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Pacific Northwest
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Facility Energy Decision System (FEDS) Assessment Report for Fort Buchanan, Puerto Rico

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February 2005

Prepared for the U.S. Department of Energy
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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

The assessment was performed by a team of engineers from Pacific Northwest National Laboratory (PNNL) under contract to the Installation Management Agency (IMA) Southeast Region Office (SERO). The effort used the Facility Energy Decision System (FEDS) model to determine how energy is consumed at Fort Buchanan, identify the most cost-effective energy retrofit measures, and calculate the potential energy and cost savings.

A team of engineers from PNNL visited Fort Buchanan on April 26-28, 2004 to collect data for the FEDS assessment. During this visit, PNNL engineers collected energy-related information and data from 41 representative buildings and other energy systems for input into the FEDS model.

The economic results presented in this report are based on the use of two different sources of capital funds to implement the energy projects; appropriated funds, and alternative financing (e.g., ESPC). The alternative financing economic input assumptions are for generic ESPC financing to illustrate the differences that the source of capital makes on the technology choices. The FEDS software is capable of performing the comprehensive assessment using other sources of capital (e.g., utility financing) with their distinct economic inputs. Thus, the site is encouraged to re-run the FEDS software using site-specific alternative financing options and reassess the results.

This report documents the findings of the FEDS assessment and model results for appropriated funds and alternative financing sources of capital for the projects. A complete list of the 119 cost-effective energy- and cost-reducing retrofit measures is included in Appendix C-1 for projects funded using appropriated fund source of capital and a complete list of 91 cost-effective energy and cost-reducing retrofit measures is included in Appendix C-2 for projects funded using alternative financing source of capital.

Table ES.1 summarizes the results of the energy assessment by retrofit category for appropriated fund source of capital. Table ES.2 summarizes the results of the energy assessment by retrofit category for alternative financing source of capital.

Table ES.1. Summary of Potential Energy and Cost Savings for Fort Buchanan Using Appropriated Source of Capital

Retrofit Category	Energy Savings (MMBtu/yr)	1st Year Savings ($/yr)	Installed Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
Cooling	5,122	169,931	1,524,565	619,686	1.64	9.0
Envelope	12,181	341,656	1,974,381	4,033,877	3.11	5.8
Hot Water	2,438	61,203	166,851	680,077	4.93	2.7
Lighting	8,463	278,332	1,500,480	3,384,964	3.25	5.4
Grand Total	**28,204**	**851,122**	**5,166,277**	**8,718,604**	**2.91**	**6.1**

Table ES.2. Summary of Potential Energy and Cost Savings for Fort Buchanan Using Alternative Financing Source of Capital

Retrofit Category	Energy Savings (MMBtu/yr)	1st Year Savings ($/yr)	Installed Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
Cooling	2,145	76,482	511,242	365,427	1.77	6.7
Envelope	9,013	275,507	1,171,372	1,591,974	2.38	4.3
Hot Water	2,177	56,903	109,966	461,311	4.68	1.9
Lighting	6,844	254,425	1,020,132	1,537,791	2.56	4.0
Grand Total	**20,179**	**663,317**	**2,812,712**	**3,956,503**	**2.45**	**4.2**

For appropriated funds source of capital in Table ES.1, Fort Buchanan can save 28,204 MMBtu/year and $851,000/year if all cost-effective retrofits are implemented. The site can reduce its energy consumption by 15.7% by implementing the 119 cost-effective energy- and cost-reducing projects identified in this report.

For alternative financing source of capital in Table ES.2, Fort Buchanan can save 20,179 MMBtu/year and $663,000/year if all cost-effective retrofits are implemented. The site can reduce its energy consumption by 11.2% by implementing the 91 cost-effective energy- and cost-reducing projects identified in this report.

In addition to this report, the Fort Buchanan energy manager will receive a complete record of the FEDS input and output files. The FEDS input files consist of the relevant building and equipment data collected and the assumptions made to perform the complex engineering analysis. The FEDS output files contain considerably more detail in support of future project development.

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Background

Fort Buchanan is the only active Army Post in the Caribbean Basin area. It supports the reserve components and active component soldiers in Puerto Rico and U.S. Virgin Islands as a power projection platform to mobilize the nation's only fully bilingual and bicultural force, a definite asset for Department of Defense (DoD) relations with central and South America. Its principal mission is the mobilization, readiness, and actual deployment of some 15,000 reserve component soldiers in Puerto Rico and the U.S. Virgin Islands. The installation also provides support to DoD operations in the Caribbean area (e.g., Operation Restore Democracy).

Spanning only 476 acres are approximately 511 buildings totaling over 2.1 million square feet of floor area, which includes 224 family housing units totaling over 449 thousand square feet. The family housing total is expected to decrease to 119 units by fiscal year (FY) 2006. The impact on the total Fort Buchanan square footage area is expected to be approximately 1.8 million square feet. The oldest buildings still in use at Fort Buchanan date back to 1941. Most family housing was built in the 1950s and 1960s.

Introduction

This report contains the results of the Facility Energy Decision System (FEDS) assessment conducted at Fort Buchanan, Puerto Rico by Pacific Northwest National Laboratory (PNNL). The scope of this activity was based on performing a site-wide energy assessment using the FEDS process to identify cost-effective energy- and cost-reduction projects. The results of the FEDS assessment will be used by the installation to develop a *Long-Range Energy Management Plan* that will outline how Fort Buchanan will meet the goals of Executive Order 13123 by FY 2010.

Purpose

The purpose of this report is to present the findings resulting from the site visit performed April 26-28, 2004 and subsequent modeling and analysis. The objective of the site visit was to collect the necessary data to conduct a detailed site assessment using the FEDS process, which would result in a list of cost-effective, energy- and cost-reduction projects for Fort Buchanan, and provide the necessary data and information to develop *the Long-Range Energy Management Plan*.

Site Visits and Teams

The formal kickoff of the site assessment at Fort Buchanan was held on the morning of April 26, 2004. The PNNL team presented an overview of the FEDS assessment process, the long-range energy management plans, and schedule for the Fort Buchanan work. Participating in this meeting were representatives from the Directorate of Public Works (DPW) and PNNL, including the following:

1. Jesus Gimenez – Energy Manager
2. Alfredo J. Riera, P.E. – Director Public Works
3. Ferdinand Torres – Operations Chief

4. Felix M. Mariani, Chief, Environmental Division
5. Rafael Perez – Acting Master Planner
6. Amy Solana – PNNL
7. Bill Chvala – PNNL

Summary of Relevant Information Collected

During the site assessment visit, the following activities occurred and relevant information collected:

- Interview with Jesus Gimenez, Energy Manager
  - List of energy-efficiency and cost reduction projects implemented at the Fort in the past
  - List of proposed energy-related projects under current consideration by the Fort
- Interview with Rafael Perez from Master Planning office
  - Presentation describing recently completed and planned construction
  - Important discussion on the status of the construction moratorium
  - List of facilities currently programmed to be demolished over the next few years
  - Demolition list for family housing
- Other data collected
  - RADDS reporting information specific to FY 2003
  - Electric rate schedule information
  - Copies of site plan and detailed maps, including one for each school and floor plans for the PX/Commissary and Building 556
  - Water and sewer consumption and cost for FY 2003
  - LPG cost and consumption for hotel to represent site-wide LPG cost
  - Memo on increase in LPG price for FY 2004
  - ECIP proposals for control systems and lighting retrofits, and for photovoltaic street lighting systems
  - Inventory of family housing exterior lighting fixtures
  - Inventory of generators onsite
  - Inventory of cooling systems for each building onsite
  - Some electrical meter data for part of FY 2003

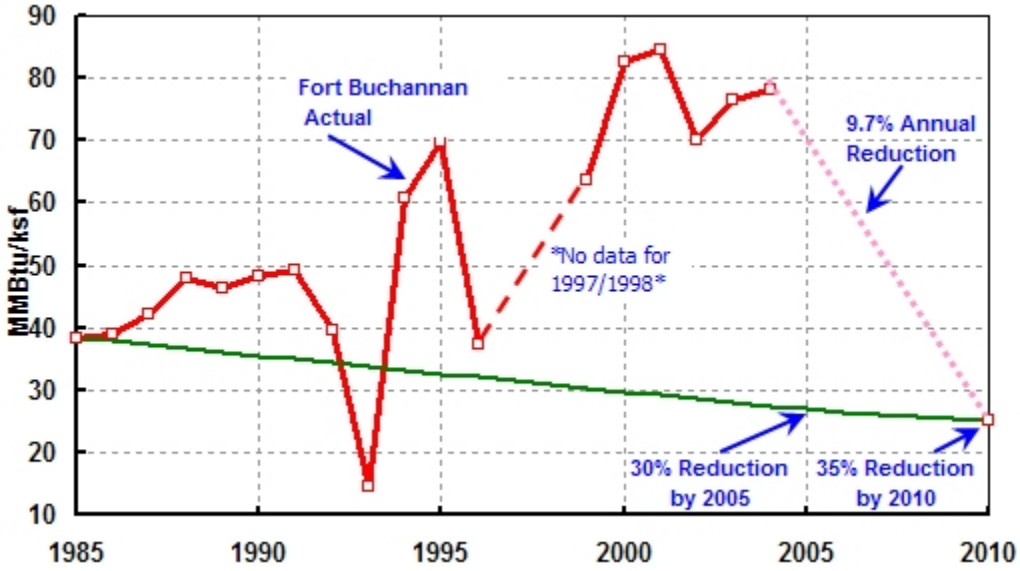
Site staff helped confirm that representative buildings for each building group were appropriate and accessible to the team. Detailed building audits were conducted on 28 buildings. The FEDS data collection forms shown in Appendix A indicate the type of information collected for each building.

Current Status

Executive Order 13123 requires that energy use intensity (MMBtu/ft^2/year) be reduced by 30% in 2005 and 35% in 2010 as compared to a 1985 baseline. Fort Buchanan is subject to this goal and is behind of the compliance glide path—103.5% above the FY 1985 baseline as compared to the FY 2004 targeted reduction of 28.5% (see figure 1). Fort Buchanan has increased energy intensity significantly since 1985 mainly because of a major increase in air conditioning in administrative facilities, barracks, and family housing. Most of these facilities were not

originally designed for air conditioning and do not have the appropriate insulation, windows, and moisture barriers in the walls, ceilings, and around the foundation.

Fort Buchanan is far above the compliance glide path, resulting in a need to reduce its energy intensity by 9.7% every year to meet the 2010 goal. In 2003, Fort Buchanan's total energy consumption was 171,711 MMBtu, with a cost of $2,783,000. The historical energy intensity for Fort Buchanan is shown in Figure 1.



Note: No values available for 1997 or 1998

Figure 1. Fort Buchanan Energy Reduction Glide Path

Description of Facilities

Fort Buchanan is located near San Juan, Puerto Rico, and during FY 2004 consisted of 511 buildings totaling approximately 2.1 million square feet, which includes 224 family housing facilities totaling over 449 thousand square feet. The scope of the FEDS assessment performed at Fort Buchanan included all facilities in the primary cantonment area including family housing.

Table 1 identifies the list of facility categories for the FEDS assessment and the facility proxies for each category. The facilities at Fort Buchanan were divided into 33 categories for modeling based on the 41 buildings visited by the team. Please note that all school buildings are included in building sets 10tr, 10is, 10es, 10ms, 10hs, and 50% of the area of 60c (cafeterias). A complete listing of the facilities (buildings) associated with each FEDS facility category is provided in Appendix B.

Table 1. List of Facilities by Facility Category Description

Facility Category Description	Proxy Facility No.	FEDS Facility Category Code	Facility Quantity	Category Area (sq. ft.)
Overhead Protection	179	1	64	17,753
Administration with Storage	509	10a	7	57,072
Administration with Storage*	556	10b1	1	41,037
Administration with Maintenance*	556	10b2	1	13,842
Training Centers	1305	10c	17	152,725
Smaller 1940s General Purpose Administration	225	10d	24	94,232
Larger 1940s General Purpose Administration	152, 390, 399	10e	6	99,228
1950s & 60s General Purpose Administration	203	10f	28	70,258
Newer General Purpose Administration	540	10g	9	38,685
School Trailers	92, 1066	10tr	34	47,346
Intermediate School	78	10is	12	49,020
Elementary School	1031	10es	13	55,473
Middle School	1073	10ms	9	73,485
High School	1062	10hs	3	80,392
Clinics	21	21	6	23,513
Older Barracks	1300, 1301	30b-1	5	47,411
2000 Army Lodging	678	30b-2	4	54,526
Las Colinas	807, 815	30sf-1	29	75,929
Coconut Grove	1134	30sf-2	127	168,780
Coqui Gardens	1280	30sf-3	48	109,328
Buchanan Heights	1011	30sf-4	20	94,985
Cold Storage*	517	40a1	1	8,585
Administration & Warehouse of Cold Storage*	517	40a2	1	8,586
1940s Storage	614	40b	9	100,640
Large Storage*	541	40c1	1	47,735
Administration of Large Storage*	541	40c2	1	2,515
Vehicle Maintenance*	528	50-1	1	6,558
Administration of Vehicle Maintenance*	528	50-2	1	3,531
Commissary*	689	60a1	1	92,290
PX*	689	60a2	1	118,853
Exchange / Security	613	60b	5	101,565
Dining	660	60c	7	82,925
Miscellaneous MWR	148, 167, 168	80	20	83,109
Total	**41 Proxies**		**511**	**2,121,921**
*Modeled as linked buildings to better analyze energy consumption in different use-areas.				

Analytical Approach

The general approach was to develop a model of the buildings and other energy-related infrastructure at Fort Buchanan, calibrate that model to actual FY 2003 energy use, and then utilize the model to predict energy consumption and identify cost-effective retrofits under TMY weather conditions for San Juan, Puerto Rico.

Buildings

Building inventory data for Fort Buchanan were obtained from the Headquarters Executive Information System (HQEIS) databases. Twenty-eight building groups were developed to represent the Fort and each of the buildings at Fort Buchanan was assigned to one of the groups. The mean building size (square footage) and vintage (age) were then calculated for each group based on the building inventory specific to Fort Buchanan. Building characteristics were developed from a combination of inferencing relationships within the FEDS model (driven by building type, size, climate, and vintage), walk-through audits of selected buildings at Fort Buchanan, and additional building data collected while visiting the Fort.

Central Energy Plants

By definition, the FEDS model considers any boiler or chiller that provides heating or cooling to more than one building a central plant. The high school, middle school, and elementary school chillers fit this definition and were modeled as chilled water central energy plants (CEPs).

Other Loads

No comprehensive inventory of exterior lighting (including street lighting) was found, but the number of street lighting poles was estimated using data from a previous light pole replacement and numbering project. Using this data and the site staff's knowledge of type and wattage of bulbs typically used, the exterior lighting annual electric consumption was estimated at 186 MWh.

The estimated annual electricity consumption for water pumping (potable water, sewage, and pool water) was nearly 965 MWh. This estimate is based on pump size and utilization data collected during the site visit.

The golf cart battery charging station was estimated to use only 5.6 MWh annually, based on nameplate data and an interview with an employee.

Electricity distribution losses were assumed to be 4% of purchased electricity.

Model Calibration

Building energy use was simulated with FEDS and combined with the non-building energy infrastructure characterization to predict the total site energy consumption for FY 2003. Uncertain elements of the modeling assumptions were adjusted until the model's energy

consumption prediction matched "reasonably well" with actual energy consumption for FY 2003. Specific model calibration results are shown below.[1]

Model Element	Fuel Type	Error*
Commissary	Electric	+2.1%
Schools	Electric	-2.5%
Total by Fuel Type	Electric	0.0%
Total Energy	All	0.0%
*Total electrical consumption was the only number that could be accurately calibrated, due to incomplete metering and LPG consumption data. Building electrical metered data was only available for 5 months of FY 2003; therefore, electrical usage for schools and the commissary was determined using a partial year. A large percentage of error is expected here. LPG consumption was missing completely for some buildings, and was estimated for the rest, although this represents a very small fraction of the total energy used, primarily in food preparation.		

The model calibration includes the family housing units in Coconut Grove (30sf-2) and Coqui Gardens (30sf-3). Because these units were occupied during the calibration year (FY2003), they must be included for proper model calibration. After the site visit, however, major demolition has taken place in those two housing areas. For this reason, no retrofits will be allowed for 30sf-2 and 30sf-3.

Description of Opportunities Identified

The number of conceivable energy conservation measures and fuel-switching opportunities at federal sites is very large. The FEDS model is used to cost-effectively identify energy saving opportunities for the site. FEDS is a software tool that provides a comprehensive method to quickly and objectively identify energy improvements that offer maximum life-cycle cost savings. FEDS determines the optimum set of cost-effective retrofits from a current database of hundreds of proven technologies. These include retrofits for heating, cooling, lighting, motors, building envelope, and hot water systems. Interactive effects are also evaluated as part of the optimization process so that energy savings are not double counted or undercounted. The results are based on life-cycle cost economics consistent with 10 CFR 436.

FEDS identifies the package of retrofits that individually and collectively minimize the life-cycle cost of building energy services, resulting in projects where the net present value (NPV) of the investment is greater than or equal to zero and the savings-to-investment ratio (SIR) is greater than or equal to one. Results are developed for government (appropriated) and alternative (e.g., ESPC and UESC) financing assumptions.

[1] For example, an error of +0.5% means that the model predicts energy consumption 0.5% higher than reported consumption.

In general, the discount rate is higher and the economic evaluation life is shorter for alternative financing compared to government financing. The economic life for the latter is set at 25 years with the discount rate adjusted each year in response to market conditions. The FY03 prescribed government discount rate of is 3.0% in real terms, i.e., in excess of general inflation was used in the analysis. Alternative financing assumptions are not prescribed, but set by negotiation between the ESCO and the federal organization. An economic evaluation life of 15 years and a real discount rate of 5.38% are used to represent alternative financing conditions in this assessment, based on a collection of prior site experiences in the Army.

Table 2 summarizes the FEDS results by retrofit category (e.g., cooling) and type (e.g., chillers) using appropriated funding as the source of capital for the projects. Table 3 summarizes the FEDS results by retrofit category using alternative financing as the source of capital for the projects. The complete list of cost-effective energy- and cost-reduction projects resulting from the FEDS modeling and analysis are presented in Appendices C-1 (appropriated funds) and C-2 (alternative financing).[2]

Table 2. Summary of All Cost-Effective Projects Identified from the FEDS Assessment for Fort Buchanan Using Appropriated Source of Capital (by retrofit category and type)

Retrofit Category	Retrofit Type	Energy Savings (MMBtu/yr)	1st Year Savings ($/yr)	Installed Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
Cooling	Chillers	4,890	157,542	1,428,730	514,156	1.56	9.1
	Package AC Units	182	10,697	77,515	104,715	3.89	7.2
	Window AC Units	50	1,692	18,320	815	1.10	10.8
	Subtotal	**5,122**	**169,931**	**1,524,565**	**619,686**	**1.64**	**9.0**
Envelope	Attic/Ceiling Insulation	5,792	153,528	789,353	1,910,546	3.38	5.1
	Foundation Insulation	1,509	33,520	368,619	220,875	1.60	11.0
	Wall Insulation	3,869	122,560	546,407	1,608,882	4.36	4.5
	Windows	1,011	32,048	270,002	293,574	2.11	8.4
	Subtotal	**12,181**	**341,656**	**1,974,381**	**4,033,877**	**3.11**	**5.8**
Hot Water	Misc. Measures	536	11,997	9,617	151,612	27.24	0.8
	Water Heaters with Misc. Measures	1,902	49,207	157,242	528,466	4.16	3.2
	Subtotal	**2,438**	**61,203**	**166,851**	**680,077**	**4.93**	**2.7**
Lights	CFLs	2,101	78,769	239,135	1,142,018	5.72	3.0
	Exit Signs	82	8,212	56,201	87,143	2.53	6.8
	HIDs	1	182	1,829	1,343	1.70	10.0
	T-8s, other Fluorescents	6,279	191,169	1,203,315	2,154,460	2.79	6.3
	Subtotal	**8,463**	**278,332**	**1,500,480**	**3,384,964**	**3.25**	**5.4**
Grand Total		**28,204**	**851,122**	**5,166,277**	**8,718,604**	**2.91**	**6.1**

[2] It should be noted that in addition to this report, the Fort Buchanan energy manager will also receive a CD ~~-ROM,~~ which includes all the FEDS input data and output project files. The input data files reflect information collected during the site visits and additional assumptions required to perform the FEDS modeling and assessment. The output project files contain significantly more detailed information to support the list of cost-effective energy projects identified in Appendices C-1 and C-2.

From Table 2, the total cost-effective energy savings is estimated at 28,204 MMBtu/year representing $851,000/year savings with an overall savings to investment ratio (SIR) of 2.91. This represents 15.7% in energy savings based on FY 2003 energy data.

The greatest energy saving potential was found in building envelope measures (12,181 MMBtu/year), followed by lighting (8,463 MMBtu/year). The largest estimated dollar savings was also building envelope ($341,000/year), again followed by lighting ($278,000/year). Miscellaneous service hot water measures (although small projects) overwhelmingly show the greatest SIR (27.25), followed by compact fluorescent lighting (5.72).

Table 3. Summary of All Cost-Effective Projects Identified from the FEDS Assessment for Fort Buchanan Using Alternative Financing as the Source of Capital (by retrofit category and type)

Retrofit Category	Retrofit Type	Energy Savings (MMBtu/yr)	1st Year Savings ($/yr)	Installed Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
Cooling	Chillers	1,986	66,697	440,930	211,771	1.52	6.6
	Package AC Units	159	9,785	70,312	153,656	3.20	7.2
	Subtotal	**2,145**	**76,482**	**511,242**	**365,427**	**1.77**	**6.7**
Envelope	Attic/Ceiling Insulation	4,487	130,603	509,314	800,639	2.63	3.9
	Foundation Insulation	139	4,348	33,897	9,710	1.28	7.8
	Wall Insulation	3,548	113,474	397,268	740,879	2.90	3.5
	Windows	839	27,082	230,893	40,746	1.17	8.5
	Subtotal	**9,013**	**275,507**	**1,171,372**	**1,591,974**	**2.38**	**4.3**
Hot Water	Misc. Measures	978	19,752	5,722	207,440	37.3	0.3
	Water Heaters with Misc. Measures	1,199	37,151	104,244	253,871	3.12	2.8
	Subtotal	**2,177**	**56,903**	**109,966**	**461,311**	**4.68**	**1.9**
Lights	CFLs	2,078	78,703	228,486	563,045	3.75	2.9
	Exit Signs	82	7,531	56,172	19,806	1.35	7.5
	HIDs	1	204	1,829	227	1.10	9.0
	T-8s, other Fluorescents	4,683	167,987	733,645	954,713	2.32	4.4
	Subtotal	**6,844**	**254,425**	**1,020,132**	**1,537,791**	**2.56**	**4.0**
Grand Total		**20,179**	**663,317**	**2,812,712**	**3,956,503**	**2.45**	**4.2**

From Table 3, the total cost-effective energy savings is estimated at 20,179 MMBtu/year representing $663,000/year savings with an overall SIR of 2.45. This represents 11.2% in energy savings based on FY 2003 energy data.

The greatest energy saving potential was found in building envelope measures (9,013 MMBtu/year), followed by lighting (6,844 MMBtu/year.) The largest estimated dollar savings was envelope ($275,000/year) followed by lighting ($254,000/year). Miscellaneous service hot water measures again show the far greatest SIR (37.31), followed by compact fluorescent lighting (3.75).

As would be expected, the total number of cost-effective retrofits is fewer (and installed cost/ capital investment is significantly less) under alternative financing source of capital, and thus the energy and dollar savings are likewise less. The total number of cost-effective retrofits using

appropriated source of capital is 119 and the total number of cost-effective retrofits using alternative financing source of capital is 91. Using appropriated funding will save 8,025 MMBTU/year and $187,805/year more than alternative financing. Utilizing alternative financing reduces the simple payback from 6.1 to 4.2 years because some projects with longer paybacks are eliminated under the alternative financing scenario.

The complete list of cost-effective energy- and cost-reduction projects is given Appendix C-1 for appropriated funds source of capital and in Appendix C-2 for alternative financing source of capital.[3]

Recommendations for More In-Depth Assessments

The FEDS model can provide an unbiased assessment of literally hundreds of energy conservation projects; unfortunately, it is not all-inclusive. While the scope of this project is limited to energy-saving projects included in the FEDS model, the energy-saving opportunities identified below were recognized during the site visit and may be worth additional consideration by the site energy staff. It is recommended that the site consider additional assessment of these potential projects.

Programmable Thermostats

The FEDS model does not consider programmable thermostats in the energy analysis. Programmable thermostats are considered a conservation measure rather than an equipment replacement or building improvement. However, during the site visit, the team did not observe any programmable thermostats; although Fort Buchanan has procured several programmable thermostats for family housing quarters and is has them on schedule the gradual installation of them. Programmable thermostats could be a useful conservation measure in smaller commercial buildings, family housing, or any building that is unoccupied during part of the day.

Humidity Control

A consistent problem witnessed during the site visit was buildings over-cooled because of discomfort with humidity. For example, classrooms with dry-bulb temperatures in the 60's with doors and windows open (which brings in more moist air) presumably because the classrooms are too cold.

Fort Buchanan should take an active position on future construction and equipment replacement that considers dehumidification strategies in addition to temperature control. Because occupants can be comfortable in warmer, dry air, this will help save money, avoid over-cooled buildings, and increase occupant comfort levels.

[3] The Fort Buchanan energy manager will also receive a CD-ROM, which includes all the FEDS input data and output project files. The input data files reflect information collected during the site visits and additional assumptions required to perform the FEDS modeling and assessment.

Possible solutions to humidity control that Fort Buchanan should consider and/or actively promote include:

- Verify (commission) temperature settings along all primary facilities to ensure these are operating to the optimum level possible.
- Installation of variable air volume (VAV) boxes in schools (may be a potential solution if that is the reason for over-cooled classrooms)
- Consider the use of desiccant wheel dehumidification on larger buildings and new construction.
- Consider heat-pipe or other "wrap-around" pre-cooling/reheat devices which remove moisture from the air.

Additional Envelope Measures

The FEDS model identified many envelope-related measures (e.g., window replacement, additional insulation) as cost-effective retrofits. While insulation and windows may not be immediately obvious, consider that the Fort is now cooling buildings that were originally built to be cooled by natural air movement. Furthermore, attacking infiltration (primarily through window replacement) will aid in the fight to reduce indoor humidity levels. Fort Buchanan DPW should support good envelope measures in future building retrofits and avoid at all cost the practice of putting plastic over open-air hurricane louvers and installing air-conditioning.

Appendix A
FEDS Data Collection Form

The following form is used to collect FEDS input data during building audits. Note that not all data types indicated on this form are applicable to all buildings. Nor is all the information indicated on this form always available. Where necessary, the FEDS model infers the values for missing data based on other known building characteristics.

FEDS Building Information for _____

Building Number / Description:			
Linked Building? YES NO If yes, position of this section:	**Occupancy Schedule:**	**Start**	**End**
Dual Use? YES NO **Use area (X of Y):**	**Weekday:**		
Use area fraction of total building floor area (%):	*(military time)* **Saturday:**		
Number of floors for this area:	**Sunday:**		
Aspect ratio (N/E - typical for set):	# Occupants: (occupied); (unoccupied)		
Normalize solar gains? YES NO	**Unoccupied Months:**		
# Zones: 1 4 5			

ENVELOPE

Roof type: BUILT-UP METAL PANEL SHINGLES/SHAKES	**Floor type:** SLAB ON GRADE CRAWL SPACE
- if built-up, deck type: WOOD CONCRETE METAL	- insulation type / thickness / R-value:
- insulation type / thickness / R-value:	- ground floor carpet (crawlspace only)? YES NO
- floor-floor height:	
- floor-ceiling height:	**Windows - #panes:** 1 2 3
- suspended ceiling? YES NO	**- frame type:** WOOD/VINYL METAL THERMAL BREAK METAL
Wall: WOOD SIDING MASONRY/WOOD MASONRY CURTAIN MET PANEL	- tinting / shading / film:
- insulation type / thickness / R-value:	**- % of wall area that is glass:**

LIGHTING

Technology Type	**Fixture Description (type, size, #lamps,** wattage, ballasts, location/application, etc.)	**% of area served** (or fixture count)	**Mounting Method***	Occupied Utilization %	Unoccupied Utilization %

IN = incandescent CF = compact fluorescent FL = fluorescent MV = mercury vapor MH = metal halide HS = high pressure sodium
LS = low pressure sodium EX = exit sign
**Exterior building-attached fixtures should be noted here*

SERVICE HOT WATER

Portion of building set served (whole buildings) (ft^2, %, or # of bldgs.)	**System 1:**	**System 2:**	**System 3:**
Fuel type			
System type	DISTRIBUTED LOOP	DISTRIBUTED LOOP	DISTRIBUTED LOOP
Equipment vintage			
Tank capacity (gallons, #tanks)			
Efficiency			
Thermostat set point, °F			
Tank insulation – thickness/R-value			
Heating capacity (loop only)			
Loop length (perimeter or stacked service)			
#Faucets / aerators installed (%)			
#Showers / low-flow showerheads installed (%)			
Note presence of: bottom boards, near tank pipe insul., tank wrap, heat traps, electronic pilots			

Auditor: _____ **Sheet** _____ **of** _____

Date: _____

HVAC

Portion of building set NOT heated (ft^2, %, or # of bldgs.)	HEATING		
Portion of building set served by this heating type (whole buildings) (sq. ft, percent, or number of buildings)	**Type 1:**	**Type 2:**	**Type 3:**
Fuel type			
Equipment type: 0=Elec. resistance baseboard 1=Forced air furnace 2=Air-source heat pump 3=Ground-coupled heat pump 4=Radiator/central steam/hot water 5=Fan coils/central steam/hot water/electricity 6=AHU/central steam/hot water 7=Radiator/single building boiler 8=Fan coils/single building boiler 9=AHU/single building boiler			
Output capacity (total per building)			
Number of pieces of equipment			
Efficiency (%)			
Equipment vintage			
Thermostat set point(s), °F			
Ventilation control mode: 0=cycle 1=constant 2=constant occupied hours/cycle unoccupied hours 3=constant occupied hours/off unoccupied hours 4=no mechanical ventilation			
Ventilation supply air (cfm)			
Outdoor air (NONE, 100%, OTHER?)			
Total fan motor capacity (hp or kW)			
Desiccant dehumidification (and heat source)?			
Portion of building set NOT cooled (ft^2, %, or # of bldgs.)	COOLING		
Portion of building set served by this equipment type (whole buildings) (ft^2, %, or # of bldgs.)	**Type 1:**	**Type 2:**	**Type 3:**
Fuel / Equip. type: 0 = evap. cooler 1 = window/wall units 2 = air heat pump 3 = water heat pump 4 = package or split DX 5 = fan coil/conv. chiller 6 = AHU/conv. chiller 7 = fan coil/absorp. chiller 8 = AHU/absorp. chiller 9 = fan coil/central chilled water 10 = AHU/central chilled water			
Output capacity (total per building)			
Number of units			
Nominal COP			
Cooling equipment vintage			
Thermostat set point(s), °F			

MISC. EQUIPMENT

	Type 1:	**Type 2:**	**Type 3:**	**Type 4:**
Type & Fuel				
Capacity				
Occupied utilization				
Unoccupied utilization				

MOTORS

	Type 1:	**Type 2:**	**Type 3:**	**Type 4:**
Horsepower				
# Motors of this type				
Occupied utilization				
Unoccupied utilization				
Other nameplate data				

NOTES

Appendix B
Facility Category Descriptions and Associated Buildings

The following table identifies the buildings in the facility categories defined by the assessment team. The table below also includes the FEDS facility category code, the proxy building number(s) audited for the purpose of developing the FEDS model, the proxy building total square footage, the total number of buildings in the category, the total square footage in that category and the % of square footage represented by the proxy buildings.

Category Description [FEDS Facility Category Code]	Proxy Building Number	Proxy Building (sq. ft)	Total Bldgs. in Category	Total Sq. Ft. in Category	Proxy Sq. Ft. % of Category
Overhead Protection [1]	**179**	**2637**	**64**	**17,753**	**14.9%**
	Buildings in this Category				
	16	165	352	398	1089
	22	179	366	558	1090
	31	182	367	570	1091
	36	184	370	579	1092
	65	185	371	625	1093
	68	191	377	626	1098
	71	198	378	674	1291
	120	234	379	800	1293
	139	237	383	834	1295
	153	255	384	835	1299
	154	267	389	998	S1300
	156	293	396	999	S1301
	158	351	397	1088	
Administration with Storage [10a]	**509**	**10,000**	**7**	**57,072**	**17.5%**
	Buildings in this Category				
	504	509	514	551	1313
	507	511			
Administration with Storage & Maintenance [10b]	**556**	**54,879**	**1**	**54,879**	**100.0%**
	Buildings in this Category				
	556				
Training Centers [10c]	**1305**	**8785**	**17**	**152,725**	**5.8%**
	Buildings in this Category				
	522	1306	1311	1318	1322
	523	1307	1312	1319	1323
	525	1308	1316	1320	1324
	1305	1310			
Smaller 1940s General Purpose Administration [10d]	**225**	**2482**	**24**	**94,232**	**2.6%**
	Buildings in this Category				
	176	212	224	233	1303
	177	218	225	376	1304
	192	219	227	518	1314
	193	220	228	746	1317
	206	223	231	1302	

Category Description [FEDS Facility Category Code]	Proxy Building Number	Proxy Building (sq. ft)	Total Bldgs. in Category	Total Sq. Ft. in Category	Proxy Sq. Ft. % of Category
Larger 1940s General Purpose Administration [10e]	**152; 390; 399**	**10,084; 29,014; 18,047**	**6**	**99,228**	**57.6%**
	Buildings in this Category				
	152	399	512	566	607
	390				
1950s & 60s General Purpose Administration [10f]	**203**	**2775**	**28**	**70,258**	**3.9%**
	Buildings in this Category				
	28	348	1022	1106	1143
	67	1017	1101	1107	1144
	202	1018	1102	1140	1145
	203	1019	1103	1141	1146
	204	1020	1104	1142	1147
	214	1021	1105		
Newer General Purpose Administration [10g]	**540**	**11,942**	**9**	**38,685**	**30.9%**
	Buildings in this Category				
	23	136	501	576	673
	25	292	540	665	
School Trailers [10tr]	**92; 1066**	**1655; 2421**	**34**	**47,346**	**8.6%**
	Buildings in this Category				
	13	89	96	1049	1070
	15	90	97	1050	1072
	18	91	99	1051	1074
	19	92	1034	1052	1095
	30	93	1046	1053	1096
	87	94	1047	1054	1097
	88	95	1048	1066	
Intermediate School [10is]	**78**	**2714**	**12**	**49,020**	**5.5%**
	Buildings in this Category				
	73	77	80	82	84
	74	78	81	83	85
	75	79			
Elementary School [10es]	**1031**	**4055**	**13**	**55,473**	**7.3%**
	Buildings in this Category				
	1029	1032	1037	1040	1042
	1030	1033	1038	1041	1043
	1031	1035	1039		
Middle School [10ms]	**1073**	**8466**	**9**	**73,485**	**11.5%**
	Buildings in this Category				
	1071	1075	1079	1083	1094
	1073	1077	1081	1085	
High School [10hs]	**1062**	**54,064**	**3**	**80,392**	**67.3%**
	Buildings in this Category				
	1060	1062	1068		
Clinics [21]	21	13,575	6	23,513	**57.7%**
	Buildings in this Category				
	21	295	312	670	676
	291				

Category Description [FEDS Facility Category Code]	Proxy Building Number	Proxy Building (sq. ft)	Total Bldgs. in Category	Total Sq. Ft. in Category	Proxy Sq. Ft. % of Category
Older Barracks [30b-1]	**1300; 1301**	**8814; 8814**	**5**	**47,411**	**37.2%**
	Buildings in this Category				
	119 (Demolished)	1232	1300	1301	1315
2000 Army Lodging [30b-2]	**678**	**36,372**	**4**	**54,526**	**66.7%**
	Buildings in this Category				
	678	679	680	681	
Las Colinas [30sf-1]	**807; 815**	**2947; 2448**	**29**	**75,929**	**7.1%**
	Buildings in this Category				
	803	809	815	821	827
	804	810	816	822	828
	805	811	817	823	829
	806	812	818	824	830
	807	813	819	825	831
	808	814	820	826	
Coconut Grove [30sf-2][4]	**1134**	**1209**	**127**	**168,780**	**0.7%**
	Buildings in this Category				
	801	1132	1166	1191(Demolished)	1216(Demolished)
	802	1133(Demolished)	1167	1192	1217
	1108(Demolished)	1134	1168	1193	1218(Demolished)
	1109	1135	1169(Demolished)	1194(Demolished)	1219
	1110(Demolished)	1136(Demolished)	1170	1195(Demolished)	1220(Demolished)
	1111(Demolished)	1137	1171(Demolished)	1196(Demolished)	1221(Demolished)
	1112	1138	1172(Demolished)	1197	1222(Demolished)
	1113(Demolished)	1139	1173	1198	1223
	1114(Demolished)	1148(Demolished)	1174	1199	1224(Demolished)
	1115	1149	1175(Demolished)	1200(Demolished)	1225(Demolished)
	1116(Demolished)	1150(Demolished)	1176	1201(Demolished)	1226
	1117	1151(Demolished)	1177(Demolished)	1202(Demolished)	1227(Demolished)
	1118	1152	1178(Demolished)	1203	1228(Demolished)
	1119(Demolished)	1153(Demolished)	1179	1204	1229
	1120(Demolished)	1154	1180(Demolished)	1205	1230(Demolished)
	1121(Demolished)	1155	1181	1206(Demolished)	1231
	1122	1156(Demolished)	1182	1207	1233(Demolished)
	1123(Demolished)	1157(Demolished)	1183(Demolished)	1208	1234
	1124(Demolished)	1158	1184	1209(Demolished)	1235
	1125	1159(Demolished)	1185	1210	1236(Demolished)
	1126(Demolished)	1160(Demolished)	1186(Demolished)	1211	1237
	1127	1161	1187	1212(Demolished)	1238(Demolished)
	1128(Demolished)	1162	1188(Demolished)	1213(Demolished)	1239
	1129	1163	1189(Demolished)	1214	1240(Demolished)
	1130(Demolished)	1164(Demolished)	1190	1215	1241
	1131(Demolished)	1165(Demolished)			

[4] The model calibration includes the family housing units in Coconut Grove (30sf-2) and Coqui Gardens (30sf-3). These units existing during the calibration year and must be included for proper model calibration. After the site visit, major demolition has taken place in those two housing areas. For this reason, no retrofits will be allowed for 30sf-2 and 30sf-3.

Category Description [FEDS Facility Category Code]	Proxy Building Number	Proxy Building (sq. ft)	Total Bldgs. in Category	Total Sq. Ft. in Category	Proxy Sq. Ft. % of Category
Coqui Gardens [30sf-3][4]	**1280**	**2244**	**48**	**109,328**	**2.1%**
	Buildings in this Category				
	1243	1253	1263	1273	1282
	1244	1254	1264(Demolished)	1274	1283
	1245	1255	1265	1275	1284
	1246	1256	1266(Demolished)	1276	1285
	1247	1257	1267	1277	1286
	1248	1258(Demolished)	1268(Demolished)	1278	1287
	1249	1259	1269	1279	1288
	1250	1260(Demolished)	1270(Demolished)	1280	1289
	1251(Demolished)	1261	1271	1281	1290
	1252	1262(Demolished)	1272		
Buchanan Heights [30sf-4]	**1011**	**4290**	**20**	**94,985**	**4.5%**
	Buildings in this Category				
	1000	1004	1008	1012	1016
	1001	1005	1009	1013	1023
	1002	1006	1010	1014	1024
	1003	1007	1011	1015	1026
Cold Storage [40a]	**517**	**17,171**	**1**	**17,171**	**100.0%**
	Buildings in this Category				
	517				
1940s Storage [40b]	**614**	**20,468**	**9**	**100,640**	**20.3%**
	Buildings in this Category				
	180	527	563	612	1309
	521	539	608	614	
Large Storage [40c]	**541**	**50,250**	**1**	**50,250**	**100.0%**
	Buildings in this Category				
	541				
Vehicle Maintenance [50]	**528**	**10,089**	**1**	**10,089**	**100.0%**
	Buildings in this Category				
	528				
Commissary / PX [60a]	**689**	**211,143**	**1**	**211,143**	**100.0%**
	Buildings in this Category				
	689				
Exchange / Security [60b]	**613**	**20,468**	**5**	**101,565**	**20.2%**
	Buildings in this Category				
	606	611	613	1242	1321
Dining [60c]	**660**	**40,329**	**7**	**82,925**	**48.6%**
	Buildings in this Category				
	76	151	1036	1064	1087
	98	660			
Miscellaneous MWR [80]	**148; 167; 168**	**7761; 17,000; 20,780**	**20**	**83,109**	**54.8%**
	Buildings in this Category				
	69	161	171	313	387
	138	166	172	380	395
	148	167	181	381	519
	159	168	183	386	1025

Appendix C-1
Comprehensive List of Cost-Effective Projects Identified from the FEDS Assessment Using Appropriated Source of Capital

The following table identifies the 119 cost-effective energy- and cost-reducing retrofit projects identified from the FEDS modeling and analysis based on the assumption that the projects will be funded using appropriated source of capital funds. Key energy and economic results are presented for each cost-effective retrofit measure. The projects are grouped by building category. More detail, supporting each line-item project recommendation, is contained in the FEDS input and output files, which are delivered to the site energy manager on a CD in conjunction with this report.

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
1	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	120	4,792	37,327	46,708	2.23	7.8
	Subtotal	120	4,792	37,327	46,708	2.23	7.8
10a	Increase Attic Insulation by R-19 from R-5 to R-24 with Blow-In Insulation	208	7,965	30,431	109,640	4.60	3.8
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	4	482	3,442	4,952	2.40	7.1
	Subtotal	212	8,447	33,873	114,592	4.37	4.0
10b1	Increase Attic Insulation by R-13 from R-5 to R-18 with Blow-In Insulation	75	2,347	16,041	25,243	2.60	6.8
	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	66	503	652	2.30	7.6
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	47	2,353	18,125	23,138	2.30	7.7
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts with Reflectors	136	5,258	32,314	60,029	2.90	6.1
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	65	2,614	22,588	9,057	1.70	8.6
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Install Faucet Aerators	3	110	348	465	4.67	3.2
	Subtotal	326	12,748	89,919	118,584	2.51	7.1
10b2	Increase Insulation in Suspended Ceiling by R-11 from R-7 to R-18	16	630	10,910	171	1.02	17.3
	Replace 100-watt Metal Halide Lamps with 100-watt High Pressure Sodium Lamps	1	182	1,829	1,343	1.70	10.0
	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	34	252	335	2.30	7.4
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts with Reflectors	28	1,129	5,934	13,886	3.30	5.3
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Faucet Aerators	2	58	162	256	5.36	2.8
	Subtotal	47	2,033	19,087	15,991	1.83	9.4

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
10c	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	97	3,103	33,759	20,815	1.60	10.9
	Subtotal	97	3,103	33,759	20,815	1.60	10.9
10d	Increase Attic Insulation by R-30 from R-5 to R-35 with Blow-In Insulation	756	29,052	79,487	431,418	6.40	2.7
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	131	4,446	44,212	33,977	1.80	9.9
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	8	859	5,724	9,285	2.60	6.7
	Subtotal	895	34,357	129,423	474,680	4.70	3.8
10e	Increase Attic Insulation by R-30 from R-5 to R-35 with Blow-In Insulation	588	22,163	83,701	306,059	4.70	3.8
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	53	1,744	23,392	7,276	1.30	13.4
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	4	421	2,898	4,448	2.50	6.9
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	293	10,556	78,965	26,984	1.60	7.5
	Subtotal	938	34,884	188,956	344,767	3.23	5.4
10f	Increase Attic Insulation by R-30 from R-5 to R-35 with Blow-In Insulation	478	18,754	59,264	270,535	5.60	3.2
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	90	2,994	34,718	17,925	1.50	11.6
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	9	992	6,665	10,665	2.60	6.7
	Subtotal	577	22,740	100,647	299,125	3.95	4.4
10g	Increase Insulation in Suspended Ceiling by R-19 from R-7 to R-26	119	4,162	41,213	31,985	1.80	9.9
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	41	1,382	14,817	9,478	1.60	10.7
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	6	643	4,311	6,901	2.60	6.7
	Replace 60-watt Incandescent Flood Lamps with 18-watt CFLs	15	1,748	272	30,247	112.20	0.2
	Subtotal	181	7,935	60,613	78,611	2.30	7.6

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
10tr	Add Blow-in Wall Insulation to Fill Available Space, from R-0 to R-22.2	3,562	113,636	397,268	1,601,093	5.00	3.5
	Increase Attic Insulation by R-30 from R-5 to R-35 with Blow-In Insulation	517	16,465	39,938	249,602	7.20	2.4
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts with Reflectors	637	26,460	157,523	307,106	2.90	6.0
	Replace 75-watt Incandescent Flood Lamps with 23-watt CFLs	42	3,295	653	56,914	88.20	0.2
	Replace Existing Electric Package AC Unit (COP=2.52) with Small Single-Zone Packaged AC Unit (COP=3.57)	154	9,701	67,503	104,434	4.00	7.0
	Replace Existing Metal Frame, Single Pane Windows with Aluminum Frame, Double Pane, Argon-Filled Windows with Super Low-e Film and Thermal Breaks	155	4,549	46,696	33,298	1.70	10.3
	Subtotal	5,067	174,106	709,581	2,352,447	4.43	4.1
10is	Add R-12.4 Interior Masonry Surface Wall Insulation	307	8,924	149,139	7,789	1.10	16.7
	Increase Roof Insulation by R-38 from R-5 to R-43 Above Suspended Ceiling	367	11,216	82,245	114,986	2.40	7.3
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	107	3,161	20,412	35,179	2.70	6.5
	Replace 300-watt Incandescent Lamps with Fluorescent Fixtures Including 2x4 3-bulb 32-watt T-8 Lamps and Electronic Ballasts	33	1,486	4,293	21,784	6.10	2.9
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts with Reflectors	549	21,923	125,456	259,628	3.10	5.7
	Replace Existing Metal Louvers and Plastic Windows with Aluminum Frame, Double Pane, Argon-Filled Windows with Super Low-e Film and Thermal Breaks	856	27,499	223,306	260,276	2.20	8.1
	Subtotal	2,219	74,209	604,851	699,642	2.33	8.2
10es	Increase Insulation in Suspended Ceiling by R-19 from R-5 to R-24	514	6,644	59,098	57,738	2.00	8.9
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	201	2,502	25,937	18,072	1.70	10.4
	Replace 300-watt Incandescent Lamps with Fluorescent Fixtures Including 2x4 3-bulb 32-watt T-8 Lamps and Electronic Ballasts	24	1,113	3,216	16,317	6.10	2.9
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts with Reflectors	947	28,979	176,896	332,074	2.90	6.1
	Replace 75-watt Incandescent Flood Lamps with 23-watt CFLs	59	4,684	936	80,904	87.50	0.2
	Subtotal	1,745	43,922	266,083	505,105	2.92	6.1

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
10ms	Increase Insulation in Suspended Ceiling by R-19 from R-5 to R-24	1,077	8,120	78,287	64,510	1.80	9.6
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	279	2,067	22,774	13,570	1.60	11.0
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	10	628	4,311	6,633	2.50	6.9
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 28-watt T-5 Lamps and Electronic Ballasts with Reflectors	1,692	39,060	273,757	412,562	2.50	7.0
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Lower Tank Temperature from 140F to 120F	9	303	302	1,510	14.70	1.0
	Subtotal	3,067	50,178	379,431	498,785	2.30	7.6
10hs	Increase Insulation in Suspended Ceiling by R-19 from R-5 to R-24	454	3,042	42,823	10,668	1.20	14.1
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	86	571	8,859	1,176	1.10	15.5
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	9	615	4,311	6,422	2.50	7.0
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 28-watt T-5 Lamps and Electronic Ballasts with Reflectors	1,237	30,500	224,145	311,751	2.40	7.3
	Replace Existing Electric Hot Water Heater with Central Heat Pump Hot Water System (COP=3.32); Wrap Tank with R-11 Fiberglass Batt Insulation; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	197	6,196	14,299	88,091	5.20	2.3
	Subtotal	1,983	40,924	294,437	418,108	2.34	7.2
21	Increase Attic Insulation by R-19 from R-7 to R-26 with Blow-In Insulation	90	3,288	12,537	45,287	4.60	3.8
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	23	736	9,996	2,952	1.30	13.6
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	2	210	1,486	2,183	2.50	7.1
	Replace 60-watt Incandescent Flood Lamps with 18-watt CFLs	18	2,138	333	36,976	112.20	0.2
	Replace Existing Air-Cooled Electric Chiller (COP=2.49) with High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.0) and Cooling Tower	198	7,021	97,291	1,229	1.01	13.9

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
21 (contd)	Replace Existing Electric Hot Water Heater with Central Heat Pump Hot Water System (COP=2.72); Wrap Tank with R-11 Fiberglass Batt Insulation; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	578	18,664	61,349	238,630	3.70	3.3
	Subtotal	909	32,057	182,992	327,257	2.56	5.7
30b-1	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	20	652	10,824	650	1.10	16.6
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	9	1,038	7,136	10,985	2.50	6.9
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	557	18,875	201,673	43,036	1.40	10.7
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Install Faucet Aerators	15	410	860	1,880	7.00	2.1
	Subtotal	601	20,975	220,493	56,551	1.46	10.5
30b-2	Increase Attic Insulation by R-30 from R-7 to R-37 with Blow-In Insulation	125	4,918	22,997	63,478	3.80	4.7
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	26	900	10,745	5,098	1.50	11.9
	Replace 60-watt Incandescent Lamps with 15-watt CFLs	544	18,867	13,489	317,733	24.60	0.7
	Wrap Propane-Fired Hot Water Tank with R-11 Fiberglass Batt Insulation; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	154	2,786	250	55,636	191.00	0.1
	Subtotal	849	27,471	47,481	441,945	10.48	1.7
30sf-1	Replace 25-watt Incandescent Lamps with 5-watt CFLs and Ballast Unit	21	755	10,649	2,617	1.20	14.1
	Replace 75-watt Incandescent Flood Lamps with 23-watt CFLs	48	3,972	696	68,714	99.70	0.2
	Replace Existing 100% Efficient Electric Hot Water Heater with 320% Efficient Residential Add-On Heat Pump Water Heater; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	296	8,462	22,608	32,875	3.70	2.7
	Subtotal	365	13,189	33,953	104,206	5.01	2.6
30sf-4	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	58	1,943	27,293	6,878	1.30	14.0
	Replace 3x40-watt Incandescent Lamps with 2x9-watt CFLs and ballast unit	543	17,680	52,989	257,436	5.90	3.0

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
30sf-4 (contd)	Replace 60-watt Incandescent Flood Lamps with 18-watt CFLs	54	6,674	960	115,529	121.40	0.1
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Install Faucet Aerators	140	4,229	4,623	20,917	13.40	1.1
	Subtotal	795	30,526	85,865	400,760	6.13	2.8
40a2	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	12	631	7,917	3,130	1.38	12.5
	Replace Existing 100% Efficient Electric Hot Water Heater with 370% Efficient Commercial Heat Pump Water Heater; Install Faucet Aerators	0	21	44	85	4.50	2.1
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Faucet Aerators	0	1	8	1	1.40	8.0
	Subtotal	12	653	7,969	3,216	1.39	12.2
40b	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	47	2,217	16,859	22,040	2.30	7.6
	Subtotal	47	2,217	16,859	22,040	2.30	7.6
40c1	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	33	252	304	2.20	7.6
	Subtotal	0	33	252	304	2.20	7.6
40c2	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	2	69	888	327	1.40	12.9
	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	35	252	354	2.40	7.2
	Subtotal	2	104	1,140	681	1.64	11.0
50-2	Increase Insulation in Suspended Ceiling by R-19 from R-7 to R-26	7	244	3,762	542	1.10	15.4
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	2	82	1,393	40	1.03	17.0
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 28-watt T-5 Lamps and Electronic Ballasts with Reflectors	22	827	5,336	9,197	2.70	6.5
	Replace Existing Electric Package AC Unit (COP=2.41) with Small Single-Zone Packaged AC Unit (COP=3.57)	28	996	10,012	281	1.20	10.1
	Subtotal	59	2,149	20,503	10,060	1.74	9.5

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
60a1	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	1	137	1,015	1,366	2.30	7.4
	Replace Existing 100% Efficient Electric Hot Water Heater with 370% Efficient Commercial Heat Pump Water Heater	66	2,357	2,802	15,892	8.30	1.2
	Replace Existing Electric Package AC Unit (COP=2.57) with Water-Cooled Centrifugal Electric Chiller, with Ultra High Efficiency Fan Coils Replacing Window Units, and Cooling Tower (overall COP=6.33)	2,195	66,250	694,817	186,245	1.40	10.5
	Subtotal	2,262	68,744	698,634	203,503	1.43	10.2
60a2	Increase Insulation in Suspended Ceiling by R-19 from R-7 to R-26	401	14,518	126,619	128,684	2.00	8.7
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	23	774	7,071	6,544	1.90	9.1
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	1	99	723	1,021	2.40	7.3
	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	8	60	87	2.40	7.5
	Replace Existing 100% Efficient Electric Hot Water Heater with 370% Efficient Commercial Heat Pump Water Heater	26	883	1,593	5,527	5.40	1.8
	Replace Existing 76% Efficient Propane-Fired Hot Water Heater with 370% Efficient Commercial Heat Pump Water Heater	36	583	1,593	2,790	3.80	2.7
	Subtotal	487	16,865	137,659	144,653	2.04	8.2
60b	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	50	1,620	18,803	9,684	1.50	11.6
	Replace 96-watt T12 Fluorescent Lamps and Magnetic Ballasts with Energy-Saving 96-watt T12 Lamps and Electronic Ballasts with Reflectors	333	12,328	56,254	160,262	3.80	4.6
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	632	21,102	144,388	94,713	2.10	6.8
	Replace Existing Electric Package AC Unit (COP=2.66) with Ultra High Efficiency Window Unit (COP=3.37)	50	1,692	18,320	815	1.10	10.8
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Install Faucet Aerators; Lower Tank Temperature from 140F to 120F	2	56	96	266	8.60	1.7
	Subtotal	1,067	36,798	237,861	265,740	2.56	6.5

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
60c	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	129	1,689	19,282	10,424	1.50	11.4
	Insulate Pipes Near Electric Hot Water Tank	16	480	2,302	264	1.10	4.8
	Replace 25-watt Incandescent Lamps with 5-watt CFLs and ballast unit	757	18,956	158,158	174,948	2.10	8.3
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	6	486	3,369	5,136	2.50	6.9
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts with Reflectors	337	9,340	46,796	117,281	3.50	5.0
	Replace Existing 69% Efficient Propane-Fired Hot Water Heater with 91% Efficient Condensing Model; Wrap Hot Water Tank with R-11 Fiberglass Batt Insulation	703	12,062	52,998	144,661	4.50	4.4
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	950	31,124	189,008	152,892	2.40	6.1
	Subtotal	2,898	74,137	471,913	605,606	2.58	6.4
80	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	91	3,085	33,444	20,810	1.60	10.8
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	13	1,426	9,491	15,414	2.60	6.7
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts with Reflectors	78	2,773	11,167	37,566	4.40	4.0
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Lower Tank Temperature from 125F to 120F	1	42	330	107	1.90	7.9
	Wrap Propane-Fired Hot Water Tank with R-11 Fiberglass Batt Insulation; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	194	3,522	336	70,310	179.80	0.1
	Subtotal	377	10,848	54,768	144,207	3.58	5.0
Grand Total		28,204	851,122	5,166,277	8,718,604	2.91	6.1

Appendix C-2
Comprehensive List of Cost-Effective Projects Identified from the FEDS Assessment Using Alternative Financing Source of Capital

The following table identifies the 91 cost-effective energy- and cost-reducing retrofit projects identified from the FEDS modeling and analysis based on the assumption that they will be funded using alternative financing source of capital funds. Alternative financing includes UESC and ESPC, as well as any other third party financing. Key energy and economic results are presented for each cost-effective retrofit measure. The projects are grouped by building category. More detail, supporting each line-item project recommendation, is contained in the FEDS input and output files, which are delivered to the site energy manager on a CD in conjunction with this report.

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
1	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	120	5,199	37,327	14,963	1.43	7.2
	Subtotal	120	5,199	37,327	14,963	1.43	7.2
10a	Increase Attic Insulation by R-13 from R-5 to R-18 with Blow-In Insulation	187	7,164	22,308	49,543	3.20	3.1
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	4	440	3,442	980	1.30	7.8
	Subtotal	191	7,604	25,750	50,523	2.96	3.4
10b1	Increase Attic Insulation by R-13 from R-5 to R-18 with Blow-In Insulation	74	2,336	16,041	7,388	1.50	6.9
	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	60	503	103	1.20	8.4
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	155	7,078	36,127	35,033	2.03	5.1
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	66	2,662	22,686	4,014	1.20	8.5
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Faucet Aerators	1	23	106	130	2.20	4.6
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Install Faucet Aerators	2	81	162	657	5.00	2.0
	Subtotal	298	12,240	75,625	47,325	1.68	6.2
10b2	Replace 100-watt Metal Halide Lamps with 100-watt High Pressure Sodium Lamps	1	204	1,829	227	1.10	9.0
	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	31	252	57	1.20	8.1
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	22	964	3,306	6,370	2.90	3.4
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Faucet Aerators	2	58	162	429	3.67	2.8
	Subtotal	25	1,257	5,549	7,083	2.17	4.4

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
10d	Increase Attic Insulation by R-19 from R-5 to R-24 with Blow-In Insulation	676	25,752	50,244	208,045	5.10	2.0
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	8	785	5,724	2,196	1.40	7.3
	Subtotal	684	26,537	55,968	210,241	4.74	2.1
10e	Increase Attic Insulation by R-19 from R-5 to R-24 with Blow-In Insulation	534	20,138	52,908	149,077	3.80	2.6
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	4	384	2,898	975	1.30	7.5
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	310	11,032	81,404	13,388	1.20	7.4
	Subtotal	848	31,554	137,210	163,440	2.32	4.3
10f	Increase Attic Insulation by R-19 from R-5 to R-24 with Blow-In Insulation	432	16,988	37,461	132,935	4.50	2.2
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	9	906	6,665	2,481	1.40	7.4
	Subtotal	441	17,894	44,126	135,416	4.06	2.5
10g	Increase Insulation in Suspended Ceiling by R-11 from R-7 to R-18	90	3,233	30,491	1,931	1.10	9.4
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	6	587	4,311	1,607	1.40	7.3
	Replace 60-watt Incandescent Flood Lamps with 18-watt CFLs	15	1,751	272	17,419	65.00	0.2
	Subtotal	111	5,571	35,074	20,957	1.89	6.3
10tr	Add Blow-in Wall Insulation to Fill Available Space, from R-0 to R-22.2	3,548	113,474	397,268	740,879	2.90	3.5
	Increase Attic Insulation by R-19 from R-5 to R-24 with Blow-In Insulation	478	15,330	25,245	128,520	6.10	1.6
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	512	23,193	87,756	145,310	2.70	3.8
	Replace 75-watt Incandescent Flood Lamps with 23-watt CFLs	42	3,311	653	32,742	51.20	0.2
	Replace Existing Electric Package AC Unit (COP=2.52) with Small Single-Zone Packaged AC Unit (COP=3.57)	159	9,785	70,312	153,656	3.20	7.2
	Replace Existing Metal Frame, Single Pane Windows with Aluminum Frame, Double Pane, Argon-Filled Windows with Super Low-e Film	139	4,124	39,932	1,439	1.04	9.7
	Subtotal	4,878	169,217	621,166	1,202,546	2.97	3.7

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
10is	Increase Insulation in Suspended Ceiling by R-19 from R-5 to R-24	269	8,377	52,223	31,799	1.60	6.2
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	98	2,911	20,412	8,788	1.40	7.0
	Replace 300-watt Incandescent Lamps with Fluorescent Fixtures Including 2x4 3-bulb 32-watt T-8 Lamps and Electronic Ballasts	33	1,539	4,293	11,171	3.60	2.8
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	432	19,270	69,891	123,739	2.80	3.6
	Replace Existing Metal Louvers and Plastic Windows with Aluminum Frame, Double Pane, Argon-Filled Windows with Super Low-e Film	700	22,958	190,961	39,307	1.20	8.3
	Subtotal	1,532	55,055	337,780	214,804	1.62	6.1
10es	Increase Insulation in Suspended Ceiling by R-11 from R-5 to R-16	393	5,135	43,723	7,781	1.20	8.5
	Replace 300-watt Incandescent Lamps with Fluorescent Fixtures Including 2x4 3-bulb 32-watt T-8 Lamps and Electronic Ballasts	24	1,152	3,216	8,368	3.60	2.8
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	748	25,756	98,548	160,285	2.60	3.8
	Replace 75-watt Incandescent Flood Lamps with 23-watt CFLs	59	4,694	936	46,424	50.60	0.2
	Subtotal	1,224	36,737	146,423	222,858	2.56	4.0
10ms	Increase Insulation in Suspended Ceiling by R-11 from R-5 to R-16	825	6,247	57,919	4,739	1.10	9.3
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	10	572	4,311	1,454	1.30	7.5
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	1,098	31,652	153,671	164,517	2.10	4.9
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Lower Tank Temperature from 140F to 120F	9	303	302	2,738	10.10	1.0
	Subtotal	1,942	38,774	216,203	173,448	1.86	5.6
10hs	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	8	559	4,311	1,324	1.30	7.7
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	796	24,914	125,822	124,657	2.00	5.1

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
10hs (contd)	Replace Existing Electric Hot Water Heater with Central Heat Pump Hot Water System (COP=3.32); Wrap Tank with R-11 Fiberglass Batt Insulation; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	197	6,196	14,299	47,848	4.30	2.3
	Subtotal	1,001	31,669	144,432	173,829	2.21	4.6
21	Increase Attic Insulation by R-19 from R-7 to R-26 with Blow-In Insulation	112	4,265	12,537	30,246	3.40	2.9
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	2	195	1,486	484	1.30	7.6
	Replace 60-watt Incandescent Flood Lamps with 18-watt CFLs	18	2,141	333	21,294	65.00	0.2
	Replace Existing Electric Hot Water Heater with Central Heat Pump Hot Water System (COP=2.72); Wrap Tank with R-11 Fiberglass Batt Insulation; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	578	18,664	61,349	125,907	3.10	3.3
	Subtotal	710	25,265	75,705	177,931	3.39	3.0
30b-1	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	10	977	7,136	2,724	1.40	7.3
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Install Faucet Aerators	15	410	860	3,257	4.80	2.1
	Subtotal	25	1,387	7,996	5,981	1.78	5.8
30b-2	Increase Attic Insulation by R-19 from R-7 to R-26 with Blow-In Insulation	110	4,282	14,537	28,405	3.00	3.4
	Replace 60-watt Incandescent Lamps with 15-watt CFLs	543	18,891	13,489	176,281	14.10	0.7
	Wrap Propane-Fired Hot Water Tank with R-11 Fiberglass Batt Insulation; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	154	2,786	250	30,543	123.10	0.1
	Subtotal	807	25,959	28,276	235,229	9.43	1.1
30sf-1	Replace 75-watt Incandescent Flood Lamps with 23-watt CFLs	48	3,965	696	39,295	57.50	0.2
	Replace Existing 100% Efficient Electric Hot Water Heater with 320% Efficient Residential Add-On Heat Pump Water Heater; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM	296	8,468	22,608	50,224	2.40	2.7
	Subtotal	344	12,433	23,304	89,519	3.45	1.9

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
30sf-4	Replace 3x40-watt Incandescent Lamps with 2x9-watt CFLs and ballast unit	543	18,816	52,989	136,094	3.60	2.8
	Replace 60-watt Incandescent Flood Lamps with 18-watt CFLs	54	6,679	960	66,479	70.30	0.1
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Install Faucet Aerators	136	4,105	2,916	38,257	14.10	0.7
	Subtotal	733	29,600	56,865	240,830	5.28	1.9
40a2	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	2	62	343	281	1.80	5.5
	Replace Existing 100% Efficient Electric Hot Water Heater with 370% Efficient Commercial Heat Pump Water Heater; Install Faucet Aerators	0	21	44	136	3.00	2.1
	Subtotal	2	83	387	417	1.99	4.7
40b	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	47	2,400	16,859	7,281	1.40	7.0
	Subtotal	47	2,400	16,859	7,281	1.40	7.0
40c1	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	30	252	39	1.20	8.4
	Subtotal	0	30	252	39	1.20	8.4
40c2	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	0	32	252	67	1.30	7.9
	Subtotal	0	32	252	67	1.30	7.9
50-2	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	15	667	2,995	3,709	2.20	4.5
	Subtotal	15	667	2,995	3,709	2.20	4.5
60a1	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	19	668	6,414	282	1.04	9.6
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	1	132	1,015	314	1.30	7.7
	Replace Existing 100% Efficient Electric Hot Water Heater with 370% Efficient Commercial Heat Pump Water Heater	66	2,357	2,802	19,337	5.50	1.2
	Subtotal	86	3,157	10,231	19,933	2.70	3.2

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
60a2	Increase Insulation in Suspended Ceiling by R-11 from R-7 to R-18	307	11,356	93,677	20,230	1.20	8.2
	Insulate Perimeter of Slab on Grade Foundation with R-12.4 Insulation	22	769	7,071	640	1.10	9.2
	Replace 2-watt LED Exit Signs with 0.35-watt Electroluminescent Exit Signs	1	95	754	222	1.30	7.9
	Replace Existing 100% Efficient Electric Hot Water Heater with 370% Efficient Commercial Heat Pump Water Heater	26	883	1,593	6,409	3.60	1.8
	Replace Existing 76% Efficient Propane-Fired Hot Water Heater with 370% Efficient Commercial Heat Pump Water Heater	36	583	1,593	4,146	2.70	2.7
	Subtotal	392	13,686	104,688	31,647	1.28	7.6
60b	Replace 96-watt T12 Fluorescent Lamps and Magnetic Ballasts with Energy-Saving 96-watt T12 Lamps and Electronic Ballasts with Reflectors	333	13,173	56,254	76,080	2.40	4.3
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	642	21,366	145,752	68,482	1.50	6.8
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Install Faucet Aerators; Lower Tank Temperature from 140F to 120F	2	56	96	469	5.90	1.7
	Subtotal	977	34,595	202,102	145,031	1.76	5.8
60c	Replace 25-watt Incandescent Lamps with 5-watt CFLs and ballast unit	756	18,455	158,158	27,017	1.20	8.6
	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	6	444	3,369	1,116	1.30	7.6
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts	268	8,045	26,070	54,751	3.10	3.2
	Replace Existing Air-Cooled Electric Chiller (COP=2.53) with Very High Efficiency Water-Cooled Reciprocating Electric Chiller (COP=4.2) and Cooling Tower	968	31,637	191,088	125,887	1.70	6.0
	Wrap Propane-Fired Hot Water Tank with R-11 Fiberglass Batt Insulation	462	8,377	338	92,253	274.00	0.0
	Subtotal	2,460	66,958	379,023	301,024	1.87	5.7

FEDS Category	Technology Change	Energy Savings (MMBtu/yr)	Annual Savings ($/yr)	Capital Cost ($)	Net Present Value ($)	SIR	Simple Payback (yr)
80	Replace 2-watt LED Exit Signs with 0.2-watt Electroluminescent Exit Signs	13	1,302	9,491	3,663	1.40	7.3
	Replace 40-watt T-12 Lamps and Magnetic Ballasts with 32-watt T-8 Lamps and Electronic Ballasts with Reflectors	78	2,923	11,167	18,198	2.60	3.8
	Wrap Electric Hot Water Tank with R-11 Fiberglass Batt Insulation; Insulate Pipes Near Tank; Install Low-Flow Showerheads to Reduce Water Flow from 4.8 GPM to 2.0 GPM; Lower Tank Temperature from 125F to 120F	1	42	330	95	1.30	7.9
	Wrap Propane-Fired Hot Water Tank with R-11 Fiberglass Batt Insulation	194	3,511	200	38,612	193.90	0.1
	Subtotal	286	7,778	21,188	60,568	3.88	2.7
Grand Total		20,179	663,317	2,812,712	3,956,503	2.45	4.2