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

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
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1 NOVEMBER 1995
FINAL SUBMITTAL
EXECUTIVE SUMMARY

Energy Management System (EMS) STUDY

Fort Belvoir, Virginia

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TABLE OF CONTENTS

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

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

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

Building 247
- FMR EMS
- PLC EMS
- DDC EMS

Building 1425
- FMR EMS
- PLC EMS
- DDC EMS

Building 3136
- FMR EMS
- PLC EMS
- DDC EMS

<u>ECOs Recommended</u>
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.

<u>ECOs Rejected</u>
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 will 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 200 - DDC EMS	SIR 1.93
Building 219 - DDC EMS	SIR 2.03
Building 247 - DDC EMS	SIR 1.91
Building 1425 -FMR EMS	SIR 7.17
- PLC EMS*	SIR 1.55
Building 3136 - FMR EMS	SIR 7.17

*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

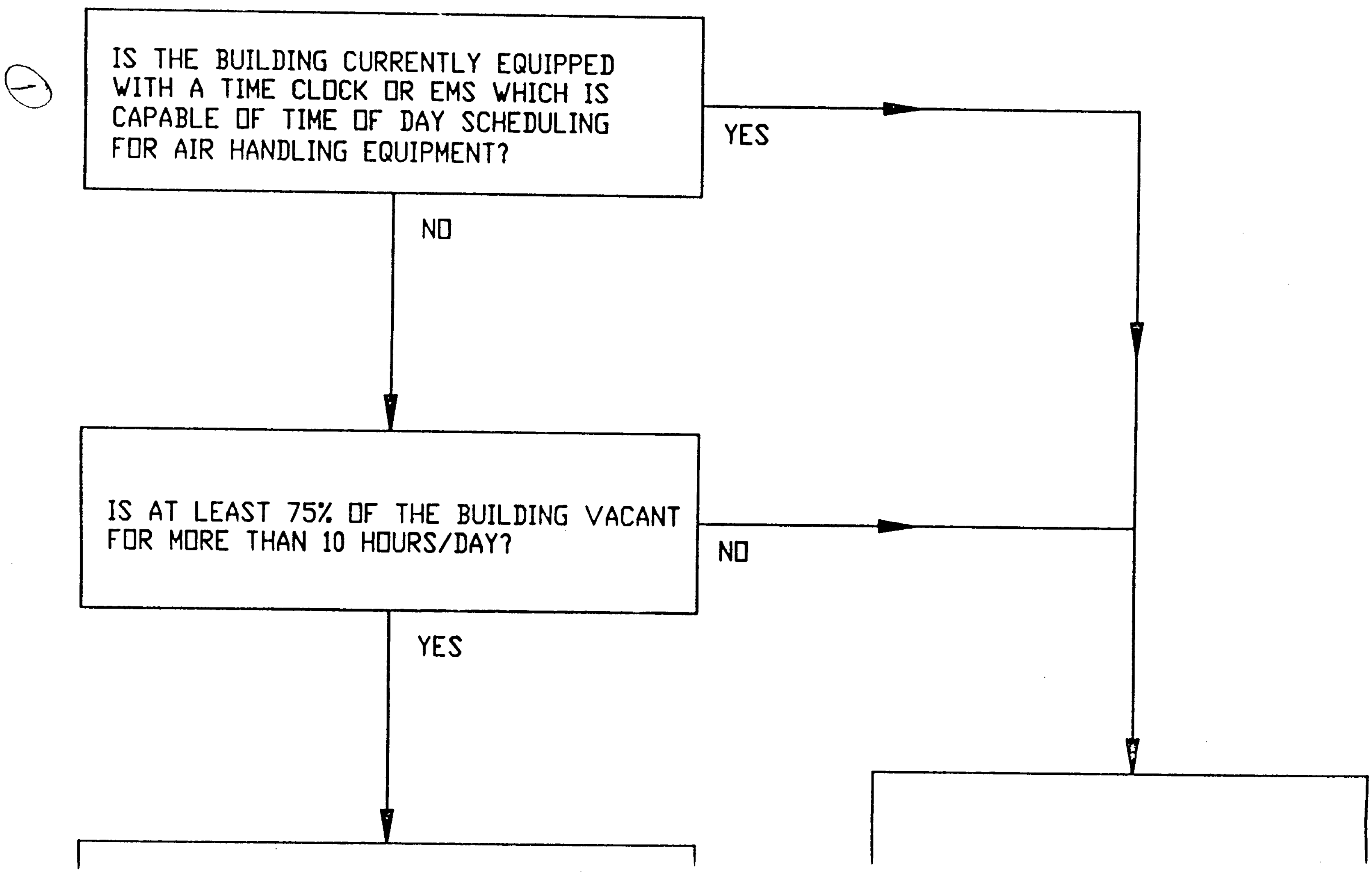
Based on the results of this study the DDC EMS provides the greatest benefit of all the system evaluated for this study. The benefits of the DDC system can best be utilized by installing the systems with an emphasis on Installation-wide control and monitoring. This can be accomplished most effectively 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.

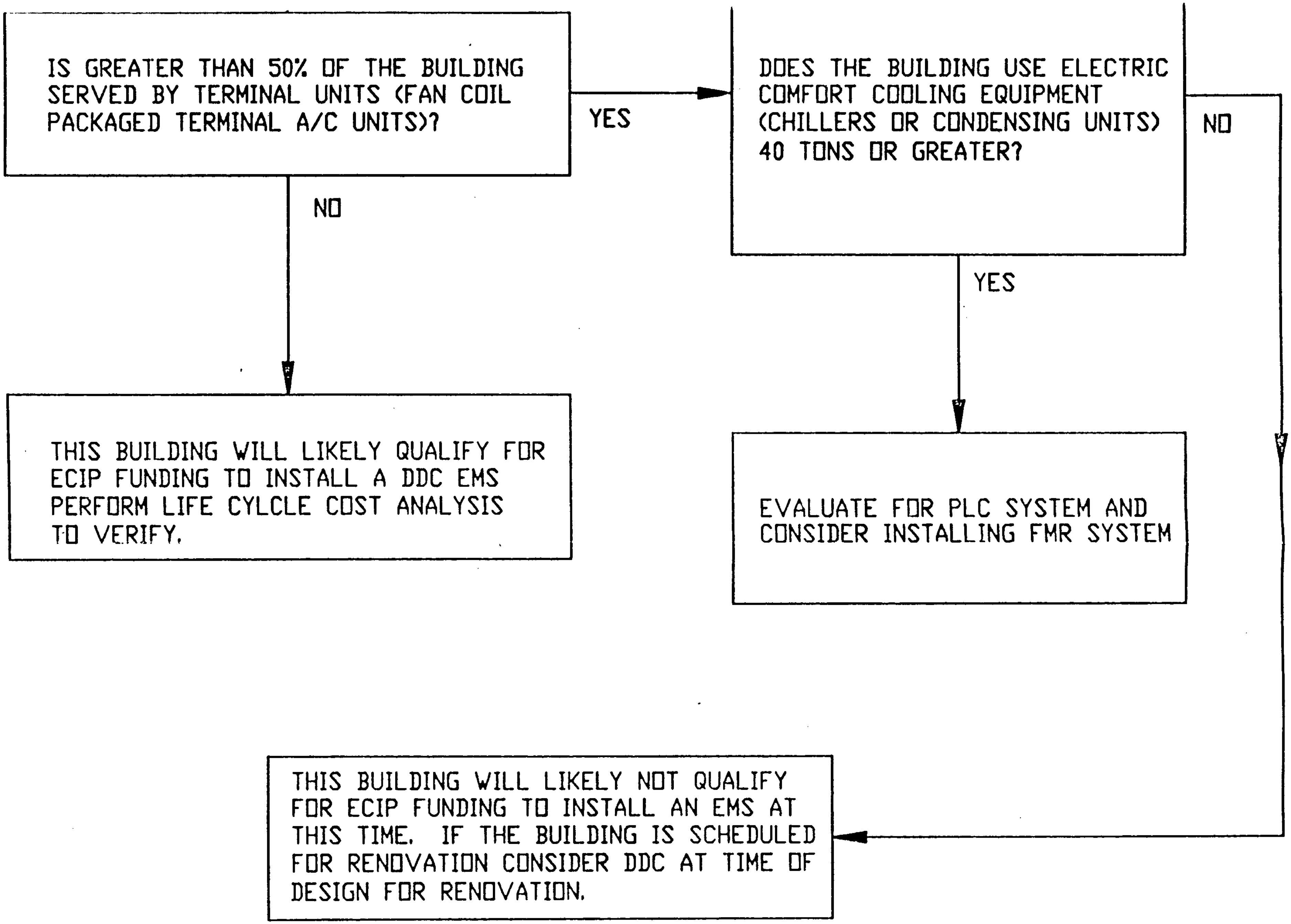
If it is not possible to perform a full scale Installation-wide implementation of the DDC systems as described above, an alternate approach can be taken. The alternate approach would be to divide the Installation into groups of buildings and acquire competitive bids for each individual group as funding 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 GREATER THAN 50% OF THE BUILDING SERVED BY TERMINAL UNITS (FAN COIL PACKAGED TERMINAL A/C UNITS)?
YES
DOES THE BUILDING USE ELECTRIC COMFORT COOLING EQUIPMENT (CHILLERS OR CONDENSING UNITS) 40 TONS OR GREATER?
NO
NO
YES
THIS BUILDING WILL LIKELY QUALIFY FOR ECIP FUNDING TO INSTALL A DDC EMS PERFORM LIFE CYLCLE COST ANALYSIS TO VERIFY.
EVALUATE FOR PLC SYSTEM AND CONSIDER INSTALLING FMR SYSTEM
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.

2

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 2

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

TOTALS for ✓ Projects 469,646 → $470K 238,999 → $239K 5,258,517 → 5,259 MBTU

*As 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 3

BUILDING	ECO	(A) ANNUAL ELECTRICAL ENERGY SAVINGS kWh	(B) ANNUAL ELECTRICAL COST SAVINGS $ (A x $.02)	© ANNUAL NATURAL GAS SAVINGS THERM	(D) ANNUAL NATURAL GAS SAVINGS $ (C x $.608)	(E) ANNUAL DISTRICT STEAM SAVINGS kLBS	(F) ANNUAL DISTRICT STEAM SAVINGS $ (E x $8.0)	(G) ANNUAL ELECTRICAL DEMAND SAVINGS $	(H) TOTAL ANNUAL COST SAVINGS $ (B+D+F+G)
Building 200	FMR	0	0	0	0	-----	-----	1,700	1,700
	PLC	60,956	1,219	7,733	4,702	-----	-----	0	5,921
	DDC	99,545	1,991	11,493	6,988	-----	-----	1,700	10,679
Building 219	FMR	0	0		0	-----	-----	1,708	1,708
	PLC	207,057	4,141	8,778	5,337	-----	-----	0	9,478
	DDC	225,961	4,519	9,553	5,808	-----	-----	1,708	12,035
Building 247	FMR	0	0		0	-----	-----	3,070	3,070
	PLC	195,215	3,904	11,710	7,120	-----	-----	0	11,024
	DDC	218,186	4,364	12,992	7,899	-----	-----	3,070	15,333
Building 1425	FMR	0	0	-----	-----	0	0	456	491
	PLC	16,374	328	-----	-----	180	1,440	0	1,768
	DDC	19,208	384	-----	-----	184	1,472	456	2,312
Building 3136	FMR	0	0	-----	-----	0	0	456	456
	PLC	10,104	202	-----	-----	194	1,552	0	1,754
	DDC	13,890	278	-----	-----	206	1,648	456	2,382

TABLE 4

BUILDING	ECO	ANNUAL ENERGY USAGE kBTU	ANNUAL ENERGY SAVINGS kBTU	ENERGY SAVINGS PERCENTAGE %
Building 200	BASELINE	5,474,798	----------	-------
	FMR	5,474,798	0	0
	PLC	4,493,455	981,343	18%
	DDC	3,985,751	1,489,047	27%
Building 219	BASELINE	5,587,411	-----------	--------
	FMR	5,587,411	0	0%
	PLC	4,003,829	1,583,582	28%
	DDC	3,861,809	1,725,602	31%
Building 247	BASELINE	10,988,125	-----------	--------
	FMR	10,988,125	0	0%
	PLC	9,150,857	1,837,268	17%
	DDC	8,944,257	2,043,868	19%
Building 1425	BASELINE	1,247,564	-----------	
	FMR	1,247,564	0	0%
	PLC	949,675	297,889	24%
	DDC	935,313	312,251	25%
Building 3136	BASELINE	1,762,334	-----	-----
	FMR	1,762,334	0	0%
	PLC	1,467,554	294,780	17%
	DDC	1,439,356	322,978	18%

EMS Capability Summary - Building 200

FEATURES:	FMR	PLC	DDC
Chilled Water Reset			X
Hot Water Reset			X
Supply Air Reset			X
Enthalpy Economizer			X
Time of Day Scheduling		X	X
Night Setback			X
Demand Limiting	X		X
"On-Line" Centralized Control			X
"On-Line" Centralized Monitoring			X
Expandability		X	X
Flexibility		X	X
Maintenance Scheduling			X
Optimum Start		X	X
Occupant Control/Override		X	X
Comfort Control		X	X
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	X
DISADVANTAGES:			
Highest Initial Cost			X
No Energy Savings	X		
Does Not Meet ECIP Funding Criteria			

EMS Capability Summary - Building 219

FEATURES:	FMR	PLC	DDC
Chilled Water Reset			X
Hot Water Reset			X
Supply Air Reset			X
Enthalpy Economizer			X
Time of Day Scheduling		X	X
Night Setback			X
Demand Limiting	X		X
"On-Line" Centralized Control			X
"On-Line" Centralized Monitoring			X
Expandability		X	X
Flexibility		X	X
Maintenance Scheduling			X
Optimum Start		X	X
Occupant Control/Override		X	X
Comfort Control		X	X
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	X
DISADVANTAGES:			
Highest Initial Cost			X
No Energy Savings	X		
Does Not Meet ECIP Funding Criteria			

EMS Capability Summary - Building 247

FEATURES:	FMR	PLC	DDC
Chilled Water Reset			X
Hot Water Reset			X
Supply Air Reset			X
Enthalpy Economizer			X
Time of Day Scheduling		X	X
Night Setback			X
Demand Limiting	X		X
"On-Line" Centralized Control			X
"On-Line" Centralized Monitoring			X
Expandability		X	X
Flexibility		X	X
Maintenance Scheduling			X
Optimum Start		X	X
Occupant Control/Override		X	X
Comfort Control		X	X
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	X
DISADVANTAGES:			
Highest Initial Cost			X
No Energy Savings	X		
Does Not Meet ECIP Criteria			

EMS Capability Summary - Building 1425

FEATURES:	FMR	PLC	DDC
Chilled Water Reset			X
Hot Water Reset			X
Supply Air Reset	N/A	N/A	N/A
Enthalpy Economizer	N/A	N/A	N/A
Time of Day Scheduling		X	X
Night Setback			X
Demand Limiting	X		X
"On-Line" Centralized Control			X
"On-Line" Centralized Monitoring			X
Expandability		X	X
Flexibility		X	X
Maintenance Scheduling			X
Optimum Start		X	X
Occupant Control/Override		X	X
Comfort Control		X	X
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

FEATURES:	FMR	PLC	DDC
Chilled Water Reset			X
Hot Water Reset			X
Supply Air Reset	N/A	N/A	N/A
Enthalpy Economizer	N/A	N/A	N/A
Time of Day Scheduling		X	X
Night Setback			X
Demand Limiting	X		X
"On-Line" Centralized Control			X
"On-Line" Centralized Monitoring			X
Expandability		X	X
Flexibility		X	X
Maintenance Scheduling			X
Optimum Start		X	X
Occupant Control/Override		X	X
Comfort Control		X	X
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	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-31-92 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. SIOH	$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%

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

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 (-)

		SAVINGS (+) COST (-) (1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+) COST(-) (4)
a.					$0
b.					$0
c.					$0
d.	TOTAL	$0			$0

C.	TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3bD4)	$61,637
4.	SIMPLE PAYBACK (1G / (2I3+3A+ (3Bd1 / ECONOMIC LIFE))):	4.9 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)

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 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.	SIOH	$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%

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

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 (-)

		SAVINGS (+) COST (-) (1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+) COST(-) (4)
a.					$0
b.					$0
c.					$0
d.	TOTAL	$0			$0

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)

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 247 - DDC EMS ECIP No.

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

1. INVESTMENT COSTS:

A.	CONSTRUCTION COST	$78,400
B.	SIOH	$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%

ENERGY	COST $ / MBTU (1)	SAVINGS MBTU / YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)
A. ELEC	5.86	744.7	$4,364	8.82	$38,490
B. DIST	5.97				
C. RESID					
D. NG	6.08	1299.2	$7,899	9.86	$77,884
G. OTHER					
H. DEMAND SAVINGS			$3,070	8.49	$26,064
I. TOTAL		2044	$15,333		$142,438

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 (-)

	SAVINGS (+) COST (-) (1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+) COST(-) (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3bD4) $19,527

4. SIMPLE PAYBACK (1G / (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)

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 - PLC EMS ECIP No.____

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

1.	INVESTMENT COSTS:	
A.	CONSTRUCTION COST	$10,330
B.	SIOH	$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%

ENERGY	COST $ / MBTU (1)	SAVINGS MBTU / YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)
A. ELEC	5.86	55.9	$328	8.82	$2,893
B. DIST	5.97				
C. RESID					
D. NG	6.08	242.0	$1,471	9.86	$14,504
G. OTHER					
H. DEMAND SAVINGS					$0
I. TOTAL		298	$1,799		$17,397

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 (-)

	SAVINGS (+) COST (-) (1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+) COST(-) (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3bD4)	$0
4. SIMPLE PAYBACK (1G / (2I3+3A+ (3Bd1 / ECONOMIC LIFE))):	6.4 YEARS
5. TOTAL NET DISCOUNTED SAVINGS (2I5+3C):	$17,397
6: SAVINGS TO INVESTMENT RATIO (SIR) (5/1G):	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 PREPARER: EINHORN YAFFEE PRESCOTT

1.	INVESTMENT COSTS:	
A.	CONSTRUCTION COST	$500
B.	SIOH	$30
C.	DESIGN COST	$28
D.	TOTAL COST (1A+1B+1C)	
E.	SALVAGE VALUE OF EXISTING	
F.	PUBLIC UTILITY COMPANY REBATE	
G.	TOTAL INVESTMENT (1D-1E-1F)	$558

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

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

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

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

A.	ANNUAL RECURRING (+/-)	$0		
(1)	DISCOUNT FACTOR (TABLE A)		8.11	
(2)	DISCOUNTED SAVINGS/COST (3A X 3A1)			$0

B. NON-RECURRING SAVINGS (+) OR COST (-)

	SAVINGS (+) COST (-) (1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+) COST(-) (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3bD4)	$0
4. SIMPLE PAYBACK (1G / (2I3+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)

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 3136 - FMR EMS ECIP No.

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

1.	INVESTMENT COSTS:	
A.	CONSTRUCTION COST	$500
B.	SIOH	$30
C.	DESIGN COST	$28
D.	TOTAL COST (1A+1B+1C)	
E.	SALVAGE VALUE OF EXISTING	
F.	PUBLIC UTILITY COMPANY REBATE	
G.	TOTAL INVESTMENT (1D-1E-1F)	$558

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

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

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

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

A.	ANNUAL RECURRING (+/-)	$0		
(1)	DISCOUNT FACTOR (TABLE A)		8.11	
(2)	DISCOUNTED SAVINGS/COST (3A X 3A1)			$0

B. NON-RECURRING SAVINGS (+) OR COST (-)

	SAVINGS (+) COST (-) (1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+) COST(-) (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

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

4. SIMPLE PAYBACK (1G / (2I3+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%