

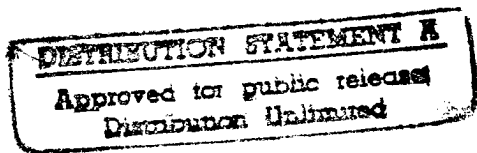
ENERGY ENGINEERING ANALYSIS PROGRAM  
100TH ASG  
GRAFENWÖHR AND VILSECK, GERMANY

ENERGY AUDIT OF DINING FACILITIES

FINAL REPORT  
AUGUST 1993

VOLUME II

NARRATIVE



PREPARED FOR:

U.S. ARMY ENGINEER DISTRICT, EUROPE  
CONTRACT NO. DACA-90-D-0065  
DELIVERY ORDER #0006

PREPARED BY:

DTIC QUALITY INSPECTED 2

GEHRMANN CONSULT GMBH  
ABRAHAM-LINCOLN STRASSE 34  
D6200 WIESBADEN, GERMANY

BAKER AND ASSOCIATES  
420 ROUSER ROAD  
CORAOPOLIS, PA 15108, U.S.A.

19971017 106

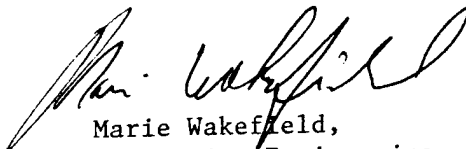


DEPARTMENT OF THE ARMY  
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS  
P.O. BOX 9005  
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO  
ATTENTION OF: TR-I Library

17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited.  
Distribution A. Approved for public release.

  
Marie Wakefield,  
Librarian Engineering

**INDEX OF VOLUMES****Volume I - Executive Summary**

- Tab 1 - Introduction
- Tab 2 - Site and Building Data
- Tab 3 - Present Energy Consumption
- Tab 4 - Historical Energy Consumption
- Tab 5 - Energy Conservation Analysis
- Tab 6 - Energy and Cost Savings
- Tab 7 - Analysis of Site Utilities

**Volume II - Narrative**

- Tab 1 - Introduction
- Tab 2 - Present Conditions
- Tab 3 - ECOs Considered
- Tab 4 - Results
- Tab 5 - Conclusions and Recommendations
- Tab 6 - Summary
- Tab 7 - Site Utility Analysis

**Volume III - Appendices**

- Tab 1 - Appendix A - Scope of Work
- Tab 2 - Appendix B - Field Survey Notes
- Tab 3 - Appendix C - ECO Checklist
- Tab 4 - Appendix D - ECO's Eliminated
- Tab 5 - Appendix E - Annual Energy Consumption Data
- Tab 6 - Appendix F - Supporting Data and Documentation for Developed Projects
- Tab 7 - Appendix G - Site Utility Analysis Data
- Tab 8 - Appendix H - Bibliography

## TABLE OF CONTENTS

**Tab 1 Introduction**

- 1.1 Project Overview**
- 1.2 Methodology**

**Tab 2 Present Conditions**

- 2.1 General Description of Grafenwöhr/Vilseck Area**
- 2.2 General Description of Grafenwöhr Building 101**
- 2.3 General Description of Vilseck Building 603**
- 2.4 Present Energy Consumption**
- 2.5 Energy Consumption Profiles**

**Tab 3 Energy Conservation Opportunities Considered**

- 3.1 ECO Checklist**

**Tab 4 ECO's Eliminated**

- 4.1 ECO's Rejected - Grafenwöhr Building 101**
- 4.2 ECO's Rejected - Vilseck Building 603**

**Tab 5 Conclusions and Recommendations**

- 5.1 Conclusions of the Survey Team - Grafenwöhr Building 101**
- 5.2 Recommended ECO's - Grafenwöhr Building 101**
- 5.3 Conclusions of the Survey Team - Vilseck Building 603**
- 5.4 Recommended ECO's - Vilseck Building 603**

**Tab 6 Summary**

- 6.1 ECO's Recommended for Implementation - Grafenwöhr Building 101**
- 6.2 ECO's Recommended for Implementation - Vilseck Building 603**

**Tab 7 Site Utility Analysis**

- 7.1 Review of Electricity Supply Contracts for Grafenwöhr and Vilseck**
- 7.2 Conclusions and Recommendations - Electrical Power Supply**
- 7.3 Review of District Hot water Supply Contracts for Grafenwöhr and Vilseck**
- 7.4 Conclusions and Recommendations - District Hot Water Supply**

## **LIST OF FIGURES**

- NF - 1 Annual Energy Use - Grafenwöhr Building 101
- NF - 2 Annual Energy Use - Vilseck Building 603
- NF - 3 Energy Consumption Profile - Grafenwöhr Building 101
- NF - 4 Energy Consumption Profile - Vilseck Building 603

## **LIST OF TABLES**

- NT - 1 Operating Schedule - Grafenwöhr Building 101
- NT - 2 Operating Schedule - Vilseck Building 603
- NT - 3 Metered Energy Consumption - Grafenwöhr Building 101
- NT - 4 Metered Energy Consumption - Vilseck Building 603
- NT - 5 Recommended ECO's - Grafenwöhr Building 101
- NT - 6 Recommended ECO's - Vilseck Building 603

**TAB 1 - INTRODUCTION****1.1 Project Overview**

1.1.1 This document contains the narrative description of the Energy Audit and Subsequent Energy/Cost Analyses performed by Gehrmann Consult, GMBH and Baker And Associates (hereinafter, the Engineers) under U.S. Army Engineer District, Europe (hereinafter, EDE) contract DACA-90-D-0065. The study was performed on two dining facilities of the 100th ASG command, Building 101 at Grafenwöhr, Germany and Building 603 at Vilseck, Germany. This project was conducted as part of the Department of the Army's Energy Engineering Analysis Program (EEAP).

1.1.2 The overall objective of this report is to identify and develop projects that can reduce the energy consumption of the aforementioned dining facilities. These projects are to be in compliance with the objectives of the Army Facilities Energy Plan (AFEP) and are to, in no way, decrease the readiness posture of the Army.

1.1.3 This study has been prepared in compliance with the General Scope of Work (SOW) dated 8 May 1992 and revised 1 September 1992 and its accompanying detailed Scope of Work. The complete SOW is included in this report as Appendix A in Volume III. All of the ECO's considered for this project are listed in Tab 3 of this Volume. All of the ECO's recommended for implementation are listed in Tab 5 of this volume. The calculated Savings to Investment Ratios (SIRs) and the relative rankings of the ECO's are also listed in Tab 4 of this volume.

**1.2 Methodology**

1.2.1 ECO's were identified during a four-day audit of the project sites in late November and early December of 1993. The ECO's identified were broken into five categories (i.e., Architectural, Electrical, Mechanical-HVAC, Mechanical-Plumbing, and Maintenance and Operations). The ECO's most suitable for rigorous evaluation were then identified

energy/cost savings calculated. In addition, O&M ECO's were identified for implementation as Low Cost/No Cost projects by the DEH/BSB staff and the building users.

- 1.2.2 The audit team was composed of an architect, two mechanical engineers and two electrical engineers. Team members were drawn from a joint venture of Gehrman Consult, GMBH and Baker and Associates. At the outset of the project the team developed a project schedule which included the following milestones:

Mobilization and Development Planning

Initial Site Fieldwork

Preliminary Report Preparation

Follow-up Site Fieldwork (as necessary)

Pre-final Report Presentation

Final Report Presentation

- 1.2.3 Mobilization and Development Planning consisted of assembling the project team, disseminating all of the paperwork received from the EDE and coordinating the project kick-off meeting with all the affected parties. In addition, an initial attempt was made to prepare an ECO checklist. The checklist was based, in large part, on the listing of potential ECO's included in the contract. However, additional ECO's, were identified using energy conservation literature from several other sources (see Bibliography, Tab 8, Volume III). These ECO's were eventually incorporated into the final ECO checklist, which can be found in Tab 3 of this Volume.

- 1.2.4 Upon arrival at Grafenwöhr, a kick-off meeting was held to introduce the audit team members to the DEH and the utility/energy staff which would be accompanying the audit team in the on-site building assessments. Specific requirements for data gathering, the specific requirements of the audit team, and the schedule for the audit were all discussed. In addition, the needs of the DEH and the objectives of the study were identified. The minutes of the kick-off meeting can be found in Appendix B, Tab 2, Volume III.



- 1.2.5 The initial site fieldwork was conducted at both Grafenwöhr Building 101 and Vilseck Building 603 over a three-day period. Specific ECO's were investigated by team members based on their respective disciplines (i.e., architecture, plumbing, HVAC, electrical). Drawings were obtained, measurements were recorded, photographs were taken, and sketches were made for potential ECO's. Non-viable ECO's were identified and the reasons for their rejection noted. The field notes for the two site visits can be found in Appendix B of Volume III. Unfortunately, due to the recent construction and the energy saving designs of both facilities, relatively few ECO's were available for the audit team to analyze. Fortunately, this indicates that both facilities are well designed, constructed, maintained, and operated.
- 1.2.6 The preparation of the Preliminary Report was divided into two parts. Gehrmann Consult was responsible for preparing all energy and cost savings calculations, and for developing the construction cost estimates for each ECO. Baker and Associates was responsible for preparing the economic analysis of each ECO and for preparing the project documentation.
- 1.2.7 The financial analysis of each ECO was conducted in accordance with the CEHSC-FU-M memorandum, "Energy Conservation Investment Program (ECIP) Guidance", dated 4 November 1992. All projects were assumed to be funded and constructed in 1993. Savings-to-Investment Ratios (SIR's) were calculated in accordance with National Institute of Standards and Technology (NIST) Handbook 135, "Life Cycle Cost Manual for the Federal Energy Management Program." A Uniform Present Worth (UPW) discount factor of 4.0 percent and the U.S. average commercial fuel price escalation rates were used in all SIR calculations.

**TAB 2 - PRESENT CONDITIONS****2.1 General Description of Grafenwöhr/Vilseck Area**

2.1.1 The U.S. Army training bases at Grafenwöhr and Vilseck lie on opposite sides of the Seventh Army Training Command, which is the largest training area in Europe. The climate is moderate with normally warm summers and cool, foggy autumns. Winter is cold and sunny, although the temperature seldom drops below -17.8° C (0°F). Winter design temperature (97.5%) is -16.1 °C (3°F) with 7313 annual heating degree days. Summer design temperature (2.5%) is 27.2 °C (81°F) with a mean coincident wet bulb temperature of 18.3 °C (65°F) and 88 annual cooling degree days. Source: TM-5-785, Engineering Weather Data.

**2.2 General Description of Grafenwöhr Building 101**

2.2.1 Grafenwöhr Building 101 is a one-story, red brick faced building with a flat roof. The building was constructed in 1982. It has a single, 250m<sup>2</sup>, dining area with a smaller, 100m<sup>2</sup>, dining area adjacent to it. This smaller dining area was added onto the original building in 1991.

2.2.2 The building has a single troop entrance with a small vestibule. Upon entering, the troops are directed to a single hot food serving line and two drink serving lines. The food preparation area, pot scrub area, and the walk-in freezers lie directly behind the serving area. The dishwashing area lies along one side of the serving area and adjacent to the dining area. The mechanical equipment room, the service entrance, and the refrigeration equipment room are spread along the opposite side of the building from the dining areas.

2.2.3 There are three air handling units in the aforementioned mechanical equipment room. One unit serves the Dining Area. A second unit ventilates the Serving Area. The third unit ventilates the Kitchen, or food preparation area. All three units are heating-only

units. Because the summers are so mild, air conditioning is not required at this location. The units serving the Kitchen and Serving Area are 100% outdoor air units. All of the air supplied by these units is exhausted through the cooking hoods and/or exhaust fans in these areas. Only the Dining Area unit has a return air system connected to it. In the summer, the return air damper to the unit is closed and exhaust fans on the roof over the Dining Area exhaust all of the air supplied by this unit.

- 2.2.4 The mechanical room also houses the domestic hot water heater/storage tank, all pumps for domestic and heating hot water, and the building's energy management control panel. Pump sets, drawing from a district hot water supply manifold, provide hot water to the three air handling units, the domestic hot water heat exchanger, and the perimeter baseboard radiation system.
- 2.2.5 Lighting in the Dining Area is provided by recessed, three-lamp fluorescent fixtures. A string of single-tube fluorescent fixtures is located in a lighting cove around the perimeter of the Dining Area. Fluorescent fixtures are used to light the remainder of the building.
- 2.2.6 Building 101 currently serves between 400 and 450 troops at lunch and dinner. Breakfast is a somewhat smaller meal. The building operates on the following schedule.

**TABLE NT-1 - OPERATING SCHEDULE - GRAFENWÖHR  
BUILDING 101**

	<b>Monday, Tuesday, Wednesday, Friday</b>	<b>Thursday</b>	<b>Saturday, Sunday</b>
<b>Breakfast</b>	0530 - 0745	0530 - 0700	0700 - 0830
<b>Lunch</b>	1115 - 1300	1115 - 1300	1200 - 1330
<b>Dinner</b>	1630 - 1800	1630 - 1800	1600 - 1730

2.2.7 Cooking begins approximately two hours prior to each meal. Clean-up takes approximately an hour and a half after every meal. A baking shift operates between 1600 and 2400 hours, every evening. However, this activity is confined to the food preparation area.

### **2.3 General Description of Vilseck Building 603**

2.3.1 Vilseck Building 603 is a one-story, yellow brick faced building with three peaked roofs running the width of the building. The building has two dining areas, one on either side of the building. A dishwashing area occupies the front-central portion of the building and the serving area occupies the rear-central portion of the building. Two hot food lines serve each of the dining areas. Along the front of the building there are two toilet rooms and an entry corridor. The entry corridor is accessed from either side of the building and serves both dining areas. Behind the serving area is the kitchen, or food preparation area. The pot scrub area, the refrigeration compressor room, the walk-in refrigerator and freezer, central stores, the electrical equipment room, the mechanical equipment room, and the employees shower are all wrapped around the food preparation area at the rear of the building. The building was completed in 1986.

2.3.2 There are five, heating-only, air handling units serving the following areas: the kitchen, the serving area, the dishwashing area, the east dining room, and the west dining room. Each unit is located in the attic space over the area it serves. The units serving the kitchen, serving, and dishwashing areas are 100% outdoor air ventilation units. The two air handling units serving the dining area are equipped with return air ductwork, which can be utilized during the heating season to minimize the amount of outdoor air which must be heated by these units. In addition to these five main air handling units, there are eleven ventilation units which are connected to the various exhaust hoods within the building. These units are not equipped with heating coils. The building's energy management control panel is also located in the attic space.

- 2.3.3 The mechanical equipment room houses two domestic hot water heating/storage tanks and the pumps for the domestic and the heating hot water systems. Pump sets, drawing from a district hot water supply manifold, supply hot water to the five main air handling units, the two domestic hot water heat exchangers, and the perimeter hot water baseboard radiation system.
- 2.3.4 Lighting in the dining area is by means of incandescent lamps mounted in architecturally dictated chandeliers. In addition, the dining area is equipped with incandescent wall washers. A string of single-tube fluorescent fixtures is located in a lighting cove around the perimeter of the dining areas. The remainder of the building is lit by recessed fluorescent lighting fixtures.
- 2.3.5 Building 603 currently serves between 600 and 625 troops at lunch and dinner. Breakfast is a somewhat smaller meal. The building operates on the following schedule:

**TABLE NT-2 - OPERATING SCHEDULE - VILSECK  
BUILDING 603**

	<b>Monday, Tuesday, Wednesday, Friday</b>	<b>Thursday</b>	<b>Saturday, Sunday</b>
<b>Breakfast</b>	0700 - 0845	0500 - 0630	0800 - 0930
<b>Lunch</b>	1130 - 1300	1200 - 1330	1130 - 1300
<b>Dinner</b>	1700 - 1830	1600 - 1730	1600 - 1730

- 2.3.6 Cooking begins approximately two hours prior to each meal. Clean-up lasts approximately two hours after each meal. A baking shift operates between 2200 and 0400 hours every night. However, this activity is confined to the food preparation area.

## **2.4 Present Energy Consumption**

- 2.4.1 The total annual energy consumption at Grafenwöhr Building 101 is 1,629,880 kWh. Of this, an estimated 1,434,295 kWh is mission-related energy (i.e., energy used for cooking, cleaning and dishwashing). The remaining 195,585 kWh are used for non-

mission related functions such as building heating, ventilating, handwashing, lighting, etc.

- 2.4.2 Energy is supplied to Building 101 by two different sources - district hot water and electricity. The building consumes 1,037,300 kWh of district hot water and 592,580 kWh of electrical energy. See Figure NF-1.
- 2.4.3 The total annual energy consumption at Vilseck Building 603 is 3,014,800 kWh. Of this, an estimated 2,653,000 kWh is mission-related energy (i.e., energy used for cooking, cleaning, and dishwashing). The remaining 361,800 kWh are used for non-mission related functions such as building heating, ventilating, handwashing, lighting, etc.
- 2.4.4 Energy is supplied to Building 603 by two different sources - district hot water and electricity. The building consumes 2,252,000 kWh of district hot water and 762,800 kWh of electrical energy. See Figure NF-2.

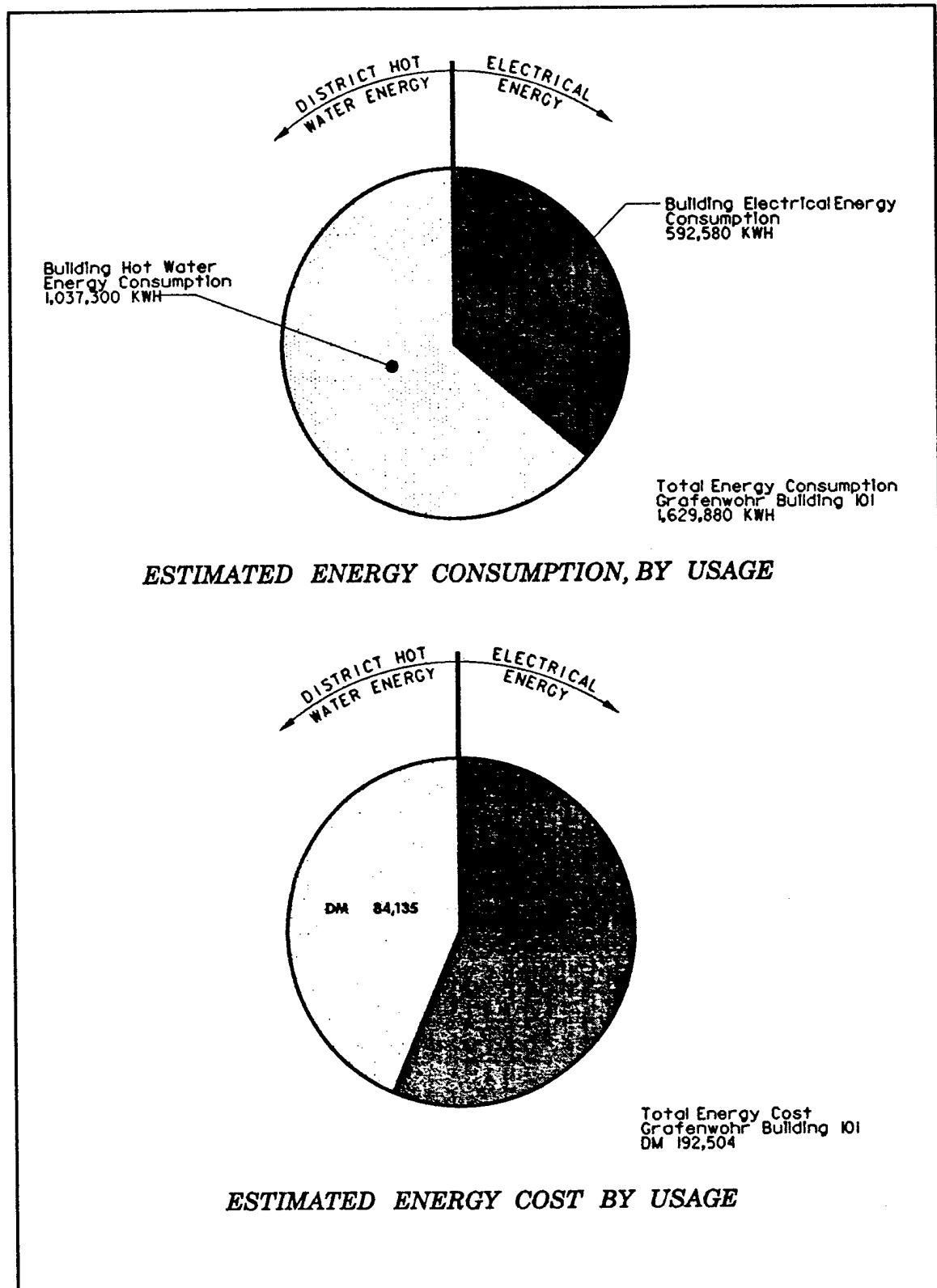
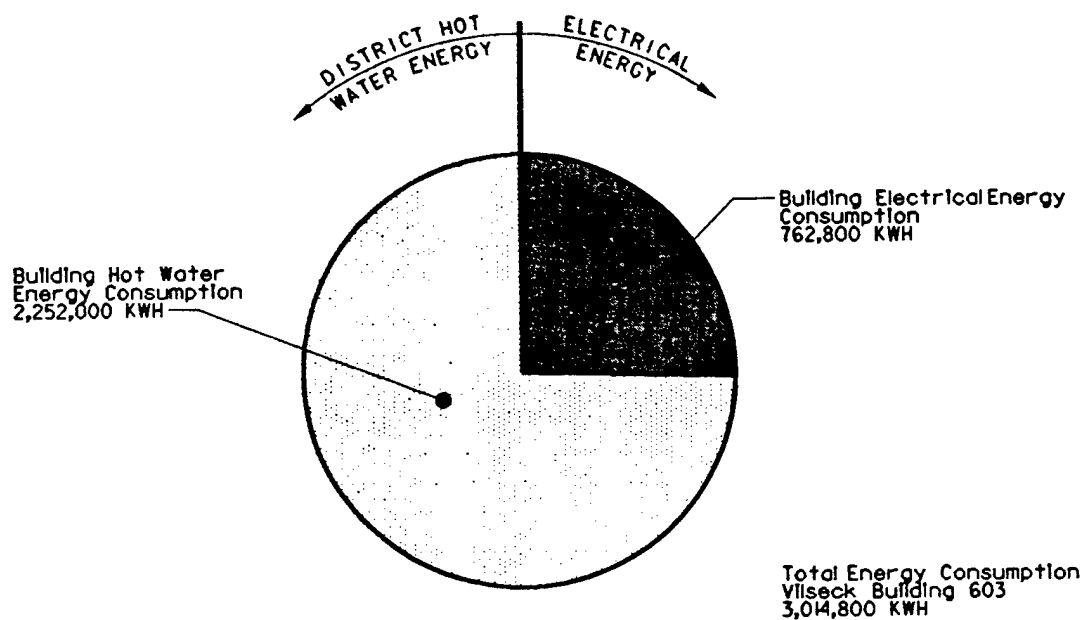
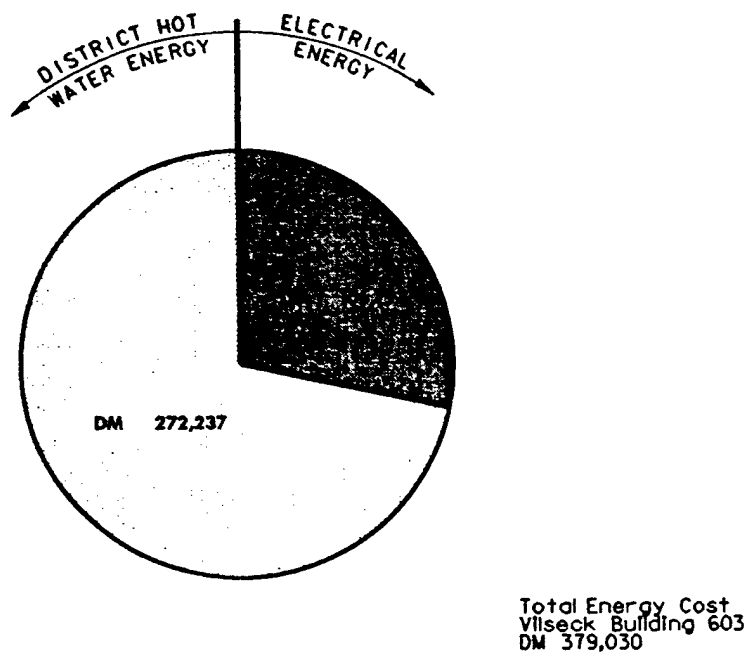


Figure NF-1 Annual Energy Use - Grafenwöhr Building 101



***ESTIMATED ENERGY CONSUMPTION, BY USAGE***



***ESTIMATED ENERGY COST BY USAGE***

Figure NF-2 Annual Energy Use - Vilseck Building 603



## 2.5 Energy Consumption Profiles

2.5.1 The following information was obtained from meters installed in the utility service lines at Building 101. Meter readings were taken by the 409th BSB staff and turned over to the audit team for analysis. No other meters were available to the audit team. Therefore, energy consumption could not be broken down further to identify the final end users. See Appendix E, Volume III, for development of building power consumption data.

**TABLE NT-3 - METERED ENERGY CONSUMPTION  
GRAFENWÖHR BUILDING 101**

<b>MONTH/YEAR</b>	<b>ELECTRICAL CONSUMPTION (KWh)</b>	<b>DISTRICT HOT WATER (KWh)</b>
January/1993	47,070*	112,800*
February/1993	47,070*	112,800*
March/1992	47,070*	112,800*
April/1992	51,550**	101,700*
May/1992	56,040	90,600
June/1992	42,170	35,800
July/1992	52,160	38,400
August/1992	54,950	45,200
September/1992	47,100	57,600
October/1992	47,700	100,600
November/1992	52,630	116,100
December/1992	47,070*	112,900

\* Average consumption for four month period.

\*\* Estimate based on average consumption for March 1993 and April 1992.

2.5.2 The tabulated data presented above has been plotted in Figure NF-3.

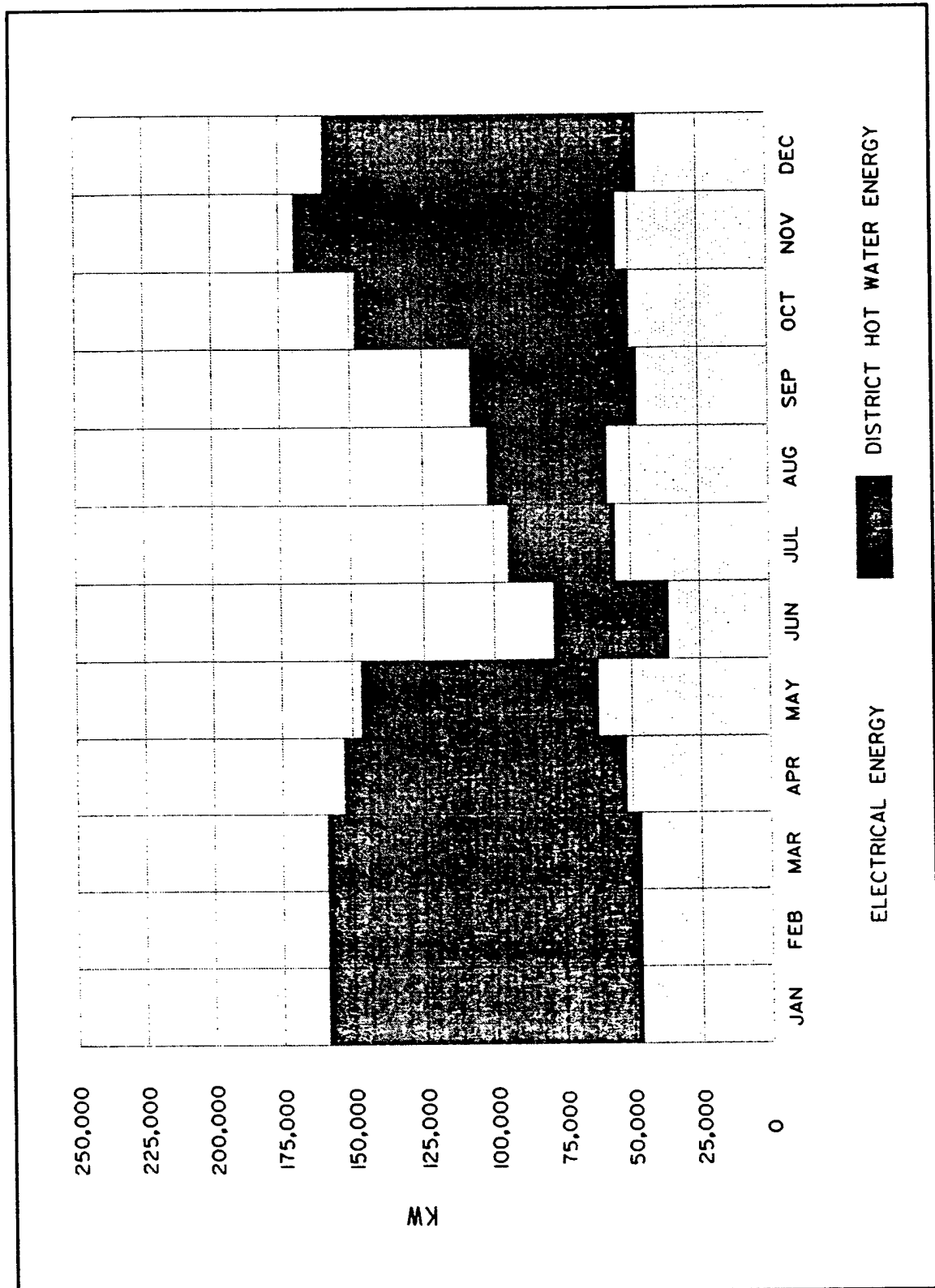


Figure NF-3 Energy Consumption Profile - Grafenwöhr Building 101

2.5.3 The following information was obtained from meters installed in the utility service lines at Building 603. Meter readings were taken by the 281st BSB staff and turned over to the audit team for analysis. No other meters were available to the audit team. Therefore, energy consumption could not be broken down further to identify the final end users. See Appendix E, Volume III, for development of building energy consumption data.

**TABLE NT-4 - METERED ENERGY CONSUMPTION  
VILSECK BUILDING 603**

<b>MONTH/YEAR</b>	<b>ELECTRICAL CONSUMPTION (KWh)</b>	<b>DISTRICT HOT WATER (KWh)</b>
January/199	66,050*	170,000***
February/199	66,050*	170,000***
March/199	66,050*	170,000*
April/199	63,550**	187,500**
May/1992	56,000	656,500
June/1992	62,500	321,000
July/1992	64,750	58,000
August/1992	64,750	45,000
September/1992	55,000	150,000
October/199	66,000*	77,000****
November/199	66,050*	77,000****
December/199	66,050*	170,000***

\* Average consumption for six month period.

\*\* Average based on preceding eleven months.

\*\* Average consumption for four month period.

\*\*\*\* Average consumption for two month period.

2.5.4 The tabulated data presented above has been plotted in Figure NF-4.

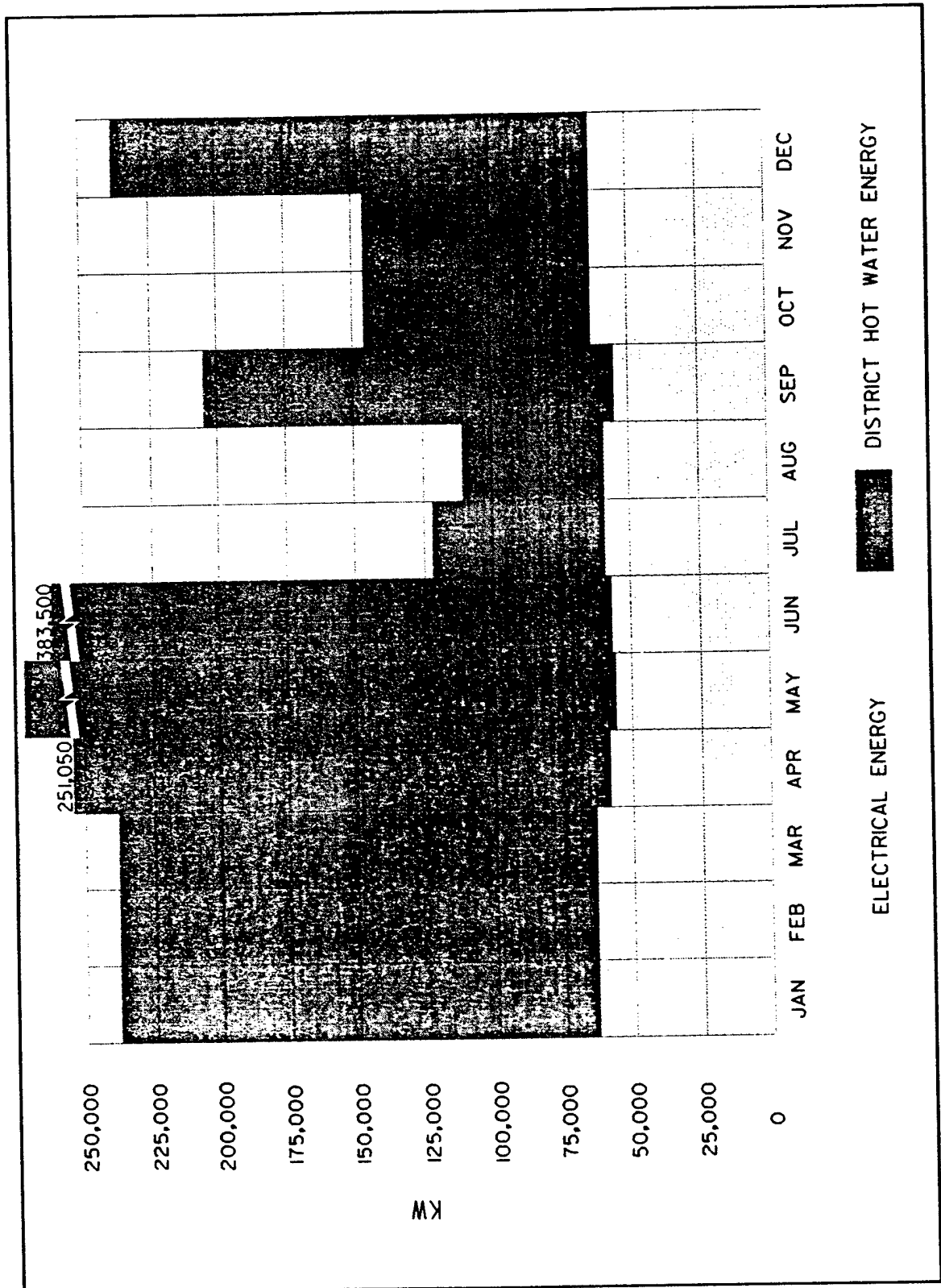


Figure NF-4 Energy Consumption Profile - Vilseck Building 603

**TAB 3 - ENERGY CONSERVATION OPPORTUNITIES****3.1 ECO Checklist**

3.1.1 The following Energy Conservation Opportunities (ECO's) were assembled from several sources and compiled into the ECO checklist used by the audit team during the site survey of Grafenwöhr Building 101 and Vilseck Building 603. The ECO's have been grouped according to system - i.e., Architectural, Mechanical - HVAC, Mechanical - Plumbing, and Electrical. Finally, a set of Operations and Maintenance (O&M) ECO's was developed. O&M Energy Conservation Opportunities cannot be rigorously evaluated as easily as the systemic ECO's. However, they are usually easily and inexpensively implemented. Therefore, the audit team felt that it was as important that it watch for and note O&M ECO's as it was to develop more cost intensive ECO's.

3.1.2 Architectural Energy Conservation Opportunities (ECO's) consist, mainly of those ECO's which will improve the thermal efficiency of the building envelope. The following twelve architectural ECO's were investigated at both the Grafenwöhr and the Vilseck sites.

- A1. Conserve energy by increasing the insulation in exterior walls.
- A2. Conserve energy by adding roof or ceiling insulation to the building to achieve a thermal resistance (R) rating of at least R-30 for the combined ceiling elements.
- A3. Conserve energy by reducing the amount of window glass in exterior walls.
- A4. Conserve energy by installing insulated panels over exterior windows.
- A5. Conserve energy by replacing single pane window glass with double or triple pane window glass.

- A6. Conserve energy by installing storm windows over exterior windows.
- A7. Conserve energy by installing solar film on exterior windows.
- A8. Conserve energy by installing shades, screens, curtains or blinds on exterior windows.
- A9. Conserve energy by reducing infiltration by means of new or improved weatherstripping and/or caulking.
- A10. Conserve energy by installing vestibules at troop entrances.
- A11. Conserve energy by installing air curtains or plastic strips at all service entrances.
- A12. Conserve lighting energy by improving the reflectivity of room surfaces.

3.1.3 Heating, Ventilating, and Air Conditioning (HVAC) system ECO's consist of changes which will improve the efficiency of the HVAC System (i.e. - air handling units, exhaust fans, piping, ductwork) and the HVAC system controls. The following twenty-five HVAC system ECO's were investigated at both the Grafenwöhr and the Vilseck sites.

- H1. Conserve energy by installing energy efficient exhaust hoods with integral make-up air ducts.
- H2. Conserve energy by recovering waste heat from exhaust air streams.
- H3. Conserve energy by changing constant volume air handling units to variable air volume (VAV) operation.
- H4. Conserve energy by balancing the HVAC system.

- H5. Conserve energy by reducing the amount of air supplied to or exhausted from the building (or space).
- H6. Conserve energy by reducing the amount of ventilation air drawn into the building by the HVAC system.
- H7. Conserve energy by installing tight-closing, low-leakage dampers on all outside air intake and exhaust openings (except at kitchen exhaust fans since damper blades could collect grease and become a fire hazard).
- H8. Conserve energy by reducing static pressure in HVAC systems.
- H9. Conserve energy by reducing supply air leakage at air handling units and supply air ductwork.
- H10. Conserve energy by insulating and/or repairing damaged insulation on HVAC system ductwork.
- H11. Conserve energy by installing ceiling-mounted circulating fans to reduce stratification within occupied spaces.
- H12. Conserve energy by recovering waste heat from refrigeration systems.
- H13. Conserve energy by ventilating the refrigeration system compressor room.
- H14. Conserve energy by replacing reciprocating type refrigeration compressors with higher efficiency scroll or rotary (screw) type compressors.
- H15. Conserve energy by re-setting heating hot water temperature according to outside air temperature and occupancy schedules.

- H16. Conserve energy by reducing pump flow rates.
- H17. Conserve energy by installing new insulation, adding additional insulation, or repairing existing insulation on heating hot water piping.
- H18. Conserve energy by repairing or eliminating all HVAC system control deficiencies.
- H19. Conserve energy by using the Energy Monitoring and Control System (EMCS) to optimize the start-up and shut-down schedules for HVAC system fans, pumps, compressors, and other motorized devices.
- H20. Conserve energy by using the EMCS to set-back space temperatures at night during the heating season.
- H21. Conserve energy by installing occupancy sensors to cycle the ventilation system "on" and "off" according to occupancy.
- H22. Conserve energy by interlocking the kitchen exhaust hoods with the cooking equipment served by each hood.
- H23. Conserve energy by installing economizer cycle controls and dampers on all ventilation systems.
- H24. Conserve energy by shutting off or reducing the amount of heating in vestibules.
- H25. Conserve energy by installing a thermal storage system.
- H26. Conserve energy by using infrared heaters in lieu of conventional (convection) heaters.



3.1.4 Plumbing System ECO's consist of changes which will improve the efficiency and/or reduce the energy consumption of the plumbing systems (i.e. - Domestic cold water, hot water and waste water systems). The following ten plumbing ECO's were investigated at both the Grafenwöhr and Vilseck sites.

- P1. Conserve energy by lowering the domestic hot water supply temperature.
- P2. Conserve energy by installing controls on the domestic hot water system to lower the heater's set-point temperature or to shut-off the heat source to the heater during non-peak periods.
- P3. Conserve energy by installing booster heaters at major hot water users and at high temperature hot water users.
- P4. Conserve energy by installing instantaneous hot water heaters in lieu of storage tank type heaters.
- P5. Conserve energy by installing additional insulation on the domestic hot water storage tanks.
- P6. Conserve energy by installing additional insulation and/or repairing existing insulation on domestic hot water piping.
- P7. Conserve energy by installing flow restrictors at domestic hot and cold water end users.
- P8. Conserve energy by installing automatic shut-off type faucets in lavatories.
- P9. Conserve energy by reclaiming waste heat from dishwasher wastewater.
- P10. Conserve energy by installing solar collectors to pre-heat domestic hot water.

3.1.5 Electrical System ECO's consist of changes which will improve the efficiency and/or reduce the energy consumption of the electrical system (i.e. - The power distribution and the lighting systems). The following twenty electrical ECO's were investigated at both the Grafenwöhr and the Vilseck sites.

- E1. Conserve energy by reducing lighting levels to minimum levels described in the Army Design Guidelines.
- E2. Conserve lighting energy by eliminating excess fixtures. Where fixtures are close enough to each other, it may be possible to eliminate excess fixtures without creating dark spots.
- E3. Conserve energy by delamping selected lighting fixtures.
- E4. Conserve energy by converting existing lighting fixtures to high efficiency fluorescent or HID fixtures.
- E5. Conserve energy by replacing the incandescent lamps in exit lights with lower wattage fluorescent lamps.
- E6. Conserve energy by installing improved reflectors on lighting fixtures and reducing the fixtures lamp wattage.
- E7. Conserve energy by replacing existing core coil ballasts with electronic ballasts in existing fluorescent lighting fixtures.
- E8. Conserve energy by replacing existing lamps with energy efficient U-tube fluorescent lamps.
- E9. Conserve energy by replacing existing incandescent bulbs with compact fluorescent bulbs.
- E10. Conserve energy by installing dimming hardware on exterior HID lighting.

- E11. Conserve energy by turning exterior lighting "on" and "off" by means of photocells.
- E12. Conserve energy by turning exterior lighting "on" and "off" by means of timers.
- E13. Conserve energy by providing task level switching for interior lights. Task level switching will allow the lighting level to be varied to match the activity within the space.
- E14. Conserve lighting energy by using photocells to turn "off" or dim interior lights (especially lights near windows) when natural daylight provides adequate illumination.
- E15. Conserve energy by turning interior lighting "on" and "off" by means of timers.
- E16. Conserve energy by turning interior lighting "on" and "off" by means of space occupancy sensors.
- E17. Conserve energy by replacing existing motors with energy efficient motors.
- E18. Conserve energy by replacing oversized/undersized motors with motors which have their peak efficiency at the actual system load.
- E19. Conserve energy by adding power factor correcting capacitors to existing motors.
- E20. Conserve energy by equipping motors which experience highly variable loads with variable frequency drives.

3.1.6 Operations and Maintenance (O&M) ECO's consist of changes to the procedures which govern the use and maintenance of the dining facility and the equipment therein. Most O&M ECO's can be classified as Low/No Cost ECO's and are, therefore, of special interest to the facility managers and users. Many O&M ECO's may be put into effect by installing time clock controls at some later date, however, all of the proposed O&M ECO's can be put into effect immediately, through the efforts of the kitchen and maintenance staffs. The following twenty-one O&M ECO's have been investigated at both the Grafenwöhr and Vilseck sites.

- OM1. Conserve energy by optimizing HVAC system start-stop times and set-back temperatures with respect to dining facility operations.
- OM2. Conserve energy by maintaining thermostat set-points at authorized temperatures.
- OM3. Conserve energy by turning "off" kitchen hot water heaters (specifically booster heaters on dishwashing equipment) when not required.
- OM4. Conserve energy by shedding or cycling electrical loads to reduce peak demand.
- OM5. Conserve energy by running the emergency generator to reduce peak demand.
- OM6. Conserve energy by maintaining all HVAC system controls in good working order.
- OM7. Conserve energy by keeping the coils (both evaporator and condenser) on all refrigeration equipment clean and unobstructed.
- OM8. Conserve energy by keeping the heat exchanger tubes in the domestic hot water heater clean. Provide water treatment if required to prevent fouling of tube

surfaces.

- OM9. Conserve energy by keeping all light fixture lenses and reflectors clean.
- OM10. Conserve energy by keeping all HVAC system filters (including exhaust hood grease filters) clean.
- OM11. Conserve energy by turning "off" all miscellaneous electrical equipment (such as vending machines) whenever it is not required.
- OM12. Conserve energy by consolidating refrigerated foodstuffs into fewer refrigerators, coolers, or freezers and turning "off" those freezers that are not required.
- OM13. Conserve energy by thawing frozen foods in refrigerated compartments.
- OM14. Conserve energy by preheating only that equipment which will be required for the meal being served.
- OM15. Conserve energy by preheating equipment immediately prior to use.
- OM16. Conserve energy by steaming (rather than boiling) vegetables whenever possible.
- OM17. Conserve energy by matching pots to burner size so that pots completely cover burners.
- OM18. Conserve energy by cooking with lids in place.
- OM19. Conserve energy by using microwave cooking equipment in lieu of conventional cooking equipment whenever possible.

- OM20. Conserve energy by avoiding the use of hot water for dish scraping.
- OM21. Conserve energy by operating dishwashers only when continuous usage can be sustained.
- OM22. Conserve energy by reducing the building's operating hours.
- OM23. Conserve energy by conducting regular steam trap inspections.

**TAB 4 - RESULTS****4.1 Results of the Analysis of ECO Checklist Items - Grafenwöhr Building 101****4.1.1 ECO A1 Conserve energy by increasing insulation in exterior walls.**

Building 101 was designed with 6 centimeters of fiberglass batt insulation in the wall cavity between the outer brick wythe and the inner concrete block wythe of the exterior wall. This exceeds the 5cm of insulation required by the "Standard Design Guidelines for Modifying Interior and Exterior Energy Systems" published by the Utilities and Energy Branch, HQ, USAREUS. See Table 1-1. Additional insulation would have only a marginal effect on the thermal characteristics of the exterior walls and would be enormously expensive since it would have to be installed on either the exterior of the building (using a system similar to the Dryvit system) or on the interior surface of the existing plaster wall. The new interior insulation would, then, have to be covered with new wood paneling and/or a new gypsum board interior wall.

**4.1.2 ECO A2 Conserve energy by adding roof or ceiling insulation to the building to achieve a thermal resistance (R) rating of at least R-30 for the combined ceiling elements.**

Building 101 was designed with 12cm of rigid board roof insulation. Assuming that the insulation is a typical expanded polystyrene board ( $R=5.0/\text{inch}$ ), the R-value of the roof assembly is estimated to be 25.18  $^{\circ}\text{F}\cdot\text{ft}^2\cdot\text{hr}/\text{BTU}$ . Increasing the R-value of the roof from the present R-25 to R-30 would have only marginal impact on the roof's thermal characteristics. Because the roof is only ten years old, the cost of re-roofing would more than offset any thermal improvement. However, when re-roofing is required, the roof insulation should be increased to achieve

a rating of R-30 for the roof assembly.

- 4.1.3 ECO A3**      **Conserve energy by reducing the amount of window glass in exterior walls.**

As presently configured, Building 101 has a glass-to-wall ratio of only 7.0 percent. There is little reason to reduce this ratio even further. The only significant amount of glazing in the building is in the dining area. Reducing this glass area further would reduce the architectural attractiveness of the space and the amount of daylight which enters the building. See ECO E14.

- 4.1.4 ECO A4**      **Conserve energy by installing insulated panels over exterior windows**

See commentary on ECO A3.

- 4.1.5 ECO A5**      **Conserve energy by replacing single pane window glass with double or triple pane window glass.**

The existing windows are already glazed with double pane, insulating window glass. Increasing the thermal efficiency of the windows by installing triple pane glass would only have a marginal effect on the thermal efficiency of the building.

- 4.1.6 ECO A6**      **Conserve energy by installing storm windows over exterior windows.**

See commentary on ECO A5.

- 4.1.7 ECO A7**      **Conserve energy by installing solar film on exterior windows.**

During the summer months, solar film does an excellent job of limiting



solar heat gain and reducing the air conditioning load. However, since Building 101 is not air conditioned, solar film would have little energy conserving benefit. During the winter months, the lack of solar film (existing condition) allows solar energy to enter the dining area. This tends to reduce the amount of heating required to keep the Dining Area comfortable. In this case, the lack of solar film is a benefit.

- 4.1.8 ECO A8**      **Conserve energy by installing shades, screens, curtains, or blinds on exterior windows.**

The windows at Grafenwöhr building 101 are already outfitted with interior curtains. See, also, commentary on ECO A7.

- 4.1.9 ECO A9**      **Conserve energy by reducing infiltration by means of new or improved weatherstripping and/or caulking.**

The weatherstripping and caulking on Building 101 was found to be in good condition.

- 4.1.10 ECO A10**      **Conserve energy by installing vestibules at troop entrances.**

Building 101 is already equipped with an entry vestibule at the troop entrance. Exterior doors not equipped with vestibules are all marked with "Emergency Exit Only" signs.

- 4.1.11 ECO A11**      **Conserve energy by installing air curtains or plastic strips at all service entrances.**

Current practice at Building 101 is to leave the kitchen make-up air unit "off" even when the kitchen hood exhaust fans are turned "on". This is done in all but the coldest weather. Since the units supplying make-up to

the kitchen and dining area are not turned on, the make-up air for the exhaust hoods is drawn into the building through the screened rear (service entrance) doors. Since this practice seems to work satisfactorily, it is likely to be continued. Therefore, an air curtain or plastic door strips, which would reduce the amount of air infiltrating into the building would be undesirable. Since the amount of outside air drawn into the building is the same, whether it is infiltration or ventilation air supplied by the make-up air units, the building's energy consumption remains constant. During extremely cold weather, the kitchen ventilation unit is turned "on" and the rear entry doors are kept closed. So air curtains or door strips would be of little use under this condition, also.

**4.1.12 ECO A12    Conserve lighting energy by improving the reflectivity of room surfaces.**

Wall and ceiling surfaces at Grafenwöhr Building 101 were found to be of a light color and kept clean. Therefore, there is little opportunity for improving surface reflectivity.

**4.1.13 ECO H1    Conserve energy by installing energy efficient exhaust hoods with integral make-up air ducts.**

Energy saving exhaust hoods are already installed in Building 101.

**4.1.14 ECO H2    Conserve energy by recovering waste heat from exhaust air streams.**

The energy-saving exhaust hoods installed in Building 101 (See commentary on ECO H1) have exhaust air streams with a very low heat content since most of the air being exhausted is outdoor air. For this reason, there is very little potential for exhaust air heat recovery. The toilet room exhaust has a somewhat higher heat content (higher

temperature) but it has a very low flow rate and a low number of operating hours. Therefore, the potential for heat recovery from toilet room exhaust is, also, very low.

**4.1.15 ECO H3      Conserve energy by changing constant volume air handling units to variable air volume (VAV) operation.**

Because two of the air handling units (kitchen and serving line units) are rarely turned on and because the building is not air conditioned, there is little or no potential energy savings expected from converting to VAV operation. VAV operation is particularly effective in reducing energy consumption when the HVAC system is in the air conditioning mode. However, it is not particularly effective in reducing energy consumption during the heating season. This is due to the fact that building heating is accomplished, primarily, through the perimeter radiation system.

**4.1.16 ECO H4      Conserve energy by balancing the HVAC system.**

There were no unexpected or extreme temperature variations within the dining areas of Building 101. This indicates that the air supplied to the area is well suited to the requirements of that space. (Note that under normal operating conditions, only the air handling unit supplying the dining area is used). Therefore, it appears that the HVAC system does not require re-balancing.

**4.1.17 ECO H5      Conserve energy by reducing the amount of air supplied to or exhausted from the building (or space).**

An investigation of the existing drawings suggests that the present air flow rates are at or below the DIN and the VDI guidelines. However, since the supply and exhaust air quantities of the existing HVAC system appear to

be satisfactory for both comfort and odor control, there is little reason to re-balance the system.

**4.1.18 ECO H6      Conserve energy by reducing the amount of ventilation air drawn into the building by the HVAC system.**

As noted previously, the air handling units serving the kitchen and the serving area are rarely used. Therefore, no energy savings can be derived from reducing the ventilation air flow rate of these units. The outdoor air damper on the dining area air handling unit appears to be operating properly to control the amount of ventilation air being supplied to the space and to minimize energy consumption.

**4.1.19 ECO H7      Conserve energy by installing tight-closing, low-leakage dampers on all outside air intake and exhaust openings (except at kitchen exhaust fans since damper blades could collect grease and become a fire hazard).**

Low-leakage dampers are already present on the air handling equipment installed in Building 101.

**4.1.20 ECO H8      Conserve energy by reducing static pressure in HVAC systems.**

The air handling unit serving the dining area appears to be operating satisfactorily. (See commentary on ECO H4). Since the system is a constant volume system, there are no VAV boxes which require some additional minimum static pressure at the box inlet. Therefore, the system static pressure is already at or near its optimum setting.

**4.1.21 ECO H9      Conserve energy by reducing supply air leakage at air handling units and supply air ductwork.**

There were no large or obvious leaks in the visible portions of the supply air ductwork or at the air handling unit casings at Building 101.

**4.1.22 ECO H10      Conserve energy by insulating and/or repairing damaged insulation on HVAC system ductwork.**

The insulation on the visible portions of the HVAC system ductwork in Grafenwöhr Building 101 appeared to be intact and in good repair. Only minor repairs are required where the vapor barrier (external skin) of the insulation has been punctured or where seam tape has come unglued.

**4.1.23 ECO H11      Conserve energy by installing ceiling-mounted circulating fans to reduce stratification within occupied spaces.**

The ceilings in Building 101 are between 2.99m. and 3.25m. high. These ceilings are too low for the interior spaces to have serious stratification problems. They are also somewhat low to have surface mounted recirculation fans installed below them.

**4.1.24 ECO H12      Conserve energy by recovering waste heat from refrigeration systems.**

The most effective way to capture waste heat from refrigeration systems is to use a heat exchanger to preheat domestic hot water with the refrigerant hot gas. However, because the domestic hot water storage tank temperature (60°C) is greater than the hot gas temperature ( $\pm 43^\circ\text{C}$ ) of the refrigerator/freezer refrigeration systems, an additional hot water storage tank would have to be installed to allow heat to be recovered from the food storage refrigeration equipment. This tank would be used to pre-heat

domestic water before it entered the existing hot water storage tank. However, there is not enough space in either the mechanical room or the refrigeration compressor room for such a storage tank.

**4.1.25 ECO H13    Conserve energy by ventilating the refrigeration system compressor room.**

The compressor room in Building 101 is already equipped with a ventilation system. This consists of an intake louver in the east wall of the room and a roof-mounted exhaust fan.

**4.1.26 ECO H14    Conserve energy by replacing reciprocating type refrigeration compressors with higher efficiency scroll or rotary (screw) type compressors.**

Given the age of Building 101 and the installed equipment, replacement of the refrigeration compressors would be impractical for two reasons. One, the equipment is less than half way through its useful life; and, two, the installed equipment should have a relatively high coefficient-of-performance (COP).

**4.1.27 ECO H15    Conserve energy by re-setting heating hot water temperature according to outside air temperature and occupancy schedules.**

The building automation system installed in Building 101 is already programmed to perform these functions.

**4.1.28 ECO H16    Conserve energy by reducing pump flow rates.**

The building automation system installed in Building 101 is already programmed to adjust hot water flow rates - using the installed variable

speed Wilo pumps - to suit the building's loads.

- 4.1.29 ECO H18    Conserve energy by repairing or eliminating all HVAC system control deficiencies.**

According to building operating personnel, the installed building controls are operating without deficiencies.

- 4.1.30 ECO H19    Conserve energy by using the Energy Monitoring and Control System (EMCS) to optimize the start-up and shut-down schedules for HVAC system fans, pumps, compressors, and other motorized devices.**

According to building operating personnel, the installed EMCS is presently used to optimize equipment performance and building comfort.

- 4.1.31 ECO H20    Conserve energy by using the EMCS to set-back space temperatures at night during the heating season.**

See commentary on ECO H19.

- 4.1.23 ECO H21    Conserve energy by installing occupancy sensors to cycle the ventilation system "on" and "off" according to occupancy.**

The occupancy schedule for this building is well defined. Therefore, the ventilation system can be controlled effectively by the EMCS and the addition of space occupancy sensors is unnecessary.

- 4.1.33 ECO H22    Conserve energy by interlocking the kitchen exhaust hoods with the cooking equipment served by each hood.**

It has been determined that re-wiring the existing cooking equipment to turn the associated exhaust hood "on" and "off" is impractical. However, training the kitchen staff to operate cooking hoods only while cooking is a viable low/no cost ECO, and will be dealt with as an O&M ECO.

- 4.1.34 ECO H23    Conserve energy by installing economizer cycle controls and dampers on all ventilation systems.**

The air handling units in Building 101 are not equipped for air conditioning. Therefore, economizer cycles are not necessary.

- 4.1.35 ECO H24    Conserve energy by shutting off or reducing the amount of heating in vestibules.**

The only vestibule in Building 101 (at the troop entrance to the building) is not equipped with any heating devices.

- 4.1.36 ECO H25    Conserve energy by installing a thermal storage system.**

Thermal storage systems are only practical for buildings equipped with air conditioning. Even then they are only viable when there are significant time-of-day incentives (from the power supplier) for consuming more power during off-peak periods and less power during peak demand periods. Since neither of these criteria are met at Grafenwöhr, there is little reason to install a thermal storage system.

- 4.1.37 ECO H26    Conserve energy by using infrared heaters in lieu of conventional**



- 4.1.37 ECO H26    Conserve energy by using infrared heaters in lieu of conventional (convection) heaters.**

Infrared heaters are best suited for exterior area heating (such as loading docks) or for areas with extremely large volumes (such as warehouses). Since neither of these types of spaces are present in Building 101 there is little reason to pursue the use of infrared heating.

- 4.1.38 ECO P1    Conserve energy by lowering the domestic hot water supply temperature.**

The hot water storage temperature of 60°C is required by Army regulations.

- 4.1.39 ECO P2    Conserve energy by installing controls on the domestic hot water system to lower the heater's set-point temperature or to shut-off the heat source to the heater during non-peak hours.**

The required controls are already present on the Building 101 domestic hot water system.

- 4.1.40 ECO P3    Conserve energy by installing booster heaters at major hot water users and at high temperature hot water users.**

The largest, single hot water consumer is the dishwasher, which is already equipped with an electrical booster heater.

**4.1.41 ECO P4      Conserve energy by installing instantaneous hot water heaters in lieu of storage tank type heaters.**

Given the relatively recent construction of Building 101, the replacement of the existing water heating equipment with instantaneous water heaters is highly impractical. In addition, heating domestic water with electricity is more expensive (in both cost and energy terms) than heating with district hot water - as is presently done.

**4.1.42 ECO P6      Conserve energy by installing additional insulation and/or repairing existing insulation on domestic hot water piping.**

The insulation on the domestic hot water system piping and storage tanks which requires repairs is located in the mechanical equipment room. All of the insulation within this space has been evaluated as part of ECO H17.

**4.1.43 ECO P9      Conserve energy by reclaiming waste heat from dishwashing wastewater.**

The present dishwasher installation would make it extremely difficult to connect a water-to-water heat exchanger to the sanitary sewer connection on the dishwasher. Also, there is little space in the mechanical room for installing the additional pumps and secondary loop heat exchanger required to recover heat from the dishwasher wastewater.

**4.1.44 ECO P10     Conserve energy by installing solar collectors to pre-heat domestic hot water.**

The total insolation (time and intensity of sunshine) in Grafenwöhr makes solar heating technically impractical.

- 4.1.45 ECO E2**      **Conserve lighting energy by eliminating excess fixtures. Where fixtures are close enough to each other, it may be possible to eliminate excess fixtures without creating dark spots.**

The lighting fixtures in Building 101 are spaced in such a manner that no fixtures can be eliminated without causing undesirable variations in the lighting levels within individual spaces.

- 4.1.46 ECO E3**      **Conserve energy by delamping selected lighting fixtures.**

See commentary on ECO E1. In some areas, selective de-lamping, rather than re-lamping with lower wattage lamps, may be the most cost effective method for reducing lighting levels to the required minimum.

- 4.1.47 ECO E4**      **Conserve energy by converting existing lighting fixtures to high efficiency fluorescent or HID fixtures.**

Both the interior and exterior fixtures at Grafenwöhr Building 101 are already either fluorescent (interior) or HID (exterior) type. Incandescent lighting is not used in this building.

- 4.1.48 ECO E5**      **Conserve energy by replacing the incandescent lamps in exit lights with lower wattage fluorescent lamps.**

This has already been done in Building 101.

- 4.1.49 ECO E6**      **Conserve energy by installing improved reflectors on lighting fixtures and reducing the fixtures lamp wattage.**

The lighting fixtures in Grafenwöhr Building 101 are relatively new

fixtures which are already equipped with efficient reflectors and low wattage lamps.

- 4.1.50 ECO E7      Conserve energy by replacing existing core coil ballasts with electronic ballasts in existing fluorescent lighting fixtures.**

ECO E7 has been evaluated fully and been rejected because it has a Savings-to-Investment Ratio (SIR) of less than 1.0.

- 4.1.51 ECO E8      Conserve energy by replacing existing lamps with energy efficient U-tube fluorescent lamps.**

For architectural reasons, the fixtures in Building 101 are not suitable for re-lamping with U-tube fluorescent lamps.

- 4.1.52 ECO E9      Conserve energy by replacing existing incandescent bulbs with compact fluorescent bulbs.**

See commentary on ECO E8.

- 4.1.53 ECO E11     Conserve energy by turning exterior lighting "on" and "off" by means of photocells.**

ECO E10 has been developed to minimize the energy used for exterior lighting. Photocells have been included in the development of ECO E10.

- 4.1.54 ECO E12     Conserve energy by turning exterior lighting "on" and "off" by means of timers.**

ECO E10 has been developed to turn the exterior lighting "on" and "off" by means of a photocell. Therefore, this ECO will not be pursued. See,

also, ECO E11.

- 4.1.55 ECO E13**    **Conserve energy by providing task level switching for interior lights. Task level switching will allow the lighting level to be varied to match the activity within the space.**

Because the Dining Facility is not a multiple use facility (i.e., the spaces are all designed for a single, specific activity) task level switching is not appropriate for this building.

- 4.1.56 ECO E15**    **Conserve energy by turning interior lighting "on" and "off" by means of timers.**

ECO E14 has been developed to minimize energy usage within the Dining areas. Therefore, this ECO will not be pursued.

- 4.1.57 ECO 16**    **Conserve energy by turning interior lighting "on" and "off" by means of space occupancy sensors.**

ECO E14 has been developed to turn the interior lighting "on" and "off" by means of a timer. Therefore, this ECO will not be pursued. See, also, ECO E15.

- 4.1.58 ECO 17**    **Conserve energy by replacing existing motors with energy efficient motors.**

Given the relatively short period of time that the existing motors have been in service, it would be both expensive and wasteful to replace them with newer motors. In addition, the efficiency of newer motors is only marginally better than that of motors built less than ten years ago.

- 4.1.59 ECO E18    Conserve energy by replacing oversized/undersized motors with motors which have their peak efficiency at the actual system load.**

On inspection, the larger (greater than 1/2 HP) motors at Grafenwöhr Building 101 were found to be well matched to their service loads.

- 4.1.60 ECO E19    Conserve energy by adding power factor correcting capacitors to existing motors.**

The motors on equipment installed in Building 101 are well suited for their service and do not require power factor correction.

- 4.1.61 ECO E20    Conserve energy by equipping motors which experience highly variable loads with variable frequency drives.**

The only motors which are subjected to this type of loading are the hot water pumps. These pumps are already equipped with variable frequency drives.

**4.2    ECO Rejected - Vilseck Building 603.**

- 4.2.1    ECO A1    Conserve energy by increasing insulation in exterior walls.**

Building 603 was designed with 6 centimeters of fiberglass batt insulation in the wall cavity between the outer brick wythe and the inner concrete block wythe of the exterior wall. This exceeds the 5cm of insulation required by the "Standard Design Guidelines for Interior and Exterior Energy Systems" published by the Utilities and Energy Branch, HQ, USAREUS. See Table 1-1. Additional insulation would have only a marginal effect on the thermal characteristics of the exterior walls and would be enormously expensive since it would have to be installed on

either the exterior of the building (using a system similar to the Dryvit system) or on the interior surface of the existing plaster wall. The new interior insulation would, then, have to be covered with new wood paneling and/or a new gypsum board interior wall.

- 4.2.2 ECO A2      Conserve energy by adding roof or ceiling insulation to the building to achieve a thermal resistance (R) rating of at least R-30 for the combined ceiling elements.**

Building 603 was designed with 12cm of fiberglass batt roof insulation. The R-value of the roof assembly is estimated to be 20.93 °F-ft<sup>2</sup>-hr/BTU. Increasing the R-value of the roof from the present R-21 to R-30 would improve the roof's thermal characteristics, but would be very expensive. Because the roof is less than ten years old, the cost of re-roofing would more than offset any thermal improvement. However, when re-roofing is required, the roof insulation should be increased to achieve a rating of R-30 for the roof assembly.

- 4.2.3 ECO A3      Conserve energy by reducing the amount of window glass in exterior walls.**

As presently configured, Building 603 has a low ratio of glass-to-wall. There is little reason to reduce this ratio even further. The only significant amount of glazing in the building is in the dining area. Reducing this glass area further would reduce the architectural attractiveness of the space and the amount of daylight which enters the building. See ECO E14.

- 4.2.4 ECO A4      Conserve energy by installing insulated panels over exterior windows**

See commentary on ECO A3.

**4.2.5 ECO A5      Conserve energy by replacing single pane window glass with double or triple pane window glass.**

The existing windows are already glazed with double pane, insulating window glass. Increasing the thermal efficiency of the existing windows by installing triple pane glass would only have a marginal effect on the overall thermal efficiency of the building envelope.

**4.2.6 ECO A6      Conserve energy by installing storm windows over exterior windows.**

See commentary on ECO A5.

**4.2.7 ECO A7      Conserve energy by installing solar film on exterior windows.**

During the summer months, solar film does an excellent job of limiting solar heat gain and reducing the air conditioning load. However, since Building 603 is not air conditioned, solar film would have little energy conserving benefit. During the winter months, the lack of solar film (existing condition) allows solar energy to enter the dining area. This tends to reduce the amount of heating required to keep the dining area comfortable. In this case, the lack of solar film is a benefit.

**4.2.8 ECO A8      Conserve energy by installing shades, screens, curtains, or blinds on exterior windows.**

The windows at Vilseck Building 603 are already equipped with interior curtains. See, also, commentary on ECO A7.

**4.2.9 ECO A9      Conserve energy by reducing infiltration by means of new or improved weatherstripping and/or caulking.**

The weatherstripping and caulking on Building 603 was found to be in



good condition.

**4.2.10 ECO A10    Conserve energy by installing vestibules at troop entrances.**

Building 603 is already equipped with an entry vestibule at the troop entrance. Exterior doors not equipped with vestibules are all marked with "Emergency Exit Only" signs.

**4.2.11 ECO A11    Conserve energy by installing air curtains or plastic strips at all service entrances.**

Current practice at Building 603 is to have make-up air for the kitchen exhaust hoods brought into the building through the ventilation system. This keeps the building at a neutral pressure with respect to the outdoors. Therefore, an air curtain or plastic door strips would do little to reduce the building's energy consumption.

**4.2.12 ECO A12    Conserve lighting energy by improving the reflectivity of room surfaces.**

Wall and ceiling surfaces at Vilseck Building 603 were found to be of a light color and kept clean. Therefore, there is little opportunity for improving surface reflectivity.

**4.2.13 ECO H1    Conserve energy by installing energy efficient exhaust hoods with integral make-up air ducts.**

Energy saving exhaust hoods are already installed in Building 603.

**4.2.14 ECO H2    Conserve energy by recovering waste heat from exhaust air streams.**

The energy-saving exhaust hoods installed in Building 603 (See

commentary on ECO H1) have exhaust air streams with a very low heat content since most of the air being exhausted is outdoor air. For this reason there is very little potential for exhaust air heat recovery. The toilet room exhaust has a somewhat higher heat content (higher temperature) but it has a very low flow rate and a low number of operating hours. The dishwasher exhaust has an even greater total heat content, but an even lower number of operating hours. Therefore, the potential for heat recovery from the toilet room exhaust and the dishwasher exhaust is, also, very low.

**4.2.15 ECO H3      Conserve energy by changing constant volume air handling units to variable air volume (VAV) operation.**

Because Building 603 is not air conditioned, there is little or no potential energy savings expected from converting to VAV operation. VAV operation is particularly effective in reducing energy consumption when the HVAC system is operating in the air conditioning mode. However, it is not particularly effective in reducing energy consumption during the heating season. This is due to the fact that building heating is accomplished, primarily, through the perimeter radiation system.

**4.2.16 ECO H4      Conserve energy by balancing the HVAC system.**

There were no unexpected or extreme temperature variations from area to area (or space to space) within Building 603. This indicates that the air supplied to each area (or space) is well suited to the requirements of that space. Therefore, it appears that the HVAC system does not require re-balancing.

- 4.2.17 ECO H5      Conserve energy by reducing the amount of air supplied to or exhausted from the building (or space).**

An investigation of the existing drawings suggests that the present air flow rates are at or below the DIN requirements and the VDI guidelines. However, since the supply and exhaust air quantities appear to be satisfactory for both comfort and odor control, there is little reason to re-balance the system.

- 4.2.18 ECO H6      Conserve energy by reducing the amount of ventilation air drawn into the building by the HVAC system.**

The outdoor air dampers on the air handling units in Building 603 appear to be operating properly to control the amount of ventilation air being supplied to the building interior. The HVAC system appears to be providing only the minimum amount of ventilation air required to make-up exhausted air and to ensure good air quality within the building.

- 4.2.19 ECO H7      Conserve energy by installing tight-closing, low-leakage dampers on all outside air intake and exhaust openings (except at kitchen exhaust fans since damper blades could collect grease and become a fire hazard).**

Low-leakage dampers are already present on the air handling equipment installed in Building 603.

- 4.2.20 ECO H8      Conserve energy by reducing static pressure in HVAC systems.**

The air handling unit serving Building 603 appear to be operating satisfactorily. Since the HVAC system is a constant volume system, there are no VAV boxes which require some additional minimum static pressure at the box inlet. Therefore, the various HVAC systems are already operating at or near their optimum static pressure setting.

**4.2.21 ECO H9      Conserve energy by reducing supply air leakage at air handling units and supply air ductwork.**

There were no large or obvious leaks in the visible portions of the supply air ductwork or at the air handling unit casings at Building 603.

**4.2.22 ECO H10      Conserve energy by insulating and/or repairing damaged insulation on HVAC system ductwork.**

The duct insulation at Vilseck Building 603 was in a very bad state of disrepair. The installing contractor had used an insulation holding pin with an adhesive pad on the pin's base which was supposed to hold the pin to the galvanized sheet metal ductwork. Because the pins were installed improperly or because the adhesive was not sufficiently strong, a large portion of the external duct insulation has fallen off the ductwork. The staff at Vilseck assured us that maintenance personnel were aware of this problem and that time and money had allocated for the necessary repairs. In addition to the fallen insulation, the insulation on the ductwork in the attic space above the kitchen has been crushed. The kitchen staff uses the ductwork in this area as a shelf for storing everything from crockery to Christmas decorations. This (crushed) insulation needs to be replaced. It is estimated that approximately 32m<sup>2</sup> insulation is damaged. However, a rigorous evaluation of this ECO results in a Savings-to-Investment Ratio of less than 1.0, which is cause for rejection of the ECO.

**4.2.23 ECO H11      Conserve energy by installing ceiling-mounted circulating fans to reduce stratification within occupied spaces.**

The ceilings in Building 603 are too low for the interior spaces to have serious stratification problems. They are also somewhat low to have surface mounted recirculation fans installed below them.

**4.2.24 ECO H12 Conserve energy by recovering waste heat from refrigeration systems.**

The most effective way to capture waste heat from refrigeration systems is to use a heat exchanger to preheat domestic hot water with the refrigerant hot gas. However, because the domestic hot water storage tank temperature (60°C) is greater than the hot gas temperature ( $\pm 43^\circ\text{C}$ ) of the refrigerator/freezer refrigeration systems, an additional hot water storage tank would have to be installed to allow heat to be recovered from the food storage refrigeration equipment. This tank would be used to pre-heat domestic water before it entered the existing hot water storage tank. However, there is not enough space in either the mechanical room or the refrigeration compressor room for such a storage tank.

**4.2.25 ECO H13 Conserve energy by ventilating the refrigeration system compressor room.**

The compressor room in Building 603 is already equipped with a ventilation system. This consists of an intake louver in the south wall of the room and a roof-mounted exhaust fan.

**4.2.26 ECO H14 Conserve energy by replacing reciprocating type refrigeration compressors with higher efficiency scroll or rotary (screw) type compressors.**

Given the age of Building 603 and the installed equipment, replacement of the refrigeration compressors would be impractical for two reasons. One, the equipment is less than half way through its useful life; and, two, the installed equipment should have a relatively high coefficient-of-performance (COP).

- 4.2.27 ECO H15** Conserve energy by re-setting heating hot water temperature according to outside air temperature and occupancy schedules.

The building automation system installed in Building 603 is already programmed to perform these functions.

- 4.2.28 ECO H16** Conserve energy by reducing pump flow rates.

The building automation system installed in Building 603 is already programmed to adjust hot water flow rates - using the installed variable speed Grundfos pumps - to suit the building's loads.

- 4.2.29 ECO H18** Conserve energy by repairing or eliminating all HVAC system control deficiencies.

According to building operating personnel, the installed building controls are operating properly.

- 4.2.30 ECO H19** Conserve energy by using the Energy Monitoring and Control System (EMCS) to optimize the start-up and shut-down schedules for HVAC system fans, pumps, compressors, and other motorized devices.

According to building operating personnel, the installed building control system is presently used to optimize equipment performance and building comfort. The building control system will be connected, shortly, to the site-wide EMCS.

- 4.2.31 ECO H20** Conserve energy by using the EMCS to set-back space temperatures at night during the heating season.

See commentary on ECO H19.

- 4.2.32 ECO H21    Conserve energy by installing occupancy sensors to cycle the ventilation system "on" and "off" according to occupancy.**

The occupancy schedule for this building is well defined. Therefore, the ventilation system can be controlled effectively by the existing building control system. The addition of space occupancy sensors is unnecessary.

- 4.2.33 ECO H22    Conserve energy by interlocking the kitchen exhaust hoods with the cooking equipment served by each hood.**

It has been determined that re-wiring the existing cooking equipment to turn the associated exhaust hoods "on" and "off" is impractical. However, training the kitchen staff to operate cooking hoods only while cooking is a viable low/no cost ECO, and will be dealt with A n O&M ECO in Tab 5 of this Volume.

- 4.2.34 ECO H23    Conserve energy by installing economizer cycle controls and dampers on all ventilation systems.**

The air handling units in Building 603 are not equipped for air conditioning. Therefore, economizer cycles are not necessary.

- 4.2.35 ECO H25    Conserve energy by installing a thermal storage system.**

Thermal storage systems are only practical for buildings equipped with air conditioning. Even then they are only viable when there are significant time-of-day incentives (from the power supplier) for consuming more power during off-peak periods and less power during peak demand periods. Since neither of these criteria are met at Vilseck, there is little reason to install a thermal storage system.

- 4.2.36 ECO H26**    **Conserve energy by using infrared heaters in lieu of conventional (convection) heaters.**

Infrared heaters are best suited for exterior area heating (such as loading docks) or for areas with extremely large volumes (such as warehouses). Since neither of these types of spaces are present in Building 603 there is little reason to pursue the use of infrared heating.

- 4.2.37 ECO P1**    **Conserve energy by lowering the domestic hot water supply temperature.**

The hot water storage temperature of 60°C is required by Army regulations.

- 4.2.38 ECO P2**    **Conserve energy by installing controls on the domestic hot water system to lower the heater's set-point temperature or to shut-off the heat source to the heater during non-peak hours.**

The required controls are already present on the Building 603 domestic hot water system.

- 4.2.39 ECO P3**    **Conserve energy by installing booster heaters at major hot water users and at high temperature hot water users.**

The largest, single hot water consumer is the dishwasher, which is already equipped with an electrical booster heater.

- 4.2.40 ECO P4**    **Conserve energy by installing instantaneous hot water heaters in lieu of storage tank type heaters.**

Given the relatively recent construction of Building 603, the replacement of the existing water heating equipment with instantaneous water heaters



is highly impractical. In addition, heating domestic water with electricity is more expensive (in both cost and energy terms) than heating with district hot water - as is presently done.

**4.2.41 ECO P6      Conserve energy by installing additional insulation and/or repairing existing insulation on domestic hot water piping.**

The insulation for the domestic hot water piping and storage tank which requires repair is located in the central mechanical space. This insulation has been evaluated as part of ECO H17.

**4.2.42 ECO P8      Conserve energy by installing automatic shut-off type faucets in lavatories.**

The installation of automatic shut-off type faucets has been rigorously investigated for Vilseck Building 603 and rejected. Reason for rejection is a Savings-to-Investment Ratio of less than 1.0.

**4.2.43 ECO P9      Conserve energy by reclaiming waste heat from dishwashing wastewater.**

The present dishwasher installation would make it extremely difficult to connect a water-to-water heat exchanger to the sanitary sewer connection on the dishwasher. Also, there is little space in the mechanical room for installing the additional pumps and secondary loop heat exchanger required to recover heat from the dishwasher wastewater.

**4.2.44 ECO P10      Conserve energy by installing solar collectors to pre-heat domestic hot water.**

The total insolation (time and intensity of sunshine) in Vilseck makes solar

heating technically impractical.

- 4.2.45 ECO E2**      **Conserve lighting energy by eliminating excess fixtures. Where fixtures are close enough to each other, it may be possible to eliminate excess fixtures without creating dark spots.**

The lighting fixtures in Building 603 are spaced in such a manner that no fixtures can be eliminated without causing undesirable variations in the lighting levels within individual spaces.

- 4.2.46 ECO E3**      **Conserve energy by delamping selected lighting fixtures.**

See commentary on ECO E1. In some areas, selective de-lamping, rather than re-lamping with lower wattage lamps, may be the most cost effective method for reducing lighting levels to the required minimum.

- 4.2.47 ECO E5**      **Conserve energy by replacing the incandescent lamps in exit lights with lower wattage fluorescent lamps.**

This has already been done at Vilseck Building 603.

- 4.2.48 ECO E6**      **Conserve energy by installing improved reflectors on lighting fixtures and reducing the fixtures lamp wattage.**

The lighting fixtures in Vilseck Building 603 are relatively new fixtures which are already equipped with efficient reflectors and low wattage lamps.

- 4.2.50 ECO E7      Conserve energy by replacing existing core coil ballasts with electronic ballasts in existing fluorescent lighting fixtures.**

The upgrading of the existing fluorescent lighting fixtures in Vilseck Building 603 has been rigorously investigated, but has been rejected. Reasons for rejection is a Savings-to-Investment Ratio (SRI) of less than 1.0.

- 4.2.50 ECO E8      Conserve energy by replacing existing lamps with energy efficient U-tube fluorescent lamps.**

For architectural reasons, the fixtures in Building 603 are not suitable for re-lamping with U-tube fluorescent lamps.

- 4.2.51 ECO E9      Conserve energy by replacing existing incandescent bulbs with compact fluorescent bulbs.**

See commentary on ECO E8.

- 4.2.52 ECO E10     Conserve energy by installing dimming hardware on exterior HID lighting.**

The installation of dimming hardware on exterior lighting at Vilseck Building 603 has been vigorously investigated, but rejected. Reasons for rejection is a Savings-to-Investment Ratio (SIR) of less than 1.0.

- 4.2.53 ECO E11     Conserve energy by turning exterior lighting "on" and "off" by means of photocells.**

ECO E10 has been developed to minimize the energy used for exterior lighting. Photocells have been included in the development of ECO E10.

- 4.2.54 ECO E12** Conserve energy by turning exterior lighting "on" and "off" by means of timers.

ECO E10 has been developed to turn the exterior lighting "on" and "off" by means of a photocell. Therefore, this ECO will not be pursued. See, also, ECO E11.

- 4.2.55 ECO E13** Conserve energy by providing task level switching for interior lights. Task level switching will allow the lighting level to be varied to match the activity within the space.

Because the Dining Facility is not a multiple use facility (i.e., the spaces are all designed for a single, specific activity) task level switching is not appropriate for this building.

- 4.2.56 ECO E14** Conserve Lighting Energy by using photocells to turn "off" or dim interior lights (especially lights near windows) when natural daylight provides adequate illumination.

This ECO was subjected to a rigorous economic evaluation (see Tab 6 of Volume III). It was eliminated because the Savings-to-Investment Ratio (SIR) of 0.94 is less than 1.0.

- 4.2.57 ECO E15** Conserve energy by turning interior lighting "on" and "off" by means of timers.

ECO E14, which contained this ECO, was evaluated and found to be too expensive for implementation. Therefore, this ECO will not be pursued.

- 4.2.58 ECO 16**      **Conserve energy by turning interior lighting "on" and "off" by means of space occupancy sensors.**

This ECO will not be pursued. See explanations of ECO E14 and ECO E15.

- 4.2.59 ECO 17**      **Conserve energy by replacing existing motors with energy efficient motors.**

Given the relatively short period of time that the existing motors have been in service, it would be both expensive and wasteful to replace them with newer motors. In addition, the efficiency of newer motors is only marginally better than that of motors built less than ten years ago.

- 4.2.60 ECO E18**      **Conserve energy by replacing oversized/undersized motors with motors which have their peak efficiency at the actual system load.**

On inspection, the larger (greater than 1/2 HP) motors at Vilseck Building 603 were found to be well matched to their service loads.

- 4.2.61 ECO E19**      **Conserve energy by adding power factor correcting capacitors to existing motors.**

The motors on equipment installed in Building 603 are well suited for their service and do not require power factor correction.

- 4.2.62 ECO E20**      **Conserve energy by equipping motors which experience highly variable loads with variable frequency drives.**

The only motors which are subjected to this type of loading are the hot water pumps. These pumps are already equipped with variable frequency drives.

**TAB 5 - CONCLUSIONS AND RECOMMENDATIONS****5.1 Conclusions of the Survey Team - Grafenwöhr Building 101**

5.1.1 The survey team has concluded that when the age and operating philosophy of the facility are taken into account, it is not surprising that the energy conservation opportunities (ECOs) at Grafenwöhr Building 101 are limited. The facility was constructed with an up-to-date thermal envelope and was equipped with modern, energy efficient electrical and mechanical systems. The building operating staff has hit upon an extremely energy efficient operating procedure. By leaving the service doors open and two of the air handling units "off", the operating cost for those two units is eliminated. This practice may not be acceptable - for comfort reasons - at other facilities, but it works well for the staff at Grafenwöhr.

5.1.2 The survey team also concluded that the kitchen staff is very much aware of their role in minimizing energy consumption. Although the staff has some margin for improvement, the facility is run without a great deal of energy waste. The staff tends to turn off electrical devices when they are not being used. Also, the maintenance of the building appears to be very good. The building's EMCS is utilized to minimize operating hours and to match pump loads to requirements. There were few examples of energy waste due to dirty filters, missing insulation, and other minor maintenance problems.

5.1.3 However, the following operating and maintenance deficiencies were observed at Grafenwöhr during the site survey team's stay there.

1. The exterior fluorescent lights at the loading dock were turned on during the day.
2. The lighting in the dishwashing area was left on at all times.

3. The cove lighting in the dining area and approximately half of the dining room lighting was left on throughout the day

5.1.4 The Army should, on a regular basis, update the training of the Dining Facility staffs - both cooking and maintenance staffs - as to energy saving practices. In addition, the Army should re-evaluate the use of the Dining Facility. Specifically, does the number of meals served warrant the number of hours that the building is kept open? Can the baking staff work between meals or during the cleanup period rather than at night? Can one dining area be left unused during low volume meals such as breakfast and weekend meals? These practices can yield significant energy savings without affecting the facility's mission if they are implemented carefully.

## 5.2 Recommended ECO's - Grafenwöhr Building 101

5.2.1 The following Energy Conservation opportunities (ECO's) have been evaluated in accordance with the methodology and documentation detailed in the project Scope of Work. All of these ECO's have been found viable in terms of Savings-to-Investment Ratio (SIR) (greater than 1.0) and Payback (less than 10.0 years). The recommended ECO's are listed in descending order of SIR (i.e., the ECO with the greatest energy savings, in Deutsch Marks, per Mark spent is listed first).

**ECO P7**      **Conserve energy by installing flow restrictors at domestic hot and cold water end users.**

Analysis has shown an estimated annual energy savings of 25,550 kWh for this ECO. This equates to an avoided energy cost of DM 2,669 at an estimated installed cost of DM 32. Savings-to-Investment Ratio is 1,418 and simple payback is less than one year.

- ECO E1**      **Conserve energy by reducing lighting levels to minimum levels described in the Army Design Guidelines.**

Analysis has shown an estimated annual energy savings of 7,266 kWh for this ECO. This equates to an avoided energy cost of DM 1,031 at an estimated installed cost of DM 808. Savings-to-Investment Ratio is 14.8 and simple payback is 1.3 years.

- ECO E14**      **Conserve lighting energy by using photocells to turn "off" or dim interior lights (especially lights near windows) when natural daylight provides adequate illumination.**

Analysis has shown an estimated annual energy savings of 2,174 kWh for this ECO. This equates to an avoided energy cost of DM 309 at an estimated installed cost of DM 3,552. Savings-to-Investment Ratio is 1.04 and simple payback is 11.5 years.

- ECO P5**      **Conserve energy by installing additional insulation on the domestic hot water storage tanks.**

Analysis has shown an estimated annual energy savings of 1,611 kWh for this ECO. This equates to an avoided energy cost of DM 169 at an estimated installed cost of DM 549. Savings-to-Investment Ratio is 5.3 and simple payback is 3.2 years.

- ECO E10**      **Conserve energy by installing dimming hardware on exterior HID lighting.**

Analysis has shown an estimated annual energy savings of 2,696 kWh for this ECO. This equates to an avoided energy cost of DM 381 at an estimated installed cost of DM 1,240. Savings-to-Investment Ratio is 3.6



and simple payback is 3.3 years.

**ECO H17** Conserve energy by installing new insulation, adding additional insulation, or repairing existing insulation on heating hot water piping.

Analysis has shown an estimated annual energy savings of 1,869 kWh for this ECO. This equates to an avoided energy cost of DM 196 at an estimated installed cost of DM 3,226. Savings-to-Investment Ratio is 1.0 and simple payback is 16.5 years.

**ECO P8** Conserve energy by installing automatic shut-off type faucets in lavatories.

Analysis has shown an estimated annual energy savings of 1,524 kWh for this ECO. This equates to an avoided energy cost of DM 159 at an estimated installed cost of DM 1,210. Savings-to-Investment Ratio is 2.3 and simple payback is 7.6 years.

5.2.2 Due to the difficulty in accurately assessing the merits of Operations and Maintenance (O&M) ECO's, they have not been included in the list above. However, it is the opinion of the audit team that ECO's Nos. OM3, OM4, and OM11 through OM22 should all be implemented. All of the ECO's are, clearly, energy savers. In addition, these ECO's are very low in cost or are of no capital cost at all. The only cost associated with these ECO's is the cost of training the kitchen staff.

### 5.3 Conclusions of the Survey Team - Vilseck Building 603

5.3.1 The survey team concluded that the age of the Vilseck Dining Facility was the primary factor in its relatively low energy use. The building has only been in operation for eight to ten years and is equipped with well constructed, modern architectural, electrical, and

mechanical systems.

5.3.2 The survey team concluded that the facility could quickly cut its energy usage by getting the maintenance staff and the kitchen staff to be more aware of energy conservation. There were many examples of operating and maintenance (O&M) energy conservation opportunities at the Vilseck facility. In particular, the staff appears to be very lax in turning off lights, exhaust hoods and cooking equipment when it is not required.

5.3.3 The following operating and maintenance deficiencies were observed at Vilseck during the site survey team's stay there.

1. A broken door closer was observed on one of the double doors at the troop entry. This door stood open during the entire six hour period of the site survey team's visit. During that time the outdoor air temperature averaged 40-45°F. The air curtain over the open door did not operate. However, the air curtain over the opposite door cycled on and off continuously.
2. Every light in the facility was turned on and left on for the entire day.
3. The exhaust hoods over the serving lines operated continuously, even when no cooking or serving was being done.
4. Several empty tray warming units were turned but were never loaded and never used.
5. The rear door (to the loading dock) was open for the entire length of the site visit.
6. The lighting level in the beverage and dessert areas was excessive.
7. The external duct insulation in the attic spaces was no longer affixed to the

ductwork in many places. Large areas of this insulation were lying on the floor. In other areas, the external duct insulation has been torn and/or crushed by unused cooking equipment and seasonal materials which have been stored on top of the ductwork. Ductwork should not be used as a storage shelf.

8. Several refrigerators were operating without any food stored in them.

#### **5.4 Recommended ECO's - Vilseck Building 603**

5.4.1 The following Energy Conservation opportunities (ECO's) have been evaluated in accordance with the methodology and documentation detailed in the project Scope of Work. All of these ECO's have been found viable in terms of Savings-to-Investment Ratio (SIR) (greater than 1.0) and Payback (less than 10.0 years). The recommended ECO's are listed in descending order of SIR (i.e., the ECO with the greatest energy savings, in Deutsch Marks, per Mark spent is listed first).

**ECO P7**      **Conserve energy by installing flow restrictors at domestic hot and cold water end users.**

Analysis has shown an estimated annual energy savings of 33,197 kWh for this ECO. This equates to an avoided energy cost of DM 4,087 at an estimated installed cost of DM 75. Savings-to-Investment Ratio is 935 and simple payback is less than one year.

**ECO E4B**      **Conserve energy by converting existing "S" type lighting fixtures to high efficiency fluorescent or HID fixtures in all spaces except the kitchen and dining spaces.**

Analysis has shown an estimated annual energy savings of 11,603 kWh for this ECO. This equates to an avoided energy cost of DM 1,624 at an estimated installed cost of DM 18,827. Savings-to-Investment Ratio

is 15.0 and simple payback is less than one year.

**ECO H24**      **Conserve energy by shutting off or reducing the amount of heating in vestibules.**

Analysis has shown an estimated annual energy savings of 9,171 kWh for this ECO. This equates to an avoided energy cost of DM 1,134 at an estimated installed cost of DM 1,344. Savings-to-Investment Ratio is 14.4 and simple payback is 1.2 years.

**ECO E1**      **Conserve energy by reducing lighting levels to minimum levels described in the Army Design Guidelines.**

Analysis has shown an estimated annual energy savings of 13,038 kWh for this ECO. This equates to an avoided energy cost of DM 1,825 at an estimated installed cost of DM 2,020. Savings-to-Investment Ratio is 10.5 and simple payback is 1.1 years.

**ECO P5**      **Conserve energy by installing additional insulation on the domestic hot water storage tanks.**

Analysis has shown an estimated annual energy savings of 2,578 kWh for this ECO. This equates to an avoided energy cost of DM 318 at an estimated installed cost of DM 878. Savings-to-Investment Ratio is 6.2 and simple payback is 2.8 years.

- ECO E14**      **Conserve lighting energy by using photocells to turn "off" or dim interior lights (especially lights near windows) when natural daylight provides adequate illumination.**

Analysis has shown an estimated annual energy savings of 2,871 kWh for this ECO. This equates to an avoided energy cost of DM 402 at an estimated installed cost of DM 768. Savings-to-Investment Ratio is 6.1 and simple payback is 1.9 years.

- ECO H17**      **Conserve energy by installing new insulation, adding additional insulation, or repairing existing insulation on heating hot water piping.**

Analysis has shown an estimated annual energy savings of 11,925 kWh for this ECO. This equates to an avoided energy cost of DM 1,468 at an estimated installed cost of DM 9,588. Savings-to-Investment Ratio is 2.6 and simple payback is 6.5 years.

- ECO E4A**      **Conserve energy by converting existing "S" type lighting fixtures in the Dining areas to high efficiency fluorescent or HID fixtures.**

Analysis has shown an estimated annual energy savings of 57,134 kWh for this ECO. This equates to an avoided energy cost of DM 7,999 at an estimated installed cost of DM 74,432. Savings-to-Investment Ratio is 1.2 and simple payback is 9.3 years.

- 5.4.2 Due to the difficulty in accurately assessing the merits of Operations and Maintenance (O&M) ECO's, they have not been included in the list above. However, it is the opinion of the audit team that ECO's Nos. OM3, OM4, and OM11 through OM22 should all be implemented. All of the ECO's are, clearly, energy savers. In addition, these ECO's are very low in cost or are of no capital cost at all. The only cost associated with these ECO's is the cost of training the kitchen staff.

**TAB 6 - SUMMARY****6.1 ECOs Recommended for Implementation - Grafenwöhr Building 101**

6.1.1 The implementation of the following ECO's is recommended for Grafenwöhr Building 101. Note: The ECO's listed in the table below were evaluated in FY93 for implementation in FY93

**TABLE NT-5 RECOMMENDED ECO's - GRAFENWÖHR BUILDING 101**

ECO NO.	ENERGY SAVINGS (KW/YEAR)	FUEL*	COST SAVINGS (DM/YEAR)	COST (DM)	SIR	PAYBACK (YEARS)
P7	87.2	DHW	2,669	32	1,418	< 0.1
E1	24.8	E	1,031	808	14.79	1.3
P5	5.5	DHW	169	549	5.30	3.2
E10	9.2	E	381	1,546	2.85	4.1
P8	5.2	DHW	159	1,210	2.26	7.6
H17	6.4	DHW	196	3,226	1.04	16.5
E14	7.4	E	309	3,552	1.01	11.5

\* MBTU = 10<sup>6</sup>BTU's

\*\* Fuel types are: Electricity (E) and District Hot Water (DHW)

6.1.2 Operations and Maintenance ECO's have not been included in the chart above. However, it is the opinion of the audit team that OM ECO's Nos. 3, 4, and 11 through 22 should all be implemented by training the kitchen staff. All of these ECO's, while clearly energy savers, are difficult, if not impossible, to evaluate for energy savings. There are, simply, too many assumptions which would have to be made to evaluate these ECO's for the calculated savings to be meaningful. In addition, most O&M ECO's are very low in cost or are of no capital cost at all. The only cost associated with many of these ECO's is the cost of the kitchen staff.

**6.2 ECOs Recommended for Implementation - Vilseck Building 603**

6.2.1 The implementation of the following ECO's is recommended for Vilseck Building 603. Note: All ECO's listed in the table below were evaluated in FY93 for implementation in FY93.

**TABLE NT-6 RECOMMENDED ECO's - VILSECK BUILDING 603**

ECO NO.	ENERGY SAVINGS (KW/YEAR)	FUEL*	COST SAVINGS (DM/YEAR)	COST (DM)	SIR	PAYBACK (YEARS)
P7	113.3	DHW	4,087	75	935	<0.1
E4B	39.6	E	1,624	18,827	15.01	0.8
H24	1.0/30.3	E/DHW	1,134	1,344	14.35	1.2
E1	44.5	E	1,825	2,020	10.47	1.1
P5	8.8	DHW	318	878	6.24	2.8
E14	9.8	E	402	768	6.07	1.9
H17	40.7	DHW	1,468	9,588	2.64	6.5
E4A	195.0	E	7,999	74,432	1.24	9.3

\* MBTU = 10<sup>6</sup>BTU's

\*\* Fuel types are: Electricity (E) and District Hot Water (DHW)

6.2.2 Operations and Maintenance ECO's have not been included in the chart above. However, it is the opinion of the audit team that OM ECO's Nos. 3, 4, and 11 through 22 should all be implemented by training the kitchen staff. All of these ECO's, while clearly energy savers, are difficult, if not impossible, to evaluate for energy savings. There are, simply, too many assumptions which would have to be made to evaluate these ECO's for the calculated savings to be meaningful. In addition, most O&M ECO's are very low in cost or are of no capital cost at all. The only cost associated with many of these ECO's is the cost of training the kitchen staff.

**TAB 7 - SITE UTILITY ANALYSIS****7.1 Review of Electricity Supply Contracts for Grafenwöhr and Vilseck****7.1.1 Supplier:**

Energieversorgung Ostbayern AG Regensburg (OBAG)

**7.1.2 Type and Amounts of Electricity Supply**

Nominal Voltage: 20,000V

Nominal Frequency: 50 HZ

Services:

	<u>Connected</u>	<u>Effective</u>
	Service	Demand
Grafenwöhr	6300 KVA	5000 KW
Vilseck	6300 KVA	5500 KW

Powerfactor = 0.9

**7.1.3 Connection Facility****7.1.3.1 Grafenwöhr**

20 KV Switching Station at Grafenwöhr Transformer Facility

**7.1.3.2 Vilseck**

20 KV Switching Station - Vilseck



## 7.1.4 Provisions for Metering

## 7.1.4.1 Grafenwöhr

Metering is done on the 20,000 volt side at the Grafenwöhr Switching Station.

The following OBAG-owned metering equipment is used:

- 2 Single Rate 4-Conductor Real Use Contact Meters
- 2 Single Rate 4-Conductor Reactive Use Contact Meters
- 1 Two-Rate Real Use Totalizer
- 1 Average Value Code Printer
- 1 Switching Clock for 15 Minute Release
- 1 "Ripple" Control Receiver
- 6 Current Transformers
- 6 Voltage Transformers

## 7.1.4.2 Vilseck

Metering is done on the 20,000 volt side at the Vilseck switching Station (formerly at the Sorghof 4 Transformer Station, Heringnahe 2).

The following OBAG-owned metering equipment is used.

- 2 single rate 4-conductor Real Use Contact Meters
- 2 single rate 4-conductor Reactive Use Contact Meters
- 1 Two-Rate Real Use Totalizer
- 1 Two-Rate Reactive Use Totalizer
- 1 Average Value Code Printer
- 1 Switching Clock for 15 Minute Release
- 1 "Ripple" Control Receiver

- 6 Current Transformers
- 6 Voltage Transformers

7.1.5 Electricity Price for energy is composed of:

7.1.5.1 Annual electrical demand charge, in KVA.

7.1.5.2 High demand (HT) period charges, in KWh.

7.1.5.3 Normal demand (NT) period charges, in KWh

7.1.5.4 Reactive Power charges, in Kvarh.

7.1.5.5 Metering equipment charges.

7.1.5.6 In addition, a charge can be levied for low demand when power consumption falls below a negotiated demand limit.

7.1.6 As of 1-1-90, the following rates are in effect:

		<u>Contract</u>	<u>Base</u>
7.1.6.1	The annual service price rate for electrical demand is:	DM/KVA 230.40	130.00
7.1.6.2	The effective rates for HT power supplied during the calendar year are:		
	for the first 1,000,000 KWh	11.35 DPf/KWh	6.85 DPf/KWh
	for the next 10,000,000 KWh	11.05 DPf/KWh	6.50 DPf/KWh
	for each additional KWh	11.05 DPf/KWh	5.70 DPf/KWh

7.1.6.3 The effective rates for NT power supplied during the calendar year are:

for the first 600,000 KWh	8.90 DPf/KWh	4.65 DPf/KWh
for the next 6,000,000 KWh	7.70 DPf/KWh	4.40 DPf/KWh
for each additional KWh	8.70 DPf/KWh	4.10 DPf/KWh

7.1.6.4 The rates for excess reactive power are:

	3.60 DPf/KWh	2.00 DPf/KWh
--	--------------	--------------

7.1.6.5 The monthly charges for metering equipment are:

	DM 15.00	DM 10.00
--	----------	----------

7.1.7 Electrical power is billed in monthly installments. At the end of each calendar year, a final billing for the services used is rendered as follows:

7.1.7.1 The annual demand rate is applied to that demand which results from the average of the two highest monthly real power demands divided by the average annual power factor.

7.1.7.2 The highest monthly service demand is the highest power in one month that is used by the customer during any 15 minute period.

7.1.7.3 The average annual power factor is calculated from the annual real and reactive power totals delivered by OBAG to the customer.

7.1.7.4 To determine demand billings, each of the two highest monthly real power demands is applied as at least 70% of the respective monthly demand service.

7.1.7.5 If the highest monthly real power service exceeds the associated [monthly] demand service, then the excess real power used over and above the demand service divided by the annual average power factor is billed additionally at 5% of the annual service rate.

**7.1.7.6 High demand period (HT) is defined as:**

6 a.m. - 9 p.m.	Mon - Fri	April thru September
6 a.m. - 10 p.m.	Mon - Fri	October thru March
6 a.m. - 1 p.m.	Saturday	All Year

**7.1.7.7 Low demand period (LT) is the remainder of the year, including legal holidays in the OBAG service region.****7.1.7.8 The above contract prices are predicted on drawing power at no less than 0.9 power factor.****7.2 Conclusions and Recommendations - Electrical Power Supply****7.2.1 Service Costs****7.2.1.1 Since the service contracts with OBAG state that 70% of the ordered contract demand must be paid for, regardless of the service peak, it is in the best interest of the User to have the ordered contract demand as low as possible.****7.2.1.2 At Grafenwöhr, the ordered contract demand (as stated on the existing Electricity Use Data Form) is 5,000 kW. However, the average power usage amounted to only 4,054 kW with a low of 3,384 kW and a peak of 4,596 kW. Therefore, the contract with OBAG should be renegotiated to set the ordered contract demand at 4,000 kW.****7.2.1.3 At Vilseck, the ordered contract demand (as stated on the existing Electricity Use Data Form) is 5,500 kW. However, the average power usage amounted to only 5,010 kW with a low of 4,224 kW and a peak of 5,576 kW. Therefore, the contract with OBAG should be renegotiated to set the ordered contract demand at 5,000 kW.**

### 7.2.2 Power Costs

- 7.2.2.1 Since power costs consist of the High Demand Period (HT) Power Price, the Low Demand Period (LT) Power Price, and the Reactive Power Price, shifting power use from the high demand period to the low demand period would (according to Item 6 in the Contract) result in a savings of 2.40 D. Pfennig/kwh. Since the annual usage at Grafenwöhr is 24,987,465 kwh and the annual usage at Vilseck is 31,518,960 kwh, a shift of only 5% of this use to the low demand period would result in an annual savings of about DM 70,000. By using the computerized Energy Management System, this 5% load shifting may be attainable without seriously affecting the normal work schedule of the two camps.

### 7.2.3 Power Factor

- 7.2.3.1 Drawing service at less than 0.9 PF is billed at a rate of an additional 3.60 D. Pfennig/kvarh. Further, the power factor influences the service cost. However, since the mean power factor in 1992 for Grafenwöhr was 0.998 and for Vilseck 0.991, any additional power factor correction will be of no significant use.

## 7.3 Review of District Hot Water Supply Contracts for Grafenwöhr and Vilseck

- 7.3.1 The thermal (heating) supply contracts between the users of the Grafenwöhr Ostlager (East Camp) and Vilseck Südlager (South Camp) on the one hand, and the heating supply contractor Fränkische Gas Liefergesellschaft Bayreuth (FGLB) on the other, have been reviewed based upon the following documents which were made available to us:

Grafenwöhr - Final Billings for the Year 1992  
Special Long-Distance Thermal Heating Contract  
Valid as of 1 JAN 68 (change in Contract Administrator)

Vilseck -      Final Billings for the Year 1992  
Billing for Heating Delivery of 5 NOV 92

- 7.3.2 The review of the FGLB contract and the subsequent comments received from the User have made it clear that there is little potential for savings costs through renegotiation of the District Hot Water Service contract.