MILCON Energy Efficiency and Sustainability Study of Five Types of Army Buildings
Summary Report USACE ERDC – CERL NREL PNNL[1] July 2011
OFHPGB Notes 01.24.12

The purpose of this Military Construction (MILCON) Energy Efficiency and Sustainability Study of Five Army Buildings was to investigate current building features and construction methods and materials to optimize energy reduction and sustainability. At a minimum, the study was to ensure that the five selected standard designs meet all applicable energy reduction and sustainable design policies.

Study Goals

- Determine the difference between 1st cost and cost to meet energy requirements (USACE std design basis, 65% fossil fuel reduction & 189.1 energy requirements)
- Would scope (mission) need to be reduced?
- Specific targets
    - Design Army buildings to be net zero ready.
    - Achieve a 65 percent reduction in overall energy consumption compared to the 2003 Commercial Building Energy Consumption Survey (CBECS, by the U.S. Department of Energy's [DOE's] Energy Information Agency).
    - Reduce both indoor and outdoor potable water usage.
    - Account for the impact of energy systems on operations and maintenance (O&M).
    - Comply with the High Performance Sustainable Buildings Guiding Principles (Guiding Principles) as stated in EO 13514. "

- Develop energy models for buildings that support net zero ready installations and that achieve 65 percent fossil fuel-generated energy reduction compared to a similar building in fiscal year 2003 (FY03) Commercial Building Energy Consumption Survey (CBECS).
    - For this study, the German Passivhaus (passive house) standards were used to go beyond the current ASHRAE standards and develop ultra-low energy buildings. The basic concept behind the passive house approach is to superinsulate a building to reduce the amount of energy required to heat, ventilate, and cool it in addition to other considerations such as building orientation, glazing areas, envelope geometry, etc.
- Reduce both indoor and outdoor potable water usage.
- Account for the impact on operations and maintenance by energy systems. "
- Comply with the High Performance Sustainable Building Guiding Principles

[1] Members of this group included the Assistant Chief of Staff for Installation Management (ACSIM), Installation Management Command (IMCOM), U.S. Army Corps of Engineers (USACE), Engineer Research and Development Center–Construction Engineering Research Laboratory (ERDC-CERL), Army Reserves, and invitations were extended to members of other services such as Navy and Air Force. This study is a result of work done by a group of government, institutional, and private sector parties. The National Renewable Energy Laboratory (NREL) and ERDC-CERL were responsible for energy modeling. ERDC-CERL and Pacific Northwest National Laboratory (PNNL) were responsible for water and sustainability information and data. Meetings were held with Savannah (COF, TEMF, Bde HQ), Fort Worth (UEPH), and Norfolk (DFAC) COSs. In addition, Fort Worth staff provided all cost estimating work. Project management was provided by HQ USACE and PNNL staff

- …developed revised building designs by working with industry experts and A&E firms to develop a “best of the best” design for each Army facility. The requirements of this effort were to optimize the mission, function, quality, and cost of the buildings. The International Building Code was used as the baseline building code. The baseline design was amended and supplemented to include anti-terrorism and force protection, EPACT 2005 compliance, LEED Silver certifiable, Army Installations, and mission-specific requirements, and select Department of Defense (DoD) Unified Facility Criteria considered critical to life safety and mission.

The approach of this study was to take these existing building designs and optimize the energy performance of each building in order to build the most energy efficient buildings possible before looking at options like renewables and cogeneration. Energy models were developed with various energy packages and options and sustainability features were identified for each building in order to meet Federal mandates. Meetings were held with USACE Centers of Standardization (COSs) to discuss how to improve the energy performance of the buildings and to have a reality check on assumptions, ideas, and options. Cost estimates were developed to determine the cost delta between the baseline buildings and proposed enhanced design options. Lastly, a LEED analysis was completed as an outcome of the energy modeling and estimating.

Energy Efficiency Measures (EEMs) considered the building envelope construction, lighting and plug load power densities and design, as well as heating, ventilation, and air-conditioning (HVAC) strategies… EEMs were modeled for each building type across 15 locations. The 15 locations were selected to represent 15 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) climate zones in the United States. The locations selected were representative cities for the climate zones. Colorado Springs was selected for climate zone 5B instead of Boise, Idaho, to more closely align with the installations at Fort Carson, Colorado. The 15 climate zones and the cities used to represent them are listed in Table 1.1

…started with a base package of low-energy features determined by CERL and NREL. These features focused specifically on a passive house approach (see Section 4.1.2.1), low infiltration rates, improved lighting strategies, reduced hot water usage and improved plug load levels that could then be modeled in combination with various HVAC features and technologies in an iterative manner….By modeling the various packages across different climate zones, energy usage and savings could be compared between the low-energy features…

The building types[2] studied were the five most commonly constructed Army building types:[3]

- Unaccompanied Enlisted Personnel Housing (UEPH barracks, 72111) Appendix A
    - 3 stories, cross between apartment buildings and college dormitories; capacity of 112 personnel in rooms. Each unit has two bedrooms (one soldier per room), one shared bathroom, a small mechanical room, and a kitchen/common area, as shown in Figure 3.1. The first floor has 18 units, a laundry room, a common area, a mechanical room, and a storage area; building is 54,771 ft2

---

[2] All bldg types are 1-3 stories - wood pilot opps - is this true for AF?

[3] FY08–09 the Army developed revised building designs by working with industry experts and A&E firms to develop a “best of the best” design for each Army facility. The requirements of this effort were to optimize the mission, function, quality, and cost of the buildings. The International Building Code was used as the baseline building code

- Tactical Equipment Maintenance Facility (TEMF repair facility, 21410) Appendix B
  - TEMF Two story, large-sized vehicle or equipment repair facility with equipment and parts, storage, and administrative offices; nominally occupied from 8 a.m. to 5 p.m., Monday through Friday building is 32,929 ft2.

- Company Operations Facility (COF government office and other public assembly, 14185) Appendix C
  - COF 2 story; hybrid of an open gymnasium-type area (readiness bays) used to store soldiers' equipment in lockers, ammunition vaults, and administrative office space. These facilities house Company administrative operations and are used to store and move supplies; the model for both the readiness bays and office are two stories, which combined have a footprint area of approximately 60,712 ft2

- Brigade Headquarters (Bde HQ government office and data center, 14182) Appendix D
  - Bde HQ 2 story; hybrid of a government office building and a secure data center. Private offices are provided for select officers and other staff. Other types of space include conference rooms, staff duty stations, message center and mail sorting, reception areas, secure documents room, showers, supplies, and vending; total square footage of the two-story building is 39,600 ft2 and each floor has 19,800 ft2.

- Dining Facility (DFAC, 72210) Appendix E
  - DFAC One story; hyybrid of a cafeteria and a high-volume fast food restaurant; patron dining area, a food service area, a kitchen, and food storage and receiving areas. The baseline building for this study serves 1,300 soldiers per meal period. Total square footage of the one-story building is 27,458 ft2.

While the goal should be to design the most efficient building at the lowest life-cycle cost (LCC), all of the building functional requirements must also be met. Major design changes, e.g., reconfiguration of barracks' room layouts and new window placement, were not considered during this study which impacted the energy savings that could be achieved. It would be beneficial to approach building design without constraints to see what impact this would have on the results and costs.

Many of the features of the buildings, such as the building form and window geometries, were fixed and not allowed to be varied. These were primarily mission-related requirements.

Energy Modeling Caveats

- The final savings determination was difficult because there is no clearly defined baseline for these Army building types within the CBECS.

- There was also initial confusion over the different energy baselines found in ASHRAE standards (modeled building energy) and Section 433 of EISA 2007 (measured building and plug load energy). This created a challenging "apples to oranges" scenario. "

- The focus became creating the most efficient building within the constraints of the analysis rather than trying to create an exact match with what were basically arbitrary

CBECS targets. Modeling and calculations were done, however, to provide results in terms of EISA 2007 and CBECS requirements.

- It is important to note that results in this study were based on total energy use as opposed to the fossil-fuel based portion of total energy use alone

Conclusions

The study was able to show the energy effectiveness of a range of efficiency measures, but it was not able to show the cost effectiveness of individual measures, nor was it able to optimize the designs for the highest energy performance at the lowest costs. This typically is done early in the design phase.

Table ES.1 MILCON Energy Study Summary

Findings	UEPH	TEMF	COF	Bde HQ	DFAC
Range of energy savings	36-66%	37-63%	34-80%	9-53%	16-38%
Range of cost increase	4.4-28.1%	6.6-10.3%	7.7-19.7%	4.8-19.1%	2.0-4.4%
Buildings that support net zero ready installations	Yes	Yes	Yes	Yes	Yes
Achieve energy savings 30% better than ASHRAE 90.1-2007	Yes	Yes	Yes	Yes	Yes
Buildings achieve 65% fossil fuel reduction compared to *source* CBECS 2003 (based on Section 433 of EISA 2007 requirement for 2015 by 2013)	0 climate zones, not met due to plug loads	All 15 climate zones	0 climate zones, 1 climate zones within 10%	0 climate zone, not met due to plug loads	0 climate zones, not met due to plug loads
30% domestic water reduction	Yes	Yes	Yes	Yes	Yes
O&M considered in energy package selection	Yes	Yes	Yes	Yes	Yes
20% reduction in use of indoor potable hot water	Yes	Yes	Yes	Yes	Yes
30% of hot water energy usage supplied by solar hot water	Yes	No	No	No	No

Findings	UEPH	TEMF	COF	Bde HQ	DFAC
Transpired solar collectors?	No	Yes	Yes	No	No
50% less outdoor potable water use	Yes	Yes	Yes	Yes	Yes
75% daylighting factor in all occupied spaces, 2% space for Critical visual tasks	Yes	Yes	Yes	No	Yes, in dining and serving areas
Inclusion of enhanced commissioning and measurement and verification	Yes	Yes	Yes	Yes	Yes
LEED 2009 Silver rating	Yes, may reach Gold on some projects	Yes, may reach Gold on some projects	Yes	Yes	Yes
Compliance with the Guiding Principles as stated in EO 13514	Yes	Yes	Yes	Yes	Yes

Energy Savings

- Low Energy Packages for all building types included increased exterior insulation, daylighting and daylighting controls, DOAS HVAC systems, improved pumps and fans, pressurization and make-up air, and top-tier ENERGY STAR® appliances and products. In addition, features such as solar hot water and transpired solar collectors were examined where appropriate
    - The analysis showed that significant energy savings are possible for all climates. However, it is very difficult to reach the EISA 2007 target for the 2015 goal of 65 percent fossil fuel reduction with building- specific efficiency measures alone. The extent of energy savings achieved is site-and facility-specific. "
        - 25 to 35 percent energy savings: The building yields the maximum energy savings for the lowest cost
        - 35 to 60 percent energy savings: Each increment of energy saved comes at an increasingly higher cost (plug load reduction, small scale renewable energy, building orientation, site specific design)
        - Above 60 percent: May be cost prohibitive without looking beyond the building (significant plug load reduction, clustering, renewable energy, cogeneration, etc.)

Table ES.2 Summary of Most Effective Energy Efficiency Measures

All Buildings
• Increased fan, pump, and HVAC efficiency • Increased daylighting and lighting power density reduction • Increased wall and roof insulation • Reduced infiltration rates • High-efficiency fixtures to reduce potable water demand • Cool roofs in climate zones 1–5 and window shading • Triple pane windows (can be extremely orientation and site specific)
UEPH
• Radiant heating and cooling • Solar hot water for 30% domestic hot water • Improved boiler and chiller efficiencies • DOAS for ventilation and humidity control • Separate ventilation for living and laundry areas
TEMF
• Reduced ventilation in repair bays • Radiant floors • Transpired solar collectors
COF
• Alternate construction option - reduced volume of conditioned air in readiness bays • VAV fans, ERV, IDEC, DOAS depending on climate zone • Transpired solar collectors depending on climate zone
Bde HQ
• Radiant heating and cooling • High efficiency chiller and boiler with GSHP
DFAC
• High efficiency or high-efficiency all-electric kitchen equipment • Exhaust hood design and flow control • Demand control ventilation on make-up air units • Passive house insulation levels for limited climate zones
DOAS = dedicated outdoor air system; ERV = energy recovery ventilation; GSHP = ground-source heat pump; HVAC = heating, ventilation, and air-conditioning; IDEC = indirect/direct evaporative cooling; VAV = variable air volume.

Costs

- Cost estimates for the baseline building and selected Low Energy Packages were also completed for climate zones based on the location of buildings in the FY13 construction program list. Appendices A through E include more detailed figures, tables, and cost estimates for each building type.
- The cost increases for the recommended Low Energy Packages for the five building types ranged from 2 percent to 10 percent with an average cost increase of 6 to 8 percent."

- This study also performed a life-cycle cost analysis[4] for two buildings in three climate zones. Three of the four building combinations had multiple low-energy packages that were life-cycle cost effective. The one building (four Low Energy Packages) that was not life-cycle cost effective was due to the increased cost for additional insulation without a proportionate increase in energy savings.These results reflect the impact of all regulatory drivers on the standard designs for the five building types.
- Security requirements (ie, blast resistant windows) increase costs for energy efficient products
    - Efficient blast-resistant window options listed in Table 4.2 by climate zone are recommended based on the climate-specific considerations with a low solar heat gain coefficient (SHGC) for warm climates and a higher value in cold climates. Table 4.2 lists requirements for window characteristics in different climate conditions resulting from this study compared to current Army requirements as well as requirements from ASHRAE 90.1 (2010, 2007), ASHRAE 189.1, and the ASHRAE Advanced Energy Guides. ERDC/CERL staff are researching triple-pane glass manufacturers who would have products that meet both current AT/FP blast-resistant and passive house requirements.

- As can be seen from the building energy reduction results, the increased cost only takes the buildings up to a certain point in terms of energy efficiency unless and until plug loads are reduced.
- Adding renewables to individual buildings to bring them above the 65 percent energy reduction target would be cost prohibitive. In terms of renewables, the cost is over six times higher than the current investment in EEMs in today's dollars. Renewables should be considered as a centralized resource either for clusters of buildings or as completely offsite, e.g., large, ground-based solar arrays. Energy costs vary by season and region and the DoD should take advantage of cost effective renewable energy technology during peak demand periods, avoiding the most expensive fossil fuel based resources and their associated environmental externalities

5.4 Summary of Cost Estimates

…estimates use a "unit cost for bill of quantities" approach and assigned a unit cost to each of the facility components…some items were not included in the original standard design and since they did not replace another system, their costs were added to the total baseline costs of the project. These added items include rainwater harvesting, enhanced commissioning, and measurement and verification.

Table 5.42 UEPH Cost Estimate Summary

[4] A 40-year life-cycle cost analysis (LCCA) was completed for the UEPH and TEMF buildings using the National Institute of Standards and Technology (NIST) Building Life-Cycle Cost Program (BLCC) version 5.3, which complies with the requirements of Title 10 of the Code of Federal Regulations Part 436 (10 CFR 436). Specifically, the MILCON Analysis, Energy Project module of BLCC was used

UEPH	Climate Zone	Baseline Building Contract Cost	Low E Package 1				Low E Package 2			
			Revised Cost	Cost Increase	% Increase	Energy Savings	Revised Cost	Cost Increase	% Increase	Energy Savings
Fort Shafter	1	$18,209,585	$19,902,998	$1,693,413	9.30%	37%	$19,957,568	$1,747,983	9.60%	49%
Fort Hood	2A	$7,585,822	$8,393,139	$807,317	10.64%	37%	$8,416,563	$830,741	10.95%	50%
Fort Bliss	3B	$8,986,431	$9,889,334	$902,903	10.05%	38%	$9,917,134	$930,703	10.36%	51%
Fort Campbell	4A	$8,597,669	$9,514,315	$916,646	10.66%	37%	$9,540,056	$942,387	10.96%	56%
Fort Lewis	4C	$10,242,658	$11,262,589	$1,019,931	9.96%	37%	$11,293,220	$1,050,562	10.26%	53%
Fort Wainwright	8	$18,080,550	$20,982,214	$2,901,664	16.05%	36%	$21,103,771	$3,023,221	16.72%	64%
			Low E Package 3				Low E Package 4			
	Climate Zone		Revised Cost	Cost Increase	% Increase	Energy Savings	Revised Cost	Cost Increase	% Increase	Energy Savings
Fort Shafter	1		$19,062,512	$852,927	4.68%	50%	$22,100,105	$3,890,520	21.37%	48%
Fort Hood	2A		$8,031,414	$445,592	5.87%	52%	$9,333,535	$1,747,713	23.04%	49%
Fort Bliss	3B		$9,382,468	$396,037	4.41%	53%	$11,009,837	$2,023,406	22.52%	48%
Fort Campbell	4A		$9,044,995	$447,326	5.20%	57%	$10,551,818	$1,954,149	22.73%	52%
Fort Lewis	4C		$10,704,097	$461,439	4.51%	55%	$12,497,217	$2,254,559	22.01%	51%
Fort Wainwright	8		$20,087,958	$2,007,408	11.10%	65%	$23,159,854	$5,079,304	28.09%	66%

Table 5.43TEMF Cost Estimate Summary

TEMF	Climate Zone	Baseline Building Contract Cost	Low E Package 1				Low E Package 2			
			Revised Cost	Cost Increase	% Increase	Energy Savings	Revised Cost	Cost Increase	% Increase	Energy Savings
Fort Bliss	3B	$7,529,077	$8,027,764	$498,687	6.62%	46%	$8,120,106	$591,029	7.85%	48%
Fort Campbell	4A	$6,969,882	$7,470,428	$500,546	7.18%	55%	$7,555,930	$586,048	8.41%	59%
Fort Lewis	4C	$8,302,808	$8,888,652	$585,844	7.06%	55%	$8,990,399	$687,591	8.28%	58%
Fort Carson	5B	$7,610,110	$8,210,887	$600,777	7.89%	56%	$8,304,084	$693,974	9.12%	62%
			Low E Package 3				Low E Package 4			
			Revised Cost	Cost Increase	% Increase	Energy Savings	Revised Cost	Cost Increase	% Increase	Energy Savings
Fort Bliss	3B		$8,119,395	$590,318	7.84%	46%	$8,211,736	$682,659	9.07%	48%
Fort Campbell	4A		$7,555,271	$585,389	8.40%	55%	$7,640,773	$670,891	9.63%	58%
Fort Lewis	4C		$8,989,615	$686,807	8.27%	55%	$9,091,362	$788,554	9.50%	57%
Fort Carson	5B		$8,303,366	$693,256	9.11%	56%	$8,396,562	$786,452	10.33%	61%

Table 5.44 Bde HQ Cost Estimate Summary

Bde HQ		Baseline Building Contract Cost	Low E Package 1				Low E Package 2			
	Climate Zone		Revised Cost	Cost Increase	% Increase	Energy Savings	Revised Cost	Cost Increase	% Increase	Energy Savings
Fort Campbell	4A	$8,535,728	$8,965,589	$429,861	5.0%	44%	$9,410,513	$874,785	10.2%	46%
Fort Lewis	4C	$10,122,092	$10,609,301	$487,209	4.8%	38%	$11,138,760	$1,016,668	10.0%	39%
Fort Drum	6A	$9,894,934	$10,575,485	$680,551	6.9%	50%	$11,087,147	$1,192,213	12.0%	54%
Fort Wainwright	8	$18,362,721	$20,142,153	$1,779,432	9.7%	58%	$21,094,290	$2,731,569	14.9%	64%
			Low E Package 3				Low E Package 4			
			Revised Cost	Cost Increase	% Increase	Energy Savings	Revised Cost	Cost Increase	% Increase	Energy Savings
Fort Campbell	4A		$9,646,657	$1,110,929	13.0%	46%	$9,781,123	$1,245,395	14.6%	48%
Fort Lewis	4C		$11,419,771	$1,297,679	12.8%	39%	$11,592,301	$1,470,209	14.5%	39%
Fort Drum	6A		$11,358,713	$1,463,779	14.8%	51%	$11,516,438	$1,621,504	16.4%	54%
Fort Wainwright	8		$21,599,637	$3,236,916	17.6%	59%	$21,868,796	$3,506,075	19.1%	67%

Table 5.45 COF Administrative Building Cost Estimate Summary

COF		Baseline Building Contract Cost	Low E Package 1				Low E Package 3			
Admin A + Readiness B + Readiness C	Climate Zone		Revised Cost	Cost Increase	% Increase	Energy Savings	Revised Cost	Cost Increase	% Increase	Energy Savings
Fort Shafter	1	$30,909,084	$33,334,464	$2,425,380	7.8%	43%	$33,295,314	$2,386,230	7.7%	60%
Fort Campbell	4A	$14,631,260	NA	NA	NA	65%	$16,254,649	$1,623,389	11.1%	68%
Fort Lewis	4C	$17,309,882	NA	NA	NA	63%	$19,335,410	$2,025,528	11.7%	67%
Fort Carson	5B	$15,923,121	$18,159,680	$2,236,559	14.0%	70%	$18,198,947	$2,275,826	14.3%	73%
Fort Drum	6A	$16,995,154	NA	NA	NA	74%	$19,688,509	$2,693,355	15.8%	76%
Fort Richardson	7A	$26,632,969	$31,493,361	$4,860,392	18.2%	77%	$31,886,041	$5,253,072	19.7%	78%

Table 5.46 DFAC Cost Estimate Summary

DFAC		Baseline Building Contract Cost	Low E Package 2				Low E Package 4			
	Climate Zone		Revised Cost	Cost Increase	% Increase	Energy Savings	Revised Cost	Cost Increase	% Increase	Energy Savings
Fort Wainwright	8	$9,749,134	$10,179,126	$429,992	4.4%	25%	$9,944,342	$195,208	2.0%	28%

5.5 Life-Cycle Cost Analysis

Assumptions for the analysis included the following:

- A 40-year life cycle was used.
- All capital investment amounts and energy savings were based on the cost estimates and energy modeling results from this study.
- Current Dollar Analysis with a 4 percent nominal discount rate (provided by the BLCC software) for operations, maintenance, and repair (OM&R) and utility costs. Initial Capital Investment was held constant with the provided cost estimate.
- The BLCC program used the DOE escalation factor for utility costs.
- For water consumption, we assumed constant usage throughout seasons. Water usage split 50/50 between summer and winter.
- Residual factor: 0 percent
- Cost adjustment factor: 0.97 percent
- Annual rate of increase annual OM&R: 4 percent

- We assumed an even distribution of total project cost between a 2-year period (April 2011 – April 2013) for cost phasing of initial costs.
- Routine Annually Recurring OM&R Costs: Assumed $100,000 per year. One percent of the Total Project Cost did not provide a constant when comparing energy savings versus total project cost.
- We assumed that the building systems maintenance is generally the same for all packages on a level- of-effort basis. This was one of the decision factors in selecting Low Energy Packages. • For the UEPH, non-recurring facility maintenance was not taken into account in the analysis.
- For the TEMF, windows (skylight) were the only system identified to not have a useful life for the entire analysis period. Cost equals material plus installation ($62,120.02).

The LCCA results show the dependency on building type and location. Not all buildings will have the same payback period because they have different EUIs and vary in how much electricity versus gas is consumed. Building locations will also factor into the LCCA because energy savings differ for each climate zone. In addition, utility rates play a big part because some locations have a much lower utility rate based on how the energy is generated in each particular region. The LCCA results (Table 5.48 through Table 5.51) show that three of the four buildings that were analyzed had various Low Energy Package options with net present values (NPVs) that were less than the baseline building alternative NPV. The TEMF at Fort Carson (climate zone 5B) was the only building where the NPV was not less than the baseline alternative. One reason for this is that the cost of the passive house insulation ($249,350) was about a third of the overall cost increase for the four low-energy alternatives. Design teams are encouraged to analyze each building in each climate zone to fine-tune the EEMs and find the right balance between energy savings and cost effectiveness.

Meeting HPSB legal requirements/targets

- All bldg types meet 30% better than ASHRAE 90.1 2007
- With regards to ASHRAE 189.1, there is a high level of confidence from this study that the five building types would meet or exceed the goal of ASHRAE 189.1 to achieve a 30 percent reduction in energy use compared to an ASHRAE 90.1-2007 building including plug loads
- Some facility types in certain regions will never achieve the 65 percent energy target through energy efficiency measures alone
- DOE change in EISA interpretation from energy at site to energy at source resulted in three outcomes:[5]
    - Fewer bldgs meeting targets in climate zones
    - Shift to all electric appliances/equipment to minimize future retrofits from gas/oil
    - Facilities reduced energy use on site to account for increased impacts of source energy use
- CBECS building categories and their related EUIs are not directly comparable to the five Army building types that were analyzed. This directly affects whether a building meets or falls short of the EISA 2007 targets for 2015. Annual target EUI for each climate zone was determined from the CBECS data and compared to the Corps baseline EUI for the designed building. The target EUI is 35 percent of the CBECS values, or a 65 percent increase in efficiency, which is a very aggressive target from the EISA 2007 legislation (see Sec 5.1).
- 5.6.1 ASHRAE 189.1 This was not a study of ASHRAE 189.1 and the recent Army policy requiring compliance with ASHRAE 189.1 was not in effect when this study

[5] Recommendations on alternative means to calculate EISA fossil fuel reduction implementation p.7

began. Therefore, this is not a comprehensive analysis, rather it is intended to "red flag" sections of ASHRAE 189.1 that may need further evaluation during the design of these buildings; e.g., some of the sections of ASHRAE 189.1 can only be evaluated based on the building site. However, in terms of ASHRAE 189.1, there is a high level of confidence from this study that using the measures described above the five building types would meet or exceed the ASHRAE 90.1-2007 energy goal of a 30 percent reduction in energy use. It is important to note that there are examples where this study exceeded the prescriptive values found in ASHRAE 189.1, such as improved insulation levels, a lower air infiltration rate, greater HVAC equipment efficiencies, and lighting concepts and strategies that exceeded the minimum requirements of the ASHRAE standard

Work Practices

- Fully integrated design is a requirement and not an option with high-efficiency buildings. All subject matter experts, including the commissioning agent and O&M staff, need to be involved from the earliest stages of the project. If this is not done, much time is wasted passing the design back forth for changes and systems, particularly HVAC systems, are not designed to their maximum efficiency to work with exterior insulation levels, roofing materials, etc. Recommendation: In cooperation with the COSs, develop guidance about how to achieve a truly integrated design regardless of building type.

- Procurement – – Procure only top-tier ENERGY STAR® appliances and equipment or appliances and equipment that can be shown to be in the top 10 percent in terms of energy efficiency where an ENERGY STAR labeling program is unavailable.
    - Develop industry partnerships for specific technologies and products to ensure availability and lower cost over time. When it is determined that technologies need further development/improvement, the Army should work with industry directly to make the changes so improved or new products can be brought to market by leveraging the buying power of all of the armed services

- O&M staff must be properly trained on new systems and technologies or high-efficiency buildings will quickly become less efficient or worse than buildings constructed in the past.

- Enhanced commissioning is important to ensure that design, installation, and startup of systems are done correctly and measurement and verification (M&V) are important to verify modeling results…. Enhanced commissioning needs to be fully incorporated into the design phase of MILCON projects which has not been done routinely in the past. This will require a reexamination of the current strategy of waiting until after the RFP is awarded before a commissioning agent is designated.

- Educate everyone to have a uniform goal. Education must be provided to USACE COSs, Army Installations staff, general contractors, architects and engineers (A&Es), and trades on new features, technologies, systems, and approaches.

- Cost optimization needs to be completed for all energy models that were a part of this study and should ideally be completed at the early stages of a project. It is important to complete it early so that the highest energy and cost efficiencies can be determined.

Portfolio considerations

- There is no single, “silver bullet” answer for these buildings. Climate zone, building site conditions, and other factors play major roles in building performance.

  - o While this study focused on passive house approaches and technologies, these should not be the prescribed path for the design team to take when it comes to incorporating measures into standard designs. For example, climate zone 1A may not be found to be appropriate for passive house insulation levels may be slightly relaxed but stringent air tightness and a DOAS system must be applied to ensure moisture/humidity control. Climate zone 5A may achieve much better results. Another example, it may not be optimal to design triple-pane windows on all four walls of a building…

    - o It is expected that for some buildings in some climate zones, current practices or current practices with relatively few changes, will result in achieving the performance targets. In other buildings and climate zones, real innovation will be needed to achieve the same results.

  - In the future, to meet ever more stringent energy targets on the path to net zero energy, buildings will need to be: grouped together to take advantage of larger, more energy efficient technologies. This will allow for the sharing of resources between buildings, e.g., waste heat in a cogeneration facility. – combined into one building for multiple life/work purposes (e.g., UEPH on the upper floors, DFAC on the main floor of a barracks complex, and a COF either on the first floor or in the basement of the barracks complex).

  - Energy costs vary by season and region and the DoD could take advantage of cost effective renewable energy technology during peak demand periods, avoiding the most expensive fossil fuel based resources and their associated environmental externalities.

    - o Lessons learned from operators of large portfolios of buildings with similar use to the DOD could offer some very practical and cost effective insights into the payback of various options within specific regions. Many large real estate firms that have taken over BRAC and other facilities and transformed them into profitable and energy efficient installations should be consulted and site visits conducted to see how this “reuse” has progressed and why landowners elected to invest in different building improvements to achieve their financial and other ownership objectives.

  - Reducing the plug loads to a level that would achieve the EISA 2007 target for 2015 fossil fuel energy reduction would require a reevaluation of mission and quality of life requirements for some standard designs, for example: – UEPH – Prescribe the types of electronic equipment that soldiers can put in their modules, e.g., light-emitting diode (LED) TVs only of a maximum size—no plasma TVs, LED computer screens only, limit kitchen appliances to a microwave, centralized laundry facilities—no in- module facilities, two-person modules versus one person.

    - o Bde HQ – Procure only LED computer screens, limit the number per person, procure only top-tier ENERGY STAR® central processing units, laptops, and related/support equipment, mandate and enforce a low maximum wattage usage per person. – DFAC – Change the menu to eliminate or minimize the need for high-energy-usage kitchen appliances and equipment. Extend the meal periods over a longer period of time to reduce the peak demand loads currently needed by kitchen appliances and equipment.

- o Determine which technologies need further development/improvement then work with industry directly to make the changes so improved or new products can be brought to market and leverage the buying power of all of the armed services.

- Occupant behavior needs to change. Whether it is turning off lights when not in use, properly using of operable windows, or not blocking HVAC vents, occupants determine the ultimate efficiency of a building. Changing these behavior patterns through education and training is essential to the long- term goal of having a net zero installation.

DETAILED NOTES ON EEMs ANALYSIS & FINDING FOLLOWS

4.1.1 HVAC

The general HVAC strategy for Army buildings was to provide high-efficiency HVAC systems which offset the sensible heating and cooling loads in the spaces and to provide separate high-efficiency dedicated outdoor air systems (DOASs), which includes a Total Energy Recovery (TER) exhaust air system to handle the ventilation requirements and the latent (moisture) load in the spaces. The outdoor air ventilation quantity provided by the DOAS should maintain the building, including the hallways, at a slightly positive pressure relative to outside to eliminate uncontrolled infiltration into the building. High efficiency, variable-speed pumps and fans should be used throughout the HVAC system. High-efficiency boilers and chillers should be used in all cases. Although HVAC strategies vary somewhat from building to building, the following lists some common examples of energy efficient options that were considered:

- DOAS with condenser reheat and individual room fan coils for soldier comfort
- advanced HVAC systems; DOAS for ventilation, pressurization and make-up air, with condenser heat recovery and Energy Recovery Ventilators, both sensible and total
- central exhaust that is used for heat recovery to pre-condition the ventilation air with Energy
- Recovery, sensible and total recovery at 80 percent
- High Efficiency Air Cooled Chiller package, COP from 2.87 to 4.4
- condensing boilers, 80 percent to 95 percent efficient
- variable and high-efficiency fans and pumps.
- radiant heating and cooling in the ceilings
- ground-source heat pump (GSHP).

4.1.2.1 Passive Haus

While the current advanced buildings practice in the United States is based on ASHRAE 90.1 (2010) and ASHRAE 189.1 (2010), the most rigorous standards for building energy efficiency resulting in ultralow energy buildings are the German Passivhaus standards. Typical passive house characteristics for central European locations include the following:

- • Airtight building shell ≤0.6 ACH @ 50 Pa pressure difference (~0.11 cfm/ft2 of the building envelope area at 75 Pa pressure difference) measured by a blower-door test.
- Annual heat requirement ≤15 kWh/m2 /year (<4.75 kBtu/ft2 /yr)
- Primary Energy ≤120 kWh/m2 /yr (38.1 kBtu/ ft2 /yr)
- Window u-value ≤0.8 W/m2 /K (0.14 Btu/hr/ft2 /°F)
- Ventilation system with heat recovery with ≥75 percent efficiency and low electric consumption @ 0.45 Wh/m3

- Thermal Bridge Free Construction ≤0.01 W/mK.

In addition to energy conservation, improved building insulation and airtightness result in a more stable room temperature between day and night, higher internal wall surface temperature in winter, and lower component internal wall temperature in summer, which improves occupant thermal comfort. Higher wall temperature in winter reduces the risk that mold or mildew may occur on the internal wall surfaces and improves the quality of life in a building.

4.1.2.2 Insulation

Recommended building insulation levels follow the passive house standard, which are noted in Table 4.1 Overhead door insulation levels were also increased to R-4 ft2 ·hr·ºF/Btu.

Table 4.1 Insulation Requirements (R-values) In order from most stringent to least stringent

4.1.2.3 Windows

Efficient blast-resistant window options listed in

By using high-efficiency windows with heat-conserving glazing, it is possible to achieve low U-values with two low emissivity coatings and filled with either krypton or argon gas. In addition, the glazing has “warm edge” insulating glass spacers along with thermal breaks throughout the framing. This means that the surface temperature of the glass inside the room is comparable with the air temperature of the room itself. The amount of total solar gain with triple-glazed windows can be as high as 60 percent, depending on glazing and gas-filling. This requires the window frame to incorporate insulation and triple glazing. Ideally, thermal bridging ideally needs to be eliminated. The Army also has a security requirement for blast-resistant windows that needs to be accounted for when the window is selected.

Table 4.2 by climate zone are recommended based on the climate-specific considerations with a low solar heat gain coefficient (SHGC) for warm climates and a higher value in cold climates. Table 4.2 lists requirements for window characteristics in different climate conditions resulting from this study compared to current Army requirements as well as requirements from ASHRAE 90.1 (2010, 2007), ASHRAE 189.1, and the ASHRAE Advanced Energy Guides. ERDC/CERL staff are researching triple-pane glass manufacturers who would have products that meet both current AT/FP blast-resistant and passive house requirements.

Table 4.2 Window Characteristics by Climate Zone (Units are US IP)

4.1.2. 4 Infiltration

Vestibules help reduce the infiltration losses (or gains) from wind and stack effect by creating an air lock entry

4.1.2.5 Lighting

Interior: The analysis focused on efficient lighting design and was based on an example of the control strategies in Table 4.4. The complete Atelier Ten report is found in Appendix F. Lighting efficiency measures include lighting power density reductions with control strategies for each zone. Plug load power densities were assumed to be the same in all building models… The lighting power density for Bde HQ was assumed to be the same as for a typical office building. For the baseline model, the lighting power density of 0.9 W/ft2 was used. This value came from Savannah District for their standard for the Bde HQ. For the efficient model, the advanced lighting design specifications were supplied by Atelier Ten. When the spaces are averaged together, an overall value of 0.7 W/ft2 is derived.

Table 4.4 UEPH Lighting Design by Atelier Ten

Table 4.5 TEMF Lighting Design by Atelier Ten.

Tables for other building types found in 4.1.5.2 Appendix F

Exterior: Light-emitting diode (LED) parking area lights were recommended to be substituted for what had been the standard exterior lighting for the five building types. However, exterior lighting was not modeled. Exterior lighting studies in recent years have showcased the use and advantages of LED lighting in terms of long-term energy savings and O&M cost due to their longer life cycles. Based on this information, the decision was made to include them in the cost estimation for each building type. "

4.1.6. Onsite Renewable Energy

4.1.6.1 Transpired Solar Collectors: A transpired solar collector (TSC) preheats ventilation air by drawing make-up air through perforated steel or aluminum cladding that is warmed by solar radiation…TSCs provide a cost-effective and energy efficient solution for preheating ventilation air, and have been recommended for buildings located in climate zones 2A to 8A. Energy savings are most significant in climate zones 3A to 7A, and the technology works particularly well for the COF and TEMF building types that have spaces of large volume that only require minimally conditioned ventilation air.

4.1.6.2 Solar Water Heating

The "Sustainable Design and Development Policy Update," dated October 27, 2010 from the Assistant Secretary of the Army – Installations, Energy, and Environment, mandates that beginning in FY13 "all new construction projects with an average daily non-industrial hot water requirement of 50 gallons or more, and located in an area shown on the NREL solar radiation maps (http://www.nrel.gov/gis/solar.html) as receiving an annual average of 4 kWh/m2/day or more will be designed to provide a minimum of 30 percent of the facility's hot water demand by solar water heating…For this study, solar hot water was deemed feasible for UEPH, but based on the 30 percent renewable energy requirement; the TEMF and DFAC may also be candidates for solar hot water that is life-cycle cost effective. Energy savings were modeled and part of the cost estimates for those building types.

4.1.7 Plug Loads

…plug loads are a major source of energy usage, particularly in the UEPH, Bde HQ, and DFAC. Reducing the plug loads in these building types may be the only way to meet EISA 2007 requirements. For example, in UEPH, the fraction of the total power consumed by plug loads increased from 29 percent in the baseline model to 43 percent in the low-energy model. This would be indicative of all buildings where the overall energy usage is reduced without reducing the plug loads. The potential EEMs common to the five building types are as follows:

- Use high-efficiency LED computer monitors.
- Replace all desktop computers (100 W each) with laptop computers (30 W each).
- Change computer power settings to "standby when idle for 15 minutes."
- Implement the use of standby switching devices. "
- Eliminate personal printers, copiers, fax machines, and scanners. Replace them with one or two multi-function print stations.
- If vending machines are in the building, use a load-managing device and de-lamp them.

- Turn miscellaneous electronics off when they are not being used or during unoccupied hours. • Investigate more efficient task lighting, such as LED task lighting per work station.

All plug load appliances and equipment are not created equal in terms of energy usage. A prioritized list should be developed that results in the greatest energy savings for least cost increase. "

- For the office spaces baseline model the plug loads were supplied by the Savannah District COS for their standard design averaged at 1.7 W/ft2. Using ENERGY STAR® equipment reduces the office plug loads to 1.35 W/ft2. Further equipment reductions were made in office spaces using Consortium for Energy Efficiency (CEE) Tier 3 equipment reduced the office plug loads to 1.20 W/ft2 for the final efficient model. The CEE Tier 1 is aligned with the ENERGY STAR® specification and represents performance that will realize energy savings and greenhouse gas reductions on a national basis. CEE Tier 2 and Tier 3 help distinguish equipment that is super-efficient and are often the basis for building-critical levels of demand reduction using these higher performing products.
- The data center loads were simulated at 5.3 W/ft2. The data center loads were not reduced for the efficient model due to lack of information for currently available advanced data center equipment."

- Based upon the current kitchen design, best-in-class high-efficiency gas and electric kitchen equipment was recommended, along with two alternative choices. The use of high-efficiency equipment also reduces exhaust and make-up air requirements, especially when paired with proper exhaust hood design, layout, and flow controls that are part of the ventilation system. Going a step further, an all-electric kitchen equipment design was considered. The all-electric scenario also positions the facility to be able to operate using 100 percent renewable energy as opposed to having to convert gas appliances and equipment at a later date and increased cost. ***Plug loads are found in Table E.2 in Appendix E.***

4.2 Water

4.2.1 Interior Potable
These include high-efficiency toilets (HETs), dual-flush toilets, composting toilets, low-flow lavatories, low-flow showers, and low-flow kitchen sinks. …Various assumptions were made with regard to occupancy, flow rates, and daily usage in order to compute the overall annual volume of water consumption. The baseline calculations use conventional fixtures. Conventional fixture flow rates were based on the values from the 2009 LEED Reference Guide for Green Building Design and Construction (USGBC 2009). The design calculations use various types of low-flow fixtures. Daily uses were based on the 2009 LEED Reference Guide for Building Design and Construction for each occupant type.

4.2.2 Exterior – Non-Potable
No potable water was used for irrigation in conformance with current Army requirements. Stormwater measures that use captured gray water for irrigation and other purposes are described in Section 5.3.1. Reuse of interior potable water potentially for boot washing or other uses was researched and installation of “purple” pipe was part of the buildings’ cost estimates."

4.3 Other Sustainability

4.3.1 Stormwater

Low Impact Development practices fall into three main categories: infiltration, storage and reuse, and evapotranspiration (ET). ET is the process of evaporation, sublimation, and transpiration of water from the earth's surface as summarized ***in Table 4.6."***

Table 4.6 Low Impact Development Techniques "

4.3.2 Enhanced Commissioning

Enhanced commissioning was driven by LEED 2009. The estimate considered the items listed below.

- Prior to the start of the construction documents phase, designate an independent Commissioning Authority (CxA) to lead, review, and oversee the completion of all commissioning process activities.
- The CxA shall conduct two commissioning design reviews of the Owner's Project Requirements (OPR), Basis of Design (BOD), and design documents prior to mid-construction documents phase and back-check the review comments in the subsequent design submission.
- The CxA shall review contractor submittals applicable to systems being commissioned for compliance with the OPR and BOD. This review shall be concurrent with A&E reviews and submitted to the design team and the owner.
- Verify that the requirements for training operating personnel and building occupants are completed.
- Develop a systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems.
- Ensure the involvement by the CxA in reviewing building operation within 10 months after substantial completion with O&M staff and occupants. Include a plan for resolution of outstanding commissioning-related issues. "

4.3.3 Measurement and Verification

[Based on LEED 2009 & ASHRAE 189.1 (more detailed)] Study acknowledged both of these sources and included M&V in the cost estimate for the building types. At the Installations level, IMCOM is currently leading Phase I of a major metering project. During this phase, all buildings that are over 29,000 ft2 or exceed $35,000 a year in utility costs will be required to be metered. Phase II of the program includes development of a Metered Building Energy Conservation Strategy that will capture and manage the resulting data. Metering is expected to be completed by the end of 2012.

4.3.4 Daylighting

[LEED 2009 basis] Techniques and systems related to daylighting include the following:

- use of passive lighting ceiling systems (e.g. light shelves) that "stretch" light into spaces with no direct daylight exposure
- louvers and overhangs (to act as shading devices)
- daylight sensors (to minimize use of powered light fixtures in areas with free light sources)
- daylighting software (to predict and analyze how daylighting will affect the building and when electrical lighting can be dimmed or turned off)
- fiber optics (to act as a hybrid solar lighting system by bringing daylighting into the building via fiber-optic fibers, without requiring large penetrations in the building envelope as a skylight or window would)

TechNotes are available for daylight sensors and light shelves (see Section 5.6.2), and the Atelier Ten Lighting Report in Appendix F contains tables with daylighting values for the different building types. "

[Note that DOE ASHRAE advanced energy guides for small retail buildings was used for COF]

5.0 Outputs and Results

5.1.1 UEPH

For the UEPH, the “Dormitory” category was chosen from the CBECS for all comparisons to CBECS data, because it was determined to be the closest match to the UEPH facility. The simulated results for the energy efficient designs including the envelope, infiltration, lighting, equipment, and HVAC energy conservation measures are shown in tables and figures below with the cumulative percent savings compared to the baseline UEPH building (B) EUI for each EEM package (P1–P13). In the tables and figures below, the “Baseline Building” or “B” is the base building model from each of the COS standard designs (baseline building assumptions for each of the five facility types are listed in each building appendix [A–E]). Each EEM or Low Energy Package is applied cumulatively to the baseline B, starting with P1 (e.g., lighting load and electric power load density reduction for UEPH), then P2, P3, and finally P4. Package P4 is considered the improved baseline high-performance or low-energy package for each building and is called “Low Energy Package 1.” Then, EEMs 5–13 are applied individually or in combination to P4 to compare the different HVAC alternatives. The results for each building are shown for both site and source. The source results are necessary for EISA 2007 compliance. The site results are necessary for all site energy reduction mandates, including EPAct 2005.

Packages P5, P8–11 appear to achieve the best results based on the energy modeling information, because they show the highest energy savings percentages.

- B Baseline Energy Budget
- P1 Lighting Load and Electric Power Load Density Reduction from 1.67 W/ft^2 to 0.835 W/ft^2 applied to B
- P2Passiv haus insulation specification; increased insulation and air tightness, reduce OA pressurization air to 65CFM due to air tightness with P1-B
- P3 Increase chiller and boiler efficiencies and all variable high efficiency pumps and fans with P2-B
- P4 Reduce hot water with 1.5gpm shower heads with P3-B +
-
- P5 Energy recovery ventilation (ERV) with P4
- P8 ERV and radiant with P4
- P11 Ground source heat pump (GSHP) and ERV with P4 *(Note: not selected in final package)*

After reviewing the data with the COSs and cost estimators, packages 5, 8 and 11 were selected in addition to the baseline Low Energy Package 4 for full cost estimates. These selections were made based on possible issues with maintenance of newer technologies and a high first cost or lack of availability of systems to be supplied by three or more vendors…
As can be seen from Figure 5.1 below, the initial EEMs show good source energy improvement and the selected packages for closer evaluation are indicated (P5, P8, and P11). Even with all of these technologies applied the targets could not be achieved, and only when internal loads are reduced further do we start seeing further improvements. Another interesting result is that when source fuels are calculated, the savings from GSHPs (P11) are not as good as expected because most of the advantages are negated when the source fuels for electricity generation are considered. In other words, GSHPs inherently need electricity to operate, and a large percentage of the electricity generation in the United States is from fossil-fuel-based power plants.

Table 5.1 Site Energy Use Intensities (EUIs) for Each Energy Efficiency Measure (EEM) Package. (Package 4 [P4], circled in red, is considered the improved baseline low-energy building.)
Table 5.2 Source EUI for Each EEM Package. (P4, circled in red, is considered the baseline low energy building.)
Table 5.32 shows the incremental percent savings for each as it is added to the previous package

In addition to the energy packages that were evaluated, 30 percent of the hot water demand was supplied with solar hot water heaters. Table 5.4 below shows the site energy savings results with the solar hot water added to the Low Energy Packages that were evaluated for the UEPH facility. For simplification purposes, P4, P5, P8, and P11 are renamed Low Energy Package 1–4 in the tables that follow. "
Table 5.4 Description of Low Energy Packages for the UEPH
Table 5.5 UEPH Cumulative Site Energy Savings of Each Low Energy Package with 30% Solar Domestic Hot Water Heating Added as Compared to the Baseline EUI "

Low Energy Package 3 was selected as the lowest energy and most cost-effective package (see Section 5.5 for LCCA analysis results). Note that the UEPH Low Energy Package 3 does not reduce fossil fuel-generated energy consumption in any climate zone sufficiently to meet the EISA 2007 fossil fuel-generated energy reduction goal of 65 percent. "

To investigate further how to reach the EISA 2007 targets, Figure 5.2 below plots the same results as Table 5.6, but also includes the breakdown of the components that make up the total building energy consumption. Although improvements have been made with the low-energy model toward meeting the EISA 2007 goals, this breakdown shows that without considering further internal load reduction, the EISA 2007 targets cannot be met. Even buildings with low internal energy loads can end up being dominated by internal loads when built or retrofitted to passive house requirements and using advanced “low-energy” systems to satisfy remaining heating and cooling needs. The remaining energy requirements will be dominated by electrical power needs for lighting, appliances, and internal processes, and by domestic hot water needs or the “mission” of the building.

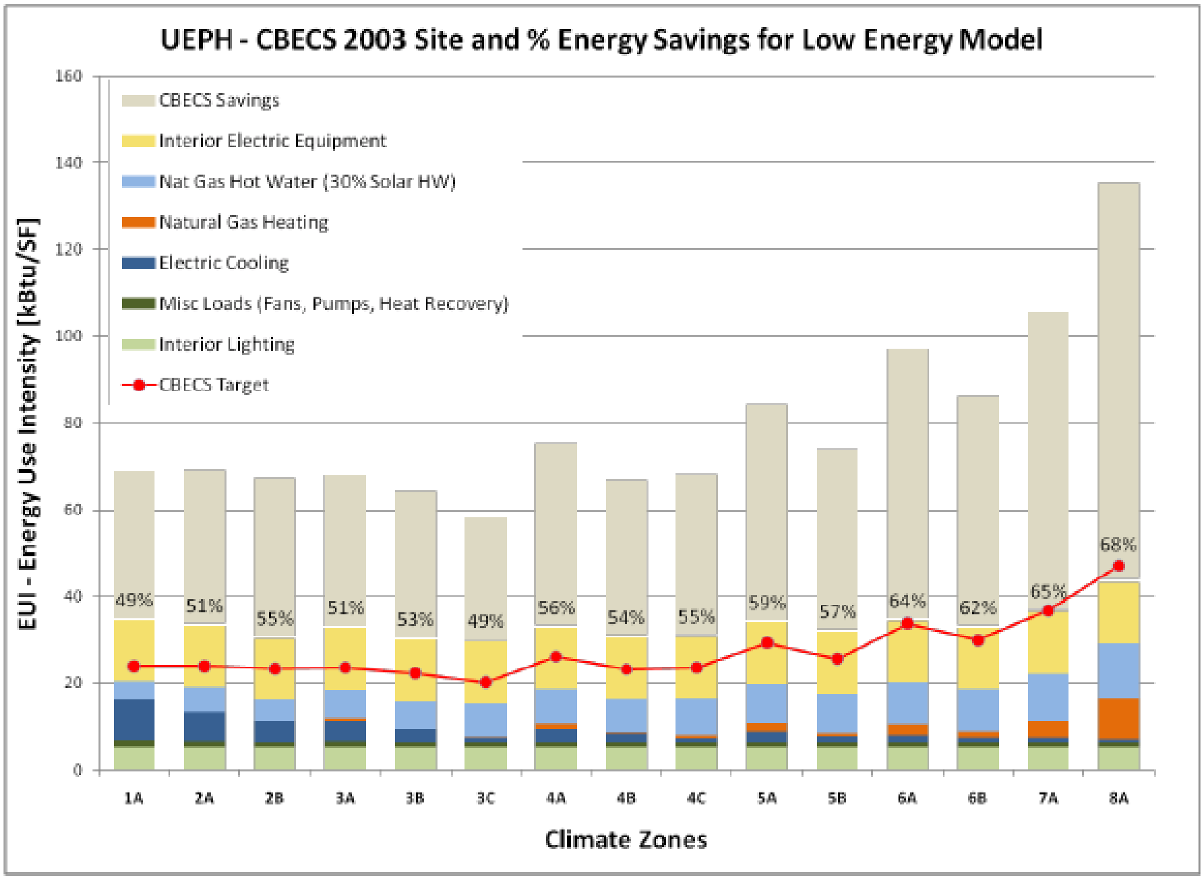

Figure 5.2 UEPH Percent Low Energy Package 3 with Comparison to EISA 2007 Targets (Site Energy)

Table 5.8 breaks down the site baseline building component energy for the UEPH by climate zone and shows that the interior lights, interior equipment/plug loads, and natural gas hot water make up from 50 percent to 86 percent of the load, varying by climate zone.

Table 5.9 shows that even after the improved lighting design, reducing hot water consumption with low-flow shower heads and improving the interior equipment/plug loads by almost 50 percent , a significant percentage of interior equipment/plug load remains. With EISA 2007, total energy is now considered. This is unlike EPACT 2005, Section 109, where the plug loads were considered unregulated. Now they are a significant part of the challenge posed by EISA 2007 requiremen "

Figure 5.3 further illustrates the point of how much the interior equipment/plug load percentage increases from the baseline building to the low-energy building in climate zone 4A. "

5.1.2 TEMF

Three iterations of Low Energy Packages followed, exploring the effects of adding TSCs to the south façade of the building, radiant floors in f Low Energy Packages followed, exploring the effects of adding TSCs to the south façade of the building, radiant floors in the repair bays and vehicle corridor, and a combination of both. Economizers were not modeled because the air handling units (AHUs) for the repair bays are dedicated to bringing 100 percent outside air and only minimally condition the air to 55 °F. A description of the four packages is found in Table 5.10 below in the repair bays and vehicle corridor, and a combination of both. Economizers were not modeled because the air handling units (AHUs) for the repair bays are dedicated to bringing 100 percent outside air and only minimally condition the air to 55 °F. A description of the four packages is found in Table 5.10 b"

Package effectiveness varies by climate zone
2 for 1A
3 for 1B to 3C
4 for 4A to 8A
Table 5.10 Description of Low Energy Packages for the TEMF

The highlighted packages in Table 5.12 were chosen as recommended low-energy packages for each climate zone. The recommendations were based upon the level of energy savings and a rough assumption on cost for TSCs and radiant floors. Achieving the highest amount of energy savings was the goal for this project. However, for climate zones 4A through 7A, the decision to install radiant floors along with TSCs was made to increase occupant comfort in the repair bays and vehicle corridor, even though the option shows slightly lower energy savings when compared to Low Energy Package 2. It is also important to note that passive house insulation levels are not recommended for all climate zones. Climate zones 1A though 2B and 3C did not show significant savings from the specified passive house insulation levels, and thus the measure was excluded from the respective low-energy model packages. However, it is recommended that that a more detailed analysis investigating insulation levels, cost, and energy savings be conducted to fine-tune and optimize the level of insulation needed for each climate zone.

Reduced lighting power density, increased daylighting, control strategies for lighting and daylighting, and passive house insulation levels were recommended for each climate zone. High-efficiency HVAC equipment and VAV fans were also recommended for each climate zone, as well as “cool roof” construction for climate zones 1A through 3B.

5.1.3 COF

For the readiness bays alone, energy recovery ventilators were recommended for climate zones 1A, 2A, 3A, and 3C to 4B. DOASs, energy recovery ventilators and fan coils were recommended for climate zones 2B and 3B, and indirect evaporative cooling was recommended for climate zones 4C to 8A. Lastly, an alternative construction design was also explored for the readiness bays, which reduced the volume of conditioned air in each module. Energy savings from this efficiency measure was significant, ranging between 16 percent and 34 percent for the readiness bays alone. However, a drastic change in the design of these modules may conflict with current Army regulations on building form and geometry, and it is recommended that this efficiency measure be examined in more depth.

The baseline building envelope features were modeled as steel frame wall construction, roof insulation entirely above deck, and door and fenestration types from ASHRAE 90.1-2007.

None of the 15 climate zones reaches or is within 5 percent of the CBECS targets

Table 5.15 Description of Low Energy Packages for the COF

5.1.4 Bde HQ

Annual site energy EUI for each climate zone was determined from the CBECS data and compared to the baseline EUI for the designed building. This theoretical study was designed to give guidance on the direction and limitations for this building type. It showed that the internal loads are very important to address and will limit the building designer's ability to meet the EISA 2007 requirements. The source of the fuels to produce the energy is also very important and ultimately will need a mix of efficient generation.

Addition of the passive house insulation package and airtightness specifications reduces the loads on the HVAC systems and reduces the impact for the type of system selected. Therefore, the HVAC system can be selected using multiple criteria with energy efficiency gains along with ease of O&M and installation preference."

None of the 15 climate zones reaches or is within 5 percent of the CBECS targets
Table 5.26 Description of Low Energy Packages for the Brigade Headquarters (Bde HQ)

Cannot meet EISA 2007 with any packages due to high plug load demand - no climate zone within 5% CBECs targets

1.5 DFAC

Reduced lighting power density, daylighting, and control strategies for both lighting and daylighting were recommended for each climate zone, along with passive house insulation for climate zones 4A through 8A. Efficiency upgrades in the HVAC system were also recommended, as well as a number of EEMs associated with the kitchen equipment. A set of best-in-class, high-efficiency kitchen equipment upgrades were paired with exhaust hood design and control options to reduce cooking, fan, and HVAC energy…ventilation (DCV) on the make-up air units (MAUs) were also explored, as well as an all-electric kitchen equipment option

Table 5.29 Summary of Low Energy Packages for the DFAC

5.3 Water Savings

The TEMF includes specialty equipment that contributes to the overall water consumption that was not accounted for in the water conservation analysis. For the COF, the toilets are the largest consumers of water. Water usage of toilets is dramatically reduced by using water-conserving fixtures. Like most office buildings, a Bde HQ consumes a minimal amount of domestic hot water. Hot water consumption was assumed to be 1.0 gal/person/day. The usage profile was taken from a typical office building schedule. The hot water supply temperature was set at 140 ºF with a mixed water temperature at the tap of 105ºF. The domestic water heating system in the baseline building models uses an 80 percent efficient boiler and the energy efficient models use a 95 percent efficient boiler. Figure 5.5 through Figure 5.7 summarize the comparison between the baseline design and the three proposed water savings options for the TEMF, COF, and Bde HQ.

Although kitchen equipment in the DFAC consumes the majority of the water, only flush and flow fixtures were addressed in the water-reduction calculations. It is assumed that with the high-efficiency equipment in the Low Energy Packages there will be water savings in addition to the savings that were calculated. Figure 5.8 below summarizes a comparison of the baseline design and three design options.

Table 5.41 Summary of Annual Water Consumption Volumes for UEPH, TEMF, COF, Bde HQ, UEPH Baseline and DFAC "

Page 109, Highlight (Yellow):
Content: "The analysis showed that significant energy savings are possible for all climates. However, it is very difficult to reach the EISA 2007 target for the 2015 goal of 65 percent fossil fuel reduction with building- specific efficiency measures alone. The extent of energy savings achieved is site- and facility-specific. Additional savings may be achievable, but the current study shows the energy savings picture as follows: • 25 to 35 percent energy savings: The building yields the maximum energy savings for the lowest cost • 35 to 60 percent energy savings: Each increment of energy saved comes at an increasingly higher cost (plug load reduction, small scale renewable energy, building orientation, site specific design) • Above 60 percent: May be cost prohibitive without looking beyond the building (significant plug load reduction, clustering, renewable energy, cogeneration, etc.) • Some facility types in certain regions will never achieve the 65 percent energy target through energy efficiency measures alone "

Tools developed

- TechNotes brief summaries of new technologies, were developed and posted to the Whole Building Design Guide website on WBDG for 19 technologies (http://mrsi.usace.army.mil/cos/TechNotes/Forms/AllItems.aspx) Each TechNote includes a description of the technology or design strategy, potential specific products, a summary of the requirements the strategy could affect, supplemental specification language or resources, and a case study emphasizing the technology
    - o Heat Island Roof - HVAC – Desiccant HVAC – Overhead Radiant Heating – Radiant Floor Heating – Commercial – Radiant Floor Heating and Cooling – Residential – Ground Source Heat Pumps • Renewables – Solar Collector Wall – Solar Hot Water • Water – Dual Flush Toilets – High Efficiency Toilets – Low-Flow Showerheads – Ultra Low Flow Faucets • Lighting – LED – Parking Lot – Light Pollution Reduction • Daylighting – Dimming Photosensor – Light Shelf – Light Tubes – Sunlight Tracking - Miscellaneous – Appliances – Enhanced Commissioning – Heat Island – Roof – Permeable Pavement – Reflective Paints 80 Another 20 TechNotes will be added to this page once their initial technical review has been completed. O&M TechNotes for O&M staff and one-page summary TechNotes for building occupants will also be developed.

  Additional feedback on the technical content and/or requests for additional topics for new TechNotes should be sent to Daniel.Carpio@usace.army.mil.

- Excel table mapping current requirements to LEED 2009: reviewed current mandates, policies, and standards and compared them to LEED 2009 to illustrate potentially attainable levels
    - o Energy Policy Act of 2005 (EPACT) • Energy Independence and Security Act of 2007 (EISA) • Executive Order (EO) 13423 • EO 13514 • High Performance and Sustainable Buildings Guiding Principles (HPSB GP) Final (dated 12/1/08) • Army Memorandum: Sustainable Design and Development Policy Update (SDD Policy, dated 10/27/10) • Other policies and mandates, including Unified Facilities Criteria (UFC), Unified Facilities Guide Specifications (UFGS), and U.S.

Codes of Federal Regulations (CFRs) • Army Engineering and Construction Bulletins (ECBs) • ASHRAE 189.1

- Mapping for the measures evaluated in this study and their compliance with ASHRAE 189.1(energy)

- Lighting Design Guide Appendix F

- Succinct summary table of regulatory drivers for building level sustainable design p.9; Table 2.3 Additional Regulatory Drivers for Sustainable Design "
    - o Army policy additions to basic federal requirements: the Army has clarified its expectations for building design in the Army Sustainable Design and Development Policy Update (Environmental and Energy Performance, October 27, 2010). In summary, the additional requirements provided in the policy include the following: • All new construction will follow the guidance in ASHRAE 189.1

- Central Solar Water Heating Systems – Design Guide (draft available from ERDC/CERL) is the first attempt to develop recommendations for optimal and reliable configurations of solar water heating systems in different climates along with design specifications, planning principles, and guidelines for such systems serving building clusters with significant usage of domestic hot water (DHW) operating in combination with central heating system"

- ERDC-CERL researchers, in collaboration with Architekturbüro Zielke Passivhäuser and Passivhaus Institut, have developed an interpretation of passive house characteristics of the building envelope to be applied to U.S. construction specifics and all 15 DOE climate zones (see Table 1.1)
    - o While the current advanced buildings practice in the United States is based on ASHRAE 90.1 (2010) and ASHRAE 189.1 (2010), the most rigorous standards for building energy efficiency resulting in ultra- low energy buildings are the German Passivhaus standards. Typical passive house characteristics for central European locations include the following: • Airtight building shell ≤0.6 ACH @ 50 Pa pressure difference (~0.11 cfm/ft2 of the building envelope area at 75 Pa pressure difference) measured by a blower-door test. • Annual heat requirement ≤15 kWh/m2/year (<4.75 kBtu/ft2/yr) • Primary Energy ≤120 kWh/m2/yr (38.1 kBtu/ ft2/yr) • Window u-value ≤0.8 W/m2/K (0.14 Btu/hr/ft2/°F) • Ventilation system with heat recovery with ≥75 percent efficiency and low electric consumption @ 0.45 Wh/m3 • Thermal Bridge Free Construction ≤0.01 W/mK. "

Research needs:

- Ventilation requirements of the repair bays –more detailed analysis needs to be completed to determine contaminant sources, contaminant concentration targets, and perceived acceptability targets.

- Process loads for a commercial kitchen are very large and make up a significant portion of HVAC and overall building energy use. Exhaust air requirements are significantly reduced with the use of high-efficiency appliances and by changing the exhaust hood design and control.

- Plug load
    - There is no metered data and very little information about plug load equipment associated with the TEMF.
    - There is very little detailed information about the plug and process loads in COF buildings, and assumptions have to be made in order to include them in the models.

  [Fabulous plugload discussion p. 42]

- Water - more accurate usage data for modeling water use

- Insulation: TEMF- it is recommended that that a more detailed analysis investigating insulation levels, cost, and energy savings be conducted to fine-tune and optimize the level of insulation needed for each climate zone.

Bundling examples
Page 42 "Passive house insulation was recommended for climate zones 4A to 8A. With a tighter envelope construction, infiltration rates were reduced, which contributes to a reduction in heating and cooling loads to the space. Lowered exhaust and make-up air ventilation requirements were also recommended. This was achieved by using high-efficiency or all-electric kitchen equipment and exhaust hood design strategies. With efficient equipment, good hood design and the use of demand-control ventilation strategies, exhaust flow requirements can be significantly reduced. "

See energy packages in section 5