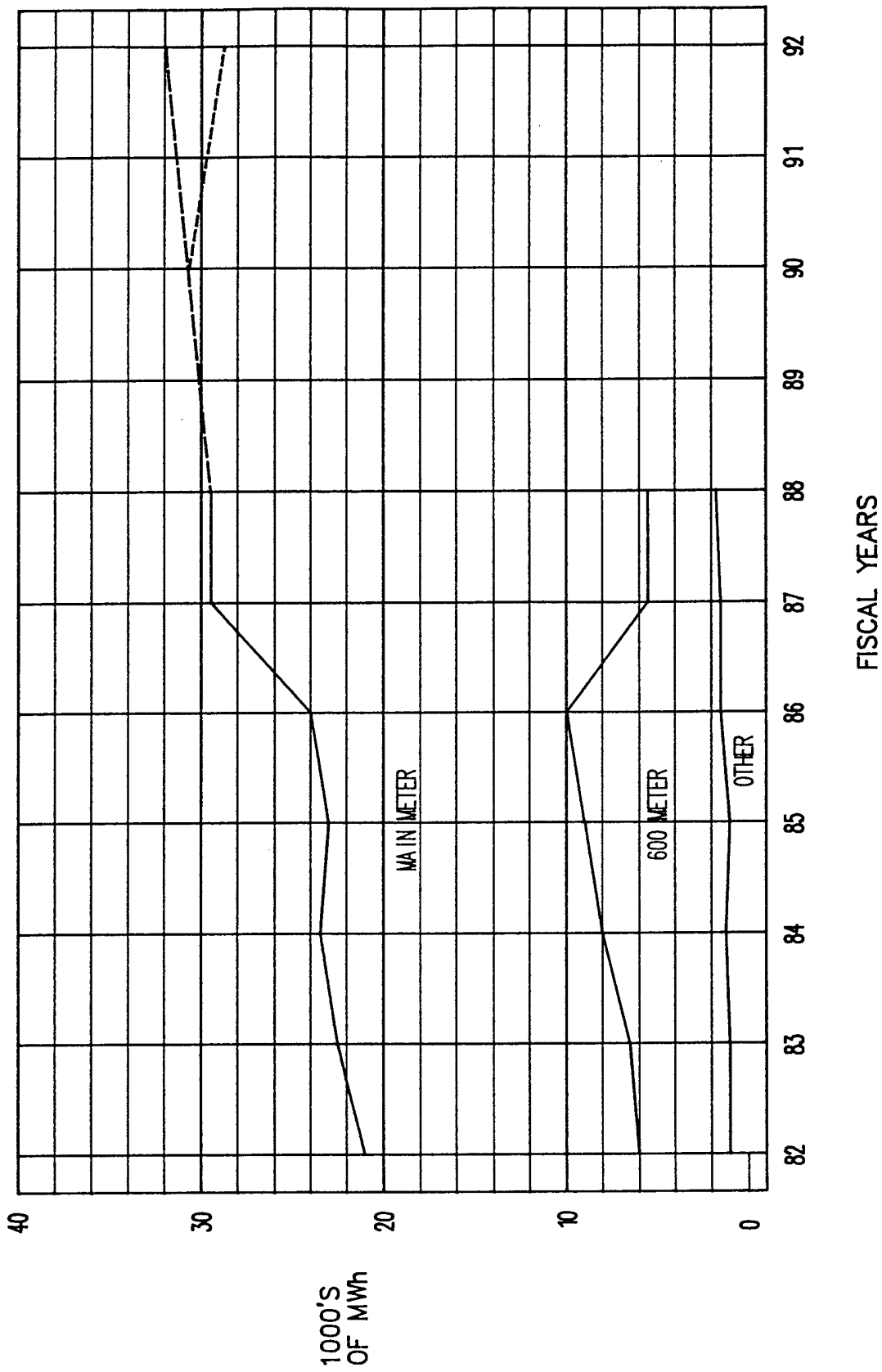


Figure 6-2. Projected Energy Consumption



APPENDIX B  
RECOMMENDED ECO CALCULATIONS