## Final Report

LIMITED ENERGY STUDY BUILDINGS 750 AND 798

FORT RICHARDSON, ALASKA

Prepared for

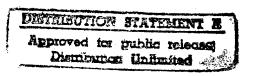
U.S. ARMY ENGINEER DISTRICT, MOBILE MOBILE, ALABAMA 36628

Under

U.S. ARMY ENGINEER DISTRICT, MOBILE INDEFINITE DELIVERY A-E CONTRACT Contract No. DACA01-94-D-0033 Delivery Order 0011 EMC No. 1406-009

19971022 132

February 1996



By

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#### LIST OF ABBREVIATIONS

AC - air conditioning

ACH - air changes per hour

AHU - air handling unit

ASHRAE - American Society of Heating, Refrigeration, and Air-Conditioning

Engineers

Btu - British thermal units

Btuh - Btu per hour

CCF - compressed cubic foot

cfm - cubic feet per minute

DPW - Department of Public Works

ECIP - Energy Conservation Investment Plan

ECO - Energy Conservation Opportunity

EMC - EMC Engineers, Inc.

F - Fahrenheit

FEMP - Federal Energy Management Program

FLA - full load amperes

ft - foot, feet ft² - square feet

gpm - gallons per minute

HID - high intensity discharge

HPS - high pressure sodium

hp - horsepower

hr - hour

HRU - heat recovery unit

HVAC - heating, ventilating, and air-conditioning

IR - infrared

KBtu - one thousand British thermal units

Klb - one thousand pounds

KSF - one thousand square feet

kW - kilowatt, one thousand watts

kWh - kilowatt-hours, one thousand watt-hours

LCCA - Life Cycle Cost Analysis

MAU - makeup air unit

MCACES - Micro Computer-Aided Cost Engineering System

MER - mechanical equipment room

R-value - the resistance of heat flow expressed in units of sq ft x hrs x °F/Btu;

R-value = 1/U-value

rpm - revolutions per minute

SF - square foot, feet

SIR - Savings to Investment Ratio: total life-cycle benefits divided by

90% of the differential investment cost

SOW - scope of work

SPV - single present value factor

SZ - single zone

UA - overall heat transfer coefficient (Btu/hr.°F)

UPV - uniform present value factor

temperature

UV - ultraviolet

V - volts

temp.

yr - year(s)

### **EXECUTIVE SUMMARY**

#### **AUTHORITY**

This study was performed and this report prepared under Contract No. DACA01-94-D-0033, Delivery Order No. 11. The delivery order was issued by U.S. Army Engineer District, Mobile, to E M C Engineers, Inc. on 15 September 1995.

#### **PURPOSE**

The purpose of this study is to identify and evaluate Energy Conservation Opportunities (ECOs) for two motor pool facilities, Buildings 750 and 798, to determine their energy savings potential, economic feasibility, and to document results for possible future funding.

#### **METHOD OF ANALYSIS**

The analysis proceeded as follows:

- Buildings 750 and 798 were surveyed and as-built drawings were collected to determine the present use, construction, occupancy patterns, lighting, equipment, and HVAC systems in both buildings.
- The existing conditions were simulated through the use of computer models. These models, referred to as the baseline models, were produced using the DOE2.1d building energy simulation program.
- The annual energy use results from the baseline computer models were compared to the available historical energy use data. This was done as a means of verifying the accuracy of the baselines.
- Potential ECOs were identified and evaluated individually. ECO evaluation included determining energy savings with the building energy simulation model, estimating construction costs, and performing a Life Cycle Cost Analysis (LCCA). Calculation of life cycle cost of each ECO was performed according to the guidance of the Energy Conservation Investment Program (ECIP).
- The ECOs which were identified to be cost effective were combined and analyzed together as one combined ECO. This is necessary to account for the synergistic effects the individual ECOs have on each other.
- The results of the baseline energy analysis and the ECO evaluations are summarized in this report. Recommendations were made based on economic factors and the

ability of the system, modified with the ECO, to maintain a comfortable environment.

• Programming documentation and supporting information for funding purposes was prepared and is presented in appendix G.

### **BASELINE ENERGY USE**

Buildings 750 and 798 are heated by steam supplied from a central plant. The central plant uses natural gas as a primary fuel source to produce steam for both heating and electrical energy generation. Since power is produced on the base there is not a demand charge for electrical energy.

The utility rates were given as \$0.0633/KWH (\$18.55/MBtu) for electricity and \$7.0693/klb (\$5.276/MBtu) for steam. The cost of natural gas varies as a function of the quantity consumed. Two ECOs examined the use of natural gas in conjunction with steam as a method of heating the buildings. In these instances, the cost of natural gas was approximately \$0.29/CCF (\$2.84/MBtu).

Annual baseline energy consumption and cost data for each building is presented in Table ES-1. The combined energy costs for these two motor pools is approximately \$175,000 per year.

The heating system in Building 750 was found to be severely under capacity. This is the result of the disabling of the under-floor heating system and the roof top MAUs. Building 798 also has had the under-floor heating system disabled. However, baseline simulations show that the remaining system is capable of maintaining thermostat setpoints during all but the coldest days of a typical year.

Table ES-1. Baseline Energy Consumption

Building Utility No. Type		Baseline Usage (MBtu/yr)	Building Area (ft²)	Baseline (MBtu/ft²·yr)	Baseline (\$/yr)	
750	Elect <del>ri</del> c	1,071.69	24600	0.044	\$19,880	
750	Steam	10,035.77	24600	0.408	\$52,949	
Subtotal					\$72,829	
798	Elect <del>ri</del> c	1,670.45	39060	0.043	\$30,987	
798	Steam	13,516.36	39060	0.346	\$71,312	
Subtotal					\$102,299	
Total					\$175,128	

## **ENERGY CONSERVATION OPPORTUNITIES (ECOs)**

The following is a brief summary of the ECOs investigated.

- **ECO 1:** Roof Insulation: The installation of additional insulation to the inside surfaces of the roof was examined at two different thicknesses: R-19 and R-30.
- **ECO 2: Wall Insulation:** The installation of additional insulation to the inside surfaces of the walls was examined at two different thicknesses: R-19 and R-30.
- **ECO 3:** Installation of New Windows: The replacement of the existing windows with new heat reflecting, low heat conductance windows was examined.
- **ECO 4:** Infiltration Remediation: The implementation of outside air infiltration remediation measures was examined.
- ECO 5: Door Insulation: Installing additional insulation on the large overhead doors, and replacing the existing personnel doors with more insulating doors was examined.
- **ECO 6:** Controls Installation: Some of the exhaust and make-up air units appear to be running during unoccupied periods. The installation of controls to shut off these units during these times was examined.
- **ECO 7: Night Setback:** The existing system is controlled by nonprogrammable single setpoint thermostats. The installation of programmable, multiple setpoint thermostats was examined.
- **ECO 8:** Heat Recovery: Currently, these buildings exhaust air from multiple locations throughout the buildings. Running ductwork from these exhaust locations to a central location and then through a packaged roof-top heat recovery unit was examined.
- **ECO 9:** Reduce Outside Air: According to occupants surveyed, the exhaust systems in these buildings are inadequate or underutilized. Occupants often open the doors to reduce the level of engine exhaust in the building. The installation of a ventilation system would reduce the amount of outside air introduced through these open doors. A ventilation system which utilizes heat recovery was examined.
- **ECO 10: High Efficiency Motors:** Replacing select motors in these buildings with high efficiency motors was examined.

- **ECO 11:** Radiant Heating: The feasibility of installing two types of radiant heating systems was examined: These systems consisted of an under-floor hot water heating system and overhead gas-fired infrared heating system.
- **ECO 12: High Efficiency Lighting:** Replacing and retrofitting the existing lighting systems in Building 798 was examined.
- **Recondition Existing HRUs:** Building 750 has a rooftop make-up air system with a heat recovery loop installed between its outside air intake and the personnel exhaust system. This system has been disabled and is no longer operative. In lieu of ECO 8, the reconditioning of this system was evaluated.
- **ECO 14:** Heat Recovery Loop: Building 798 has a large make-up air unit which brings in 100% outside air. This unit is intended to replenish some of the air that is being removed from the building by the exhaust systems. The installation of a run-a-round propylene glycol based heat recovery loop between the make-up air and a portion of the exhaust air systems was evaluated.

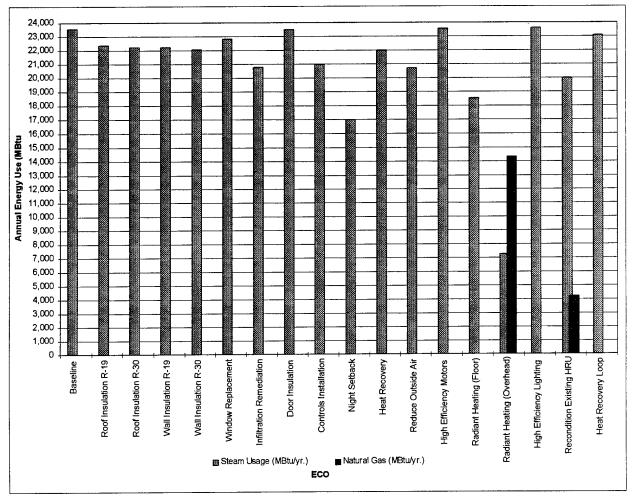
Table ES-2 below presents the results of the analysis for each ECO. The table is sorted in descending order based on the discounted SIR for each ECO.

Table ES-2. Summary of Results

ECO	Description	Electric Savings (\$/yr)	Steam Savings (\$/yr)	Natural Gas Savings/Cost (\$/yr)	Total Energy Savings (\$/yr)	Total Installed Cost (\$)	Simple Payback (yrs)	Dis- counted SIR
7	Night Setback	<b>\$5,</b> 360	<b>\$34,67</b> 3	N/A	\$40,033	\$16,401	0.41	23.10
6	Controls	\$1,211	\$13,637	N/A	\$14,849	\$6,366	0.43	22.20
4	Infiltration	<b>\$1,655</b>	\$14,699	N/A	\$16,354	\$47,316	2.89	6.30
11b	Radiant Heat (Gas)	N/A	\$85,848	(\$40,078)	<b>\$</b> 45 <b>,77</b> 0	\$194,524	4.25	4.37
13	Recond. Exist. HRUs	(\$2,225)	\$18,828	(\$12,156)	\$4,447	\$16,186	3.64	3.75
14	Heat Recovery Loop	\$299	\$2,627	N/A	<b>\$2,92</b> 6	\$25,470	8.71	2.09
10	High Eff. Motors	\$483	N/A	N/A	\$483	\$4,629	9.60	1.57
9	Control Outside Air	\$1,339	\$15,031	N/A	\$16,370	\$377,065	23.03	0.79
11a	Radiant Heat (Floor)	\$9 <b>,</b> 178	\$26,594	N/A	\$35,773	\$870,376	24.33	0.73
5	Insulate Doors	\$30	\$438	N/A	\$468	\$11,952	25.53	0.72
1a	Roof Insul. (R-19)	\$615	\$6,180	N/A	\$6,796	\$206,502	30.39	0.60
12	High Eff. Lighting	\$752	(\$291)	N/A	\$461	\$15,644	19.85	0.56
2a	Wall Insul. (R-19)	\$437	<b>\$7,11</b> 5	N/A	<b>\$7,</b> 552	\$269,828	35.73	0.51
8	Heat Recovery	\$810	\$8,183	N/A	\$8,993	\$326,427	36.30	0.50
<b>2</b> b	Wall Insul. (R-30)	\$522	<b>\$7,7</b> 59	N/A	\$8,281	\$321,795	38.86	0.47
3	Windows	\$328	\$3,866	N/A	\$4,193	\$257,280	61.35	0.30
1b	Roof Insul. (R-30)	\$712	<b>\$7,</b> 083	N/A	\$7 <i>,</i> 794	\$623,573	80.00	0.23
	Combined ECOs	\$3,372	\$105,173	(\$23,927)	\$84,619	\$310,892	3.67	4.83

A graphical representation of the annual energy use for the baseline models and each of the ECOs is presented in Figures ES-1 and ES-2 below.

Figure ES-1. Steam & Gas Energy Use for Baseline and Examined ECO Modifications



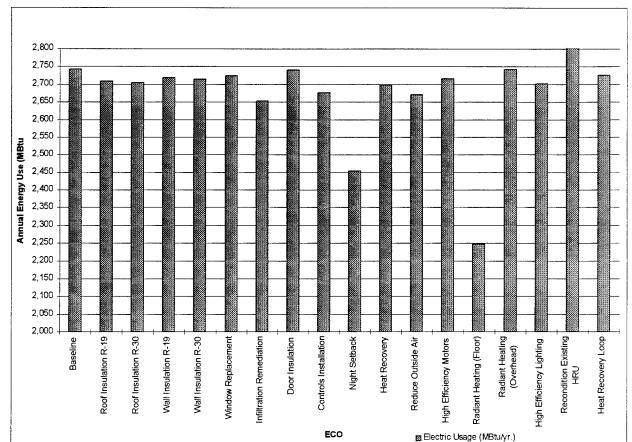


Figure ES-2. Electric Energy Use for Baseline and Examined ECO Modifications

## **RECOMMENDATIONS**

To qualify for government funding, ECOs must have a discounted Savings to Investment Ratio (SIR) greater than 1.25 and a simple payback less than 10 years. Qualified projects with investment costs less than \$300,000 will qualify for the Federal Energy Management Program (FEMP). A qualified project with an investment cost greater than \$300,000 can qualify for the Energy Conservation Investment Plan (ECIP) or FEMP funding. Table ES-3 on the following page presents the ECOs recommended for implementation.

Table ES-3. Summary of Recommended ECOs

ECO	Applied to Bldg.	Description	Electric Savings (\$/yr)	Steam Savings (\$/yr)	Natural Gas Savings/Cost (\$/yr)	Total Energy Savings (\$/yr)	Total Installed Cost (\$)	Simple Payback (yrs)	Dis- counted SIR
7	Both	Night Setback	\$5,360	\$34,673	N/A	\$40,033	\$16,401	0.41	<b>2</b> 3.10
6	<b>7</b> 98	Controls	\$1,211	\$13,637	N/A	\$14,849	\$6,366	0.43	22.20
4	Both	Infiltration	\$1,655	\$14,699	N/A	\$16,354	<b>\$47,31</b> 6	2.89	6.30
11b	Both	Radiant Heat (Gas)	N/A	\$85,848	(\$40,078)	<b>\$45,77</b> 0	\$194,524	4.25	4.37
13	<b>7</b> 50	Recond. Exist. HRUs	(\$2,225)	\$18,828	(\$12,156)	\$4,447	<b>\$16,18</b> 6	3.64	3.75
14	<b>7</b> 98	Heat Recovery Loop	\$299	\$2,627	N/A	\$2,926	<b>\$25,47</b> 0	8.71	2.09
10	Both	High Eff. Motors	\$483	N/A	N/A	\$483	<b>\$4,62</b> 9	9.60	1.57
		Combined ECOs	\$3,372	\$105 <b>,17</b> 3	(\$23,927)	\$84,619	\$310,892	3.67	4.83
Combined MBTU Savings 182 19,934 (8,425) 11,691									

In addition to saving significantly on annual energy costs the installation of an overhead gas-fired infrared heating system (ECO 11b) would solving the heating capacity problems in these buildings. For these reasons, it is highly recommended.

Due to the pressurization and infiltration problems in Building 750, it is also highly recommended that the existing rooftop make-up air unit (MAU) with heat recovery be reconditioned and brought back on line (ECO 13). This would improve the comfort level of the occupants, increase the capacity of the building, and result in a savings on the annual energy costs.

As a result of the remote location and extreme weather in Alaska, material and labor costs are generally more expensive than in the remaining part of the continental United States. Alaska is also very rich in energy resources which makes the cost of energy relatively inexpensive. When these two factors are combined, the result is that many ECOs that traditionally pay well in other parts of the country are not economically feasible in this location.

The following ECOs were not found to be cost effective:

Table ES-4. ECOs Not Recommended

ECO	Description	Electric Savings (\$/yr)	Steam Savings (\$/yr)	Natural Gas Savings/Cost (\$/yr)	Total Energy Savings (\$/yr)	Total Installed Cost (\$)	Simple Payback (yrs)	Dis- counted SIR
9	Control Outside Air	\$1,339	<b>\$15,</b> 031	N/A	\$16,370	\$377,065	23.03	0.79
11a	Radiant Heat (Floor)	\$9 <b>,</b> 178	\$26,594	N/A	\$35 <i>,</i> 773	\$870,376	24.33	0.73
5	Insulate Doors	\$30	\$438	N/A	\$468	\$11,952	25.53	0.72
1a	Roof Insul. (R-19)	\$615	\$6,180	N/A	<b>\$6,79</b> 6	\$206,502	30.39	0.60
12	High Eff. Lighting	\$752	(\$291)	N/A	\$461	\$15,644	19.85	0.56
2a	Wall Insul. (R-19)	\$437	\$7,115	N/A	\$7 <b>,</b> 552	\$269,828	35.73	0.51
8	Heat Recovery	\$810	\$8,183	N/A	\$8,993	\$326,427	36.30	0.50
2b	Wall Insul. (R-30)	\$522	<b>\$7,7</b> 59	N/A	\$8,281	\$321,795	38.86	0.47
3	Windows	\$328	\$3,866	N/A	\$4,193	\$257,280	61.35	0.30
1b	Roof Insul. (R-30)	\$712	\$7,083	N/A	\$7,794	\$623,573	80.00	0.23