

**ENERGY REPORT**

**ENERGY ENGINEERING  
ANALYSIS PROGRAM**

**ENERGY SURVEY OF BOILER  
AND CHILLER PLANTS**

**YUMA PROVING GROUND, ARIZONA**

OCT. 94

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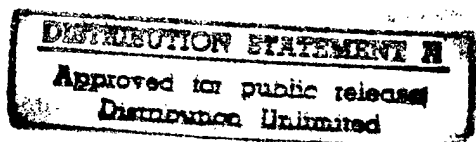
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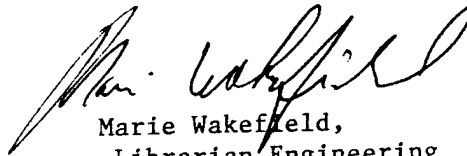


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## **1.0 Executive Summary**

### **1.1 Introduction**

This report summarizes all work for the Energy Survey of Boiler and Chiller Plants, Energy Engineering Analysis Program (EEAP) at U.S. Army Yuma Proving Ground, Arizona, authorized under Contract DACA05-92-C-0155 with the U.S. Army Corps of Engineers, Sacramento District, California.

The purpose of this study is to develop projects and actions that will reduce facilities energy consumption and operating costs at Yuma Proving Ground. Implementation of these projects will contribute to achieving the goal of the Army Facilities Energy Plan of a reduction in energy consumption per square foot of building floor area of 20 percent by FY2000 from FY1985 baseline levels.

The survey and evaluation effort was limited to chillers and direct expansion cooling units in Buildings 451, 506, 2105, 3482, 3490, and 3510 and boilers in Building 506.

### **1.2 Energy Conservation Analysis**

A summary of all potential energy conservation opportunities (ECOs) investigated is presented in Table 1-1. This table includes a matrix of reasons for eliminating ECOs from further consideration. A summary of analysis results for recommended ECOs is presented in Table 1-2, and a summary of analysis results for ECOs rejected is presented in Table 1-3.

### **1.3 ECIP Project Developed**

An ECIP-qualifying project covering energy improvements in the surveyed facilities was developed that includes the following retrofit measures:

- a. Replace two steam boilers with one modular hot water boiler system in Building 506.
- b. Install chilled water temperature reset controls on three chillers (one in Building 506 and two in Building 2105).
- c. Replace the converted 45-ton glycol chiller for ice-on-coil system at Building 506 with an efficient unit designed for cold temperature application.
- d. Install duty cycling controls on four chillers (one in Building 451 and three in Building 3490).



e. Modify lighting fixtures and install lighting controls as follows:

- (1) Retrofit fluorescent fixtures with electronic ballasts and T8 lamps in Buildings 451, 506A, 506B, 506C, 2105 and 3490.
- (2) Retrofit 4-lamp fluorescent fixtures with 3-lamp electronic ballasts, T8 lamps and specular reflectors in Buildings 457, 506B, 2105 and 3490.
- (3) Replace incandescent fixtures with surface mounted T8 and compact fluorescent fixtures in Buildings 451, 506A and 506B.

f. Install occupancy sensors (ceiling or wall-switch mounted) in Buildings 451, 506A, 506B, 2105 and 3490.

g. Install additional (explosion-proof) light fixture switching in Building 3482.

The following ECIP project data is taken from the DD Form 1391 life cycle cost analysis summary sheet (note that more up-to-date criteria and discount factors are used to prepare funding documents, thus, results may not be the same as presented in this report):

Construction cost (including SIOH, design and utility rebates)	.....	\$632,257
Annual energy savings		
• Electricity	.....	.3,321 million Btu
• No. 2 fuel oil	.....	.466 million Btu
• Liquefied petroleum gas (LPG)	.....	.578 million Btu
Annual dollar savings	.....	\$119,952
Savings-to-investment ratio (SIR)	.....	2.64
Simple payback period	.....	5.3 years
Analysis date	.....	January 1994

#### 1.4 Conversion to Non-chlorofluorocarbon Refrigerants

In response to the production phaseout of CFCs and HCFCs as mandated by the Montreal Protocol, the scope of the study included an analysis of conversion to non-CFC refrigerants for the surveyed chillers. Recommendations to contain existing refrigerants, retrofit with HFC-type refrigerants, or completely replace chillers, along with associated costs, are summarized in Table 1-4.

3,321  
466  
578  
-----  
4,365



**Table 1-1  
Summary of ECO Evaluations**

No.	Description of ECO	SIR Greater Than 1.0	SIR Less Than 1.0	Recommended Project
<b>Building 506 Boiler Efficiency Improvements</b>				
B1	High Efficiency Burners and O <sub>2</sub> Trim Controls	✓		
B2	Install Engineered Turbulators in Fire Tubes	✓		
B3	Automatic Boiler Blowdown with Heat Recovery	✓		
B4A	New Modular Boilers for Heating and Domestic Water	✓		✓
B4B	New Modular Boilers for Domestic Water Only		✓	
<b>Cooling Equipment ECOs</b>				
Chilled Water Temperature Reset (Buildings 506 C-1, 2105 C-1 and C-5)		✓		✓
Chilled Water Temperature Reset (Buildings 451, 2105 C-2, 3490 C-1, C-2 and C-3)			✓	
Replace Glycol Chiller at Building 506		✓		✓
Electronic Expansion Valves (Buildings 3482 and 3510)			✓	
Optimize Cooling Tower Control (Condenser Water Temperature)			✓	
Manifold Chillers C-1, C-2 and C-3 at Building 3490		✓		✓
Duty Cycling Controls, Demand Limiting		✓		✓
Shading Air Cooled Condensers			✓	
Evaporative Precooling			✓	
<b>Lighting and Control ECOs</b>				
A	Retrofit: 1-Lamp Electronic Ballast and T8 Lamp	✓		Most
B	Retrofit: 2-Lamp Electronic Ballast and T8 Lamps	✓		✓
C	Retrofit: 3-Lamp Electronic Ballast and T8 Lamps	✓		✓
D	Retrofit: 4-Lamp Electronic Ballast and T8 Lamps	✓		Most
E	New Fixture: 1-Lamp Electronic Ballast and T8 Lamp		✓	
F	New Fixture: 2-Lamp Electronic Ballast and T8 Lamps	✓		Most
G	New Fixture: 3-Lamp Electronic Ballast and T8 Lamps — Explosion Proof		✓	
H	Retrofit: 3-Lamp Electronic Ballast and T8 Lamps and Specular Reflector	✓		✓
I	Retrofit: Occupancy Sensor Lighting Control — Ceiling Mounted	✓		✓
J	Retrofit: Occupancy Sensor Lighting Control — Auto. Wall Switch	✓		✓
K	New Fixture: 2-Lamp Compact Fluorescent, 2 x 13W/ST4	✓		✓
L	New Fixture: 2-Lamp Electronic Ballast and T8 Lamps, 2' Surface Mount	✓		✓
M	Install Switching for Assembly Rooms — Building 3482	✓		✓
<p><b>Notes:</b> Only one Boiler Efficiency project group may be implemented: (B1, B2 and B3), B4A or B4B. B4A is recommended.</p> <p>Lighting and control ECOs where recommendations are shown as "Most" are evaluated separately for each building; buildings in which the ECOs show SIRs &gt; 1 are recommended.</p>				



Table 1-2  
Recommended Energy Conservation Opportunities

Project / Number	Description	Electric Savings kW	Electric Savings kWh/Yr	Fuel MBTU/Yr Distillate	LPG	Energy Cost Saved \$/Year LCC \$	O&M Cost Saved \$/Year LCC \$	Investment \$	Simple Payback SIR	ARR	Economic Measures	
<b>Recommended Building 506 Boiler Efficiency Improvement Projects</b>												
B1	New Burners & O2 Trim	-	330	346	346	\$6,923	(\$1,320)	(\$14,177)	1.17	11.1	5.6%	
B2	Engineered Turbulators	-	164	163	163	\$3,371	(\$519)	(\$5,674)	16.8	0.8	26.1%	
B3	Auto-Blowdown w/ Heat Recovery	-	3	2	2	\$49.81	\$622	\$73,011	4.27	2.4	15.0%	
<b>Totals for B1, B2 &amp; B3</b>		-	497	511	511	\$10,344	(\$4,958)	(\$53,260)	2.27	5.28	10.4%	
B4A	Modular Boilers for Heating & DHW	-	-	466	578	\$10,435	\$131,662	\$191,387	2.84	4.3	11.5%	
B4B	Modular Boilers for DHW Only	-	-	200	247	\$4,467	(\$1,980)	(\$21,265)	0.47	29.7	-0.6%	
<p>Note: Boilers in building 506 are dual fueled, alternating between No. 2 Fuel Oil (Distillate) and LPG; boilers serve building 506 only.</p> <p>Recommendation: Implement B4A - Each of the above project groupings are mutually exclusive, e.g., project B4A cannot be economically justified if the group of B1, B2 &amp; B3 are implemented.</p>												
<b>Recommended Cooling Equipment Energy Conservation Opportunities Evaluated</b>												
Chilled Water Temperature Reset (506 C-1, 2105 C-1 & C-5)		-	146,584	-	-	\$12,166	\$137,481	(\$1,584)	(\$17,012)	3.98	2.86	14.6%
Replace Glycol Chiller 506 C-2		-	80,000	-	-	\$6,640	\$75,032	-	\$62,506	1.20	9.43	5.8%
Manifold Chillers C-2 & C-3 at Building 3480		-	92,825	-	-	\$7,704	\$87,060	(\$1,320)	(\$14,177)	1.27	8.98	6.2%
Duty Cycling Controls		36.8	-	-	-	\$1,164	\$13,157	(\$132)	(\$1,418)	1.80	6.32	8.7%
<b>Total of Recommended Cooling Equipment ECOs</b>		<b>36.8</b>	<b>319,409</b>	-	-	<b>\$27,675</b>	<b>\$312,730</b>	<b>(\$3,036)</b>	<b>(\$32,606)</b>	<b>1.79</b>	<b>6.36</b>	<b>8.6%</b>
<b>Recommended Lighting &amp; Control Energy Conservation Opportunities Evaluated</b>												
A	1-Lamp Electronic Ballast & TB Lamp (2106S1 & 506A)	2.0	13,893	-	-	\$1,153	\$13,031	(\$104)	(\$1,115)	1.51	7.51	7.4%
B	2-Lamp Electronic Ballast & TB Lamps	50.3	213,214	-	-	\$17,697	\$199,973	(\$1,580)	(\$17,073)	1.54	7.39	7.5%
C	3-Lamp Electronic Ballast & TB Lamps	18.2	72,093	-	-	\$5,984	\$67,616	(\$602)	(\$6,463)	1.65	6.87	6.1%
D	4-Lamp Electronic Ballast & TB Lamps (506A & C)	2.3	7,868	-	-	\$653	\$7,379	(\$72)	(\$770)	1.22	9.29	5.9%
F	2-Lamp Electronic Ballast & TB Lamps (506B)	10.6	35,226	-	-	\$2,924	\$33,039	\$6,132	\$65,954	3.04	3.80	12.5%
H	3-Lamp Electronic Ballast & TB Lamps & Specular Reflector	20.8	75,828	-	-	\$6,277	\$70,930	(\$108)	(\$1,178)	2.03	5.57	9.5%
I	Ceiling Mounted Sensor Switch (2106, 3490, 506)	-	76,063	-	-	\$6,313	\$71,340	\$0	\$0	2.29	4.93	10.4%
J	Automatic Wall Sensor Switch (451, 3480, 2105)	-	61,408	-	-	\$5,097	\$57,594	\$0	\$0	2.80	4.04	11.9%
K	2-Lamp Compact Fluorescent 2 x 13W/5T4	4.1	16,076	-	-	\$1,334	\$15,078	\$1,003	\$10,769	1.90	5.81	9.1%
L	2-Lamp Elect. Ballast & TB Lamps, 2' Surface Mount	15.6	51,567	-	-	\$4,282	\$48,384	\$6,138	\$87,399	3.74	2.92	14.1%
M	Install Light Switching for Assembly Rooms - Bldg 3482	-	30,680	-	-	\$2,548	\$28,775	\$0	\$0	1.89	5.98	9.0%
<b>Total of Recommended Lighting &amp; Control ECOs</b>		<b>123.6</b>	<b>653,735</b>	-	-	<b>\$54,260</b>	<b>\$613,138</b>	<b>\$12,786</b>	<b>(\$137,425)</b>	<b>2.13</b>	<b>5.27</b>	<b>9.9%</b>
<b>GRAND TOTAL OF RECOMMENDED ECOs</b>		<b>160.4</b>	<b>973,144</b>	<b>466</b>	<b>578</b>	<b>\$92,370</b>	<b>\$1,057,530</b>	<b>\$27,580</b>	<b>\$296,205</b>	<b>2.14</b>	<b>5.27</b>	<b>9.9%</b>
Includes Project B4A only from Boiler Efficiency Improvements												



Table 1-3  
Energy Conservation Opportunities Not Recommended

Project / Number	Description	Electric Savings kW	Electric Savings kWh/Yr	Energy Cost Saved \$/Year	LCC \$	O&M Cost Saved \$/Year	LCC \$	Investment \$	SIR	Payback	ARR
<b>Cooling Equipment Energy Conservation Opportunities Not Recommended</b>											
	Chilled Water Temperature Reset (451, 2105 C-2, 3490)	-	8,225	\$683	\$7,712	-	-	\$50,505	0.15	73.98	-7.81%
	Optimize Cooling Tower Control (Condenser Water Temperature Reset)	Project not recommended because none of the chilled water systems evaluated is large enough.									
	Shade Air Cooled Condensers from Sunlight	Project not recommended: all but 1 A/C chiller are located on the North sides of their buildings.									
	Evaporative Precooling of Air Cooled Condenser Air	Project not recommended because life cycle energy cost savings are less than the investment.									
<b>Lighting &amp; Control Energy Conservation Opportunities Not Recommended</b>											
A	1-Lamp Electronic Ballast & T8 Lamp (2105N, S2 & 3490)	0.90	3,567	\$296	\$3,345	(\$31)	(\$334)	\$4,284	0.70	16.17	2.07%
D	4-Lamp Electronic Ballast & T8 Lamps (2105S2 & 506B)	1.11	3,075	\$255	\$2,884	(\$101)	(\$1,083)	\$2,976	0.61	19.27	1.06%
E	New Fixture for Lighting ECO A (451, 508, 2105 & 3490)	2.74	10,808	\$897	\$10,135	(\$80)	(\$863)	\$46,326	0.20	56.74	-6.13%
F	2-Lamp Electronic Ballast & T8 Lamps (451)	0.30	1,098	\$91	\$1,031	\$170.6	\$1,832	\$3,708	0.77	14.15	2.72%
G	3-Lamp Elect. Bal. & T8 Lamps - Explosion Proof (3482 & 3510)	28.91	64,242	\$5,332	\$60,253	\$2,155	\$23,140	\$632,295	0.13	84.46	-8.70%
I	Ceiling Mounted Sensor Switch (506A)	0.00	3,947	\$319	\$3,608	\$0	\$0	\$7,323	0.49	22.94	-0.32%
J	Automatic Wall Sensor Switch (506A & B)	0.00	19,989	\$1,660	\$18,758	\$0	\$0	\$40,890	0.46	24.63	-0.79%

**Table 1-4  
Non-Chlorofluorocarbon Refrigerant Conversion Recommendations (1)**

Building Number	Unit Description (2)	Contain Refrigerant	Replace Refrigerant	Replace Unit	Recommended Investment (3)	Explanation
451	55 Ton A/C Reciprocating Chiller	\$ 12,500	-	\$ 60,574	\$ 14,000	Unit is now only 7 years old. Contain refrigerant until a replacement unit is needed.
506	220 Ton W/C Centrifugal Chiller C1	\$ 12,500	\$ 17,680	\$ 159,424	\$ 178,555	Unit is now 20 years old and is due for replacement at this time.
506	45 Ton A/C Reciprocating Glycol Chiller C2	\$ 12,500	-	\$ 55,898	\$ 62,606	Analysis shows that replacing this unit now is the most cost effective choice.
2105	125 Ton W/C Centrifugal Chiller C1	\$ 12,500	\$ 16,728	\$ 145,558	\$ 163,025	Unit is now 17 years old and is due for replacement at this time.
2105	40 Ton W/C Reciprocating Chiller C2	\$ 12,500	-	\$ 46,792	\$ 52,408	Unit is now 17 years old and is due for replacement at this time.
2105	125 Ton W/C Centrifugal Chiller C5	\$ 12,500	\$ 16,728	\$ 145,558	\$ 14,000	Unit is only 10 years old. Contain refrigerant until a replacement unit is needed.
3482	62 Ton W/C Reciprocating DX Unit	\$ 12,500	-	\$ 53,992	\$ 60,471	Unit is now 24 years old and is due for replacement at this time.
3490	25 Ton A/C Reciprocating Chiller C1	\$ 12,500	-	\$ 32,138	\$ 14,000	Unit is now only 7 years old. Contain refrigerant until a replacement unit is needed.
3490	50 Ton A/C Reciprocating Chiller C2	\$ 12,500	-	\$ 57,312	\$ 14,000	Unit is now only 7 years old. Contain refrigerant until a replacement unit is needed.
3490	100 Ton A/C Reciprocating Chiller C3	\$ 12,500	-	\$ 112,800	\$ 14,000	Unit is now only 7 years old. Contain refrigerant until a replacement unit is needed.
3510	40 Ton W/C Reciprocating DX Unit	\$ 12,500	-	\$ 38,932	\$ 14,000	Unit was converted to HFC-134a in 1993. Retrofit refrigerant containment equipment.
<b>Total Probable Construction Cost</b>					<b>\$ 601,064</b>	

- Notes:**
1. Recommended options are displayed in **Bold-Face** type.
  2. Condenser types: A/C = Air Cooled; W/C = Water Cooled
  3. Investment includes construction costs plus 6% for SOH and 6% for design.

**Life Cycle Cost Analysis Summary**  
**Energy Conservation Investment Program (ECIP)**

Location: Yuma Proving Ground, Arizona      Region No. 4      Project No.  
 Project Title: ECIP Facility Energy Improvements - Total Project      Fiscal Year FY96  
 Analysis Date: January 1994      Economic Life: 15 & 20 Years      Preparer: KELLER & GANNON

**1. Investment Costs**

A. Construction Costs	<u>\$ 565,547</u>	
B. SIOH	<u>\$ 33,933</u>	
C. Design Cost	<u>\$ 33,933</u>	
D. Total Cost (1A + 1B + 1C)	<u>\$ 633,413</u>	
E. Salvage Value of Existing Equipment		<u>\$1,206</u>
F. Public Utility Company Rebate		<u>\$0</u>
G. Total Investment (1D-1E-1F)		<u>\$632,207</u>

**2. Energy Savings (+)/Cost(-):**

Date of NISTIR 85-3273 Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU(1)	Saving MBTU/Yr(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec. 15 Year	<u>\$24.32</u>	<u>2,231</u>	<u>\$54,260</u>	<u>12.49</u>	<u>\$677,707</u>
B. Elec. 20 Year	<u>\$24.32</u>	<u>1,090</u>	<u>\$26,511</u>	<u>15.64</u>	<u>\$414,631</u>
C. Dist 20 Year	<u>\$13.25</u>	<u>466</u>	<u>\$6,174</u>	<u>17.47</u>	<u>\$107,866</u>
D. LPG 20 Year	<u>\$7.37</u>	<u>578</u>	<u>\$4,263</u>	<u>19.21</u>	<u>\$81,884</u>
E. Other					
F. Demand Savings	<u>\$31.68/kW</u>	<u>36.75</u> kW	<u>\$1,164</u>	<u>15.64</u>	<u>\$18,210</u>
G. Total		<u>4,366</u>	<u>\$92,372</u>		<u>\$1,300,298</u>

Demand savings are based on \$1.98/kW/Mo @ 6 Months + 10 times rate for 1 Mo.; 20 year life.

**3. Non Energy Savings (+) or Cost (-):**

A. Annual Recurring (+/-)	15 Years	<u>\$12,796</u>	<u>\$27,580</u> Total per Year
	20 Years	<u>\$14,784</u>	
(1) Discount Factor (Table A)	15 Years		<u>11.85</u>
	20 Years		<u>14.74</u>
(2) Discounted Savings/Cost (3A x 3A1)			<u>\$369,544</u>

**B. Non Recurring Savings (+) or Cost (-)**

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.	_____	_____		_____
b.	_____	_____		_____
c.	_____	_____		_____
d. Total				

C Total Non Energy Discounted Savings (3A2 + 3Bd4) \$369,544

4. First Year Dollar Savings (2G3 + 3A + (3Bd1/Years Economic Life)):	<u>\$119,952</u>
5. Simple Payback (1G/4):	<u>5.27</u> Years
6. Total Net Discounted Savings (2F5 + 3C):	<u>\$1,669,842</u>
7. Savings to Investment Ratio (SIR) 5/1G:	<u>2.64</u>