ENERGY MANAGEMENT SYSTEM (EMS) STUDY

FORT BELVOIR, VIRGINIA
Department of the Army
Baltimore District, Corps of Engineers

COE Project No: DACA31-92-D-0061

EYP Project No: 60692.00

1 NOVEMBER 1995
FINAL SUBMITTAL
EXECUTIVE SUMMARY
Based on SOW, these Energy Studies are unclassified/unlimited. Distribution A. Approved for public release.

Marie Wakefield,
Librarian Engineering
Energy Management System (EMS) STUDY

Fort Belvoir, Virginia

Prepared by:

EINHORN YAFFEE PRESCOTT
ARCHITECTURE AND ENGINEERING, P.C.
The Flour Mill
1000 Potomac Street, N.W., Ste. L-1
Washington, DC 20007-3238
(202) 471-5000

PROJECT NUMBER: DACA31-92-D-0061
Delivery Order # 0004
TABLE OF CONTENTS

EXECUTIVE SUMMARY

A. INTRODUCTION ................................................................. page I-1
B. PURPOSE ................................................................. page I-1
C. BUILDING INFORMATION ................................................ page I-1
D. PRESENT ENERGY CONSUMPTION ................................. page I-2
E. ENERGY CONSERVATION ANALYSIS ............................. page I-3
F. EXTRAPOLATION OF RESULTS ....................................... page I-7
G. TABULATION OF RESULTS ............................................. page I-10
I. EXECUTIVE SUMMARY

A. INTRODUCTION
General Location: Fort Belvoir is an 8,656 acre Post held fee simple by the US Army. It is located in the Commonwealth of Virginia, 14 miles south of Washington, D.C., situated primarily on a peninsula of the Potomac River. Interstate 95 and US Route 1 provide primary transportation links to Norfolk, Washington, DC, and other cities. Fort Belvoir is an Army Installation under the Command of the United States Military District of Washington (MDW).

Installation Mission: Since 1988 and its transfer to the MDW, Fort Belvoir's mission has shifted from training to service to MDW and the National Capitol Region (NCR). Within its eight mission elements are: contingency military support to the NCR, Regional Administrative Center, Regional Logistics Support, Regional Recreation Center, Classroom Center, Housing and other regional activities. The Installation is now referred to as "U.S. Army Fort Belvoir".

Ft. Belvoir has been tasked, by Executive Order 12902, with reducing the total energy consumption on the Installation by 30% of the FY1985 level by the year FY2005. The purpose of this study is to determine the most effective Energy Management Systems (EMS) to install to assist in meeting this challenge. The analysis performed was based upon five buildings of different function, occupancy and scheduling, as well as different types of mechanical systems. Three different EMS types were analyzed for their advantages and applicability to each building. The results of this study are to be used to evaluate other buildings on the Installation. The three types of systems analyzed for this study are the FM Relay (FMR), the Power Line Carrier (PLC) and the Direct Digital Control (DDC) Systems.

B. PURPOSE
The purpose of this study is to compare three different types of energy management systems and determine which system would be most effective in each of a variety of different buildings. The three systems chosen for this analysis are the FM Relay (FMR), Power Line Carrier (PLC) and Direct Digital Control (DDC) systems. The analysis performed was based upon five buildings of different function, occupancy, and scheduling as well as different types of mechanical systems. The recommendations listed in this report are to be applied over the entire Installation using the criteria listed for evaluating each building. This study will develop the recommended strategies for applying energy management systems (EMS) to many of the buildings at Ft. Belvoir.

C. BUILDING INFORMATION
The following is a list of the buildings which were analyzed for this study:

Building 200 - 26,256 square foot recreation facility
Building 219 - 32,937 square foot finance office building w/ auditorium
Building 247 - 148,067 square foot classroom building
Building 1425 - 15,430 square foot administrative office building

Building 3136 - 11,760 square foot office building

Building energy simulations were performed for each building to determine the cost effectiveness of EMS application to each building. This information along with initial investment, maintenance and replacement costs were used to perform life cycle cost analysis for each system type being recommended.

D. PRESENT ENERGY CONSUMPTION

The estimated present energy consumption for each building is shown in Table 1 on page I-3. This table reflects the results of the energy simulation calculations for each building as it existed at the time this study was conducted. This is true for all buildings except building 1425. This building is presently equipped with a control system which utilizes a time clock to provide time of day scheduling. In an effort to provide a comparative analysis for other buildings which are similar in size and system type, but do not have time of day scheduling, it was decided that this building will be analyzed as if it were not equipped with a time clock. For this reason the results of the analysis for building 1425 are not applicable to this building but may be used as an example when evaluating other similar buildings.
Table 1. Estimated Present Annual Energy Consumption

<table>
<thead>
<tr>
<th></th>
<th>Building 200</th>
<th>Building 219</th>
<th>Building 247</th>
<th>Building 1425</th>
<th>Building 3136</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Energy (kWH)</td>
<td>727,922</td>
<td>903,608</td>
<td>2,045,422</td>
<td>265,769</td>
<td>346,101</td>
</tr>
<tr>
<td>Electrical Energy (kBTU)</td>
<td>2,484,398</td>
<td>3,083,111</td>
<td>6,981,025</td>
<td>907,070</td>
<td>1,181,243</td>
</tr>
<tr>
<td>Electrical Cost ($)</td>
<td>14,558</td>
<td>18,072</td>
<td>40,908</td>
<td>5,315</td>
<td>6,922</td>
</tr>
<tr>
<td>Natural Gas (Therm)</td>
<td>29,904</td>
<td>25,043</td>
<td>40,071</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Natural Gas (kBTU)</td>
<td>2,990,400</td>
<td>2,504,300</td>
<td>4,007,100</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Natural Gas Cost ($)</td>
<td>18,182</td>
<td>15,226</td>
<td>24,363</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>District Steam (kLBS)</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>254</td>
<td>434</td>
</tr>
<tr>
<td>District Steam (kBTU)</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>340,360</td>
<td>581,560</td>
</tr>
<tr>
<td>District Steam Cost ($)</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>2,034</td>
<td>3,472</td>
</tr>
<tr>
<td>Total Annual Energy (kBTU)</td>
<td>5,474,798</td>
<td>5,587,411</td>
<td>10,988,125</td>
<td>1,247,564</td>
<td>1,762,334</td>
</tr>
</tbody>
</table>

E. ENERGY CONSERVATION ANALYSIS

ECOs Investigated
The following is a list of the ECOs investigated for this study:

Building 200
- FMR EMS
- PLC EMS
- DDC EMS

Building 219
- FMR EMS
- PLC EMS
- DDC EMS

EYP PROJECT NUMBER 60692.00
Building 247
- FMR EMS
- PLC EMS
- DDC EMS

Building 1425
- FMR EMS
- PLC EMS
- DDC EMS

Building 3136
- FMR EMS
- PLC EMS
- DDC EMS

**ECOs Recommended**
The following is a list of the ECOs recommended as a result of this study:

Building 200          DDC
Building 219          DDC
Building 247          DDC
Building 1425         FMR, PLC
Building 3136         FMR

*The recommendations made for building 1425 are for comparison of similar buildings which are not equipped with an EMS. They do not apply to building 1425.

**ECOs Rejected**
The following is a list of ECOs which were rejected as a result of this study

Building 200
- FMR
- PLC

Building 219
- FMR
- PLC

Building 247
- FMR
- PLC

Building 1425
- DDC

Building 3136
- PLC
- DDC

The above listed ECO recommendations and rejections are based on the following criteria:

Building 200, 219, and 247:
Although the FMR system results in the highest SIR and the shortest payback period, this system does not provide comprehensive EMS capability and will not save energy. As shown in the capabilities summary the FMR is capable of demand limiting only. This eliminates the FMR from consideration as a solution to the problem of reducing the total energy consumption for the entire Ft Belvoir Installation. This system should be considered, however, for use with any building which has comfort cooling using electric chillers or condensing units and is not equipped with an EMS which is capable of demand limiting. Because of the short payback period and ease of installation, the FMR can be applied in a temporary fashion to buildings which may be scheduled for EMS installation beyond 2 years in the future. FMR systems installed for this purpose can be removed, after the new EMS is installed, and then re-used for another building on the Installation. When installing the FMR system care must be taken to ensure that the relays are used to initiate a normal equipment shut-down and not to simple disconnect the incoming power to the equipment. Until the entire Installation is outfitted with an EMS that is capable of demand limiting, the FMR should be applied as described above to generate cost savings at a very attractive SIR.

The PLC provides an substantial energy savings and SIR for each individual building as shown in Table 1 on page I-3, Table 2 on page I-11 and Table 3 on page I-12. The system, as evaluated in this study, is capable of providing time of day scheduling which accounts for the majority of energy savings attributable to this type of EMS. The PLC performs this time of day scheduling at the lower cost and a higher SIR than the DDC system.

The DDC system provides the greatest energy savings potential of the three systems evaluated, as shown in Tables 1 through 3. This is important as Ft. Belvoir continues toward the goal of reducing the total energy consumption by 30% of the FY1985 levels by the year FY2005. In addition to the increased energy savings potential the DDC system offers several features which are not available on the typical PLC system. These features, which are important ingredients for a comprehensive EMS in a multiple building Installation such as, Ft. Belvoir are as follows:

- On-Line monitoring and control of the building systems from a central location.
- The DDC system provides this capability through a network arrangement which can utilize the existing fiber optics at Ft. Belvoir or dedicated phone lines between the various buildings. The typical PLC is capable of only intermittent communications via a modem in a central computer and the controller in each building.
Demand limiting based on an Installation-wide strategy which monitors the electric demand at the main electric sub-station providing power to all of Ft. Belvoir. The PLC is capable of demand limiting or load shedding within each individual building only. It is not capable of controlling the demand strategy for all of the buildings on the Installation. The DDC system can be equipped to continuously monitor the electric demand from a meter at the sub-station and implement the appropriate demand limiting strategy for every building connected to a central control computer. This integrated approach is necessary at Ft. Belvoir because the demand charges assessed by the electric company are based on the maximum electric demand for the entire Installation not for the individual buildings.

Increased control system reliability and maintainability. The DDC system installation will require the replacement of many of the existing pneumatic sensors, controllers and actuators each system. For this reason the control system reliability will be significantly increased in two ways. First the new components will be replacing components which are, in many cases over twenty years old and second the sensors and controllers used in the modern DDC systems are superior in many ways to the older pneumatic components. The DDC systems also require less maintenance since all of the logic functions are performed by solid state controllers with no moving parts as compared to the old pneumatic receiver controllers and logic controllers which require periodic calibration. The economic impact attributable to this increased reliability is impossible to accurately estimate but is generally thought to be significant in most cases. The PLC system utilizes all of the existing control components and will not increase the reliability or maintainability of the control systems.

Building 1425:
The FMR EMS should be installed on the chiller serving this building, because of the short payback period and ease of installation, the FMR can be applied When installing the FMR system care must be taken to ensure that the relays are used to initiate a normal equipment shut-down and not to simple disconnect the incoming power to the equipment. The existing control system in this building is currently equipped with the capability to provide the time-of-day scheduling which has been shown in this study to provide the largest single economic advantage of an EMS. Therefore, it is not advisable to install an EMS with time-of-day scheduling capabilities.

When analyzing similar size buildings served primarily by perimeter fan-coil units and central air cooled chilled water, and district steam heated hot water systems the PLC should be considered as an option for maximum energy savings while meeting ECIP funding criteria.

For new buildings or buildings where major mechanical renovation is planned the DDC system should be considered for applications similar to this building. Because the DDC system would provide all of the control system and EMS capabilities the required investment in the EMS portion would be considerably less than “adding” EMS capabilities to existing systems.

Building 3136:
The age and condition of the fan coil units and the control system in this building make it a candidate for a mechanical system replacement. An example is that the fan coil units are not equipped with control valves to stop the flow of water through coil when cooling or heating is not needed. This situation causes the fan coil units to act as radiators during the heating season even after the thermostat has been satisfied and has cycled the fan off. The installation of total system EMS at the time of new equipment installation would be more cost effective.

The building is served by a packaged air cooled chiller which can be cycled to provide electrical demand savings. This building should be equipped with and FMR relay and entered into a demand limiting schedule in accordance with the strategy outlined in Example 2.1 on page II-2 of this report.

**ECIP Projects Developed**
The following is a list of ECIP Projects developed as a result of this study:

| Building     | EMS Type | SIR  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 200</td>
<td>DDC EMS</td>
<td>1.93</td>
</tr>
<tr>
<td>Building 219</td>
<td>DDC EMS</td>
<td>2.03</td>
</tr>
<tr>
<td>Building 247</td>
<td>DDC EMS</td>
<td>1.91</td>
</tr>
<tr>
<td>Building 1425</td>
<td>FMR EMS</td>
<td>7.17</td>
</tr>
<tr>
<td>Building 1425</td>
<td>PLC EMS</td>
<td>1.55</td>
</tr>
<tr>
<td>Building 3136</td>
<td>FMR EMS</td>
<td>7.17</td>
</tr>
</tbody>
</table>

*The PLC recommendation made for building 1425 are for comparison of similar buildings which are not equipped with an EMS. This does not apply to building 1425.*

The supporting data for these projects is shown in tabular form in Section F of this summary along with the Life Cycle Cost Analysis Sheets for the ECIP Projects.

**F. EXTRAPOLATION OF RESULTS**

Based on the results of this study the DDC EMS provides the greatest benefit of all the system evaluated for this study. The benefits of the DDC system can best be utilized by installing the systems with an emphasis on Installation-wide control and monitoring. This can be accomplished most effectively by packaging all of the buildings on the post which meet the criteria for EMS installation and acquiring competitive bids from qualified manufacturers and installers with experience in large multiple building Installations. It is also important to specify the requirement that all of the buildings be linked to a central control computer via a network arrangement utilizing the existing fiber optic facilities where possible and dedicated phone lines elsewhere. Another major consideration in evaluation of the manufacturers and installers is the availability and reliability of the support personnel who will be responsible for maintaining the system. It is also important that the manufacturers provide sufficient training...
for Installation or contract personnel who are responsible for maintaining the mechanical equipment.

If it is not possible to perform a full scale Installation-wide implementation of the DDC systems as described above, an alternate approach can be taken. The alternate approach would be to divide the Installation into groups of buildings and acquire competitive bids for each individual group as funding becomes available. The disadvantage to utilizing this alternative approach is that the different manufacturers will likely be used for each group of buildings. This would require the installation of a central control computer for each different manufacturer or an integration package would be required to consolidate the systems into one central control computer. There are manufacturers who are currently providing integration packages which are capable of communicating with the systems of major control manufacturers. Care must be taken to specify that the control manufacturers and the integrator’s systems must are compatible.

For small buildings which are served primarily by perimeter fan-coil units and central air cooled chilled water, and district steam heated hot water systems the PLC should be considered as an option for maximum energy savings while meeting ECIP funding criteria. These PLC systems should be limited in use to smaller buildings up to 20,000 sq. ft. and two stories or less with simple AC power distribution systems. The PLC systems have reportedly experienced operating problems when connected to AC power system which have a high level of electronic equipment usage. The availability of competitive vendors is limited and care should be taken when selecting systems to chose vendors with a documented history of successful installations similar to the application being considered.

The results of this study can also be extrapolated to assist energy auditors in selecting buildings for EMS implementation. The flow chart on the following page can be used as a preliminary test in selecting these buildings.
EMS BUILDING EVALUATION FLOWCHART

IS THE BUILDING CURRENTLY EQUIPPED WITH A TIME CLOCK OR EMS WHICH IS CAPABLE OF TIME OF DAY SCHEDULING FOR AIR HANDLING EQUIPMENT?

IS AT LEAST 75% OF THE BUILDING VACANT FOR MORE THAN 10 HOURS/DAY?
IS GREATER THAN 50% OF THE BUILDING SERVED BY TERMINAL UNITS (FAN COIL PACKAGED TERMINAL A/C UNITS)?

NO

THIS BUILDING WILL LIKELY QUALIFY FOR ECIP FUNDING TO INSTALL A DDC EMS PERFORM LIFE CYCLE COST ANALYSIS TO VERIFY.

YES

DOES THE BUILDING USE ELECTRIC COMFORT COOLING EQUIPMENT (CHILLERS OR CONDENSING UNITS) 40 TONS OR GREATER?

NO

EVEREVALUATE FOR PLC SYSTEM AND CONSIDER INSTALLING FMR SYSTEM

YES

THIS BUILDING WILL LIKELY NOT QUALIFY FOR ECIP FUNDING TO INSTALL AN EMS AT THIS TIME. IF THE BUILDING IS SCHEDULED FOR RENOVATION CONSIDER DDC AT TIME OF DESIGN FOR RENOVATION.
Because the recommended control strategy for DDC installation involves Installation-wide systems, it may be necessary to implement these systems in buildings which do not show a payback. This is true because the goal is to maximize the energy savings for the entire Installation.

G. TABULATION OF RESULTS

Tables 2 on page I-11, Table 3 on page I-12 and Table 4 on page I-13, list the results of the energy conservation analyses for each investigated Energy Conservation Opportunity (ECO). In addition, the EMS Capability Summary Tables compare the features of each system and their advantages and disadvantages relative to each building studied.

Life Cycle Cost Analysis Summary Sheets are included for all developed projects meeting ECIP Criteria.
<table>
<thead>
<tr>
<th>BUILDING</th>
<th>ECO</th>
<th>TOTAL SAVINGS $</th>
<th>INITIAL INVESTMENT $</th>
<th>SIR</th>
<th>SIMPLE PAYBACK YEAR(S)</th>
<th>TOTAL ANNUAL ENERGY SAVINGS KBTU</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMR</td>
<td>14,909</td>
<td>1,115</td>
<td>13.37</td>
<td>1</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PLC</td>
<td>59,601</td>
<td>12,711</td>
<td>4.69</td>
<td>3</td>
<td></td>
<td>981,343</td>
<td></td>
</tr>
<tr>
<td>DDC</td>
<td>152,246</td>
<td>78,764</td>
<td>1.93</td>
<td>5</td>
<td></td>
<td>1,489,047</td>
<td></td>
</tr>
<tr>
<td>Building 219</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMR</td>
<td>14,979</td>
<td>1,673</td>
<td>8.95</td>
<td>1</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PLC</td>
<td>91,836</td>
<td>12,516</td>
<td>7.34</td>
<td>2</td>
<td></td>
<td>1,583,582</td>
<td></td>
</tr>
<tr>
<td>DDC</td>
<td>146,518</td>
<td>72,141</td>
<td>2.03</td>
<td>5</td>
<td></td>
<td>1,725,602</td>
<td></td>
</tr>
<tr>
<td>Building 247</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMR</td>
<td>26,923</td>
<td>558</td>
<td>48.29</td>
<td>1</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PLC</td>
<td>108,303</td>
<td>14,914</td>
<td>7.26</td>
<td>2</td>
<td></td>
<td>1,837,268</td>
<td></td>
</tr>
<tr>
<td>DDC</td>
<td>166,883</td>
<td>87,416</td>
<td>1.91</td>
<td>5</td>
<td></td>
<td>2,043,868</td>
<td></td>
</tr>
<tr>
<td>Building 1425</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMR</td>
<td>3,999</td>
<td>558</td>
<td>7.17</td>
<td>2</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PLC</td>
<td>17,893</td>
<td>11,518</td>
<td>1.55</td>
<td>6</td>
<td></td>
<td>297,889</td>
<td>*</td>
</tr>
<tr>
<td>DDC</td>
<td>33,374</td>
<td>48,993</td>
<td>.68</td>
<td>--</td>
<td></td>
<td>312,251</td>
<td>*</td>
</tr>
<tr>
<td>Building 3136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMR</td>
<td>3,999</td>
<td>558</td>
<td>7.17</td>
<td>2</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PLC</td>
<td>17,938</td>
<td>10,464</td>
<td>1.68</td>
<td>6</td>
<td></td>
<td>294,780</td>
<td></td>
</tr>
<tr>
<td>DDC</td>
<td>32,715</td>
<td>48,614</td>
<td>.67</td>
<td>--</td>
<td></td>
<td>322,978</td>
<td></td>
</tr>
</tbody>
</table>

*TAs noted in Section III D, these figures are not applicable to Building 1425 because it is currently equipped with an EMS. These figures are for comparison to buildings which are similar but are not equipped with an EMS.*
<table>
<thead>
<tr>
<th>BUILDING</th>
<th>ANNUAL ELECTRICAL ENERGY SAVINGS kWh</th>
<th>ECO COST $</th>
<th>ANNUAL DISTRICT STEAM SAVINGS $</th>
<th>ANNUAL DISTRICT STEAM SAVINGS $</th>
<th>ANNUAL DISTRICT NATURAL GAS SAVINGS $</th>
<th>ANNUAL DISTRICT NATURAL GAS SAVINGS $</th>
<th>TOTAL ANNUAL COST $</th>
<th>TOTAL ANNUAL SAVINGS $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 200</td>
<td>60,095</td>
<td>99,545</td>
<td>FMR</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Building 219</td>
<td>207,057</td>
<td>1,411</td>
<td>PLC</td>
<td>1,219</td>
<td>7,733</td>
<td>4,702</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Building 247</td>
<td>225,961</td>
<td>4,159</td>
<td>DDC</td>
<td>1,991</td>
<td>6,988</td>
<td>6,598</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Building 425</td>
<td>195,215</td>
<td>3,909</td>
<td>PLC</td>
<td>3,904</td>
<td>11,710</td>
<td>7,120</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Building 3136</td>
<td>218,186</td>
<td>4,364</td>
<td>DDC</td>
<td>12,992</td>
<td>12,992</td>
<td>7,899</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Building 3136</td>
<td>10,104</td>
<td>0</td>
<td>FMR</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Building 3136</td>
<td>13,890</td>
<td>0</td>
<td>PLC</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Building 3136</td>
<td>202</td>
<td>202</td>
<td>DDC</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BUILDING</td>
<td>ECO</td>
<td>ANNUAL ENERGY USAGE kBTU</td>
<td>ANNUAL ENERGY SAVINGS kBTU</td>
<td>ENERGY SAVINGS PERCENTAGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>--------------------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building 200</td>
<td>BASELINE</td>
<td>5,474,798</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FMR</td>
<td>5,474,798</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PLC</td>
<td>4,493,455</td>
<td>981,343</td>
<td>18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DDC</td>
<td>3,985,751</td>
<td>1,489,047</td>
<td>27%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building 219</td>
<td>BASELINE</td>
<td>5,587,411</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FMR</td>
<td>5,587,411</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PLC</td>
<td>4,003,829</td>
<td>1,583,582</td>
<td>28%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DDC</td>
<td>3,861,809</td>
<td>1,725,602</td>
<td>31%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building 247</td>
<td>BASELINE</td>
<td>10,988,125</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FMR</td>
<td>10,988,125</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PLC</td>
<td>9,150,857</td>
<td>1,837,268</td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DDC</td>
<td>8,944,257</td>
<td>2,043,868</td>
<td>19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building 1425</td>
<td>BASELINE</td>
<td>1,247,564</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FMR</td>
<td>1,247,564</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PLC</td>
<td>949,675</td>
<td>297,889</td>
<td>24%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DDC</td>
<td>935,313</td>
<td>312,251</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building 3136</td>
<td>BASELINE</td>
<td>1,762,334</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FMR</td>
<td>1,762,334</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PLC</td>
<td>1,467,554</td>
<td>294,780</td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DDC</td>
<td>1,439,356</td>
<td>322,978</td>
<td>18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### EMS Capability Summary - Building 200

<table>
<thead>
<tr>
<th>FEATURES:</th>
<th>FMR</th>
<th>PLC</th>
<th>DDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hot Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Supply Air Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Enthalpy Economizer</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Time of Day Scheduling</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Night Setback</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Demand Limiting</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>&quot;On-Line&quot; Centralized Control</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>&quot;On-Line&quot; Centralized Monitoring</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Expandability</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Maintenance Scheduling</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Optimum Start</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Occupant Control/Override</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Comfort Control</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

### ADVANTAGES:

- Increased Control System Reliability/Maintainability: X
- Increased Equipment and Control System Life: X
- Highest Savings - To- Investment Ratio (SIR): X
- Provides Highest Total Energy Savings: X
- Meets ECIP Funding Criteria: X

### DISADVANTAGES:

- Highest Initial Cost: X
- No Energy Savings: X
- Does Not Meet ECIP Funding Criteria: X
<table>
<thead>
<tr>
<th>FEATURES:</th>
<th>FMR</th>
<th>PLC</th>
<th>DDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hot Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Supply Air Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Enthalpy Economizer</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Time of Day Scheduling</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Night Setback</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Demand Limiting</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>“On-Line” Centralized Control</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>“On-Line” Centralized Monitoring</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Expandability</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Flexibility</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Maintenance Scheduling</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Optimum Start</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Occupant Control/Override</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Comfort Control</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ADVANTAGES:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased Control System Reliability/Maintainability</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased Equipment and Control System Life</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Highest Savings - To- Investment Ratio (SIR)</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Provides Highest Total Energy Savings</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Meets ECIP Funding Criteria</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>DISADVANTAGES:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest Initial Cost</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>No Energy Savings</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Does Not Meet ECIP Funding Criteria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEATURES:</td>
<td>EMR</td>
<td>PLC</td>
<td>DDC</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Chilled Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hot Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Supply Air Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Enthalpy Economizer</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Time of Day Scheduling</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Night Setback</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Demand Limiting</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>“On-Line” Centralized Control</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>“On-Line” Centralized Monitoring</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Expandability</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Maintenance Scheduling</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Optimum Start</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Occupant Control/Override</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Comfort Control</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ADVANTAGES:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Control System Reliability/Maintainability</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased Equipment and Control System Life</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Highest Savings - To- Investment Ratio (SIR)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Provides Highest Total Energy Savings</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Meets ECIP Funding Criteria</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DISADVANTAGES:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest Initial Cost</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>No Energy Savings</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Does Not Meet ECIP Criteria</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**EMS Capability Summary - Building 1425**

<table>
<thead>
<tr>
<th>FEATURES:</th>
<th>FMR</th>
<th>PLC</th>
<th>DDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hot Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Supply Air Reset</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Enthalpy Economizer</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Time of Day Scheduling</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Night Setback</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Demand Limiting</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>“On-Line” Centralized Control</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>“On-Line” Centralized Monitoring</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Expandability</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Maintenance Scheduling</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Optimum Start</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Occupant Control/Override</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Comfort Control</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

**ADVANTAGES:**

- Increased Control System Reliability/Maintainability | X
- Increased Equipment and Control System Life | X
- Highest Savings - To- Investment Ratio (SIR) | X
- Provides Highest Total Energy Savings | X
- Meets ECIP Funding Criteria | X | X

**DISADVANTAGES:**

- Highest Initial Cost | X
- No Energy Savings | X
- Does Not Meet ECIP Funding Criteria | X
## EMS Capability Summary - Building 3136

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>FMR</th>
<th>PLC</th>
<th>DDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hot Water Reset</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Supply Air Reset</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Enthalpy Economizer</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Time of Day Scheduling</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Night Setback</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Demand Limiting</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>“On-Line” Centralized Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“On-Line” Centralized Monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expandability</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Maintenance Scheduling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimum Start</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Occupant Control/Override</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Comfort Control</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

## ADVANTAGES:

- Increased Control System Reliability/Maintainability: X
- Increased Equipment and Control System Life: X
- Highest Savings - To- Investment Ratio (SIR): X
- Provides Highest Total Energy Savings: X
- Meets Funding Criteria: X

## DISADVANTAGES:

- Highest Initial Cost: X
- No Energy Savings: X
- Does Not Meet ECIP Funding Criteria: X
LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Ft. Belvoir, VA REGION NO. 3 PROJECT NO. DACA-31-32-D0061 Del Order 4
PROJECT TITLE: Ft. Belvoir EMS Study FISCAL YEAR 95
DISCRETE PORTION NAME: BUILDING 200 - DDC EMS INSTALLATION ECIP No.

ANALYSIS DATE: 1/95 ECONOMIC LIFE: 10 YEARS PREPARER: EINHORN YAFFEE PRESCOTT

1. INVESTMENT COSTS:

A. CONSTRUCTION COST $70,640

B. SIOL $4,238

C. DESIGN COST $3,885

D. TOTAL COST (1A+1B+1C) 

E. SALVAGE VALUE OF EXISTING EQUIPMENT 

F. PUBLIC UTILITY COMPANY REBATE 

G. TOTAL INVESTMENT (1D-1E-1F) $78,763

2. ENERGY SAVINGS (+)/COST(-):

DATE OF NISTIR -4942-1 USED FOR DISCOUNT FACTORS (Oct 1994) DISCOUNT RATE: 3.1%

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>COST $ / MBTU (1)</th>
<th>SAVINGS MBTU / YR (2)</th>
<th>ANNUAL $ SAVINGS (3)</th>
<th>DISCOUNT FACTOR (4)</th>
<th>DISCOUNTED SAVINGS (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ELEC</td>
<td>5.86</td>
<td>339.7</td>
<td>$1,991</td>
<td>8.82</td>
<td>$17,561</td>
</tr>
<tr>
<td>B. DIST</td>
<td>5.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. RESID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. NG</td>
<td>6.08</td>
<td>1149.3</td>
<td>$6,988</td>
<td>9.86</td>
<td>$68,902</td>
</tr>
<tr>
<td>G.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. DEMAND SAVINGS</td>
<td>$1,700</td>
<td>8.49</td>
<td>$14,433</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. TOTAL</td>
<td></td>
<td>$10,679</td>
<td></td>
<td></td>
<td>$100,896</td>
</tr>
</tbody>
</table>

3. NON-ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-) $5,560

(1) DISCOUNT FACTOR (TABLE A) 8.49

(2) DISCOUNTED SAVINGS/COST (3A X 3A1) $47,204
**B. NON-RECURRING SAVINGS (+) OR COST (-)**

<table>
<thead>
<tr>
<th></th>
<th>SAVINGS (+)</th>
<th>YEAR OF OCCUR.</th>
<th>DISCOUNT FACTOR</th>
<th>DISCOUNTED SAVINGS (+)</th>
<th>COST (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>d. TOTAL</td>
<td></td>
<td>$0</td>
<td></td>
<td></td>
<td>$0</td>
</tr>
</tbody>
</table>

**C. TOTAL NON ENERGY DISCOUNTED SAVINGS \((3A2+3bD4)\)**

\[ $61,637 \]

4. SIMPLE PAYBACK \((1G / (2R+3A+3Bd1 / ECONOMIC LIFE))\):

\[ 4.9 \text{ YEARS} \]

5. TOTAL NET DISCOUNTED SAVINGS \((2I5+3C)\):

\[ $148,100 \]

6. SAVINGS TO INVESTMENT RATIO (SIR) \((5/1G)\):

\[ 1.88 \]

7. ADJUSTED INTERNAL RATE OF RETURN (AIRR):

\[ 9.82\% \]
LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

PROJECT TITLE: Ft. Belvoir EMS Study FISCAL YEAR: 95 DISCRETE PORTION NAME: BUILDING 219 - DDC EMS INSTALLATION
ECIP No. ANALYSIS DATE: 1/95 ECONOMIC LIFE: 10 YEARS PREPARER: EINHORN YAFFEE PRESCOTT

1. INVESTMENT COSTS:

A. CONSTRUCTION COST $64,700
B. SI0H $3,882
C. DESIGN COST $3,559
D. TOTAL COST (1A+1B+1C) 
E. SALVAGE VALUE OF EXISTING 
F. PUBLIC UTILITY COMPANY REBATE 
G. TOTAL INVESTMENT (1D-1E-1F) $72,141

2. ENERGY SAVINGS (+)/COST(-):

DATE OF NISTIR 4942-1 USED FOR DISCOUNT FACTORS (Oct 1994) DISCOUNT RATE: 3.1%

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>COST $ / MBTU (1)</th>
<th>SAVINGS MBTU / YR (2)</th>
<th>ANNUAL $ SAVINGS (3)</th>
<th>DISCOUNT FACTOR (4)</th>
<th>DISCOUNTED SAVINGS (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ELEC</td>
<td>5.86</td>
<td>770.3</td>
<td>$4,514</td>
<td>8.82</td>
<td>$39,813</td>
</tr>
<tr>
<td>B. DIST</td>
<td>5.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. RESID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. NG</td>
<td>6.08</td>
<td>955.3</td>
<td>$5,808</td>
<td>9.86</td>
<td>$57,267</td>
</tr>
<tr>
<td>G. OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. DEMAND SAVINGS</td>
<td>$1,708</td>
<td>8.49</td>
<td>$14,501</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. TOTAL</td>
<td>$12,028</td>
<td></td>
<td>$111,581</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. NON-ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-) $3,710

(1) DISCOUNT FACTOR (TABLE A) 8.49
(2) DISCOUNTED SAVINGS/COST (3A X 3A1) $31,498
**B. NON-RECURRING SAVINGS (+) OR COST (-)**

<table>
<thead>
<tr>
<th></th>
<th>SAVINGS (+)</th>
<th>COST (-) (1)</th>
<th>YEAR OF OCCUR. (2)</th>
<th>DISCOUNT FACTOR(3)</th>
<th>DISCOUNTED SAVINGS(+)</th>
<th>COST(-) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>d. TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
</tbody>
</table>

**C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3bD4)**

$45,999

4. SIMPLE PAYBACK (1G / (2I3+3A+ (3Bd1 / ECONOMIC LIFE)): 4.6 YEARS

5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $143,079

6. SAVINGS TO INVESTMENT RATIO (SIR) (5/1G): 1.98

7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 10.40%
LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

PROJECT TITLE: Ft. Belvoir EMS Study  FISCAL YEAR 95  DISCRETE PORTION NAME: BUILDING 247 - DDC EMS

ANALYSIS DATE: 1/95  ECONOMIC LIFE: 10 YEARS  PREPARER: EINHORN YAFFEE PRESCOTT

1. INVESTMENT COSTS:

| A. CONSTRUCTION COST | $78,400 |
| B. SIHOH | $4,704 |
| C. DESIGN COST | $4,312 |
| D. TOTAL COST (1A+1B+1C) |  |
| E. SALVAGE VALUE OF EXISTING |  |
| F. PUBLIC UTILITY COMPANY REBATE |  |
| G. TOTAL INVESTMENT (1D-1E-1F) | $87,416 |

2. ENERGY SAVINGS (+)/COST(-):

DATE OF NISTIR-4942-1 USED FOR DISCOUNT FACTORS (Oct 1994)  DISCOUNT RATE: 3.1%

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>COST $ / MBTU (1)</th>
<th>SAVINGS MBTU / YR (2)</th>
<th>ANNUAL $ SAVINGS (3)</th>
<th>DISCOUNT FACTOR (4)</th>
<th>DISCOUNTED SAVINGS (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ELEC</td>
<td>5.86</td>
<td>744.7</td>
<td>$4,364</td>
<td>8.82</td>
<td>$38,490</td>
</tr>
<tr>
<td>B. DIST</td>
<td>5.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. RESID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. NG</td>
<td>6.08</td>
<td>1299.2</td>
<td>$7,899</td>
<td>9.86</td>
<td>$77,984</td>
</tr>
<tr>
<td>G. OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. DEMAND SAVINGS</td>
<td></td>
<td>$3,070</td>
<td>8.49</td>
<td>$26,064</td>
<td></td>
</tr>
<tr>
<td>I. TOTAL</td>
<td></td>
<td>2044</td>
<td>$15,333</td>
<td></td>
<td>$142,438</td>
</tr>
</tbody>
</table>

3. NON-ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-) | $2,300
(1) DISCOUNT FACTOR (TABLE A) | 8.49
(2) DISCOUNTED SAVINGS/COST (3A X 3A1) | $19,527
### B. NON-RECURRING SAVINGS (+) OR COST (-)

<table>
<thead>
<tr>
<th>SAVINGS (+)</th>
<th>YEAR OF OCCUR. (2)</th>
<th>DISCOUNT FACTOR(3)</th>
<th>DISCOUNTED SAVINGS (+)</th>
<th>COST (-) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>d. TOTAL</td>
<td>$0</td>
<td></td>
<td></td>
<td>$0</td>
</tr>
</tbody>
</table>

### C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3bD4)

$19,527

### 4. SIMPLE PAYBACK (1/G / (2I3+3A+ (3Bd1 / ECONOMIC LIFE)):

5.0 YEARS

### 5. TOTAL NET DISCOUNTED SAVINGS (2I5+3C):

$161,965

### 6. SAVINGS TO INVESTMENT RATIO (SIR) (5/1G):

1.85

### 7. ADJUSTED INTERNAL RATE OF RETURN (AIRR):

7.65%
LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

PROJECT TITLE: Ft. Belvoir EMS Study    FISCAL YEAR 95
DISCRETE PORTION NAME: BUILDING 1425 - PLC EMS    ECIP No. ______
ANALYSIS DATE: 1/95    ECONOMIC LIFE: 10 YEARS    PREPARER: FINHORN YAFFEE PRESCOTT

1. INVESTMENT COSTS:
   A. CONSTRUCTION COST  $10,330
   B. SION                $620
   C. DESIGN COST         $568
   D. TOTAL COST (1A+1B+1C)  
   E. SALVAGE VALUE OF EXISTING  
   F. PUBLIC UTILITY COMPANY REBATE  
   G. TOTAL INVESTMENT (1D-1E-1F)  $11,518

2. ENERGY SAVINGS (+)/COST(-):
   DATE OF NISTIR 4942-1 USED FOR DISCOUNT FACTORS (Oct 1994)    DISCOUNT RATE: 3.1%

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>COST $ / MBTU (1)</th>
<th>SAVINGS MBTU / YR (2)</th>
<th>ANNUAL $ SAVINGS (3)</th>
<th>DISCOUNT FACTOR (4)</th>
<th>DISCOUNTED SAVINGS (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ELEC</td>
<td>5.86</td>
<td>55.9</td>
<td>$328</td>
<td>8.82</td>
<td>$2,893</td>
</tr>
<tr>
<td>B. DIST</td>
<td>5.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. RESID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. NG</td>
<td>6.08</td>
<td>242.0</td>
<td>$1,471</td>
<td>9.86</td>
<td>$14,504</td>
</tr>
<tr>
<td>G. OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. DEMAND SAVINGS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. TOTAL</td>
<td></td>
<td>298</td>
<td>$1,799</td>
<td></td>
<td>$17,397</td>
</tr>
</tbody>
</table>

3. NON-ENERGY SAVINGS (+) OR COST (-):

   A. ANNUAL RECURRING (+/-) $0
   (1) DISCOUNT FACTOR (TABLE A) 
   (2) DISCOUNTED SAVINGS/COST (3A X 3A1) $0
### B. Non-Recurring Savings (+) or Cost (-)

<table>
<thead>
<tr>
<th></th>
<th>Savings (+)</th>
<th>Year of Occur. (2)</th>
<th>Discount Factor (3)</th>
<th>Discounted Savings (+) Cost (-) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>d. TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
</tbody>
</table>

### C. Total Non Energy Discounted Savings (3A2+3bD4)

|                  |             |                     |                     | $0                                   |

4. **Simple Payback** \((1G / (2I+3A+3Bd1 / Economic Life)))\): 6.4 YEARS

5. **Total Net Discounted Savings** \((2I5+3C)\): $17,397

6. **Savings to Investment Ratio (SIR)** \((5/I1G)\): 1.51

7. **Adjusted Internal Rate of Return (AIRR)**: 7.44%
# LIFE CYCLE COST ANALYSIS SUMMARY

**ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)**

**LOCATION:** Ft. Belvoir VA  
**REGION NO.:** 3  
**PROJECT NO.:** DACA-31-92 D0061 Del. Order 4  
**PROJECT TITLE:** Ft. Belvoir EMS Study  
**FISCAL YEAR:** 95  
**DISCRETE PORTION NAME:** BUILDING 1425 - FMR EMS  
**ECIP No.:**  
**ANALYSIS DATE:** 1/95  
**ECONOMIC LIFE:** 10 YEARS  
**PREPARERED:** EINHORN YAFFEE PRESCOTT

## 1. INVESTMENT COSTS:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>CONSTRUCTION COST</td>
<td>$500</td>
</tr>
<tr>
<td>B.</td>
<td>SIOH</td>
<td>$30</td>
</tr>
<tr>
<td>C.</td>
<td>DESIGN COST</td>
<td>$28</td>
</tr>
<tr>
<td>D.</td>
<td>TOTAL COST (1A+1B+1C)</td>
<td></td>
</tr>
<tr>
<td>E.</td>
<td>SALVAGE VALUE OF EXISTING</td>
<td></td>
</tr>
<tr>
<td>F.</td>
<td>PUBLIC UTILITY COMPANY REBATE</td>
<td></td>
</tr>
<tr>
<td>G.</td>
<td>TOTAL INVESTMENT (1D-1E-1F)</td>
<td>$558</td>
</tr>
</tbody>
</table>

## 2. ENERGY SAVINGS (+)/COST(-):

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>COST /MBTU (1)</th>
<th>SAVINGS MBTU / YR (2)</th>
<th>ANNUAL $ SAVINGS (3)</th>
<th>DISCOUNT FACTOR (4)</th>
<th>DISCOUNTED SAVINGS (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ELEC</td>
<td>5.86</td>
<td>0</td>
<td>$0</td>
<td>8.82</td>
<td>$0</td>
</tr>
<tr>
<td>B. DIST</td>
<td>5.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. RESID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. NG</td>
<td>6.08</td>
<td>0</td>
<td>$0</td>
<td>9.86</td>
<td>$0</td>
</tr>
<tr>
<td>G. OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. DEMAND SAVINGS</td>
<td></td>
<td></td>
<td>$456</td>
<td>8.49</td>
<td>$3,871</td>
</tr>
<tr>
<td>I. TOTAL</td>
<td></td>
<td>0</td>
<td>$0</td>
<td></td>
<td>$3,871</td>
</tr>
</tbody>
</table>

## 3. NON-ENERGY SAVINGS (+) OR COST (-):

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>ANNUAL RECURRING (+/-)</td>
<td>$0</td>
</tr>
<tr>
<td>(1)</td>
<td>DISCOUNT FACTOR (TABLE A)</td>
<td>8.11</td>
</tr>
<tr>
<td>(2)</td>
<td>DISCOUNTED SAVINGS/COST (3A X 3A1)</td>
<td>$0</td>
</tr>
</tbody>
</table>
B. NON-RECURRING SAVINGS (+) OR COST (-)

<table>
<thead>
<tr>
<th>SAVINGS (+)</th>
<th>YEAR OF OCCUR. (2)</th>
<th>DISCOUNT FACTOR(3)</th>
<th>DISCOUNTED SAVINGS(+)</th>
<th>COST(-) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td>d. TOTAL</td>
<td>$0</td>
<td></td>
<td></td>
<td>$0</td>
</tr>
</tbody>
</table>

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3bD4) $0

4. SIMPLE PAYBACK (1G / (2)+3A+ (3Bd1 / ECONOMIC LIFE)): 1.2 YEARS

5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $3,871

6. SAVINGS TO INVESTMENT RATIO (SIR) (5/1G): 6.94

7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 22.7%
## LIFE CYCLE COST ANALYSIS SUMMARY

**ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)**

<table>
<thead>
<tr>
<th>LOCATION: Ft. Belvoir, VA</th>
<th>REGION NO. 3</th>
<th>PROJECT No. DACA-31-92 D0081</th>
<th>Del. Order 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISCRETE PORTION NAME: BUILDING 3136 - FMR EMS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ANALYSIS DATE: 1/95**  **ECONOMIC LIFE: 10 YEARS**  **PREPARER: EINHOR NYAFFEE PESCOTT**

### 1. INVESTMENT COSTS:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. CONSTRUCTION COST</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>B. SICH</td>
<td>$30</td>
<td></td>
</tr>
<tr>
<td>C. DESIGN COST</td>
<td>$28</td>
<td></td>
</tr>
<tr>
<td>D. TOTAL COST (1A+1B+1C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. SALVAGE VALUE OF EXISTING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. PUBLIC UTILITY COMPANY REBATE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. TOTAL INVESTMENT (1D-1E-1F)</td>
<td>$558</td>
<td></td>
</tr>
</tbody>
</table>

### 2. ENERGY SAVINGS (+)/COST(-):

**DATE OF NISTIR -4942-1 USED FOR DISCOUNT FACTORS**  (Oct 1994)  **DISCOUNT RATE: 3.1%**

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>COST $ / MBTU (1)</th>
<th>SAVINGS MBTU / YR (2)</th>
<th>ANNUAL $ SAVINGS (3)</th>
<th>DISCOUNT FACTOR (4)</th>
<th>DISCOUNTED SAVINGS (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ELEC</td>
<td>5.86</td>
<td>0</td>
<td>$0</td>
<td>8.82</td>
<td>$0</td>
</tr>
<tr>
<td>B. DIST</td>
<td>5.97</td>
<td>0</td>
<td>$0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. RESID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. NG</td>
<td>6.08</td>
<td>0</td>
<td>$0</td>
<td>9.86</td>
<td>$0</td>
</tr>
<tr>
<td>G. OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. DEMAND SAVINGS</td>
<td>$456</td>
<td>8.49</td>
<td>$3,871</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. TOTAL</td>
<td></td>
<td>0</td>
<td>$0</td>
<td></td>
<td>$3,871</td>
</tr>
</tbody>
</table>

### 3. NON-ENERGY SAVINGS (+) OR COST (-):

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ANNUAL RECURRING (+/-)</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>(1) DISCOUNT FACTOR (TABLE A)</td>
<td>8.11</td>
<td></td>
</tr>
<tr>
<td>(2) DISCOUNTED SAVINGS/COST (3A X 3A1)</td>
<td>$0</td>
<td></td>
</tr>
</tbody>
</table>
B. NON-RECURRING SAVINGS (+) OR COST (-)

<table>
<thead>
<tr>
<th>SAVINGS (+)</th>
<th>YEAR OF OCCUR, (2)</th>
<th>DISCOUNT FACTOR(3)</th>
<th>DISCOUNTED SAVINGS (+) COST (-) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. TOTAL</td>
<td>$0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3bD4) $0

4. SIMPLE PAYBACK (1G / (2)(3+3A+ (3Bd1 / ECONOMIC LIFE)): 1.2 YEARS
5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $3,871
6. SAVINGS TO INVESTMENT RATIO (SIR), (5/1G): 6.94
7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 22.7%