FINAL REPORT

LIMITED ENERGY STUDY, POWER DISTRIBUTION

FORT GREELY, ALASKA

Prepared for

U.S. ARMY ENGINEER DISTRICT, MOBILE
MOBILE, ALABAMA

Under

U.S. ARMY ENGINEER DISTRICT, MOBILE
INDEFINITE DELIVERY A-E CONTRACT
CONTRACT NO. DACA01-94-D-0033
DELIVERY ORDER NO. 003

EMC ENGINEERS, INC.

E M C ENGINEERS, INC.
DENVER, COLORADO

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

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By

E M C Engineers, Inc.
2750 S. Wadsworth, Suite C-200
Denver, Colorado 80227
303/988-2951

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LIST OF ABBREVIATIONS

A	-	ampere
ACSR	-	aluminum conductor steel reinforced
ANSI	-	American National Standards Institute
ASCE	-	American Society of Civil Engineers
ASME	-	American Society of Mechanical Engineers
AWG	-	American Wire Gauge
BIL	-	basic insulation level
CNW	-	condenser water
CNWP	-	condenser water pump
CNWR	-	condenser water return
CNWS	-	condenser water supply
COE	-	Corps of Engineers
CRTA	-	Cold Regions Test Activity
CT	-	current transformer
Δ	-	(Delta) Greek letter notation for electrical equipment connected in a "delta" configuration
ECIP	-	Energy Conservation Investment Program
ECO	-	Energy Conservation Opportunity
EMC	-	E M C Engineers, Inc.
EPR	-	Ethylene Propylene Rubber
EPRI	-	Electric Power Research Institute
F	-	Fahrenheit
FEMP	-	Federal Energy Management Program
ft	-	foot, feet
gal	-	gallons
GL	-	ground line
gpm	-	gallons per minute
hp	-	horsepower
hr	-	hour
IEEE	-	Institute of Electrical and Electronic Engineers
IL	-	in-line
kA	-	one thousand ampere
kV	-	one thousand volts
kW	-	kilowatt, one thousand watts
kWh	-	kilowatt-hours, one thousand watt-hours
LCCA	-	life cycle cost analysis
LF	-	load factor
lb/hr	-	pounds per hour
MCACES	-	Mechanical Cost Accounting Computer Estimating System
MW	-	megawatt, one-thousand kilowatts
NBS	-	National Bureau of Standards
NEC	-	National Electric Code
NESC	-	National Electrical Safety Code
NIST	-	National Institute of Standards and Technology

OA/FA	-	liquid-immersed, self-cooled/forced-air-cooled
OH	-	overhead
O&M	-	operation and maintenance
P	-	perpendicular
PF	-	power factor
ϕ	-	(Phi) Greek letter notation for "phase"
ϕ-N	-	shorthand notation for a phase-to-neutral wire connection
ϕ-ϕ	-	shorthand notation for a phase-to-phase wire connection
psia	-	pounds per square inch absolute
psig	-	pounds per square inch gage
rpm	-	revolutions per minute
sec	-	second
SIR	-	Savings-to-Investment Ratio
SOW	-	scope of work
sq ft	-	square foot
temp.	-	temperature
UG	-	underground
V	-	volt(s)
VAR	-	volts-ampere reactive
XLPE	-	Cross-Linked Polyethylene
Y	-	short hand notation for electrical equipment connected in an "ungrounded wye" configuration
YGRD	-	short hand notation for electrical equipment connected in a "grounded wye" configuration
yr	-	year(s)

EXECUTIVE SUMMARY

AUTHORITY

This study was performed and this report prepared under Contract No. DACA01-94-D-0033, Delivery Order No. 003. The Delivery Order was issued by U.S. Army Engineer District, Mobile, to E M C Engineers, Inc. on 28 September 1994.

PURPOSE

The purpose of this study is to evaluate the Energy Conservation Opportunity (ECO) associated with converting the existing Ft. Greely power distribution system from a 2400 volt, 3-wire, ungrounded delta distribution system to a 4160 volt, 4-wire, grounded wye distribution system.

METHOD OF ANALYSIS

The analysis proceeded as follows:

- A limited site survey of the overhead and underground distribution system, the central power and heating plant, the substations, and other facilities was performed to determine the parameters of the existing system and evaluate its physical condition. The evaluation of the systems physical condition included insulators, crossarms, poles, wires, connectors, generators and transformers.

- Two computer models were developed for the electric power distribution system. One for the existing system (1995 to 1997), to investigate the pre-realignment scenario and one for the reduced system (post 2001), to investigate the post-realignment scenario. Two load flow studies were performed on each model. One with the system voltage modeled at 2400 V and the other with the system voltage modeled at 4160 V. The difference in system losses between the two operating voltages was determined for each scenario and used in the economic calculations.

- Two construction cost estimates were developed using the MCACES Program with the 1994 Fairbanks database. One cost estimate for converting the existing electric distribution system from a 2400 volt, 3-wire, ungrounded delta system to a 4160 volt, 4-wire, grounded wye system and one cost estimate for converting the reduced electric distribution system from a 2400 volt, 3-wire, ungrounded delta system to a 4160 volt, 4-wire, grounded wye system. The construction cost estimate for each scenario was used in the economic calculations.

at this site. At the very least, ground fault detection should be implemented as determined in previous studies.

1. INTRODUCTION

1.1 AUTHORITY FOR STUDY

This study was performed and this report prepared under Contract No. DACA01-94-D-0033, Delivery Order No. 003. The Delivery Order was issued by U.S. Army Engineer District, Mobile, to E M C Engineers, Inc. on 28 September 1994.

1.2 PURPOSE OF STUDY

The purpose of this study is to evaluate the Energy Conservation Opportunity (ECO) associated with converting the existing Ft. Greely power distribution system from a 2400 volt, 3-wire, ungrounded delta distribution system to a 4160 volt, 4-wire, grounded wye distribution system.

1.3 SCOPE OF WORK

The Scope of Work (SOW) for this energy study is included in Appendix A of this report. The following services are required by the SOW:

- Perform a limited site survey of the overhead and underground distribution system, the central plant, and other facilities was performed to determine the parameters of the existing system and evaluate its physical condition. The evaluation of the systems physical condition includes insulators, crossarms, poles, wires, connectors and transformers.

- Perform computer modeling of the distribution system to determine the system losses associated with operating at 2400 volts and 4160 volts for both the pre-realignment (before 1997) and post-realignment (after 2001) scenarios.

- Determine the construction costs associated with converting the distribution system from a 2400 volt, 3-wire, ungrounded delta to a 4160 volt, 4-wire, grounded wye.

- Determine the cost of providing electrical service to post-realignment buildings directly from the Golden Valley Electric Association (GVEA) distribution system. [EMC was instructed not to address this issue.]

- Perform life cycle cost analysis (LCCA) according to Energy Conservation Investment Program (ECIP) and Federal Energy Management Program (FEMP) criteria.

- Provide a comprehensive report presenting field survey data, methods of analysis and recommendations of the study.

- Prepare ECIP/FEMP programming documentation for ECOs which meet government funding criteria.

1.4 DEMAND AND ENERGY COSTS

The demand and energy costs for electricity delivered to Fort Greely from GVEA and Fort Wainwright were taken from data provided by Fort Wainwright personnel. Approximately 83% of the electric energy used at Fort Greely is derived from Fort Wainwright generators and wheeled over GVEA distribution lines for the cost of wheeling. The remaining 17% is purchased directly from GVEA at a cost based on their GS-2 rate schedule. Demand charges are based on the peak kW used per month, regardless of whether it is wheeled or purchased power. In order to simplify the analysis for this study, the energy costs were evaluated over the one year period starting on the first day of September 1993 and ending on the last day of August 1994. The energy costs from the two different suppliers, Fort Wainwright and GVEA, were weighed based upon the percentage used from each source at Fort Greely and summed to obtain an average energy cost. The demand charge remains the same in either case. The electric rates used in this study are as follows:

- Electric demand charge: $6.25/kW/month
- Electric energy charge: $0.0711 per kWh

If the demand charge is incorporated into the energy charge to further simplify the calculations, the electric energy charge will be $0.832 per kWh.

1.5 CONSTRUCTION COST ESTIMATING

ECO construction costs were taken primarily from the MCACES construction cost estimating database for Fairbanks (1994). When the cost information in this database was inadequate, vendor quotes or the 1995 Means Electrical Cost Data were used. An additional 20% location factor was added to all costs that were not taken from the MCACES database to account for added shipping expenses and other charges associated with Fort Greely's remote location and/or extreme weather. Additional markups used for the LCCA include:

- 15% for contractor's overhead.
- 10% for contractor's profit.
- 3% for contractor's bond.
- 20% for contingency.

- 4% for escalation.
- 5% for SIOH.
- 6% for design costs.

1.6 LIFE CYCLE COST ANALYSIS METHODOLOGY

The Life Cycle Cost Analysis (LCCA) methodology used in this study is a Present Worth analysis. It compares the present worth of the energy cost savings associated with the distribution system improvements over a 20 year period (reflected back into the first year of the period) with the construction cost or investment necessary to implement the distribution system improvements in the first year of the period. The Savings-to-Investment Ratio (SIR) must be greater than 1.25 in order to qualify under the ECIP Program. Thus, the energy cost savings over a 20 year period must be 25% greater than the investment required in the first year. Operation and maintenance (O&M) costs were neglected because there is no significant difference in O&M between 2400 volts and 4160 volts.

Economic analyses were performed in accordance with the January 1994 ECIP guide. Uniform Present Value (UPV) factors are based on a 4.1 percent DOE discount rate (for FEMP projects). The UPV factors were taken from Table A-2 and Ba-4 of the NISTIR 85-3273-10 (Rev. 10/95), Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis 1996, (the current annual supplement to the NIST Handbook 135 and NBS Special Publication 709). The economic and service life of equipment was taken from Appendix B of the ECIP guide. Copies of all the appropriate LCCA factors are found in Appendix J.

The following UPV factors, adjusted for average fuel price escalation, were taken from the NIST 135 Supplement for Industrial Customers.

Life (Years)	Electricity	Natural Gas	Non-Energy
20	14.47	17.32	13.47

1.7 ORGANIZATION OF DOCUMENT

This report is organized as follows:

- Section 2 describes the existing electrical distribution system and the field tests performed to evaluate its physical condition.

- Section 3 discusses in detail the system model and load flow analysis used to determine the system losses for the existing electrical distribution system.

- Section 4 describes the electrical distribution system after realignment has reduced the number of facilities served.
- Section 5 discusses in detail the system model and load flow analysis used to determine the system losses for the reduced electrical distribution system.
- Section 6 summarizes the results of Sections 2 through 5 and recommends a course of action.