ESTCP Project Outbrief

Design, Monitoring, and Validation of a High Performance Sustainable Building

EW-200724
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EW-200724: Design, Monitoring, and Validation of a High Performance Sustainable Building

Technology

Demonstrate, through measured performance, that the whole building design process using off-the-shelf building materials and technologies would perform better than a similar, traditionally designed building without increasing costs

Demonstration

Apply whole building design process to the CESS high-performance building design and compare the annual energy use, water use, and indoor environmental quality of the CESS with a matched pair

Technical & Economic Performance Results

- Sought: 14 quantitative and qualitative metrics were sought
- Achieved: 10 were successfully met or exceeded

Project Hurdles

- Future construction of high-performance buildings should require that the contractors have prior experience with LEED-certified projects
- Re-calibration of monitoring equipment needs to be communicated when it occurs, as it may impact data analysis

Technology Transfer Outlook

USACE COS incorporated the strategies into 5 popular designs

Performers: Army, PNNL, CERL, Southface, and CH2MHill

Demonstration Site(s): Fort Bragg, NC

Project Team

- Pacific Northwest National Laboratory – Kim Fowler, Will Gorrissen, Dan Skorski, Angela Kora, Janelle Downs
- U.S. Army IMCOM Southeast – Manette Messenger (Retired)
- Fort Bragg – Rob Harris, Ray Barbeau
- CH2MHill – Christy Etter
- Southface Energy Institute – Anne Rogers, Adam West
- Army Construction Engineering Research Laboratory – Annette Stumpf, Richard Schneider
- Savannah District – Catherine Bingham, Gary Poling

Technical Objectives

- Demonstrate that whole building design and off-the-shelf building materials can create better building performance within typical cost ranges.

Fort Bragg Combined Emergency Services Station - CESS

Longstreet Fire Station

Performance Objectives & Results

Performance Objective	Metric	Data Requirements	Success Criteria	Results
Quantitative Objectives—DESIGN				
1. Reduce DESIGN energy consumption (*Energy*)	Modeled energy use as estimated for LEED credit EAc1	Model energy use of final high performance design and compare it to ASHRAE 90.1-2004 theoretical building baseline	50% reduction in BTU/square foot	Achieved energy savings of 34% and energy cost savings of 35% using the ASHRAE Standard 90.1-2004 Appendix G. Received EAc1 credits.
4. Reduce DESIGN potable water consumption for domestic uses (*Water*)	Modeled potable water use as estimated for LEED credit WEc3	Model/estimate domestic water use of final high performance design and compare to EPAct 2005 theoretical building baseline	30% reduction in domestic water use per occupant	Achieved 83% reduction in potable water use over ASHRAE baseline building case. Received WEc3 credit.
6. Reduce DESIGN potable water use for vehicle washing (*Process Water*)	Modeled potable water use for vehicle wash as estimated for LEED credit WEc2	Model/estimate vehicle wash water use of high performance design and compare it to estimate for theoretical building baseline	20% reduction in vehicle wash water use	LEED scorecard verifies 100% reduction in process water use and receipt of WEc2 credit.
8. Reduce construction waste during DESIGN and construction phases (*Waste*)	Reduction of construction waste through recycling as documented through LEED credit MRc2	Provide construction waste recycling documentation	75% of construction waste is recycled	Diverted 55 tons of material from landfill (90.43% recycled) and received LEED credits for MRc2.
Qualitative Objectives–DESIGN				
10. Achieve LEED rating for high performance building (*Whole Building*)	Platinum	LEED documentation	Certification by USGBC as LEED Platinum building	Achieved LEED Platinum certification March 6, 2012.
12. Reduce environmental impact of materials specified in DESIGN	Specify environmentally preferable materials in accordance with LEED credits MRc4, MRc5, MRc6, MRc7, and EQc4	Provide materials use documentation	20% recycled content, 20% regional materials, 2.5% rapidly renewable materials, 50% of wood FSC certified, and low-emitting materials are used	Achieved the criteria for each requirement through design and construction for LEED credits

Performance Objectives & Results

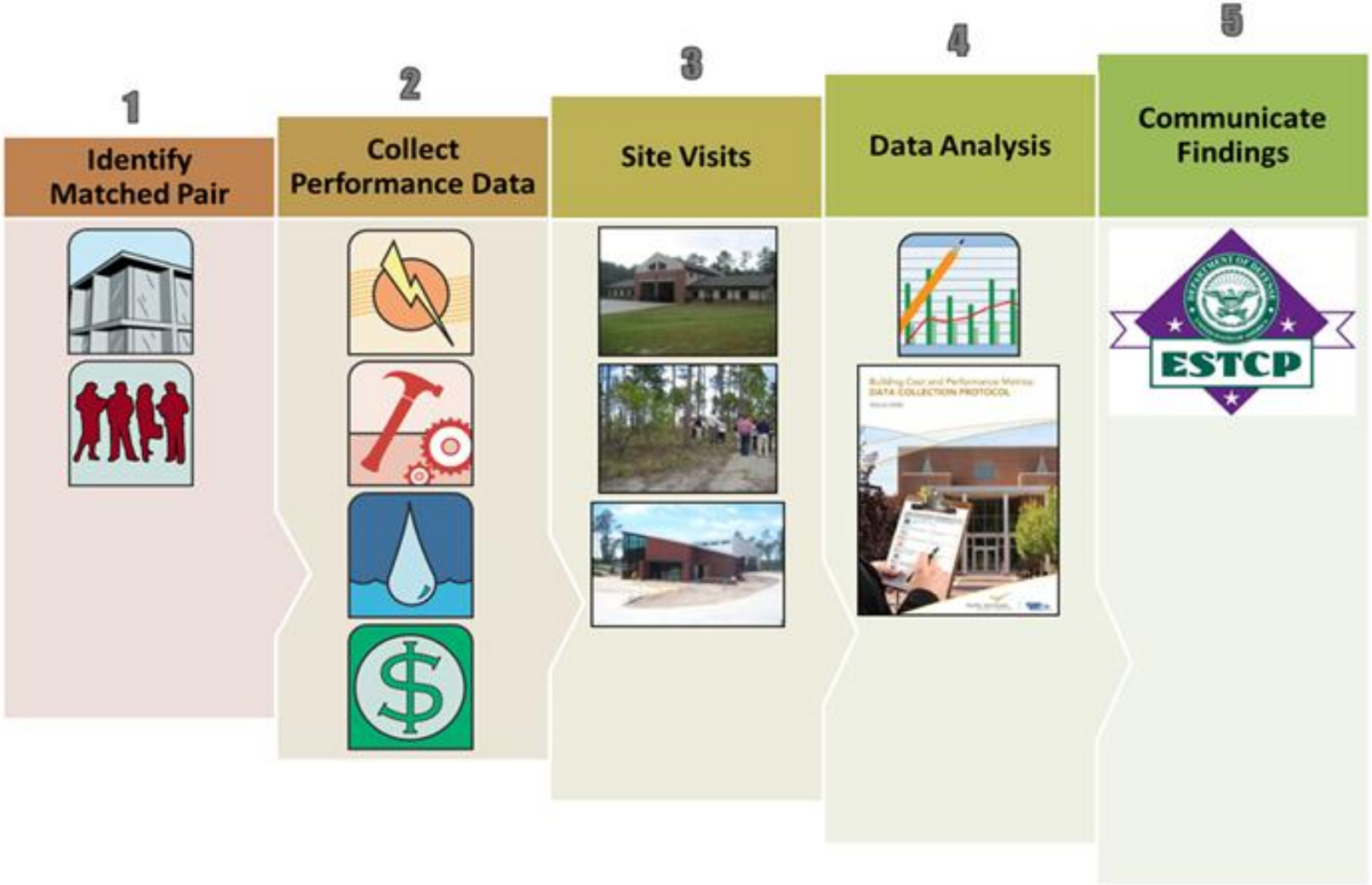
Performance Objective	Metric	Data Requirements	Success Criteria	Results
Quantitative Objectives–MEASURED				
2. Reduce MEASURED facility energy use (*Energy*)	Reduction of building energy use	Energy use of high performance building (CESS) and existing baseline building (Longstreet)	High performance building uses 50% less energy per square foot than existing baseline building	Achieved 21% decrease in energy use/sq ft and 33% decrease in energy use/occupant
3. Reduce MEASURED greenhouse gas footprint (*Energy)*	Reduction of building related greenhouse gas footprint	Analyze building energy use and energy sources for greenhouse impact	Operation of a high performance building results in 25% lower carbon emissions compared to the existing building baseline	Did not achieve reduction over existing baseline building. Longstreet uses natural gas for heating/cooling, which significantly lowers the CO_2 equivalents
5. Reduce MEASURED potable water consumption for domestic uses (*Water*)	Reduction of potable water use for domestic uses	Domestic water use and rainwater capture of high performance building and existing baseline building	High performance building uses 30% less water than existing baseline building	Measured >90% reduction in potable water use, but lack of confidence in values due to metering issues
7. Reduce MEASURED potable water use for vehicle washing (*Process Water*)	Reduction of potable water use for vehicle wash	Vehicle wash water use and rainwater capture of high performance building and existing baseline building	High performance building uses 20% less water than existing baseline building	Based on potable water metering data, CESS used 92% less potable water than Longstreet; The CESS building used 23% less total water (potable + rainwater) than Longstreet for vehicle washing.

Performance Objectives & Results

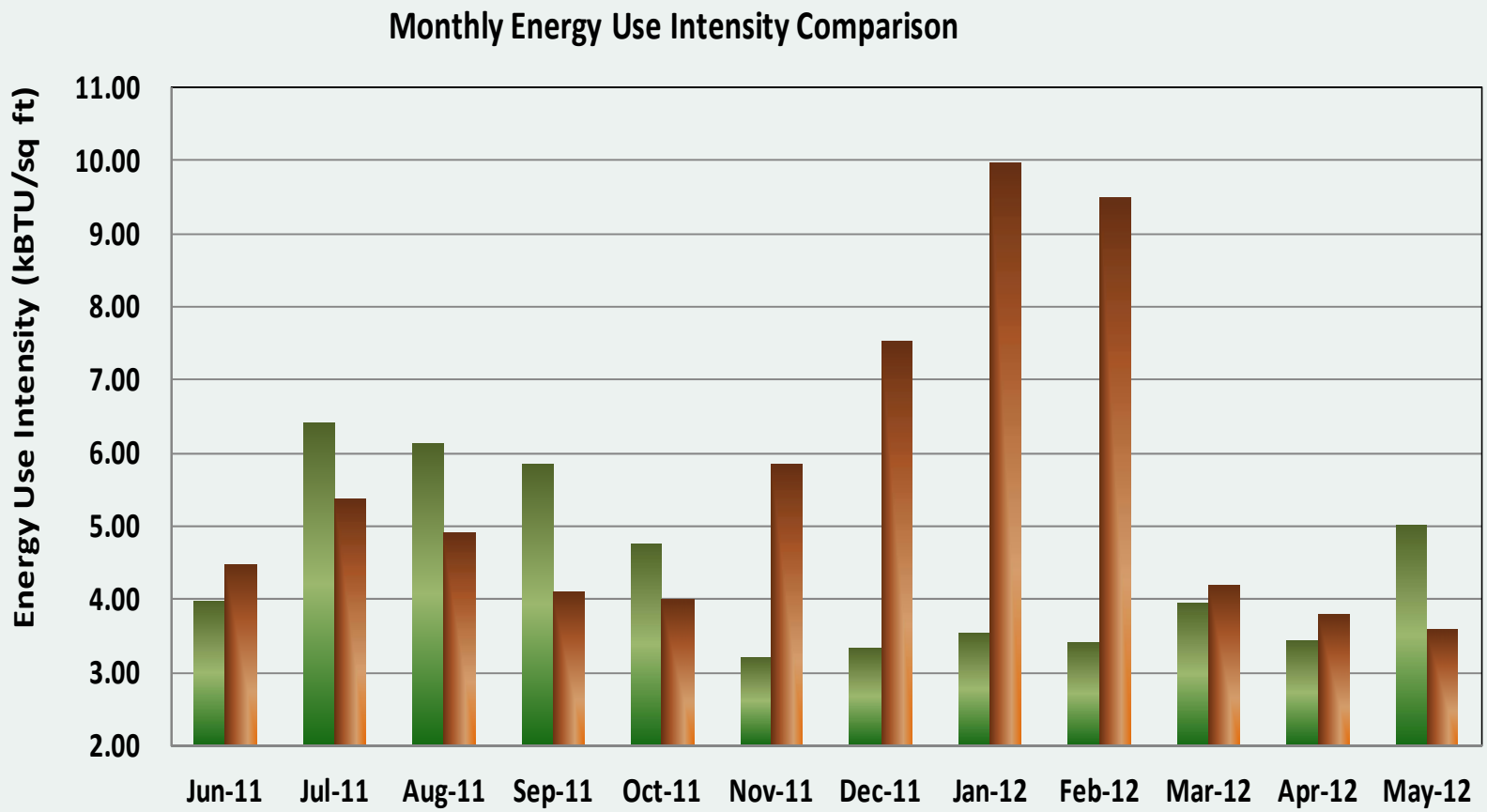
Performance Objective	Metric	Data Requirements	Success Criteria	Results Qualitative Objectives MEASURED
13. Increase MEASURED occupant satisfaction	Interviews with fire chiefs and occupants at each building noted satisfaction on the following - general building - lighting quality - thermal comfort (*IEQ*)	Information from occupants regarding satisfaction with building design components and function	Occupants indicate satisfaction with building performance and features.	Building occupants of both buildings expressed high levels of satisfaction and pride. Positive feedback for: - Daylighting in common spaces and -Lighting control -cooling and heating control when systems functioned properly Negative feedback for: -CESS flooring materials in one room -insufficient training for maintenance staff on integrated systems for HVAC units in CESS
14. Decrease Required Maintenance Actions	Number of routine and repair maintenance visits	Log for each building indicating the date, and maintenance action	CESS high-performance building requires less maintenance than Longstreet Fire Station	23 maintenance calls were logged for CESS versus 34 calls for Longstreet; of those, 57% of CESS maintenance was for repairs, whereas 91% of maintenance calls at Longstreet Fire Station were for repairs.

(a) Not evaluated, no methods for quantifying individual building waste contribution.
(b) Not evaluated because sensors not installed/available.

Technical Approach

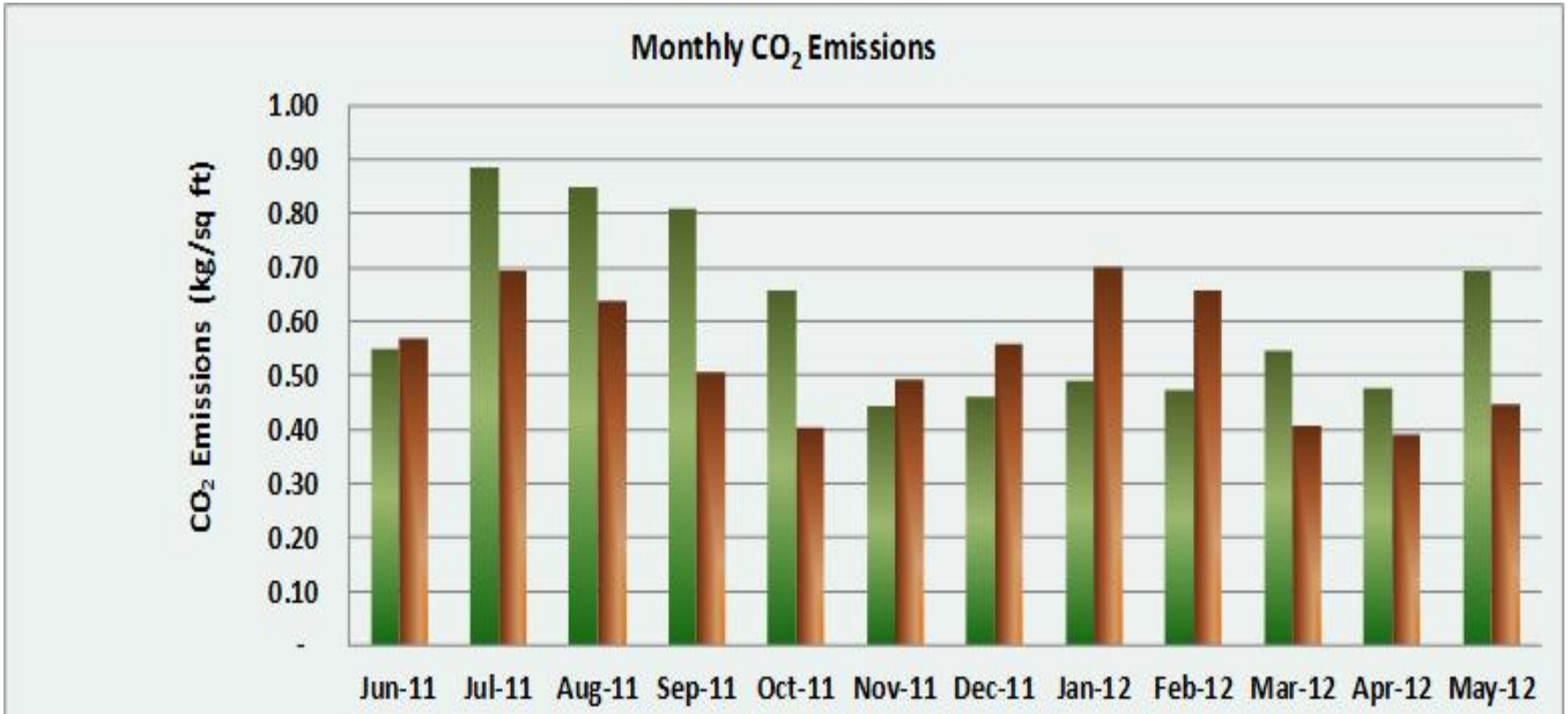


Results



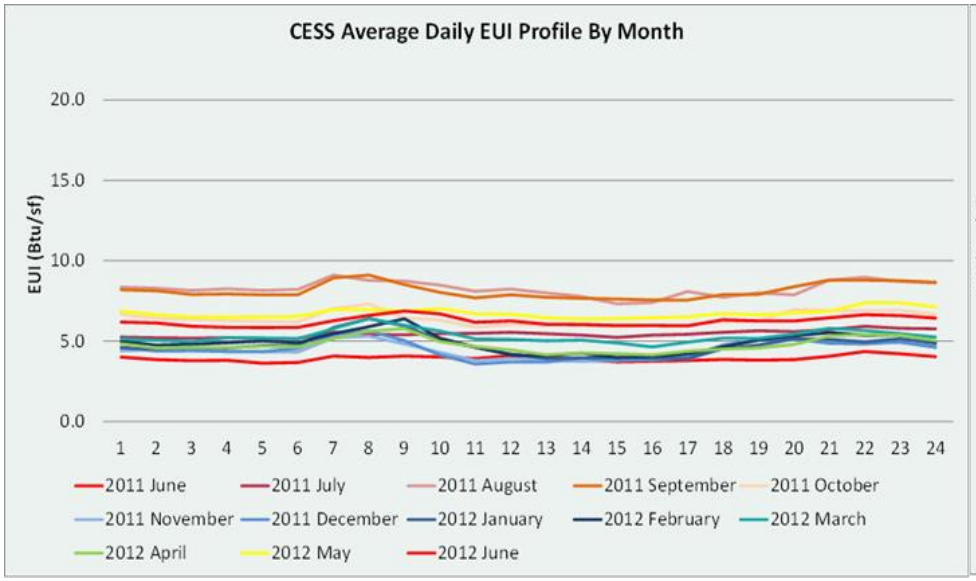
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12
CESS (kBTU/sq ft)	3.96	6.40	6.14	5.86	4.76	3.20	3.33	3.53	3.42	3.94	3.44	5.01
Longstreet (kBTU/sq ft)	4.49	5.36	4.90	4.09	4.00	5.85	7.53	9.98	9.49	4.20	3.79	3.60

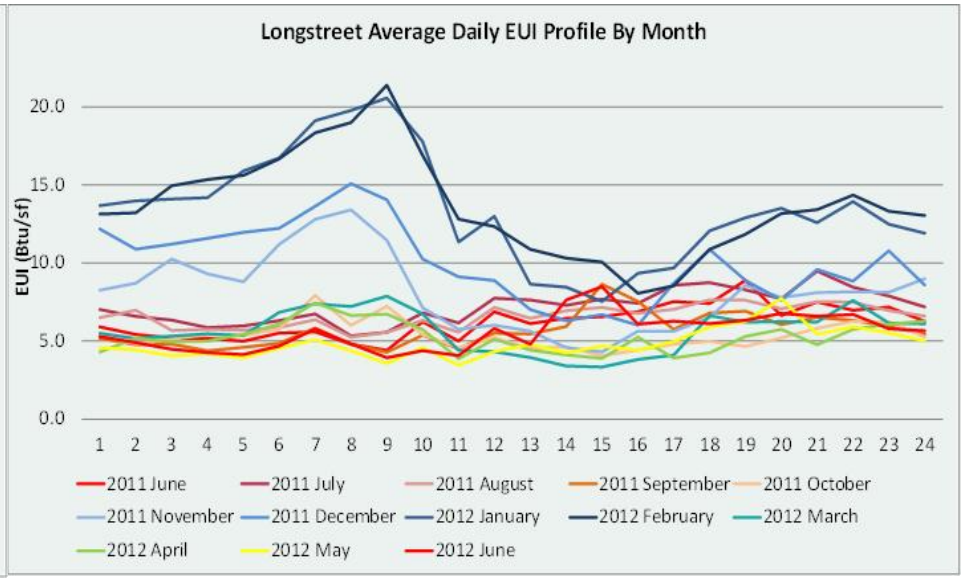
Results



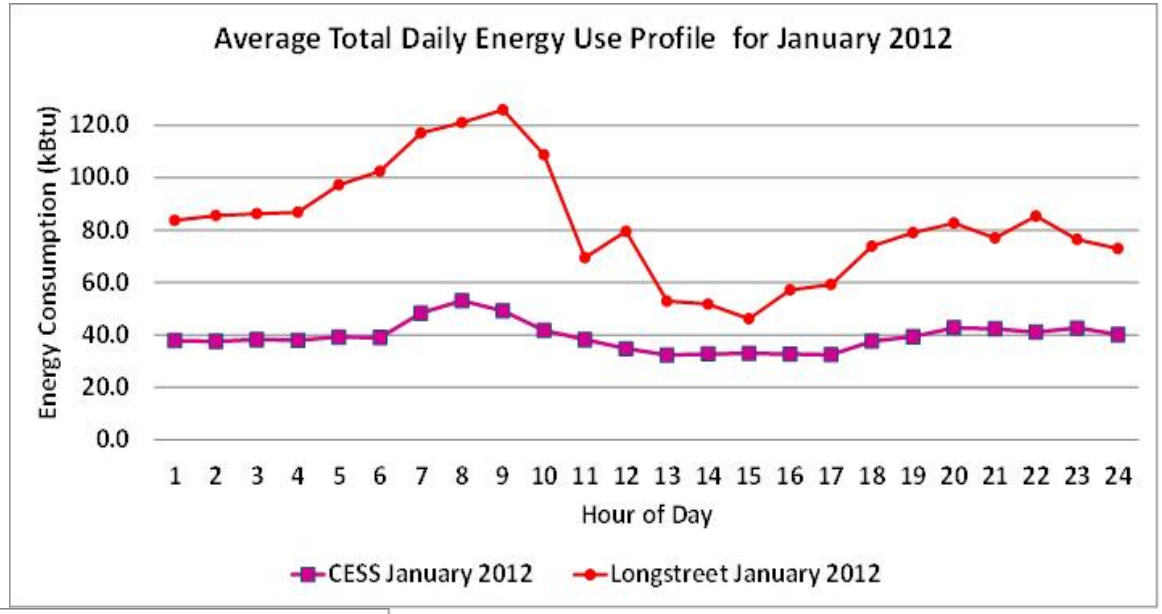
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12
CESS (kg CO2e/sq ft)	0.55	0.89	0.85	0.81	0.66	0.44	0.46	0.49	0.47	0.55	0.48	0.69
Longstreet (kg CO2e/sq ft)	0.57	0.69	0.64	0.51	0.40	0.49	0.56	0.70	0.66	0.41	0.39	0.45

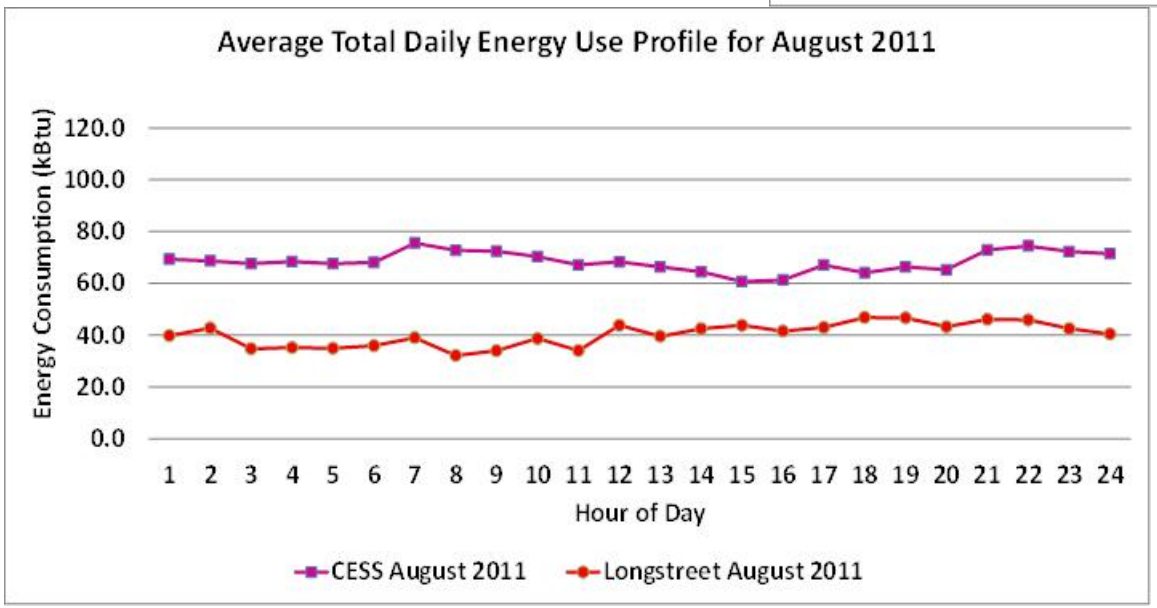
Results


CESS Average Daily EUI Profile By Month
EUI (Btu/sf)
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
2011 June
2011 July
2011 August
2011 September
2011 October
2011 November
2011 December
2012 January
2012 February
2012 March
2012 April
2012 May
2012 June


Longstreet Average Daily EUI Profile By Month
EUI (Btu/sf)
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
2011 June
2011 July
2011 August
2011 September
2011 October
2011 November
2011 December
2012 January
2012 February
2012 March
2012 April
2012 May
2012 June

Results


Average Total Daily Energy Use Profile for January 2012
Energy Consumption (kBtu)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day
CESS January 2012
Longstreet January 2012


Average Total Daily Energy Use Profile for August 2011
Energy Consumption (kBtu)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day
CESS August 2011
Longstreet August 2011

Issues/Lessons Learned

- Communicate sustainable design goals with the design contractor prior to a design charrette. Sustainable design goals need to be known by all parties and reiterated throughout the design process.
- Provide technical information on innovative design strategies and technologies to the design contractor prior to the design charrette.
- Sustainable design experts in mechanical, electrical, structural, and civil engineering are essential participants at the charrette and on the design team to aid in successful design of a high-performance building.
- Design charrette energy modeling should include estimations of load calculations so that the chosen systems are appropriately sized.
- Have a LEED Administrator managing the project that works for the Army rather than a contractor.
- Allow sufficient time for thorough design reviews. The project should schedule reviews so as to allow three to four phased reviews possibly by discipline.
- At a minimum, **future construction** of high-performance buildings **should require that the contractor has prior experience on LEED-certified projects** (e.g., 3 references with positive feedback).
- When construction teams are dealing with unfamiliar technologies, they should be required/encouraged to bring in experts to assist in cost-related decisions.
- Construction contractor needs to review and acknowledge the LEED documentation responsibilities identified in the design specifications.
- **Data need to be provided to the data analysts on a frequent and regular basis so that real-time or near real-time analyses and quality control checks can be performed.**
- **Re-calibration of monitoring equipment needs to be communicated when it occurs, as it may impact data analysis.**
- Changes to the building systems and/or other operations need to be communicated to the monitoring team so that any potential changes in the data can be noted.

Technology Transfer

- Army Corps of Engineers' Centers of Standardization (COS) adopted the whole building design process and strategies used in this ESTCP project
  - The COS implemented the whole building design techniques and strategies in the redesign of the five building types most often constructed by the Army
  - 19 TechNotes were developed to inform future Army construction projects
  - TechNote tool expanded into operations and additional design strategies
- Data management and analysis tools are being used by USACE HQ to assess the measured energy use for standard designs to identify opportunities for design improvements

Publications

- Fowler KM. 2011. Assessing Federal Green Building Performance. Greenbuild 2011, Toronto, Canada, October 2011.
- Fowler KM. 2010. Potential Additional LEED Points/Sustainable Design Strategies for UEPH. UEPH Design Options Meeting, August 18, 2010.
- Fowler KM. 2009. Fighting Fire with Fire: Fort Bragg Goes Platinum with a new LEED Fire Station. OFEE Federal Environmental Symposium East and West, Bellevue, WA and Bethesda, MD, June 2, 2009.
- Rauch EM and KM Fowler. 2008. Post Occupancy Evaluations in Federal Buildings. World Energy Engineering Congress, Washington, D.C., October 1-3, 2008.
- Fowler KM and EM Rauch. 2008. Whole Building Performance Measurement. GovEnergy 2008 Conference, Phoenix, Arizona, August 5-7, 2008.
- Rauch EM and KM Fowler. 2008. Assessing Whole Building Performance. Air and Waste Management Association ACE Conference, Portland, Oregon, June 23-27, 2008.
- Rauch EM and KM Fowler. 2008. Sustainably Designed Building Performance. Office of the Federal Environmental Executive Environmental Symposium East and West, June 3-5 and 17-19, 2008, Washington, D.C., and Big Sky Montana.
- Stumpf A. 2008. Using Building Information Modeling during Design Charrettes - A Case Study. Joint Services Environmental Management Conference, Denver, Colorado, May 7, 2008.
- Stumpf A. 2008. Sustainable Design and Development Workshop - A Case Study at Fort Bragg NC. Joint Services Environmental Management Conference, Denver, Colorado, May 7, 2008.
- Messenger M. 2007. High Performance Buildings: Fact or Fiction? May 2007.
- Messenger M. 2007. Documenting the Business Case for Sustainable Design. June 2007.
- Messenger M. 2007. The Conundrum of a Sustainable Army. August 2007.
- Shepherd C. 2007. Center of Standardization Weds Two Ideals in Design for Emergency Services. Public Works Digest, March/April 2007.