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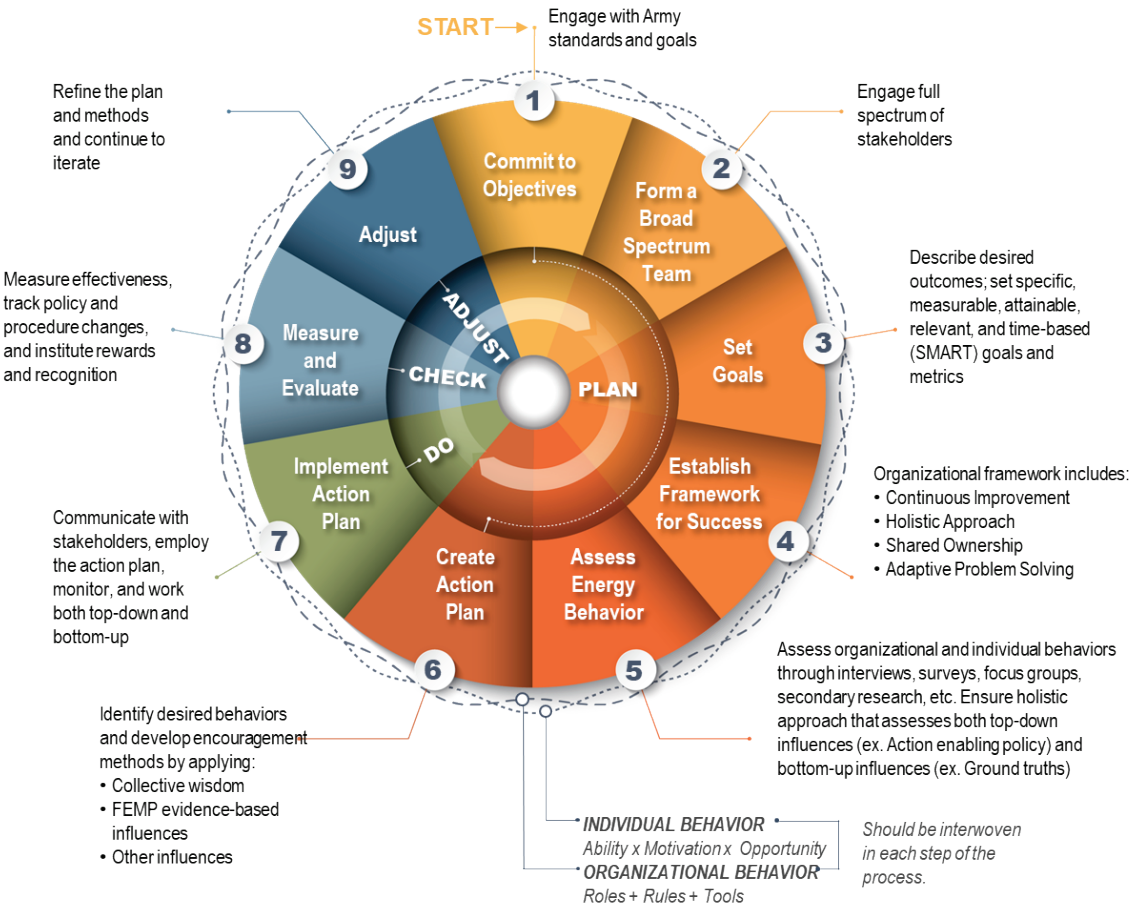
Enhancing Army Energy Culture with Behavioral Approaches

Eileen T. Westervelt, Paul M. Loechl, Sarah A. Clark, and Courtney E. DuPont

August 2020



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Enhancing Army Energy Culture with Behavioral Approaches

Eileen T. Westervelt, Paul M. Loechl, Sarah A. Clark

U.S. Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
2902 Newmark Dr.
Champaign, IL 61824

Courtney E. DuPont

Booz Allen Hamilton
1550 Crystal Drive, Suite 300
Arlington, VA 22202

Final Technical Report (TR)

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Abstract

Facility energy efficiency efforts too often underperform because of people's choices and actions in their use of technology. Recognizing this challenge, Army energy guidance calls for establishing an informed energy-conscious culture of stewardship to meet mission resilience requirements. However, the details for implementing that guidance have not been established. This report provides two primary products to address these needs: (1) a Human-Centered Efficiency Process (HCEP), which is a coordinated nine-step process to use best practices in energy behavior, and (2) an outline of a strategy to build a culture of efficiency. The practical HCEP is synthesized from energy management, change management, and Army processes (After Action Report [AAR] and Commander's Intent), as well as insights from federal personnel. It is built around an organizational framework and a continuous improvement process that systematically enables people to use technology effectively and efficiently. The culture strategy consists of a method of assessing the current status of the Army's energy culture; a vision of a desired end state; and a path toward change.

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Preface

This study was conducted for the Office of the Assistant Secretary of the Army for Installation Energy and Environment (ASA[IE&E]) under Project Number 039D88/347875, "Energy Culture Investigation." The technical monitor was Mr. Paul M. Volkman.

The work was performed by the Energy Branch of the Facilities Division, U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Ms. Mariangelica Carrasquillo-Mangual was Acting Chief of the Energy Branch and Ms. Giselle Rodriguez was Chief of the Facilities Division. Ms. Michelle Hanson was Deputy Director and Dr. Kumar Topudurti was the Acting Director of ERDC-CERL.

COL Teresa A. Schlosser was Commander of ERDC, and Dr. David W. Pittman was the Director.

This project would not have been possible without the help and participation of many people. The assistance of the following people is gratefully acknowledged: CW5 Corey Hill, Jay Tully, Brianna Morton, and Irene Andsager from CERL, Lisa Brundage of Booz Allen Hamilton, leadership from G9 (formerly ACSIM), Office of Energy Initiatives (OEI), Headquarters, U.S. Army Corps of Engineers (HQUSACE), Component level energy managers and staff (U.S. Army Installation Management Command [IMCOM], Army Reserve [AR], National Guard [NG]), facility support staff from Fort Bragg, Fort Knox, and Presidio of Monterey Army Garrison.

Executive Summary

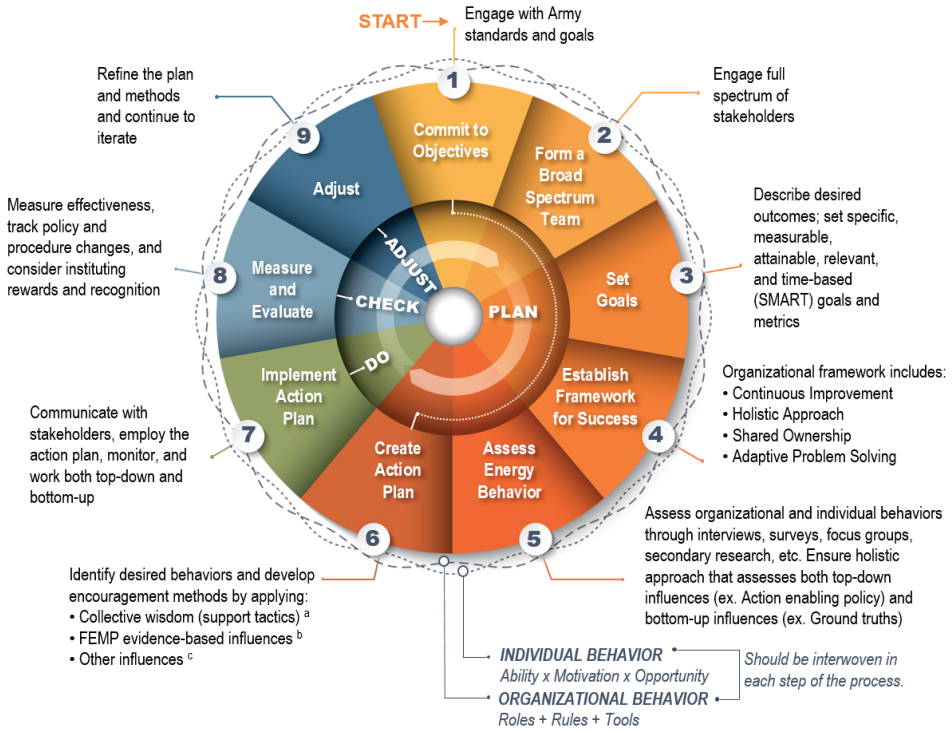
There is a compelling need to address the role of human actors in facility energy efficiency efforts as the Army seeks to maximize energy performance in the built environment to support the energy resilience of its installations. Attention to the human side of energy systems is a necessary component that enables efficiency projects to achieve their full technical potential and, equally important, to sustain savings over time. This effort to address the behavior of people involves systematically supporting people to use technology effectively and efficiently, and ultimately shifting cultural norms to embrace shared ownership of energy outcomes. Such an effort requires an understanding of the reasons people act the way they do, and practical strategies for influencing those behaviors at both the individual and organizational level.

This work was undertaken to recommend an approach to using behavioral methods to advance efficiency in the Army, and to identify implications for Army policy and procedures. Primary products are:

1. The Human-Centered Efficiency Process (HCEP), which is a practical, coordinated, nine-step process to utilize best practices in energy behavior, and
2. An outline of a strategy to build a culture of efficiency.

The HCEP is a continuous improvement process that systematically moves people toward efficiency (Figure ES-1). It is a synthesis of best practices from energy management, change management, and Army processes (After Action Report [AAR] and Commander's Intent); as well as proven methods of influence in the federal sector, and collective wisdom on bridging efficiency gaps from Army energy management practitioners. This combination of multidisciplinary methods makes the process uniquely helpful for managing facility energy systems as a whole with both technical and human elements. A hallmark of the process is the foundational organizational framework (Figure ES-2) that supports success through continuous improvement, shared ownership, adaptive problem solving and a holistic systems approach.

Figure ES-1. Human-centered efficiency process.



Notes:

[a] Sample Tactics to Support People (collective wisdom):

- Installation specific design guide
- Retain savings from efficiency at installations
- Facility operator coaching
- Community of practice for energy behavior
- Mock billing

[b] Federal Energy Management Program (FEMP) Evidenced-Based Methods for Change:

- Social Network & Communication
- Multiple Motivations
- Leadership
- Commitment
- Information & Feedback
- Infrastructure
- Social Empowerment

[c] Additional Behavior Influences:

- Addressing Cognitive Biases
- Overcoming Resistance
- Partnerships

Figure ES-2. Foundational organizational framework.

Strategy for culture change

The culture strategy consists of three components:

1. Status: a *preliminary* characterization of the current status of Army's culture in terms of its relationship with efficiency along with a method of assessing the current status in a larger population. Additional data gathering is needed to understand the Army's large enterprise more fully,
2. Vision: a candidate vision of a desired end state, and
3. Path: the recommended first steps in a path toward change.

Both top-down (beginning with Army leadership) and bottom-up (beginning with the individual) actions are required over the long term (5+ years) to effect the needed change, i.e., establish an informed energy-conscious culture of stewardship that impacts people's choices and actions regarding energy and supports mission energy resilience. The full range of facility stakeholders needs to be affected by the culture shift including designers, building managers, operations and maintenance technicians, energy managers, leadership and occupants, so that they are all pulling toward a common goal. When a critical mass of people (~80%) adopt norms, the fabric of the culture shifts to a "new normal."

The strategy is a high-level planning tool to guide overall efforts. This skeleton strategy, provided below, will require tailoring and adaptation at the installation level to reflect local circumstances.

1. Status: Preliminary characterization of current energy culture (60 interviews, 78 survey responses, primarily civilians)

- Civilian leadership, facility support administrators, resource managers, and researchers have strong efficiency mindset
- HVAC and controls staff ambivalent about efficiency, believe it competes with comfort
- Soldiers are not engaged with efficiency, believe it competes with mission, is inconsequential, or feel they have little control
- Drivers: legislated goals, comfort, environmental impact, altruism, mission
- Barriers: funding, leadership, staffing, coordination, quality data, motivation, sharing of methods, training
- Extensive collective wisdom on tactics to support energy stakeholders resides with staff.

2. Vision: Candidate desired end state

- Self-sustaining, self-correcting culture of efficiency
- Saving millions for the mission, directing resources to critical loads
- Optimal resource use (cost effective, risk appropriate)
- Engaged shared ownership
- Action enabling policy informed by ground truth
- ALL-IN efficiency for resiliency.

3. Path: Recommended path toward efficiency

- *Incorporate energy stewardship into current resilience initiatives* led by top Army leadership
    - Revive the energy stewardship objective as a mission enabler that is established at the home station; embed energy utilization goals and reinforcing mechanisms into daily processes
    - Employ commitment, accountability, visibility, messaging, and a diverse team
- *Increase funding* allocations for building support staff and equipment repair to demonstrate priority of optimized facilities.

- *Expand and tailor data collection* to understand local issues and opportunities.
- *Initiate benchmarking* of behavioral approaches.
- *Make a behavioral approach Standard Operating Procedure* to enable optimal efficiency by tailoring and adapting the energy culture strategy to local circumstances, establishing a supporting organizational framework (Figure ES-2) and using the nine-step HCEP (Figure ES-1) to address both individual and organizational behavior.
- *Establish a repository* of behavioral methods to share success stories across the organization.
- *Conduct behavioral demonstrations* to establish ground level methods and impacts.
- *Track policy revisions*. Incorporate behavioral insights into organizational rules, roles, and tools, support individual ability, motivation, and opportunity.
- *Review previous energy data analyses* which appears to show Army electric energy use many times greater than expected to discover root causes.

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1 Introduction

1.1 Background

An early energy efficiency demonstration of advanced insulation and high-performance windows in an existing barracks building (Westervelt 1990) involved the design of a technically optimized retrofit using state-of-the-art energy simulations. Contrary to expectations, the retrofitted (Figure 1) building did not achieve the anticipated energy savings. Inspection of the building while it was in use revealed that the newly installed high-performance windows were often left open while the heat was running.

Figure 1. Energy behavior example.

Using technology to full advantage requires the informed choices and actions of people. Turning off heating before opening windows is an example of human actions that support energy efficiency. On the superficial level, the explanation for why the new technology had failed to achieve the expected results was simple: the occupant, the Soldier, had misused the technology. (In the Soldier's defense, the building was overheated.) However, deeper investigation revealed that the root causes for the way this building was operated resulted from the choices and actions of the full range of stakeholders: from the designer who remodeled the open bay barracks and

divided it into dorm-style rooms without changing the HVAC to accommodate those changes; to the Director of Public Works who prioritized fixing pot holes in the street over fixing a failed steam relief valve; to the energy manager who had the outdoor air damper chained to meet mandated energy reductions, leaving the place uncomfortably underventilated; to the HVAC technician who bypassed all temperature control in the building in an effort to satisfy comfort complaints; to the occupant who barricaded his radiator with a bookcase and then put in a call for more heat. All these parties had a role in the building's failed performance, including the researcher, who engineered the insulation demonstration as a technical problem requiring nothing more than running calculations, materials choices, and construction monitoring.

In fact, such technical solutions are only a first step to bringing about the desired, more comprehensive reduced energy solution. Optimal energy management requires an integrated systems approach. The building occupants and technology users —people— are an integral part of the energy system and must be incorporated into the resiliency solution. People do not "get in the way" of advanced technical solutions; they are the reason the technology is employed, the reason the building was built, to provide safe, comfortable, productive places for people to live and work.

A more comprehensive reduced energy solution must systematically address the involvement of people in the lives of facilities by employing multidisciplinary insights to bring about the next level of efficiency. This requires a holistic approach to energy use that recognizes that a building's energy performance is affected by the interaction of a full range of people and equipment. This integrated view of facility systems goes beyond stovepipe technical solutions (that consider equipment alone) or stovepipe social solutions (that consider occupants alone) to help them work together In complementary fashion. Fortunately, Army leadership has recognized that too.

There is a compelling need to address the role of human actors in facility energy efficiency efforts as the Army seeks to maximize energy performance in the built environment to support installations' energy resilience. The military and the private sector alike are calling energy behavior research the "next frontier" in energy efficiency (Cohen 2015, Keim 2014). The energy industry itself recognizes the central influence of people on energy performance, and recently the Association of Energy Engineers added

a new chapter on human behavior and energy efficiency to their *Guide to Energy Management,* a well-established industry resource (see Mazzi et al. 2015). Attention to the human side of energy systems is often found to be the necessary enabling component of efficiency projects to achieve their full technical potential and retain savings over time. The Army needs to leverage behavioral science insights in combination with engineering science to reap the full advantage of energy efficiency efforts, meet requirements of EISA 2007 to reduce energy use, and move toward the culture of efficiency called for in Army energy guidance.

Drivers to establish an Army path to optimal energy efficiency by supporting people are multi-layered and include:

- Widespread military and federal guidance calling for establishing a culture of efficiency
- Increased focus on facility performance to meet current threats
- Need to increase facility comfort for Soldier retention and training effectiveness
- The advantage of "training as we fight" by establishing a mindset and habit of energy stewardship at home installations that can translate to the field where energy supply convoys have casualties
- Widespread experience with efficiency efforts that have fallen short of technical potential and that involve a large combination of stakeholders. Technology is not the complete answer, people need to use technology effectively and efficiently.

This preponderance of practical need is driving an innovative multidisciplinary solution centered on people as an integrated part of facility energy systems.

This effort to address the behavior of people requires systematically supporting people to use technology effectively and efficiently, and shifting cultural norms to embrace shared ownership of energy outcomes. At both the individual and organizational level, such an effort requires an understanding of the reasons people act the way they do, and practical strategies for influencing those behaviors.

Although greatly needed and called for in Army guidance, *actively* attending to the human side of facility energy management is not quickly embraced as part of standard operating procedures at Army installations.

Common responses to the call for an efficiency culture include: assuming that the human side of facility energy management will take care of itself because it is common sense; or conversely, that it is too complex for anyone other than behavioral scientists; or most typically, that technology will save the day and outsmart the uninformed choices of people. While there is some truth in each those perspectives, until now there has been no established set of Army methods detailing how to approach this for the Army as a whole. This work was undertaken to recommend an approach to implement behavioral approaches that will improve efficiencies in the Army, and to identify implications for Army policy and procedures.

1.2 Key terminology

A few definitions of terms will establish our understanding of select words and phrases:

- *Culture*. In this project references to culture refer to the beliefs, values and actions (or behavior) of a people.
- *Energy Behavior*. Energy behavior refers to the *use* of technology by people, where use is *choices* and *actions* of those people. Many people hear of "energy behavior" and immediately think of building occupant awareness campaigns that encourage people to turn off lights when they leave a room via a sticker on the light switch. This is a valid energy behavior technique. However, robust energy behavior programs can (and should) encompass far more than facility end users, as efforts can seek to influence *any* of the people involved with *any* phase of the life of our buildings – *wherever people and technology meet*. Energy behavior efforts overlap and are entwined with facility design, purchasing, and construction activities, as well as energy management, facility upgrade, energy operations tasks, occupation of the facility, and ultimately disposal or repurposing.
  It is instructive to realize that many energy behavior measures look identical to retro-commissioning measures (such as keeping HVAC equipment in automated control and setting room thermostats appropriately) as these facility operational improvements are dependent on the sustained behavior of building operators and occupants.
- *Systems Approach*. A systems approach is a method of addressing complex problems as an interrelated and interdependent collection of sub-systems. It is an integrated, holistic approach. In this project, a

systems approach considers both technology and people as parts of the facility energy system.

- *Energy Efficiency*. Energy efficiency is a measure of the provided energy services (e.g., heating, cooling, ventilation, lighting, and offices appliances, etc.) compared to the needed consumption of energy to provide those services (e.g., natural gas into a boiler, electricity to an appliance). More efficient processes provide those services for a reduced input of energy.
- *Energy Resilience*. Energy resilience is the ability to anticipate, endure, and quickly recover from challenges, such as power outages, and physical, and cyber-attacks. The Department of Defense defines energy resilience, in part as "the ability to avoid, prepare for, minimize, adapt to, and recover from anticipated and unanticipated energy disruptions in order to ensure energy availability and reliability sufficient to provide for mission assurance and readiness …" (National Defense Authorization Act, NDAA 2018).
- *Energy Efficiency for Energy Resilience*. The project team asserts that energy efficiency improvements that result from behavioral approaches to energy management support energy resilience efforts at Army installations. The relationship between efficiency and resilience takes the form of decreased impact of potential threats, freed up operating capital, and increased adaptive capacity. During a power interruption, the electricity needs of more efficient systems can be met with less alternate supply (e.g., fewer generators), reduced dependence on outside sources, reduced demand on energy infrastructure (which leads to increased reliability), and greater flexibility to direct remaining energy resources to priority assets. This flexibility aided emergency response and recovery at Misawa Air Base in Japan when a tsunami took out electric supplies and behavioral approaches enabled limited fuel to be allocated to critical assets (FEMP 2012). The reduced dependence on outside energy sources can insulate against price volatility and resource availability bottlenecks, and well as resupply vulnerabilities. In forward operating bases the link between efficiency and resilience is very strong as refueling convoys endure casualties. Now that installations are recognized as the new battlefront, supply chain vulnerabilities are part of the resilience equation. Additionally, decreased energy loads allow for extension of shelter in place activities. Furthermore, energy efficiency provides reduced environmental impacts, and reduced lifecycle costs for long-term savings (Carmichael and Jungclaus 2018, Ribiero et al. 2015).

1.3 Objective

The objective of this effort is to gain insights into Army energy culture and behavioral approaches to efficiency to inform policy and procedures that can shift individual and organizational behavior toward energy efficiency.

1.4 Vision for a culture of efficiency

The proposed vision of an ideal end state for an optimal culture of efficiency was guided by our research. It describes what success looks like but will need further development and socialization with Army leadership. It is presented as a candidate for discussion.

***Ideal End State*: A self-sustaining, self-correcting culture of efficiency** in the Army to strengthen installation energy resilience. Bridging opportunity gaps in efficiency with people.

- **Saving millions for the mission.** (A 14% savings on an annual $1B Army energy bill = $140M/ per year in estimated potential portfolio impact.) Even small percentage changes in the billion-dollar facility energy bill are substantial. Depending on starting conditions, behavioral approaches can yield 4% to 40% savings on individual buildings.*
- **Optimal resource use.** Not theoretical efficiency limits but cost effective, risk appropriate levels with built-in efficiency as the default.
- **Engaged, shared ownership.** Everyone deputized to assist; all empowered to engage their creativity, suggest innovations, and implement ideas to the extent practicable.
- **Action enabling policy informed by ground truth.** Both top-down and bottom-up efforts that result in sufficient adoption such that the culture tips to a new normal with efficiency as its fabric.
- **ALL-IN efficiency for resiliency.** Including designers, building managers, operations and maintenance technicians, energy managers, leadership, and occupants.

* On individual buildings, if the behavioral change is e.g., turning off the light switch when leaving a room, savings are closer to 4%; if the change is getting technology investments to reach their potential, 40% is possible. We reasoned that retro-commissioning (RCx) activities are considered behavioral changes of equipment operators and typically yield 16% savings (Evan Mills, LBNL, 2009), and would apply to all buildings. Additional behavioral changes of stakeholders beyond the equipment operators, and changes that allow technology to reach its energy potential would be added to these impacts, so 20% impact seems plausible. Furthermore, we assumed that 30% of energy use cannot be reduced at all due to mission requirements, so the portfolio savings is estimated as 20% of 70% of the annual energy bill, or 14% of $1B/yr, yielding $140M/yr savings potential across the facility portfolio.

1.5 Approach

1.5.1 Tasks to accomplish project objective

Using the energy behavior initiatives of the military already identified in a previous CERL project, Energy Behavior Screening Review,* this effort took a deeper dive into understanding the energy culture of the military and attempts to steer it toward greater efficiency.

- **Energy Policy Review:** The effort began with a policy review that compiled and distilled energy policy documents that impact either the Army or other armed services.
- **Energy Culture Literature Review:** We proceeded with a literature review that investigated and summarized publications and initiatives that are pertinent to military energy culture change.
- **Army Website Screening:** We then conducted a website screening of Army installations to identify mentions of installation efficiency efforts in general and behavioral efforts in particular.
- **Noblis Behavioral Study Review:** Although this project had originally hoped to gain understanding from participating in the review of a large-scale energy behavior project conducted by Noblis for the Environmental Security Technology Certification Program (ESTCP) (Noblis 2018), Noblis' project did not proceed due to significant concerns with energy meter data accuracy.
- **Behavioral Efficiency Methods Review:** We examined behavioral approaches to energy efficiency to identify best practices to employ. We synthesized an assortment of methods into a coordinated HCEP.
- **Preliminary Energy Culture Assessment:** The study proceeded with developing and conducting an initial assessment of Army energy culture through a series of interviews and questionnaires.
- **Conference Participation:** Aspects of this work were presented at two national conferences.
- **Recommendations and Documentation:** Investigation findings and recommendations of our efforts are summarized in this report.

* Eileen T. Westervelt, Sarah A. Clark, Aaron C. Petri, and Juliana M. McMillan-Wilhoit. 2018. *Army Energy Behavior Screening Review*. Internal report to ASA(IE&E).

1.5.2 Methods to undertake the project tasks

We developed our approach for the ambitious goal of understanding and shaping culture change for our massive organization by breaking the effort into pieces, getting help, working in parallel, collaborating, and systematically addressing all facility stakeholders.

- **Subdividing:** We have broken our efforts into manageable tasks: where are we now, where do we want to go, how will we get there.
- **Getting help:** We have a multidisciplinary team of helpers and advisors that include engineers, sustainability specialists, social scientists, active military and former military, people with past success in military culture change, Army leadership, psychologists, college professors, business administrators, and energy behavior influencers from four countries.
- **Leveraging work of others:** Especially Energy Star, Federal Energy Management Program (FEMP), and Army methods.
- **Working in parallel/collaborating:** Leveraging and collaborating with complementary projects such as facility controls investigations, installations of the future, ISO 50001 Energy Management Systems demonstration at Fort Bragg, and Installation Energy and Water Plan (IEWP) efforts.
- **Collaborating:**
    - Socializing work with many levels of Army leadership from strategy and policy (ASA-IE&E, OEI) to resourcing (DCS-G9), to support (HQUSACE) and execution (AMC/IMCOM, Fort Bragg, Fort Knox, Presidio of Monterey), as well as Army Reserves and Army National Guard
    - Networking with energy managers and energy influencers in the military and in industry (Energy Exchange, Building Commissioning Association, Behavior Energy and Climate Change, Energy Behavior Collaborative)
- **Systematically addressing facility stakeholders:**
    - Determining lay of land (players, policies, programs, methods) with literature & policy review, web search, and interviews
    - Distilling behavioral methods into coordinated approach that can affect individual and organizational behavior to bring about culture change
    - Family of interview/surveys by stakeholder:
        * Assessing the pulse of efficiency culture (Is efficiency important? To whom? Why? Possible? How?)
        * Identifying gaps in efficiency/soliciting recommendations for change (Where are holes? How to fill?)

- Mapping efforts that support efficiency to individual stakeholders (Are we helping everyone?)
- Tracking policy revisions for opportunities to steer organization toward efficiency.

2 Findings

2.1 Overview

Behavioral approaches to energy efficiency provide a higher level of impact to facilities beyond the current status quo resulting from technology implementation such as advanced controls, building envelope upgrades, and energy efficient equipment. The top horizontal line in Figure 2 shows a building's baseline energy consumption over time. It is the high energy consumption line. The addition of efficient technology reduces energy consumption to the middle line. Addressing the human factors further reduces consumption to the bottom line. However, it is the human factor, the behavior of people that can return consumption levels to the starting point, with no savings realized from the baseline. So, it is by supporting people to use technology effectively that the technology can have the greatest impact so that the system as a whole can achieve and maintain the lowest consumption levels.

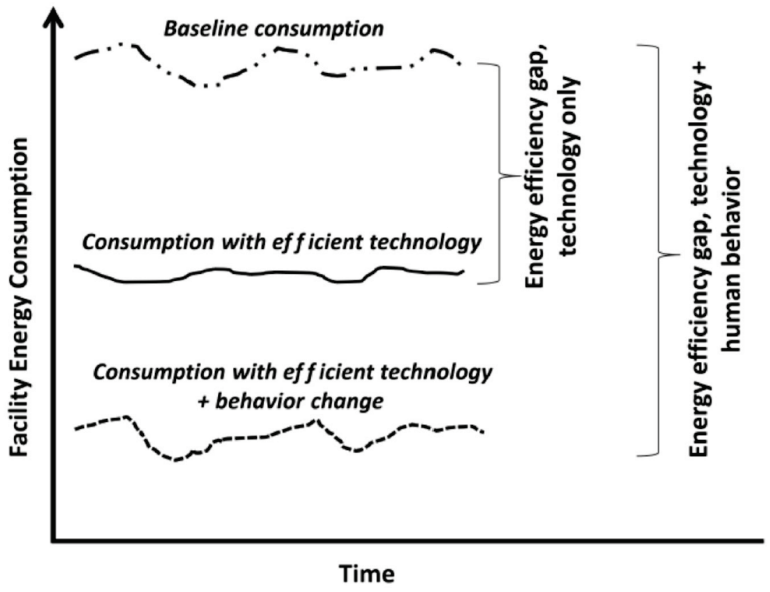


Figure 2. Behavioral impact on efficiency.

A systematic review of military and federal policy, and behavioral approaches from the military, academia, and industry allowed development of an informed and coordinated strategy for a culture change toward efficiency.

2.2 Energy policy review

The energy guidance of each of the Armed Services —Army, Air Force, and Navy (including the Marine Corps)— and of the Federal Government (Table 1) recognizes that developing an informed energy culture of efficiency is key to reaching full potential for resilient energy operations. This work analyzed these guidance documents to identify the main energy culture themes expressed in the documents; to catalog the language related to energy culture; to establish the authority and scope of the current guidance; and to track those areas where an expanded understanding of behavioral approaches could be incorporated into future guidance as it is developed. The analysis identified four key themes:

1. A mindset of energy efficiency supports mission resilience and maximizes effectiveness,
2. Leadership sets the tone for organizational priorities,
3. Stakeholders at every level must be included as collaborators in energy culture initiatives, and
4. Ongoing education and training are critical elements for successful, sustained lasting energy culture change.

Consequently, there is ample authority from these citations to incorporate behavioral approaches into energy management efforts.

Table 1. Main Energy Culture Themes in Military and Federal Policy.

Military or Federal Policy (Page[s] referencing energy culture)	Main Energy Culture Themes
Army	
1. Army Regulation (AR) 420-1 (HQDA 2008) (21, 22, 50, 66, 67, 71, 79, 129)	Energy stewardship in housing and installation residential areas
2. Army Energy Security and Sustainability Strategy (ES^2) (HQDA 2015) (3, 5, 6, 7, 11)	Increasing energy competence and building a more resilient energy culture through education and training Lead by example: "Army leaders at all levels must make sustainability an integral part of our Army culture and values…the Army ethos and values are a foundation for executing the Army's mission and leadership is the catalyst that makes the decisive difference" Behavioral and operational change is needed to maximize efficiencies Collaboration with the surrounding communities
3. IMCOM Building Energy Monitor Handbook (IMCOM 2016) (3, 4, 6, 10)	Establish a culture of increased energy and water stewardship by building relationships between assigned units, tenant organizations, service members, and garrison energy professionals by sharing responsibilities for their energy footprint and programs. A listing of numerous ways to reduce the energy footprint and influence energy culture change.

Military or Federal Policy (Page[s] referencing energy culture)	Main Energy Culture Themes
4. Installations, Energy and Environment Strategy (IEE) 2025 (ASA(IE&E) 2016a) (11)	Lead by example and encourages us to leverage the Army culture to shape resource-informed behavior
5. Department of the Army Policy Guidance for Installation Energy and Water Plans (IEWP) (ACSIM 2018) (16, 28, 33, 34, 36, 37, 38, 41, 42)	Examining the behavior of occupants, operators, and other stakeholders that influence Energy & Water resource consumption and installation Identify primary ways to reduce demand by changing occupant behavior and optimizing O&M: Awareness programs, staff training, using risk-management strategies, stakeholder collaboration to engage individuals in energy & water delivery, security, and efficiency
6. 2015 Progress Report: Army Net Zero Initiative (ASA(IE&E) 2015) (iv, 6, 8, 9, 11, 13, 19, 20, B.6, C.8, D.8)	Creating a culture that recognizes the value of sustainability measured not just in terms of financial benefits, but in terms of the benefits to quality of life, relationships with local communities, the preservation of options for the Army's future, and maintaining mission capability and resilience Changes in occupant behavior can reduce costs, thereby freeing up funds for other critical mission needs. Encouraging good behavior creates habits in the workplace that carry over to the home and fosters a sense of community among Soldiers and units.
7. Multi-Domain Operations (x, 19, 25, C-10)	Maximize human potential. Strong alliances and partnerships, American technological innovation, and a culture of performance generate decisive and sustained U.S. advantages. Incorporate human factors into campaign and operations planning, training, and exercises
8. Installation Energy and Water Resilience Policy, Army Directive 2020-03 (McCarthy 2020) (Definitions are included in Encl 2.) (2, Encl 2: 2, 3)	Effective system operation through planning, personnel, and equipment to support critical mission requirements, where "systems operation" considers the personnel and procedures needed to maintain effective system operation including trained personnel, and operational procedures for conservation. Efficiency and conservation support resilience.
Note: Army policy documents reviewed that do not include energy culture or behavior references: Army Installations 2025 Energy and Water Goal Attainment Responsibility Policy for Installations	
Air Force	
8. Energy Flight Plan 2017 (SAF/IE 2017) (3, 10, 11, 13, 17, 21)	Adoption of the ideas of multi-level members to address energy challenges Cooperation at every level, coupled with an understanding of how energy usage impacts every mission Implementation of an all-encompassing energy culture to include research, development, test and evaluation Continued initiative to increase awareness and influence the behavior of the people carrying out the mission to optimize our fuel consumption
9. Air Force Instruction (AFI) 90-1701 (SAF/IEE 2014) (16, 29)	"Make energy a consideration in all we do."
10. 2017 Spangdahlem Air Base Installation Energy Plan (Spangdahlem Air Base 2017) (5, 7)	Reducing energy waste will increase cost savings and decrease the manpower needed to oversee and operate energy systems. Infrastructure efficiency gains can be negated by humans
Note: Air Force policy documents reviewed that do not include energy culture or behavior references: Air Force Policy Directive (AFPD) 90-1701 Energy Management 2016 (SAF/IEE 2014) Environmental Handbook: Joint Base Elmendorf-Richardson (JBER 2013)	

Military or Federal Policy (Page[s] referencing energy culture)	Main Energy Culture Themes
Navy	
11. Department of the Navy's Energy Program for Security and Independence (USDON 2010.) (16, 17, 18, 20)	Communication and awareness are critical to achieving the Secretary of the Navy's energy goals Building partnerships
Marine Corps	
12. Unit Energy Manager (UEM) Handbook (USMC 2105) (1, 11, 12)	"Energy Ethos" UEM must survey, record, report Marine energy behavior and activity
Federal	
13. Energy Independence and Security Act, Public Law 110-140 (EISA 2007) (179)	Encourage behavior change among population served by the eligible entity
14. Energy Policy Act of 2005 (EPAct 2005) (544)	Recommend strategies based on end user behavior change to obtain low-cost environmental gains
15. DoD Directive 4180.01, DoD Energy Policy (DoD 2017b) (9)	Educate and train personnel in valuing the energy mission
16. National Defense Strategy (DoD 2018) (4, 10, 11)	Defense objective: Continuously delivering performance with affordability and speed as we change Departmental mindset, culture, and management systems Drive budget discipline and affordability to achieve solvency: continue to drive greater efficiency in procurement of materiel and services while pursuing opportunities to consolidate and streamline We must use creative approaches, make sustained investments, and be disciplined in execution
Note: Federal policy documents reviewed that do not include energy culture or behavior references: Executive Order (EO) 13834, 2019 *Efficient Federal Operations* (The White House 2019) EO 13783, 2017 Promoting Energy Independence and Economic Growth (The White House 2017)	

2.3 Literature review

This investigation found 19 studies directly related to military energy behavior (Table 2). Study topics were quite broad, ranging from direct attempts to influence people's behaviors, to the accidental finding that behavior matters, to theoretical studies of methods of influence, to first- or second-hand observational assessments, to a recommended strategy document to embed energy stewardship in the Army culture. End uses ranged from residential (barracks), to commercial (administration), to industrial (airplane hangars) buildings; to military operations including tactical vehicles, training platforms, and forward operating bases.

These sources documented several experimental attempts, primarily focused on building occupants, to address the human dimensions of energy

use in military facilities (Fort Carson, Joint Base Andrews; Detroit Arsenal, Marine Corps Air Station New River, and Camp Lejeune). Two studies focused on military sites (Fort Irwin and the Oregon National Guard) that partnered with local utilities to acquire energy and cost savings. Several studies revealed that the Army's Net Zero Installations all include occupant engagement as part of their energy program. In complementary efforts, the Navy has investigated behavioral methods to influence *operational* energy use to reduce the casualties associated with attacks on fuel supply convoys. All services have high-level energy awareness campaigns and some ground level engagement efforts. The energy culture strategy proposed by Science Applications International Corporation, Inc. (SAIC) (Entry 16 in Table 2) has substantial merit; select aspects of it are included in our recommendations.

The following section summarizes key findings from this literature review, including a discussion of challenges encountered and strategies for success. Table 2 lists the aspects relevant to our objective of improved facility energy efficiency. Several entries are amplified in section 2.3.2.

2.3.1 Key findings

Systematic attention to the human elements of energy use is necessary for efficiency outcomes. Strategies for success in military energy behavior efforts included:

- Providing information and feedback to energy users on their energy use (through billing or fuel gauges)
- Giving training on recommended efficiency behaviors
- Establishing energy champions
- Developing a building energy monitor position description
- Logging non-energy benefits
- Conducting energy savings competitions
- Disseminating multi-media information and education
- Forming partnerships with utility efficiency programs
- Including behavioral components in (typically Net Zero) installation efforts.

Challenges in energy behavior efforts included:

- Lack of internal motivation in Soldiers
- Insufficient leadership support
- Highly variable occupancy in buildings (especially barracks), which makes savings estimates problematic
- Suspect energy data at installations
- Disallowance of cellular data transfer.

Table 2. Literature review of "energy behavior" efforts pertinent to the military.

Effort or Study	Description
1. Fort Belvoir, VA Residential Efficiency Demonstration (Andres and Loudermilk 2011)	• An efficiency demonstration of residential building upgrades (insulation, high-performance windows, motion sensors and more) alongside a control building with no upgrades, resulted in the control building being the most efficient due to frugal occupant behavior
2. United States Marine Corps (USMC) Truck Idling Intervention (Mahoney 2015)	• Mojave Desert, CA • One platoon added fuel gauges to their trucks to give drivers feedback and reduce engine idling 40%
3. Booz Allen Hamilton Energy Behavior Study with Air Force and Marines in Barracks, Administration Buildings and Hangars (Michael 2015)	• Multi-month savings competitions in barracks, administration, and airplane hangar buildings. Up to 14% energy savings over multiple months. Surveys, interviews, and focus groups established needs and approach to energy behavior engagement and training campaigns, savings competitions, and energy champion program changed people's opinions and actions involving energy. Developed Unit Energy Manager (UEM) Handbook. Working on policy to institute its use.
4. University of Maryland Study at Joint Base Andrews, MD (Shen et al. 2016)	• Residential energy feedback yielding 3-5% energy savings
5. Pacific Northwest National Lab (PNNL) Barracks Study at Fort Carson, CO (Wolfe 2014)	• Three-month intervention in barracks buildings involved enhancing the Building Energy Monitor (BEM) role with training on walk-through audit procedures and on methods to support occupant behavior change (through reminders, compliments, feedback, and addressing concerns) • Targeted behaviors included nighttime computer shutdown and temperature setbacks • Compliance for behaviors was 24% to 64%. Energy savings for computers was 1% of energy for computer shutdown, and 1% of energy for thermostat setback • Other positive outcomes: occupants felt equipped with skills, felt personally responsible for change, believe energy efficiency is important, and the BEM role is being rewritten to be more proactive

Effort or Study	Description
6. 3M Study of Barracks and Administration Buildings at Fort Bliss, TX (Erickson et al. 2014)	• Study terminated without completion. An ESTCP demonstration project on Energy Reduction through Real Time Electricity Monitoring and Feedback in barracks and administration buildings. No savings shown due to high variability in facility occupancy, low intrinsic motivation of occupants, and no leadership support. Cellular meter data sharing was stopped due to security concerns which terminated study. • Recommend future behavioral studies at Officer Candidate Schools to influence future leaders.
7. Oregon Army National Guard (Gibson 1998)	• Working with the Energy Trust of Oregon in the Strategic Energy Planning Program, OR
8. Noblis ESTCP Energy Behavior Interventions Feasibility Study for Barracks and Administration Buildings (Unpublished project slide presentation to ESTCP 2018)	• Effort terminated in feasibility phase. • Electrical energy data from hundreds of tri-service barracks and administrative buildings were analyzed for potential siting of a randomized control trial (RCT) of behavioral interventions. • Individual building data were problematic, often non-existent, and required significant clean up. Due to the high variability of available data, a large sample size was required to show statistical significance of potential savings. • There were insufficient quantities of barracks buildings with acceptable data streams. The quantity of administrative buildings with adequate data appears to be sufficient for the desired study. • However, final recommendation was to put off the study indefinitely until the services get more and better-quality utility data.
9. John Peter's Master's Thesis on Operational Energy in the Navy, Naval Postgraduate School, CA (2016)	• "Factors that influence human behavior and negatively affect energy consumption in USMC ground units during operations." • Peters focused on the vulnerability inherent in current battlefield energy requirements and usage of the USMC. Information provided from service member reports of field conditions. Technical strategies to decrease this vulnerability factor are not sufficient due to a lack of both human behavior considerations and integration. • Energy behavior inefficiencies: (1) employment of generators well below their design capacity, (2) environmental control units, (3) vehicles. • To combat the energy inefficiencies that occur due to these behaviors, Peters suggests strategies to improve the behavior of the individual to maximize the efficiency of the organization: (1) training and education, (2) policy and planning, (3) leadership, and (4) communication.

Effort or Study	Description
10. Eric Rollman's Master's Thesis on Facility Energy in the Air Force, USMC Command and Staff College, VA (2016)	• *Energy Culture in the Air Force: Installation Energy Management Reorganization* • Programmatic reorganization will positively influence energy culture change in the Air Force • A focus on the social aspect of the energy efficiency landscape will offer "lasting change and energy success" • Leadership is a critical pivot point at different levels of the chain of command to introduce and reinforce positive change
11. Russell Gibson's Master's Thesis on Facility Energy in the Army, U.S. Army Command and Staff College, KS (1998)	• "Energy Behavior Change and Army Net Zero Energy: Gaps in the Army's Approach to Changing Energy Behavior" Energy Behavior and Net Zero efforts • Energy behavior not part of Army mission, not priority • Energy culture assessments needed • Behavior research needed • Need to articulate link between operational and facility energy
12. Fort Irwin Electric Demand Response (ASA(IE&E) 2015)	• Fort Irwin partnered with their local utility, Southern California Edison to minimize power use during specific times • The installation informed personnel of each event using social media • The outcome that year, and each subsequent year, has been at least a $52,000 billing credit and $1.7M in avoided electricity costs
13. Detroit Arsenal, MI Commander's Energy Conservation Cup (ASA(IE&E) 2015)	• The competition consisted of 14 buildings tracking monthly energy consumption over a six-month period with consumption compared to the same period from the previous year • During the first 6 months, a total of $72,000 was saved. The first-place building saved over 17% from the previous year.
14. U.S. Army Garrison Benelux Awareness Campaign in Schools (ASA(IE&E) 2015)	• A school awareness campaign included student drawing contests and training for teachers on energy and water conservation, which resulted in a cost savings over one year of $6,720.
15. Fort Riley, KS Residential Program (ASA(IE&E) 2015)	• Smart meters provided water data to help inform residents about reducing water use • Overall, the program showed an 8% savings in monthly water use.

Effort or Study	Description
16. The Proposed Change Strategy by SAIC to Embed Energy Stewardship into the Army's Culture (Sweeney and Horner 2012)	• Primary focus operational energy • Culture change from energy consumers to energy stewards to enhance Army's ability to accomplish core mission • Objectives: mindset of energy as critical enabler, using energy wisely, empowering creativity and adaptability, sharing methods, applying stewardship to personal life • This effort was elevated to high-level Army leadership (Chief of Staff Gen. Casey in 2012),* but was not prioritized, and relegated to G-4 Logistics Operational Energy to pursue • Recommends an exclusively top-down approach. Very high-level leadership engagement essential for success • Critical Gap in previous efforts is wrong lead on effort. Delegation of lead is ineffective
17. Naval Postgraduate School Operational Energy (Salem and Gallenson 2014)	• "A Study of Human Behavior & Operational Energy, Analysis and Recommendations for the Marine Corps to Increase its Operational Reach" • Observations and interviews with Marines in field exercises • Problem: operational energy use is a vulnerability because supply chains endure casualties • Many factors impact energy use, but human behavior was the focus • Findings: need integration of efficiency behaviors into energy use behaviors; roles and attitudes are important, energy reduction requires revising the structure of training exercises, increasing accountability for fuel use, strengthening leadership role, improving fuel planning, developing information systems, increasing usability of support systems • To change behavior: align with the organizational objectives and values; take a portfolio approach looking at the full life cycle of equipment; engage stakeholders • Study recommendations: attack the problem holistically; take a lifestyle approach; actively manage the change over time

* Phone call with Patrick Sweeney, 4 November 2019, re: Sweeney and Horner (2012).

Effort or Study	Description
18. Carolina Health Care Study (Cowan 2016)	• Not a military site, but a large institutional organization with high variability in load profiles (40 hospitals, 400 clinics) that applied behavioral approaches for efficiency • Top level leadership showed strong support • Provided multiple levels of training to equipment operators • Incentivized efficiency for equipment operators (both in-house and contracted) • Provided pre-approved upgrade list for equipment operators • Establish tracking of HVAC system control changes • Conducted in-depth interviews with leadership • Conducted surveys with equipment operators at regularly scheduled meetings which lead to high response rate • Tailored solutions required at individual sites, no single solution, but a continuous improvement process
19. Army War College Climate Change Report (2019)	• "Implications of Climate Change for the U.S. Army" • Behavioral insights: • Army lacks a culture of environmental stewardship, not part of operational mission which focuses on the ends (of domination) but not the means (environmental impact) • Cultural change is a senior leader responsibility and a long-term endeavor • Army hierarchical culture resists suggestions from lower ranking individuals • Recommendations: • Incorporate environmental stewardship into formal mission statements and messaging • Invest in operational simulators and alternative energy or energy efficient training platforms • Use efficiency technologies in facilities • Institute energy accountability metrics and meaningful incentives (such as game room in barracks) • Re-energize the Senior Energy and Sustainability Council (SESC) of Colonels. Add high visibility coordination meetings

2.3.2 Energy behavior literature review highlights

2.3.2.1 Booz Allen Hamilton energy behavior study with Air Force and Marines (2016)

Booz Allen Hamilton managed and evaluated energy behavior campaigns with the U.S. Air Force and U.S. Marine Corps in 2016.

For the "I am Air Force Energy" campaign, the team conducted focus groups, surveys, and energy manager interviews and found that a majority of those surveyed thought that energy impacted their work "slightly" or "not at all."

Booz Allen developed a campaign that placed Airmen at the center of the initiative, used personal stories, and personalized fuel and energy use. After communications outreach, leadership engagement, and energy savings competitions, a post-survey revealed 68% of the 70,000 Airmen who recalled the campaign took an energy efficient action.

After focus groups, stakeholder interviews, and Marine Corps-wide surveys, the "Marine Corps Energy Ethos" behavior change program found that communication must be data-driven and simple, must hold Marines accountable, must be tied to the mission, and must be personal.

As part of a FEMP award-winning installation energy program, the team launched a strategic communications campaign entitled "You Have the Power." The campaign distributed posters, tip sheets, and point of interaction stickers. It developed a champions program called the "Unit Energy Manager (UEM) Program." The program used a variety of policy, handbooks, leadership engagement, and grassroots outreach. It developed and executed time-bound, measurable Energy Efficiency Initiatives (EEIs) at Marine Corps Air Station New River, North Carolina (MCAS New River), that functioned as pilot activities to various engagement techniques including gamification and routine facility walkthroughs. Individual EEIs within the units (at buildings including administrative offices, barracks, and hangars) at MCAS New River yielded energy savings of up to 14% in participating unit facilities over multi-month periods.

After communications engagement, implementing the UEM program, and sharing energy use data, a post-survey found that 75% of the Marines who recalled the campaign took an energy efficient action.

For both the Air Force and Marine Corps initiatives, the main takeaways for implementing behavior change were to:

1. Incorporate institutional context
2. Gain leadership buy-in
3. Develop partnerships
4. Leverage existing materials
5. Repeat the message.

2.3.2.2 3M™ Study at barracks and administrative buildings, Fort Bliss, TX (Erickson et al. 2014)

The 3M™ study examined if providing real time electrical use feedback to building occupants and facility managers would result in decreased energy use savings. At Fort Bliss, current transformers (CT) were installed on circuits in 14 barracks buildings at Fort Bliss and 13 work buildings at the 309th Aerospace Maintenance and Regeneration Group. Measurements from the CTs were transmitted via local gateways and cell phone networks to a cloud-based software platform. This fully integrated set of hardware and software is referred to as the 3M™ Energy Analyzer. Electrical usage information was displayed in various formats on a web-based application that could be viewed by building occupants. Representative examples of data formats include charts and graphs for facility managers and competitive leaderboards for barracks residents" (Erickson et al. 2014: ix). Furthermore, the 3M™ study participants were divided into a control group and an experimental group after baseline data were collected for both groups.

Findings indicated: "No difference in behavioral based energy reduction was observed between the experimental group and the control group. Several factors contributed to this result including high occupant variability due to field deployments, lack of intrinsic motivation among the resident population, and low levels of support from the chain of command to include extrinsic motivators in the study. One of the significant non-controllable variables was barracks occupancy level. Uncontrolled occupancy lev-

els resulting from unexpected field deployments caused highly unpredictable data patterns and eventually caused termination of the study before completion" (Erickson et al. 2014; ix). Unfortunately, in regard to the installed metering system, the planned energy use experiment could not be conducted due to an Operational Security (OPSEC) related shutdown of the system. However, even though full performance objectives for the study could not be fully met, the authors expressed the belief that this study could inform future work in the following ways:

- The metering technology was reliable and was easy to install and commission.
- The technology is sensitive to changes in electrical use as demonstrated during occupant deployments, during reduced energy allocations, and in correlation to ambient temperatures.
- Single Soldier barracks residents have little intrinsic motivation to change their electricity use behavior.
- Stronger command hierarchy support is likely required to produce energy saving behavioral changes in the barracks population.
- Access to data is not the only necessary component of a successful behavioral energy reduction effort.
- Engagement and commitment from upper level leadership was an implementation issue, so the authors suggest that "ESCTP should consider conducting future studies at Officer Candidate Schools where the future leaders of our military are being trained to understand the energy security issues."*

2.3.2.3 John Peters' master's thesis on USMC ground units during operations (2016)

Peters' thesis, *Factors That Influence Human Behavior and Negatively Affect Energy Consumption in USMC Ground Units during Operations,* focused on the vulnerability inherent in current battlefield energy requirements and usage of the USMC. The author argues that technical strategies to decrease this vulnerability factor are not sufficient due to a lack of both human behavior considerations and integration. The data were sourced from "reports of the real-world operational environment of Afghanistan in addition to USMC training exercises taking place in the desert regions of the southwest United States and the tropical areas of Southeast Asia that

* Environmental Security Technology Certification Program (ESTCP)

captured the employment of energy producing and consuming devices as well as related user behaviors" (Peters 2016:17). The textual analysis of this body of work revealed behavior trends that indicated that the human element is a responsible factor in a number of energy inefficiencies.

This analysis uncovered three main areas in which behavior played a prominent role in energy inefficiencies (Peters 2016:33-39):

1. Employment of generators well below their design capacity: Inadequate power planning and power distribution, excess equipment, and failure to use subject matter experts.
2. Environmental control units: Poor awareness of the impact that practices have on energy expenditures, and inattention of leadership.
3. Vehicles: Lack of confidence in equipment, perception of plenty, poor understanding of the impact idling has on fuel consumption, and incidental operators.

To resolve the energy inefficiencies that occur due to these behaviors, Peters suggests the following strategies to improve the behavior of the individual to maximize the efficiency of the organization (Peters 2016:41-43):

- Training and Education: Knowledge of the importance of the energy efficiency (education) and the vehicle by which this is communicated to audiences (training) is critical for both short- and long-term change.
- Policy and Planning: "The use of Marine Corps utility officers and chiefs during mission planning and execution, combined with implementation of unit level SOPs regarding energy use behaviors is likely to yield measurable improvements in operational energy efficiencies without adversely impacting mission effectiveness" (42).
- Leadership: All levels of leadership must be integrated in any energy saving strategy so that Marines are continuously informed of the importance of sound and efficient energy practices, led by example, and responsibility and accountability are maintained (43).
- Communication: A feedback loop is necessary to adequately communicate impacts of change.

The author also recommends the following actions, deemed appropriate for the organization, for consideration:

- Schoolhouse training and education of energy-related behaviors.
- Train as you fight.
- Develop unit level SOPs for energy efficient practices.

2.3.2.4 Eric Rollman's master's thesis on Air Force energy culture (2016)

Rollman's main focus in his theoretical thesis work, *Energy Culture in the Air Force: Installation Energy Management Reorganization*, is centered on people and, more broadly, programmatic reorganization that will positively influence energy culture change in the Air Force.

For example, Rollman suggests that

> The Air Force must reorganize the installation level energy program, moving the base energy manager to the Air Force command level office (Wing Staff), and empower the base energy manager with the authority and personal systems approach skills to influence an energy culture change at the installation level.

A focus on the social aspect of the energy efficiency landscape, he argues, will offer "lasting change and energy success" (Rollman 2012: iii). More specifically, leadership is a critical pivot point at different levels of the chain of command to introduce and reinforce positive change and is primed to use the unique, hierarchical, highly technical culture of the USAF to influence this positive change.

2.3.2.5 Russell Gibson's master's thesis on Army energy behavior and installation net zero efforts (1998)

The theoretical approach Gibson outlines in his thesis, *Energy Behavior Change and Army Net Zero Energy; Gaps in the Army's Approach to Changing Energy Behavior*, echoes that of Rollman's, but is situated in the Army domain rather than the Air Force, specifically Army net zero installations. The research is guided by two levels of research questions:

Primary Research Question:

> What gaps exist in the current Army approach to accomplish the behavioral and resulting cultural change required to meet Army net zero goals?

Secondary Research Questions:

> What change model should the Army apply and how?

> How should the Army institute organizational changes that will bring about the required behavioral changes required to meet net zero energy goals? What particular changes are required? What lessons can we learn and apply from other government agencies, service branches, and the private sector? How can the Army implement this change when it is not the primary mission, therefore not seen as a priority throughout the force?

Unfortunately, empirical observations were not conducted due to time constraints and installation access. However, following a review of the "literature on change in general and case studies of other cultural change in the Army as well as throughout the military and in the private sector" (Gibson 2014:8), Gibson offers several theoretical recommendations (Gibson 2014:89-91):

- The Army assess its energy culture by conducting assessments organization wide as well as at individual installations to determine members' attitudes about energy and conservation.
- With a clearer understanding of its culture, the Army continue to conduct research on energy behavior to the extent practical.
- The Army needs to create a better link between operational energy and installation energy and both ultimately to energy security for the Army and our nation.
- Saving energy is a full-time mission!

2.3.2.6 The proposed change strategy by SAIC to embed energy stewardship into Army culture (2012)

- Objectives: Mindset of energy as critical enabler, using energy wisely, empowering creativity and adaptability, sharing methods, applying stewardship to personal life.

- This effort was elevated to high-level Army leadership (Chief of Staff Gen. Casey in 2012),* but was not prioritized, and relegated to G-4 Logistics Operational Energy to pursue.
- Recommends an exclusively top-down approach. Very high-level leadership engagement essential for success: Secretary of the Army (SECARMY) and Chief of Staff of Army (CSA), and Sergeant Major of the Army (SMA) not logistician led efforts leveraging technology.
- Critical gap in previous efforts is wrong lead on effort. Delegation of lead is ineffective.
- Establish guiding coalition of Army leadership to develop tactics.
- Long-term (7 to 10-yr) effort with top-driven focus, enthusiasm, resources, and persistence reinforcement. Extensive list of embedding mechanisms: metrics, accountability including command assessments and personnel performance assessments, energy allocation budgets with consequences (savings or fines), acronyms, symbols, widespread reporting, After Action Reviews, personalized storytelling, operational energy planning tool, training, awards, savings competitions, multimedia communications, skill identifiers, certifications, recruiting, rites and rituals, leveraging Army values and Warrior Ethos, efficient facility design, equipment controls, identification of influential stakeholders (including congressmen).
- Recommends analysis of resistance (common causes: ambivalence, negative impact on interests, attachment to old culture, rigid perspectives, clashes with values, breach of personal compact, insufficient need, excessive change, disagreement with methods, perceived efficacy) and methods to address: communication, involvement, facilitation and support, negotiation, manipulation, and coercion as last resort.
- Recommends characteristics of vision statement: simple, inspirational, realistic, guidance with flexibility, aligns with values, concise.
- Authors are social scientists.
- Does not mention inclusion of installation facility support/ resource management personnel.
- Mr. Kidd was reviewer of report (as DASA E&S) (Sweeney and Horner 2012).

* Phone call with Patrick Sweeney, 4 November 2019, re: Sweeney and Horner (2012).

Note: The CERL research team believes this approach has substantial merit. However, we advise that it be combined with the recommendations of this report, which include both top-down and bottom-up efforts, the full spectrum of stakeholders (especially installation facility support), and the collective wisdom of Army personnel.

2.4 Army website screening

A screening of 50 Army installation websites was conducted to uncover other energy saving and energy culture programs. Twenty-three of these sites had applicable content that is provided in Table 3.

Broad themes that emerged from these locations are:

1. Very few installations are reporting on the inclusion of energy culture considerations within energy saving programs. Net zero installations were the most active in adopting behavioral approaches.
2. Energy savings impacts are often not listed on the websites.
3. Knowing which installations are conducting innovative energy saving programs is helpful to note in order to build partnerships.
4. Community engagement, though lacking in common practice, was impactful when employed.

Table 3. Review of Army energy efficiency programs posted on their websites.

Installation	Existing Programs
1. Anniston Army Depot, AL	• "Reducing our tracks," a general environmental protection program • Sept 2018-Turbine processes shop going green
2. Fort Rucker, AL	• Utility Energy Service Contracts (UESC) Projects to reduce utility costs and meet energy consumption goals. Examples include the installation of a central chilled water loop, chiller plant modernization, direct digital control systems for heating and cooling systems, and heat recovery chillers • The Hatch Stagefield photovoltaic array supplies excess power over their needs and allows Fort Rucker to sell power back to Alabama Power at their avoided cost. The project has taken Hatch to net zero for electricity • Alabama Power completed the installation of 90-acre photovoltaic array with a rated capacity of 10.6 Megawatts • Exterior LED lighting across post • Fort Rucker used 115.79 MMBTU/KSF of electricity in FY 2003 compared 87.51 MMBTU/KSF in FY16, a 25% reduction • Water intensity has had a steady reduction over the last several years

Installation	Existing Programs
3. Fort Huachuca, AZ	• Entered into a contract with Schneider electric to establish a collection of energy saving projects: https://www.myheraldreview.com/news/business/fort-huachuca-unveils-new-power-plant-project/article_d18c93fe-54e9-11e8-b56f-63d218981e49.html
4. Fort Irwin, CA	• Fort Irwin solar project
5. *Sierra Army Depot, CA	• Net zero pilot installation
6. *Fort Hunter Liggett, CA	• Net zero pilot installation
7. Presidio of Monterey, CA	• Directorate of Public Works (DPW) Energy conservation brochure/video • Active energy manager • Intermittently enforced BEM program
8. *Fort Carson, CO	• Net zero pilot installation
9. Fort Benning, GA	• BEM handbook posted in “sustainability” (But BEM website not functioning) • Community outreach programs (no details posted) • “Living Green” tips page • Tech: Windtronics, 30-megawatt solar project, compressed natural gas station
10. Fort Gordon, GA	• Partnership: http://griffitheng.com/portfolio-items/fort-gordon-energy-efficient-upgrades/
11. Fort Stewart, GA	• Email survey to gauge Army housing • DPW/O&M page, has an FAQ to engage the occupant, tenant • Solar panels
12. Fort Shaffer/ Schofield Barracks/ Pohakuloa Training Area/ Wheeler Army Airfield, HI	• Energy conservation FAQs • BEM/ UECO training on site • Videos that could relate to energy culture were listed but no links were provided • Sustainability tips
13. *Fort Detrick, MD	• Informative site • Net zero pilot installation • “Responsible Detrick” energy conservation awareness program • BEM program, outlined in Fort Detrick reg 11-27 and the BEM handbook • Incentive awards program (customers are encouraged to submit suggestions) • https://mybaseguide.com/news/178-56234/fort_detrick_sustainable_energy_projects_help_Army_garner_award

Installation	Existing Programs
14. U.S. Military Academy West Point, NY	• West Point energy council
15. Fort Bragg, NC	• No energy initiatives listed on main site, but sustainablefortbragg.com is a very informative site (through DPW but not "Army endorsed"): • The Green Boot Program • The BEM Program • Awareness initiatives • Community events
16. Fort Sill, OK	• "You Have the Power" • All links to events 2012 and before • Facilities manager handbook (like the BEM)
17. Fort Sam Houston, TX	• Community partnerships: http://www.jbsa.mil/News/News/Article/1058825/partnership-helps-jbsa-understand-the-uses-of-microgrid-technology/ • Engagement: http://www.jbsa.mil/News/News/Article/1394447/go-green-for-the-holidays/
18. Fort Hood, TX	• Link (at the bottom of the main page) to net zero (but at the moment focuses on trash): https://www.hood.Army.mil/NetZero/ • Note: The energy management is located in DPW under environmental (not O&M), • 2015: Hybrid renewable energy project and vehicle to grid initiative: http://kdhnews.com/fort_hood_herald/across_the_fort/Army-official-views-fort-hood-s-energy-initiatives/article_6d6742f4-2506-11e5-ac8c-d309a4a0f901.html
19. *Fort Bliss, TX	• See Net Zero Final Environmental Impact Statement Report, sections 2-1 and 2-3 mention energy behavior change. Recommend awareness, training, and mock billing to change behavior.
20. Fort AP Hill, VA	• Projects include the installation of an exterior finish and insulation system on 10 transient training barracks; replacement of fuel oil-fired hot water boilers and split system air-conditioning units in three dining facilities with more efficient and cleaner hybrid systems; and the installation of high-efficient windows in training support buildings
21. Fort Lee, VA	• Installed variable exhaust hoods • Installation of the Future: https://www.Army.mil/article/209859/fort_lee_energy_management_system_harbinger_to_installation_of_the_future • Made significant changes in how they operate the buildings through increased controls and retrofits

Installation	Existing Programs
22. Joint Base Lewis-McChord, WA	• Green Living videos produced at Joint Base Lewis-McChord, Wash. Including: (https://www.youtube.com/watch?v=catuXyVRZoY) which had 291 views • Focused on what the programs at JBLM were • Units battle for sustainability, 10 k in grants to Morale, Welfare and Recreation (MWR) fund for meeting sustainability goals. (https://www.airforcemedicine.af.mil/MTF/Joint-Base-Lewis-McChord/News-Events/Article/767386/jblm-units-battle-for-sustainability/)
23. Fort McCoy, WI	• Fort McCoy achieved significant reduction in water consumption of 27% from fiscal year 2015 to fiscal year 2016. Michael Miller, Russell Sanborn, Emmet Peterson, Robert Thompson, and Brad Noth, led major efforts that contributed to this feat including changes to irrigation patterns, replacement of 1940s-era water mains, synchronization of fire flow testing with annual distribution system flushing, and plumbing fixture retrofits. Additionally, close monitoring and maintenance of the chlorine residual in the potable water system enabled Fort McCoy to reduce annual costs associated with disinfection chemicals by 75%, compared to other municipalities in the state. • Support the IMCOM Service Culture Initiative. Part of their Strategic Plan is “Stewardship of Fort McCoy's fiscal and natural resources, energy, and environment is imperative.”
*Net Zero Installation	

2.5 Noblis energy behavior study review

In 2018, Noblis, funded by ESTCP, initiated a large-scale, tri-service experimental project to test a small set of energy behavior intervention strategies through a structured randomized control trial (RCT) (the gold standard approach for gauging social science impact). The effort examined the two largest classes of buildings in the DoD: unaccompanied housing and offices. These facility types, which exist on every installation, account for almost a third of DoD’s facility footprint. They also represent two classes or types of buildings where there is an expectation that behavioral interventions can be effective at reducing energy consumption. The results were expected to provide guidance and evidence of the optimal approaches for military facilities with realistic cost and return on investment estimates. However, the project was stopped during the feasibility analysis due to major inconsistences in energy data. Noblis observed that energy data needed greater integrity and reliability before a large-scale trial could yield valid results.

The Noblis analysis found that significant energy data massaging was needed before observations could be made, and deemed their proposed experiment impractical. They also found that Army energy data were especially problematic and observed that Army electrical energy use intensity (EUI) for administration buildings appeared to be three times that of both the other services and the national mean consumption found in the civilian Commercial Buildings Energy Consumption Survey (CBECS), and the Army's electrical EUI for barracks buildings appeared to be seven times that of the other services. Noblis concluded that the Army data were invalid and unusable (see Figures 3 and 4).

Figure 3. Army Admin Building Electric EUI apparently 3X CBECS and other services.

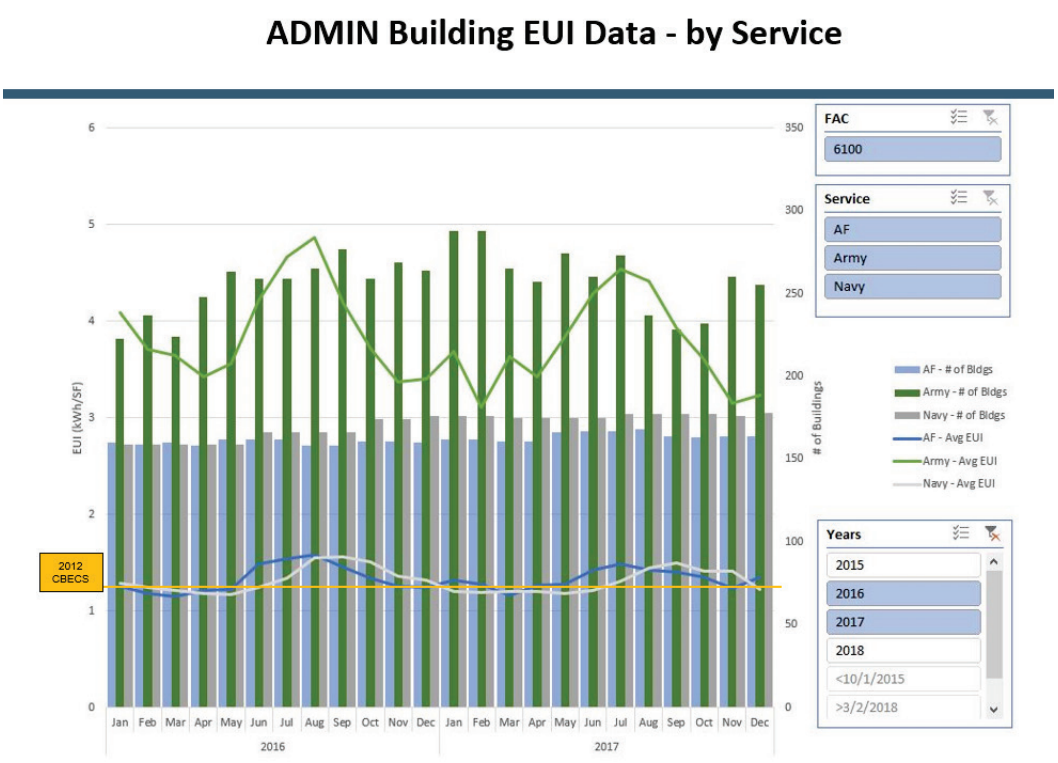
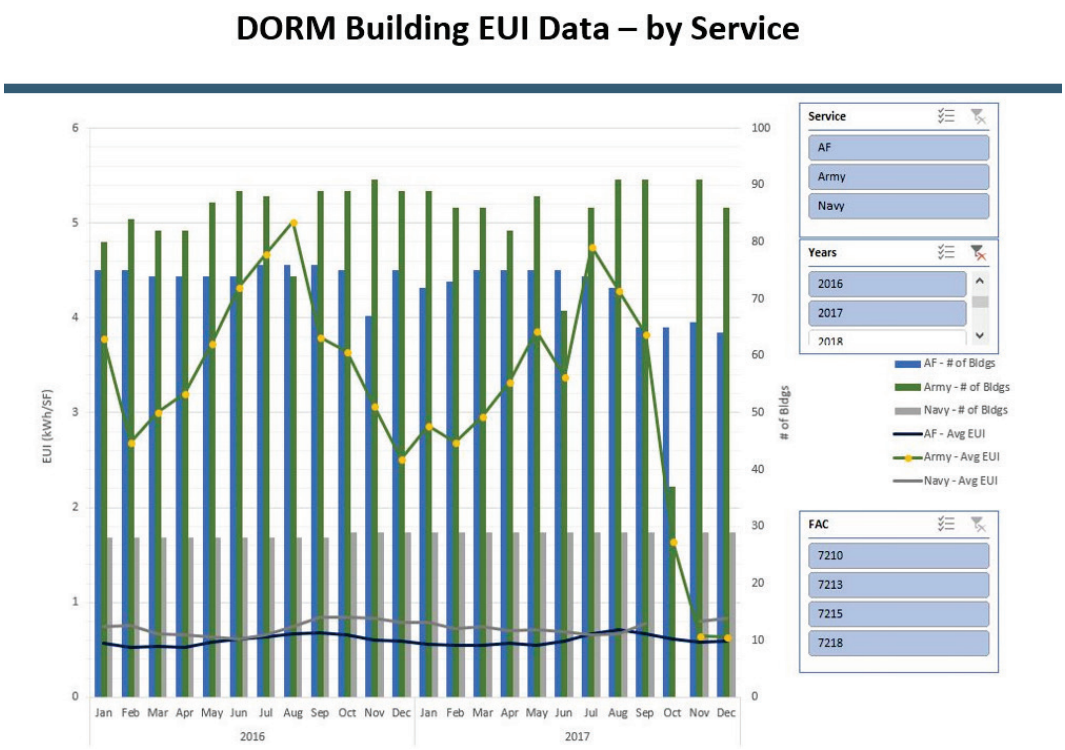


Figure 4. Army Barracks Electric EUI Apparently 7 X Other Services.



Our research team is not convinced that Army energy data across hundreds of facilities is all invalid and is intrigued that these results might signal very significant savings opportunities to improve efficiencies. We recommend additional investigation into the integrity of Army meter data, and investigation of the existing facility operations that result in widespread intense energy consumption. It may be that there are meter multipliers that were incorrectly applied, or that the needs and mission of the Army are not comparable to the other services or the civilian population.

Furthermore, we expect that, although the energy data of the collective military may not be ready to a large-scale experiment, there are many lessons that can and should be learned from smaller scale behavioral demonstrations and will propel us toward our energy resiliency goals.

2.6 Behavioral methods review

2.6.1 Collected best practices

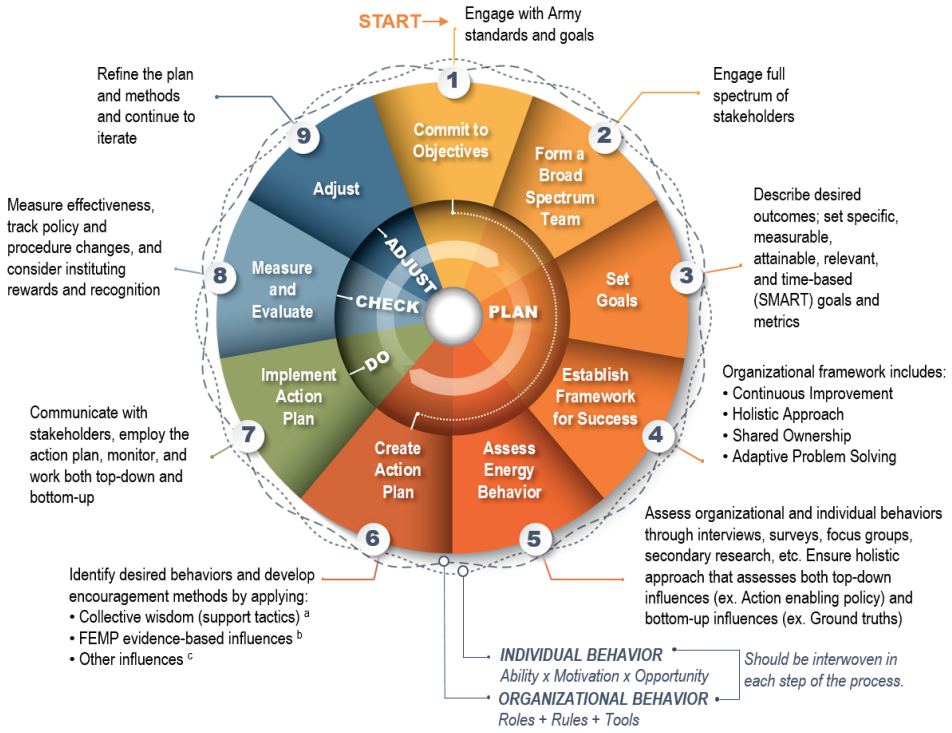
A review of behavioral approaches to improving energy efficiency in the military, government, academia and private industry revealed an assortment of applicable insights and approaches that have been synthesized into an overall process presented below.

The recommended HCEP (Figure 5), is based on a continuous improvement cycle with a supporting organizational framework. Continuous improvement is an ongoing, iterative effort of gradual increases in effectiveness used to achieve goals. The continuous improvement cycle is used and recommended by many organizations and programs including Energy Star, the Installation Strategic Sustainability Plan (ISSP), the Installation Energy and Water Management Plans, the ISO 50001 Energy Management Systems Standard, as well as the Army's After Action Report (AAR).

The supporting organizational framework (Step 4 in Figure 5) includes a holistic approach that supports both human and technical aspects of efficiency, which incorporates the full spectrum of stakeholders with shared ownership in the outcome (source: Michael Martel, U.S. Army), and uses adaptive problem solving (source: U.S. Army) to allow for adjustments to organization and situational conditions. Within this framework, energy-related behavior at both the individual and organizational level is first assessed, and then addressed using the collective wisdom of stakeholders and established methods of behavior influence. These methods include FEMP's recommended evidenced-based principals that effect organizational change. A key feature of the recommended HCEP is that individual and organizational behaviors are addressed simultaneously and throughout the process to optimize effectiveness.

Figure 5 schematically illustrates the recommended HCEP. Table 4 lists and describes each step in detail, including the FEMP evidenced-based organizational change principals and other influence methods.

Figure 5. Human-centered efficiency process (HCEP) schematic.



Notes:

[a] Sample Tactics to Support People (collective wisdom):

- Installation specific design guide
- Retain savings from efficiency at installations
- Facility operator coaching
- Community of practice for energy behavior
- Mock billing

[b] FEMP Evidenced-Based Methods for Change:

- Social Network & Communication
- Multiple Motivations
- Leadership
- Commitment
- Information & Feedback
- Infrastructure
- Social Empowerment

[c] Additional Behavior Influences:

- Addressing Cognitive Biases
- Overcoming Resistance
- Partnerships

Table 4. Details of Human-Centered Efficiency Process.

Best Practice	Details	Methods
A. Employ Human-Centered Efficiency Process		
Step 1: Commit to Objectives		
	• Engage with Army ethos, values, executive orders, Army and federal policy, resiliency needs, etc.	
Step 2: Form a Broad-Spectrum Team		
	• The full spectrum of people involved with the life of a facility (e.g., designer, construction team, commissioning authority, administrator, equipment operator, building occupant) affect operations, and have insights to share, and should be engaged in plans to improve operations	
Step 3: Set Goals		
	• Describe desired outcomes to allow formulation of approach and focus • Make specific, measurable, and verifiable • Establish metrics: Quantitative and qualitative aspects of movement toward goal	• Examples: energy and cost impacts, improved comfort, increased equipment life, attitudes toward facility energy, understanding of the connection between energy and mission requirements, awareness of energy efficient best practices, and knowledge of how to use energy efficient technologies
Step 4: Establish Organizational Framework for Success		
4a. Continuous Improvement	• An ongoing effort focused on gradual increases in effectiveness and/or efficiency • Employ Plan-Do-Check-Adjust Cycle with iterations • Institute leadership review for gravitas, visibility, support • Be a learning organization • Establish web of involvement so no single point of failure	• Think long term (several years) from the start, need to allow people to form new habits, and establish new ways of doing business • Build on existing continuous improvement processes: • Energy Star Energy Management Process • Installation Strategic Sustainability Plan (ISSP) • Installation Energy and Water Management Plans • ISO 50001 Energy Management Systems • After Action Report (AAR)
4b. Holistic Approach	• An approach that supports both the human and technological elements of energy efficiency to improve facility performance • Need to look beyond purely technical solutions to achieve and maintain results	
4c. Shared Ownership	• A collaborative, team-based approach where multidisciplinary stakeholders are invested in the outcome, and are empowered to contribute to and take ownership of specific pieces of a larger-scale effort	• The Commander's Intent process instills collective ownership of the mission
4d. Adaptive Problem Solving	• Results oriented, willing to change course if progress not occurring • Recognizes that unforeseen changes will occur and require changes in thinking	• The Commander's Intent process encourages evolution of thought as circumstances evolve

Best Practice	Details	Methods
Step 5: Assess Energy Behavior		
5a. Organizational Behavior	• Sum of Rules, Roles, and Tools (RRT)	• Review the building technology, the interactions of people with that technology and the processes supporting efficient choices and actions. • Review interplay of organizational and individual behavior. Are RRT informed by actual activities that are taking place (ground truth)? Does policy enable individual action?
i. Review Rules	• The formal and informal rules that affect workplace behavior (laws, policies, requirements, procedures, norms)	• Ask: What are the policies, procedures, and norms (informal rules) that support the present behaviors and the encouragement methods that apply? • Establish supporting policy, institute procedures, foster norms • Set goals, create position descriptions, institute performance standards, reporting requirements, training requirements, change organizational structure, add budget lines to support initiatives, articulate values
ii. Review Roles	• The people within an organization who are important to achieving and maintaining efficiency goals	• Ask: What/whose behavior matters with regard to a given issue? What needs to change? Can goal be achieved through targeted groups or everyone's behavior? • Establish roles with accountability and expectations, position descriptions • Engage those with leadership, authority, resources, and influence for necessary buy-in first • Multiple levels engaged for organizational change
iii. Review Tools	• Employ supporting infrastructure (technologies, processes, and systems) to meet needs	• Ask: What technologies, processes, and systems are in place or needed to support desired behaviors and outcomes? • Resources (money, people, materials, time), training, references, systems • Revise maintenance practices, standard operating procedures (e.g., timely response to comfort complaints), retro-commissioning, efficiency requirements in purchasing, equipment settings, occupant responsive technology
5b. Individual Behavior	• Product of Ability, Motivation, Opportunity (AMO)	• Review the building technology, the interactions of people with that technology, and the processes supporting efficient choices and actions. • Check that all three factors are in place; any factor missing yields no action. • Review interplay of organizational and individual behavior. Are RRT informed by ground truth? Does policy enable individual action?
i. Review Ability	• The awareness, knowledge, and skill to choose and act efficiently	• Ask: What behaviors are desired? Do individuals know what needs to be done and how? • Media campaign for awareness, education for knowledge, training for skills

Best Practice	Details	Methods
ii. Review Motivation	• The desire and mindset to choose and act efficiently (rules, values, norms, habits, perceptions)	• Ask: Are there external or internal motivators to drive efficient action? • Persuasion changes external motivation to internal • Internal motivation promotes creativity • Extensive demands may get action but will cost social capital • There are many internal drivers to action that are contrary to rational decisions – see cognitive biases
iii. Review Opportunity	• The circumstance to support efficiency (roles, tools, accommodation)	• Ask: Do individuals have the authority, means, and accommodation to perform in ways to meet desired outcomes? • Consider the who, when, and where of energy behavior • Accessibility to controls and signage on controls facilitates proper usage
Step 6: Create Action Plan		
6a. Identify Desired Behaviors.	• Collaboratively with stakeholders choose and detail behaviors that support goals and are meaningful to those impacted.	• Examples: Turning equipment down or off to match needs and avoid waste (i.e., turning lights off when leaving a room).
6b. Develop Encouragement Methods	• Approaches to support people to make choices and take actions that promote efficiency	• Examples: Information and feedback, education, contests, social norms, prompts, defaults, RRT including gamification
i. Apply Collective wisdom of cultural pulse, gaps & bridges to efficiency	• Use pertinent insights and ideas from a broad range of stakeholders, including those at front line of technology use	• See Stakeholder Support Tactics Table 5 for 76 tactics to help efficiency from installation personnel
ii. Apply FEMP Evidence-based Influences	• Use methods of influence that other governmental efficiency programs have found effective	• See common methods from FEMP award winners Section B below
iii. Apply Other Influences	• Use common methods of influence in industry at large	• See detailed influences Section C below
Step 7: Implement Action Plan		
7a. Communicate	• Accessible explanations of the initiative • Get the word out to affected stakeholders via appropriate media	• Messaging affects motivation • Choices are affected by the framing of the presentation of options
7b. Initiate	• Employ action plan	
7c. Monitor.	• Watch operations and gather data.	
7d. Work Both Top-down and Bottom-up	• Employ influencing methods for both the organization as whole and for individuals	
Step 8: Measure and Evaluate (Periodically determine progress toward goals)		
8a. Effectiveness.	• Consider what is working to further aims, and what efforts should be discontinued.	
8b. Input to Policy, Procedures	• Track pertinent policy and procedures to recommend new insights for inclusion at appropriate times	
8c. Rewards and Recognition	• Stakeholder and other awards, celebrate success along the way to goals	• Encourage self-nomination as well as nominating others

Best Practice	Details	Methods
Step 9: Adjust Methods		
9a. Refine Plan	• Change the plan to reflect achievable, relevant goals, add both short- and long-term waypoints	
9b. Refine Methods	• Change methods to reflect learning from mistakes, or new trial approaches that may be fruitful	
9c. Iterate	• Continue to build on efforts incrementally over time to achieve and sustain results	
B. Apply FEMP Evidenced-Based Principles to Guide Change (expanded detail of Step 6bii above)		
Influence people (both organizations and individuals)		
Gleaned from review of FEMP Federal Energy Efficiency Award Winners		
Social Network & Communication	• Seeing and hearing others (people, groups, institutions, firms) behave differently inspires change	
Multiple Motivations	• People almost always change their way of doing things for more than one reason	
Leadership	• People change because workplace rules change, and visible leadership communicates management commitment	
Commitment	• People change when they make definite commitments to change, especially when those commitments relate to future conditions	
Information & Feedback	• People change because they receive actionable information and feedback	• Includes awareness, training, incentives, persuasion, and urgency. Education provides information and theory, training develops skills. Ask: who benefits? Review current and future stakeholders
Infrastructure	• People change because changed infrastructure makes changes easy and/or desirable	• Changing defaults to desired choices helps
Social Empowerment	• People who feel they can reach desirable social goals often do	
Continuous Change	Change takes time (5+ years)	
C. Apply Other Behavior Influences (expanded detail of Step 6biii above)		
Addressing Cognitive Biases:	• Common mental shortcuts in thinking related to efficiency cause people to act irrationally (not logically or in their best interest)	
Status Quo & Professional Bias	• Established behaviors resist change	• Includes habits, rules of thumb
Self-Serving Bias	• People generally believe they perform better than average	
Mental Accounting	• Subjective categorization and coding of economic outcomes may prevent change	• Example: Wanting to distribute resources evenly may not reflect best economic or engineering option
Risk/Loss Aversion	• Avoiding loss is often preferred to acquiring gains	
Anchoring & Adjustment	• Gravitation to pre-defined reference, even if irrelevant	
Group Think	• Groups tend to reach consensus to minimize conflict and may skip detailed evaluations	

Best Practice	Details	Methods
Assess and Address Resistance to Change	• Common Causes: ambivalence, negative impact on interests, attachment to old culture, rigid perspectives, clashes with values, breach of personal compact, insufficient need, excessive change, disagreement with methods, perceived efficacy • Methods to remedy: communication, involvement, facilitation and support, negotiation, manipulation, and coercion as last resort	
Partnerships.	• Establish mutually beneficial relationships with new groups such as neighboring communities or industry to potentially share assets, complement existing skillsets, and broaden perspectives.	• Engage other military groups.

2.6.2 Consider logic model in action plans and program evaluation

Within the holistic systems approach shown in Figure 5 and in approaches such as those described in ISO 50001, an organization develops action plans or campaigns designed to affect or change behavior in targeted population groups within their organization or mission. For example, an installation may want to reduce the number of incidences when windows are left open by occupants while the building heating system is running or increase the use of the practice of logging service calls by building technicians so that building operations are more efficient. Campaign plans to improve energy efficiency from these groups are most effective in producing results when they follow a logic model. A logic model is used to describe the effectiveness of programs by showing the linkages among program resources, activities, outputs, and short-, intermediate-, and long-term outcomes. Since the logic model illustrates the sequence of cause and effect relationships, it acts as a systems approach to communicate the path to a desired result (University of Idaho-Extension).

Figure 6 shows the typical logic model process. It begins by identifying an issue or problem that the organization wants to change within a target population group. Next steps are basic input-process-outputs actions designed and put in place to produce measurable outcomes. Inputs include people, funding, and other resources. Outputs are the results of activities or processes. Output measures answer the question: “How do you know they really did that?”

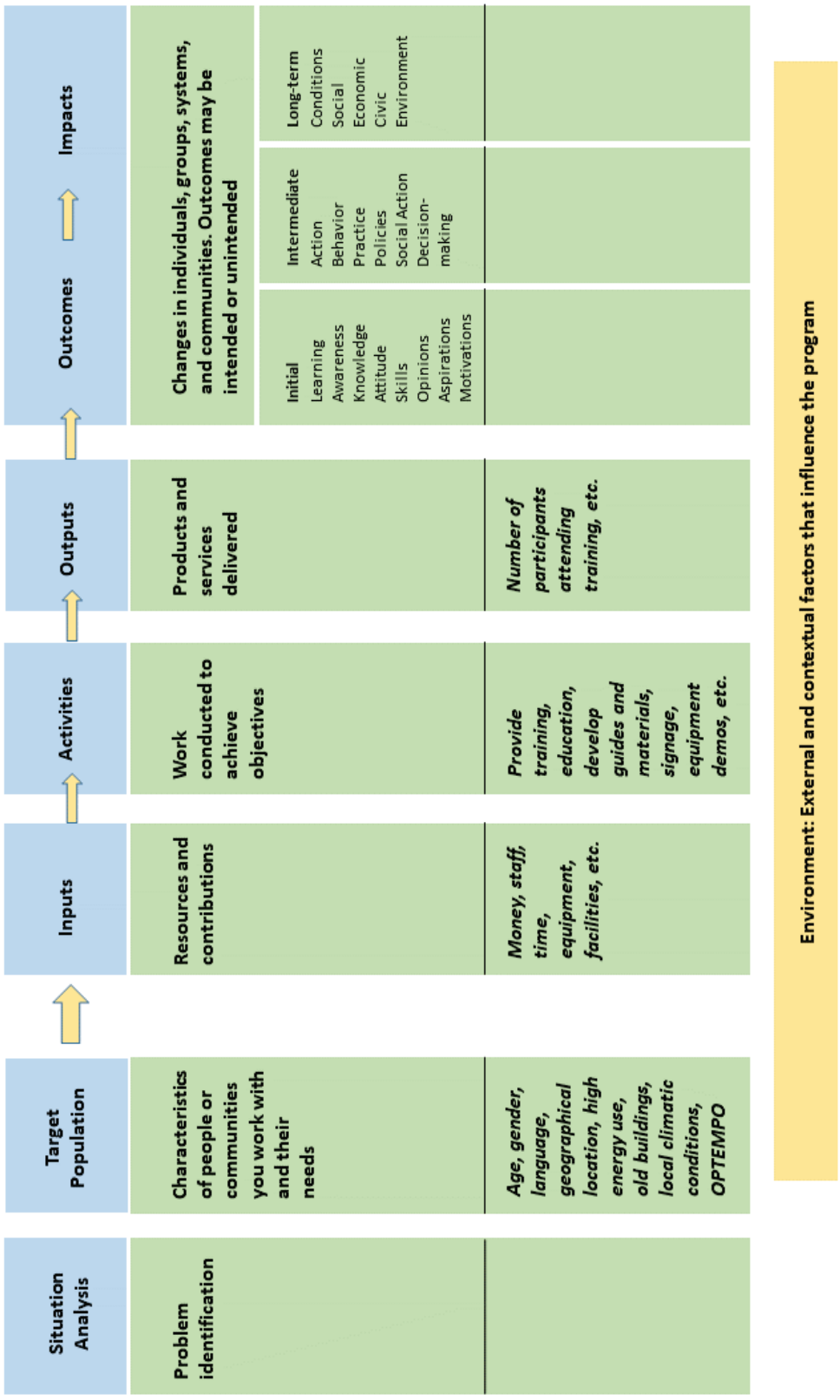


Figure 6. Typical Logic Model (Adapted from Henert [2010]).

Outcomes, however, are all about impact. They answer the question: "What difference did your campaign make?" It is important to note that outcome indicators should be measurable and should allow the organization to answer questions such as:

- Did participants show the desired level of knowledge increase, enhanced awareness, or motivation?
- Were improved management practices adopted, behaviors modified, or policies altered to expectations of the program?

The outcomes should also allow the organization to understand the extent to which environmental, economic, political, or social factors affected or were affected by the program. Identification of appropriate, measurable indicators early in the process helps greatly toward developing a sound and useful program and helps to identify the baseline data that are needed and that may already be available.

2.7 Energy culture assessment interviews and questionnaires

2.7.1 Assessment approach

Investigation of the human side of facilities energy management included interviews and questionnaires of a wide range of facility stakeholders.

Insights in this section were gleaned from four sources:

1. Conversations/interviews with approximately 60 facility stakeholders.
2. A facility controls questionnaire from about 50 IMCOM installations.
3. Round 1 energy culture questionnaire from 10 installation personnel who were primarily DPW facility support people (with a few teachers/ administrators). This group is referred to as the Facility Support Staff in the analysis.
4. Round 2 energy culture questionnaire from 18 energy researchers in USACE. This group is referred to as the Facility Energy Researcher in the analysis.

Over the past year, the research team has conversed with approximately 60 stakeholders in DoD energy efficiency (including Army leadership, a Garrison Commander, DPWs, Installation and Component Energy Managers, HVAC technicians, Controls Contractors, Sustainability Managers, Strategic Planners, key players in Institutional Energy Behavior e.g., FEMP, LBNL, Noblis, Booz Allen Hamilton). Most conversations were in person (during team visits to Washington, D.C., Fort Bragg, Fort Knox,

Presidio of Monterey, Energy Exchange conference and Installations of the Future Industry Day) but some occurred over the phone.

Primary areas of discussion included: Is efficiency important? To whom and why? Can you make a difference? Who needs help and how? What are the drivers and barriers to efficiency?

Early meetings with Army civilian leadership helped to formulate a landscape of issues to develop pilot questionnaires for later use. Questionnaire scope and content evolved over time.

Questionnaire Pilots to small sample groups were employed to establish methods to determine:

- The pulse of the culture concerning energy efficiency in terms of individual preferences, knowledge, actions, and perceptions
- The gaps in efficiency practices that separate us from our optimally efficient selves
- End user recommended methods of bridging gaps in efficiency by supporting people to use technology effectively and efficiently

Additional data gathering will yield a fuller perspective of our organizational relationship with energy efficiency. Interview, focus group, and survey details are provided in Appendix D.

2.7.2 Preliminary energy culture assessment

The pulse of the Army's energy culture in the pilot sampled population included the following observations:

- Human interaction with technology can make or break efficiency efforts.
- Electric grid resilience is top priority for installation facility support leadership and energy managers and takes precedence over efficiency.
- Efficiency is of high importance to facility support staff. A primary driver for efficiency is the need to meet energy and cost reduction goals, followed by the need to reduce environmental impact. This group saw facility policy and leadership actions as supporting efficiency. They felt free to share their insights with leadership. The most meaningful reward for their efficiency efforts would be to improve fa-

cility comfort (40% of this group had significant challenges with comfort in their workspace). After comfort improvement, making a difference, and building upgrades were seen as desirable outcomes of efforts.
- Facility energy researchers were most driven to efficiency to reduce environmental impact. They were willing to support efficiency initiatives.

Barriers to efficiency revealed in the interviews and questionnaires included:

- Insufficient funding in both design and operations is largest barrier to efficiency and leads to inefficient facility operation.
- Facility HVAC operators are ambivalent about efficiency.
- Soldiers are not engaged with energy efficiency.
- Facility support staffing is inadequate.
- Access and coordination of information is challenging.
- Training is too limited.
- Significant opportunities exist for HVAC and control technician best practices (documents management, equipment modification logging, controls calibration, training).

A detailed review of the interviews and questionnaires is provided in Appendices A and B.

2.7.3 Collected energy stakeholder support tactics

The interviews, questionnaires and literature search to date resulted in a broad reaching collection of tactics to support people to use energy effectively and efficiently. Seventy-six distinctive tactics were identified and mapped to the affected facility stakeholder (Table 5). Approximately 40% of these approaches are in place in at least one location and are recommended for broader implementation by facility stakeholders. These tactics are recommended for review during the development of energy behavior encouragement methods (Step 6bi in Table 4) of the HCEP.

Table 5. Energy stakeholders support tactics (collective wisdom from field).

Stakeholder	Evidence of Some Support in Place (most need expansion)	Opportunities for Bridging Gaps in Efficiency Support
1. Designer	• Facility Design Guides and Criteria • Whole Building Design Guide • Criteria Change Request • Communities of Practice – USACE • Engineering Construction Bulletin • Public Works Digest	• Installation Specific Design Guides with efficiency as default, accessibility and signage for controls, interlock of windows with HVAC • Feedback from end users (with post occupancy reviews) • Feedback from retro-commissioning efforts
2. Construction Contractor	• New Construction Commissioning (Cx)	• 3rd Party Cx thru IDIQ • Cx started in Design Development Phase
3. Administrator *(Including Resource Manager)*	• Legislated Savings goals, reporting, Installation Status Reports • Contracted O&M fences labor, details tasks • FEMP/Energy Star training • Maintenance Data Management System (MDMS) training (benchmarking, dashboards, monitoring based commissioning) • Certified Energy Manager Certification (other AEE certifications) • Energy Exchange Conference • Quarterly Energy Manager calls (IMCOM)	• Behavioral approach checklists • Position descriptions • Table of Distribution & Allowances (TDA) additions for staffing • Increased funding for maintenance • Retained savings from efficiency • Sharing of ideas across installations • Inclusion of efficiency in job performance appraisal • Energy Use Dashboards • Establish cyber-secure energy benchmarking methods
4. Purchasers	• Third party financing (Energy Savings Performance Contracts, Utility Energy Savings Contracts) • Green Procurement Program • Energy Star • SOW templates	• Multiple Award Task Orders (MATOCs) • Other Transaction Authority (OTA)

Stakeholder	Evidence of Some Support in Place (most need expansion)	Opportunities for Bridging Gaps in Efficiency Support
5. Facility Operators	• RCx training • Sustainment Management Systems • Pre-approved low/no cost changes • Required training for federal building personnel • Established training budget for DPW.	• Building Automation Dashboard • Operational Data Analytics • Tiered onsite training • Building Operators Certification • Coaching, periodic checkups on best practices • Expanded use of online training • Troubleshooting guides • Maintenance coordination between HVAC techs and UMCS operators • Maintenance tracking (Logbook and/or bar codes) • Accessible as-built construction documents (get as part of Cx) • Wireless UMCS/ Maintenance Mgmt. System • Approved Cyber Packages • Career path to promotion • Peer champions • Incentivizing efficiency in paycheck, maintenance contract, performance appraisal.
6. Occupants	• Awareness fairs, In-brief training • Residential efficiency rebates • Building Energy Monitors/ Peer Champions • Self Help upgrades • Barracks plug load disconnection safety checks.	• Mock billing • School programs • Savings competitions • Signage on lighting, thermostats • Persuasion of the desirability for efficiency • Signed efficiency commitment.

Stakeholder	Evidence of Some Support in Place (most need expansion)	Opportunities for Bridging Gaps in Efficiency Support
7. All	• Energy Awards (FEMP, Sec Army) • Pull-the-plug electricity disconnection exercises • Suggestion box	• Continuous Improvement Structures: • Energy Star Energy Management Process • ISSP • Installation Energy and Water Management Plans • ISO 50001 Energy Management Systems • AAR • All hands quarterly meetings need energy effort update every quarter • Installation level recognition of energy wins • Establishing accountability and incentives for efficiency • Capture non-energy benefits of efficiency efforts (productivity, equipment life, job satisfaction, etc.) • Capture stories of challenges and success (they instruct and inspire) • Establish Communities of Practice for Energy Stewardship • Re-energize SESC of Colonels

2.8 Conference participation

Two organizations that were involved with facility energy performance invited conference presentations on the Army's energy culture efforts. Efforts presented include the keynote address of the *2019 Building Commissioning Association's (BCxA) Conference*, "Adding Energy Behavior to the Building Performance Equation," and a breakout session on "Scaling Up Sustainability Through Institutional Culture Change" at the *2019 Behavior Energy and Climate Change (BECC) Conference*. The feedback from these events was very positive and resulted in fruitful discussions that helped refine research efforts and create seeds for future collaboration.

3 Conclusions and Recommendations

3.1 Conclusions

Facility energy efficiency efforts too often underperform because of people's choices and actions (behavior) in their use of technology. The Army's energy guidance recognizes that people's behaviors are key to optimal energy operations and calls for establishing an informed energy-conscious culture of stewardship to meet mission resiliency requirements. However, the details for implementing that guidance have not been established. This effort provides many of the needed details by providing a practical behavioral approach to efficiency and a strategy to effect a culture of efficiency.

The HCEP is a continuous improvement process that systematically moves people toward efficiency and is built around an organizational framework that promotes success.

A culture of efficiency can be established by systematically supporting people to use technology effectively and efficiently and, by ultimately shifting cultural norms, to embrace shared ownership of energy outcomes. Both top-down (Army leadership) and bottom-up (individual) actions are required over the long term (5+ years). When a critical mass of people (~80%) adopt norms, the fabric of the culture shifts to a new normal (Sweeney and Horner 2012).

The benefits of employing behavioral approaches are extensive; they include both energy and non-energy impacts:

- Reaching technical potential of efficiency
- Using energy to full advantage, reducing waste, directing resources to critical loads
- Improving comfort and productivity, extending equipment life, retaining Soldiers
- Engaging the workforce
- Establishing efficiency habits for home station, field, and future employment endeavors.

The following strategy may be used to change energy culture to improve efficiency. A strategy is a high-level planning tool to guide overall efforts. It will need tailoring and adaptation at the installation level to reflect local circumstances.

1. Assess the current status of energy culture

   Using the energy culture assessment template (Appendix D), document cultural relationship with efficiency; solicit insights on improvements. Sample multiple locations for fuller perspective.

   A preliminary assessment (60 interviews, 78 survey responses, primarily civilians) noted the following:

   - Civilian leadership, facility support administrators, resource managers, and researchers have a strong efficiency mindset
   - HVAC and controls staff ambivalent about efficiency, believe it competes with facility comfort objectives
   - Soldiers are not engaged with efficiency, believe it competes with or is inconsequential to the mission
   - Drivers: legislated goals, comfort, environmental impact, altruism, mission
   - Barriers: funding, leadership, staffing, coordination, quality data, motivation, sharing of methods, training
   - Extensive collective wisdom on tactics to support energy stakeholders resides with both military and civilian staff

2. Determine the desired end state

   The proposed vision of an ideal end state for optimal efficiency was guided by our research. It will need further development and socialization with Army leadership. Key features are presented as a candidate for discussion:

   - Self-sustaining, self-correcting culture of efficiency
   - Saving millions for the mission, directing resources to critical loads
   - Optimal resource use (cost effective, risk appropriate)
   - Engaged shared ownership
   - Action enabling policy informed by ground truth
   - ALL-IN efficiency for resiliency

3. Establish and employ a path to move the organization toward the end state.

   The path forward will need to consider the multiple levels of the organization and their interplay. It should use the HCEP mentioned above and detailed in the findings section of this report. Implementing this process at the installation level with benchmarking of current practice, and behavioral demonstrations will produce the needed ground truth insights for potential policy changes. The following section includes nine recommended steps that the Army can take to move to a higher level of efficiency.

3.2 Recommendations

3.2.1 Human-centered approach to efficiency

This work recommends a behavioral approach to efficiency synthesized from best practices in facility management, organizational and individual change management, and existing Army methods (such as AARs, and the Commander's Intent process) as well as proven methods of influence and collective wisdom on bridging efficiency gaps from federal personnel that can systematically move people toward efficiency. Its multidisciplinary approach and federal sector insights make it particularly helpful for managing Army facility energy systems as a whole with both technical and human elements.

This recommended combined approach may be summarized as:

1. Establishing a supporting framework (Figure 7) that is conducive to success with organizational rules of engagement including:
   a. Continuous Improvement
   b. Shared Ownership
   c. Adaptive Problem Solving
   d. Holistic systems approach.
2. Supporting organizational efficiency behaviors that endure the test of time and changes in personnel by using the Rules, Roles, and Tools Methodology (see Table 4 and Appendix E) to track and influence policy; establish roles; and institute procedures, methods, and infrastructure that lead to efficiency
3. Supporting individual efficiency behaviors by using the Ability, Motivation, and Opportunity Methodology (See Table 4) to improve the well-being and performance of employees, thus improving organizational performance.

4. Monitoring and influencing the factors of change iteratively over time using the collective wisdom gained from interviews and surveys (See Table 5) and established methods of influence (See Table 4).

Figure 7. Recommended supporting framework for HCEP.

3.2.2 Way forward for Army

1. **Incorporate energy stewardship into current resilience initiatives led by top Army leadership**. Social science experts recommend that, unless high-level Army leadership takes the lead in committing to efficiency with authority and follow through, the rank and file Soldier will not fully embrace it either. Delegating this effort to logistics personnel or installation energy managers will not bring about the desired culture change. It may to helpful to meet with leaders to discuss where energy efficiency stands in their priorities, and to discuss how energy efficiency affects their commands. Key features of this effort include:
   a. Reviving the energy stewardship objective as a mission enabler that is established at the home station and embedding energy utilization goals and reinforcing mechanisms into daily processes.
   b. Employing a broad-spectrum team to instill a sense of commitment and accountability and giving the initiative high visibility using appropriate messaging.

2. **Increase funding allocations for building support staff to demonstrate priorities.** The large portfolio of facilities owned by the Army will require significantly more people than currently employed to support them if increases in energy performance are desired. This may take the form of in-house or contracted support.
3. **Expand and tailor data collection to determine local issues and opportunities.** Conduct enhanced data gathering at one to three Army installations with a more refined data gathering approach than earlier efforts. Research questions will be tailored to specific stakeholder groups (e.g., interviews with administrators; targeted questionnaires for planning, design, procurement, construction, operations; and brief surveys for building occupants) and address topics missed in first round efforts. The team will work to gain buy-in and increase staff participation in data gathering efforts for more broad-spectrum insights. (*FY20 seed funding received).*
4. **Initiate benchmarking of behavioral approaches.** Create a graded checklist and benchmark current energy efficiency practices (both business structure and tactic utilization) at one to three sites against collected best practices for influencing energy behavior. Consider a future requirement for energy behavior benchmarking at select sites or as part of their IEWPs. (*FY20 seed funding received).*
5. **Make a behavioral approach Standard Operating Procedure for energy management.** Tailor and adapt the energy culture strategy to local circumstances. Optimize energy management by actively applying the insights of energy behavior with the organizational framework of continuous improvement, shared ownership, holistic approach, and adaptive problem solving. Employ the HCEP to influence both individual and organizational behavior toward efficiency.
6. **Establish repository of energy behavior methods and initiatives** Establish an online repository for sharing behavioral methods and insights to allow parties across the organizations to benefit from the experiences and successes of other locations. (*FY20 seed funding received).*
7. **Conduct behavioral demonstrations to establish ground level methods and impacts.** Conduct multi-pronged demonstration projects that include detailed data collection at selected sites, development of a collection of methods/tactics that support energy efficient behavior, implementation of these support methods/tactics, and evaluation and documentation of outcomes. *See Appendix C for more details on the proposed demonstration projects.* (*FY20 preliminary seed funding received).*
8. **Continue Monitoring Policy and Procedures.** Incorporate behavioral insights into organizational rules, roles, and tools, support individual

ability, motivation, and opportunity. In addition to the recommended edits to AR 420-1 (HQDA 2008) the team provided this year; we will continue to monitor Army policies and procedures to find opportunities to incorporate energy efficient behavior best practices.

9. **Review previous energy data analyses.** The analysis of energy data for a potential RCT of energy behavior impacts by Noblis showed that Army electric energy use intensities are vastly higher (three to seven times) than that of other services and national medians. The source of this variation should be established as it may indicate an extensive opportunity for savings in Army administrative and barracks buildings.

Bibliography

Cited works

Articles and websites

Andres, Richard, and Micah Loudermilk. 2011. "Improving Military Energy Behavior and Culture." *Live Better Magazine*. 34. http://livebettermagazine.com/article/improving-military-energy-behavior-culture/.

Carmichael, Cara, and Matt Jungclaus. 2018. "A Resilience Strategy Based on Energy Efficiency Delivers Five Core Values." Basalt, CO: Rocky Mountain Institute. https://rmi.org/a-resilience-strategy-based-on-energy-efficiency-delivers-five-core-values/.

Cohen, Dan. 2015. *Changing Behavior Represents Next Frontier in Reaching Military's Energy Goals*. Washington, DC: Association of Defense Communities.

Cowan, Kady. 2016. "Designing Energy Behavior Leading Change." *ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, DC: American Council for an Energy-Efficient Economy (ACEEE). https://aceee.org/files/proceedings/2016/data/papers/8_743.pdf.

Erickson, Megan, and Peter Eisenberg. 2014. *Energy Reduction through Real Time Electricity Monitoring*. Environmental Security Technology Certification Program (ESTCP) Final Report EW-201258. Alexandria, VA: ESTCP. https://www.serdp-estcp.org/Program-Areas/Installation-Energy-and-Water/Energy/Conservation-and-Efficiency/EW-201258.

Gibson, Russell. 1998. *Energy Behavior Change and Army Net Zero Energy: Gaps in the Army's Approach to Changing Energy Behavior*. Master's thesis. Fort Leavenworth, KS: U.S. Army Command and General Staff College. https://apps.dtic.mil/sti/citations/ADA610963.

Keim, Brandon. 2014. "The Hot New Frontier of Energy Research is Human Behavior." *Wired.com*. https://www.wired.com/2014/06/energy-and-human-behavior/.

Mahoney, Chris. 2015. "The Next Energy Revolution Won't Be in Wind or Solar. It Will Be in Our Brains." *The Washington Post*. https://www.washingtonpost.com/news/energy-environment/wp/2015/01/22/the-next-energy-revolution-wont-be-in-wind-or-solar-it-will-be-in-our-brains/?noredirect=on&utm_term=.defe1661bc75.

Mazzi, E, K. Cowan, and E. Westervelt. 2015. "Human Behavior and Facility Energy Management." in B. Capehart, W. Turner, and W. Kennedy. *Guide to Energy Management*, 8th ed. Lilburn, GA: The Fairmont Press.

Metzger, I., A. Kandt, and O. VanGeet. 2011. *Plug Load Behavioral Change Demonstration Project*. NREL/TP-7A40-52248. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy11osti/52248.pdf.

Michael, Laura. 2015. "It's Not Green. It's Red, White and Blue: Military Energy Messaging." 2015 *Behavior, Energy & Climate Change Conference, Sacramento, CA*. https://beccconference.org/wp-content/uploads/2015/10/presentation_michael.pdf.

Peters, John. 2016. *Factors That Influence Human Behavior and Negatively Affect Energy Consumption in USMC Ground Units during Operations*. Master's thesis. Monterey, CA: Naval Postgraduate School. https://apps.dtic.mil/dtic/tr/fulltext/u2/1029902.pdf.

Rollman, Eric. 2012. *Energy Culture in the Air Force: Installation Energy Management Reorganization*. Master's thesis. Quantico, VA: USMC Command and Staff College. http://www.dtic.mil/dtic/tr/fulltext/u2/a601450.pdf.

Salem, Anita, and Ann Gallenson. 2014. *A Study of Human Behavior & Operational Energy, Analysis and Recommendations for the Marine Corps to Increase Its Operational Reach*. Faculty and Researchers' Publications 2014-10. Monterey, CA: Naval Postgraduate School. https://calhoun.nps.edu/handle/10945/44731.

Shen, Meng, Robert Young, and Qingbin Cui. 2016. "The Normative Feedback Approach for Energy Conservation Behavior in the Military Community." *Energy Policy*. 98:19-32.

Sweeney, Patrick, and Donald Horner. 2012. *The Proposed Change Strategy to Embed Energy Stewardship into the Army's Culture*. Fort Belvoir, VA: U.S. Army Logistics Innovation Agency (LLA). http://www.dtic.mil/dtic/tr/fulltext/u2/a588881.pdf.

U.S. Army War College. 019. *Implications of Climate Change for the U.S. Army*. Washington, DC: Center for Climate % Security, https://climateandsecurity.org/2019/10/25/u-s-Army-war-college-possible-collapse-of-the-military-mission-in-20-years-due-to-climate-change/

Westervelt, Eileen T., G. Russ Northrup, and Linda K. Lawrie 1990.*Applying Energy Conservation Retrofits to Standard Army Buildings: Data Analysis and Recommendations*. USACERL Technical Report E-90/11. Champaign, IL: U.S. Army Construction Engineering Research Laboratory (USACERL) (now known as the Engineer Research and Development Center, Construction Engineering Research Laboratory [ERDC-CERL]).

Wolfe, A. K, E. L. Malone, J. Heerwagen, J. Dion. 2014. "Behavioral Change and Building Performance: Strategies for Significant, Persistent and Measurable Institutional Change." Washington, DC: U.S. Department of Energy. https://www.energy.gov/sites/prod/files/2014/06/f16/change_performance.pdf.

Military and federal energy guidance documents

2018 NDAA (National Defense Authorization Act). 2017. National Defense Authorization Act for Fiscal Year 2018. Pub. L. No. 115-91 115th Congress.

ASA(IE&E) (Assistant Secretary of the Army for Installations, Energy and Environment). 2015. *2015 Progress Report, Army Net Zero Initiative*. Washington, DC: ASA(IE&E). https://www.asaie.army.mil/Public/ES/doc/2015%20Net%20Zero%20Progress%20Report.pdf.

———. 2016a. *Army Installations, 2025*. Washington, DC: ASA(IE&E). https://www.army.mil/e2/c/downloads/455380.pdf.

ACSIM (Assistant Chief of Staff for Installation Management). 2018. Memorandum. Subject: Guidance for Installation Energy and Water Plans (IEWPs). Washington, DC: ACSIM.

DoD (U.S. Department of Defense). 2017b. DoD Directive 4180.01, Energy Policy. https://www.hsdl.org/?abstract&did=753157.

———. 2018. *Summary of the 2018 National Defense Strategy*. https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

EISA (Energy Independence and Security Act of 2007). 2007. https://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf.

EPAct (Energy Policy Act of 2005). 2005. https://www.govinfo.gov/content/pkg/PLAW-109publ58/pdf/PLAW-109publ58.pdf.

HQDA (Headquarters, Department of the Army). 2008. *Army Facilities Management*. Army Regulation (AR) 420-1. Washington DC: HQDA. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN15517_R420_1_admin_FINAL.pdf.

———.2015. *Army Energy Security and Sustainability (ES²) Strategy*. https://www.army.mil/e2/c/downloads/394128.pdf.

IMCOM (U.S. Army Installation Management Command). 2016. *Building Energy Monitor Handbook*. Fort Sam Houston, TX: Headquarters, IMCOM. https://home.army.mil/lewis-mcchord/application/files/1915/7366/8063/IMCOM_BEM_HANDBOOK_1-19-2017.pdf

JBER (Joint Base Elmendorf-Richardson). 2013. *2013 JBER Environmental Awareness*. http://www.jber.jb.mil/Portals/144/Services-Resources/environmental/public-Docs/Environmental-JBER-Environmental-Handbook.pdf.

McCarthy, Ryan D. 2020. Memorandum. Subject: Army Directive 2020-03 (Installation Energy and Water Resilience Policy). Washington, DC: Office of the Secretary of the Army. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN21689_AD2020_03_FINAL_Revised.pdf.

SAF/IE (Secretary of the Air Force/Installations, Environment and Energy). 2017. *Air Force Energy Plan 2017-2036*. Washington DC: SAF/IE. https://www.safie.hq.af.mil/Portals/78/ AFEnergyFlightPlan2017.pdf?ver=2017-01-13-133958-503.

SAF/IEE (Deputy Assistant Secretary of the Air Force for Environment, Safety and Infrastructure). 2014. *Energy Management*. Air Force Instruction 90-1701. Washington D.C: SAF/IEE. http://static.e-publishing.af.mil/production/1/saf_ie/publication/afi90-1701/afi90-1701.pdf.

Spangdahlem Air Base. 2017. *2017 Spangdahlem Air Base Installation Energy Plan: United States Air Forces in Europe*. http://www.spangdahlem.af.mil/Portals/10/documents/Spangdahlem%20Air%20Base%202017%20%20Installation%20Energy%20Plan.pdf?ver=2017-07-17-042800-623

USDON (U S. Department of the Navy). 2010. *Department of the Navy's Energy Program for Security and Independence*. Washington, DC: U. S. Department of the Navy. https://www.secnav.navy.mil/eie/ASN%20EIE%20Policy/Naval_Energy_Strategic_Roadmap.pdf.

USMC (Department of the Navy, United States Marine Corps). 2015. *Unit Energy Manager Program Handbook for Unit Energy Managers*. Washington, DC: USMC. https://www.mcicom.marines.mil/portals/57/docs/uem_handbook_01212015.pdf.

White House, The. 2017. *Promoting Energy Independence and Economic Growth*. EO 13783. https://www.federalregister.gov/documents/2017/03/31/2017-06576/promoting-energy-independence-and-economic-growth.

———. 2018. *Efficient Federal Operations*. EO 13834. https://www.federalregister.gov/documents/2018/05/22/2018-11101/efficient-federal-operations.

Uncited works

Articles and websites

Andres, Richard. 2009. *Energy Behavior and National Security: Creating a Green Military*. http://www.eesi.org/files/andres_111809.pdf.

Bohannon, Dennis. 2016. "U.S. Army Sweeps Federal Energy and Water Management Awards." *U.S. Army*. Website. https://www.army.mil/article/179441/us_Army_sweeps_federal_energy_and_water_management_awards.

Booth, S., J. Barnett, K. Burman, Josh Hambrick, M. Helwig, and R. Westby. 2010. *Targeting Net Zero at Marine Corps Air Station Miramar: Assessment and Recommendations*. NREL/TP-7A40-47991. Golden, CO: National Renewable Energy Laboratory (NREL).

Callahan, M., K. Anderson, S. Booth, J. Katz, T. Tetreault. 2011. *Lessons Learned from Net Zero Energy Assessments and Renewable Energy Projects*. NREL/TP-7A40-51598. Golden, CO: NREL.

Henert, Ellen. 2003. *Enhancing Program Performance with Logic Models*. Madison, Wi: University of Wisconsin-Extension. https://fyi.extension.wisc.edu/programdevelopment/files/2016/03/lmcourseall.pdf.

Jagels, George. 2014. "USMC Energy: Extending the Corps' Reach." *DoD Power & Energy Magazine*. https://tacticaldefenseme-dia.com/usmc-energy-extending-the-corps-reach/.

Judd, KS., M. Zalesny, T. Sanquist, N. Fernandez. 2013. *The Role of Occupant Behavior in Achieving Net Zero Energy: A Demonstration Project at Fort Carson*." PNNL-22824. Richland, WA: Pacific Northwest National Laboratory (PNNL). https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22824.pdf.

Keysar, Elizabeth, Kathy Lahaye, and Karrie Fristoe. 2017. "Medcom Announces Practice Greenhealth 2017 Award Winners." U.S. Army Website. https://www.army.mil/article/186276/medcom_announces_practice_greenhealth_2017_award_winners.

Kimbrough, Jonelle. 2016. "Army Reserve Senior Sustainability Council Charter Signed by Senior Leadership." *U.S. Army Reserve*. Website. http://www.usar.Army.mil/News/News-Display/Article/810595/Army-reserve-senior-sustainability-council-charter-signed-by-senior-leadership/.

Kimbrough, Jonelle. 2017. "Army Reserve Honored with Federal Energy Management Program Awards." *U.S. Army*. Website. https://www.army.mil/article/197003/Army_reserve_honored_with_federal_energy_management_program_awards.

Marin-Garcia, Jaun A., and Juan Martinez Tomas. 2016. "Deconstructing AMO Framework: A Systematic Review." *Intangible Capital* 12(4):1040-1087. https://core.ac.uk/download/pdf/81577887.pdf.

Martel, Micheal. 2014. *Get Er Done, The Green Beret Guide to Productivity*. Waco, TX: PCG Business.

McMakin, Andrea, Regina Lundgren, and Elizabeth Malone. 2000. *Handbook for Promoting Behavior-Based Energy Efficiency in Military Housing*. Washington, DC: U.S. Department of Energy, Federal Energy Management Program (FEMP). https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-12254.pdf

Papamikrouli, Louiza. 2008. "The Motivation-Opportunity-Abilities Model." *KANE CRES*. Website. Athens, Greece: Center for Renewable Energy Sources and Saving. http://www.cres.gr/behave/pdf/Motivation_Opportunity_model.pdf

Ribeiro, David, Eric Mackres, Brendon Baatz, Rachel Cluett, Michael Jarret, Meegan Kelly, and Shruti Vaidyanathan. 2015. *Enhancing Community Resilience through Energy Efficiency*. Report U1508. Washington, DC: American Council for an Energy-Efficient Economy (ACEEE). https://www.aceee.org/research-report/u1508.

Shen, Meng, Qingbin Cui, and Liping Fu. 2015. "Personality Traits and Energy Conservation." *Energy Policy* 85:322-334.

Surash, Jack. 2017. "Army Energy Resilience Efforts Recognized at Annual Department of Energy Awards Ceremony." *U.S. Army*. Website. https://www.army.mil/article/197403/Army_energy_resilience_efforts_recognized_at_annual_department_of_energy_awards_ceremony.

USDOE (U.S. Department of Energy). 2020. *Federal Energy Management Program*. Website. Washington, DC: USDOE Office of Energy Efficiency & Renewable Energy. https://www.energy.gov/eere/femp/federal-energy-management-program

———. 2020. *2012 Federal Energy, and Water Management Award Winners*. Website. Washington, DC: USDOE Office of Energy Efficiency & Renewable Energy. https://www.energy.gov/eere/femp/2012-federal-energy-and-water-management-award-winners.

USEIA (U.S. Energy Information Administration). 2019. *Commercial Buildings Energy Consumption Survey (CBECS)*. Web page. Washington, DC: USEIA. https://www.eia.gov/consumption/commercial/

USEPA (U.S. Environmental Protection Agency). 2019. *Energy Star*. Website. Washington, DC: USEPA. https://www.energystar.gov/

Military and federal energy guidance documents

ASA(IE&E) (Assistant Secretary of the Army for Installations, Energy and Environment). 2009. *Army Energy Security Implementation Strategy*. Washington, DC: ASA(IE&E). http://www.asaie.Army.mil/Public/Partnerships/EnergySecurity/docs/Army_Energy_Security_Implementation_Strategy_AESIS_January-2009.pdf.

———. 2016b. *Installations, Energy and Environment Strategy 2025*. Washington, DC: ASA(IE&E). https://www.Army.mil/e2/c/downloads/455381.pdf.

———. 2016c. *2015 Progress Report Army Net Zero Initiative*. Washington, DC: ASA(IE&E). http://www.asaie.Army.mil/Public/ES/doc/2015%20Net%20Zero%20Progress%20Report.pdf.

———. 2017. Memorandum. Subject: Energy and Water Goal Attainment Responsibility Policy for Installations. Washington, DC: ASA(IE&E). http://www.asaie.Army.mil/Public/ES/doc/Energy%20and%20Water%20Goal%20Attainment%20 Policy.pdf.

DoD (U.S. Department of Defense). 2009. DoD Instruction 4170.11. Subject: Installation Energy Management. https://www.acq.osd.mil/dodsc/library/dodi-4170-11-installation.pdf.

———. 2016. *Department of Defense Strategic Sustainability Performance Plan*. https://denix.osd.mil/sustainability/dodsspp/unassigned/department-of-defense-strategic-sustainabilityperformance-plan-fy-2016/.

HQDA (Headquarters, Department of the Army). 2013. Memorandum. Subject: Army Operational Energy Policy. https://www.asaie.army.mil/Public/ES/doc/Army%20Operational%20Energy%20Policy%2030%20Apr%202013.pdf.

———. 2017. Memorandum. Subject: Army Directive 2017-17, Installation Energy and Water Security Policy. http://www.asaie.Army.mil/Public/ES/doc/Army_Directive_2017-07.pdf.

HQTRADOC (Headquarters, U.S. Army Training and Doctrine Command). 2018. *The U.S. Army in Multi-Domain Operations 2028*. TRADOC Pamphlet 525-3-1. Fort Eustis, VA: HQTRADOC. https://www.tradoc.Army.mil/Portals/14/Documents/MDO/TP525-3-1_30Nov2018.pdf

NAVFAC (Naval Facilities Engineering Command). 2017a. *Heating Ventilating, Air-Conditioning*. Unified Facilities Criteria 3-410-01 Washington DC: U.S. Army Corps of Engineers (USACE), NAVFAC (Preparing Activity), U.S. Air Force Civil Engineer Center (AFCEC). https://www.wbdg.org/FCC/DOD/UFC/ufc_3_410_01_2013_c4.pdf.

NEPA (National Environmental Policy Act). 1969. https://ceq.doe.gov/laws-regulations/laws.html

SAF/IEN (Deputy Assistant Secretary of the Air Force for Operational Energy). 2016. *Energy and Water Management*. Air Force Policy Directive 90-17. Washington DC: SAF/IEN. http://static.e-publishing.af.mil/production/1/saf_ie/publication/afpd90-17/afpd90-17.pdf.

White House, The. 2009. *Federal Leadership on Environmental, Energy, and Economic Performance*. Executive Order (EO) 13514. Revoked with the publication of EO 13693 (2015). *Planning for Federal Sustainability in the Next Decade*.

———. 2015. *Planning for Federal Sustainability in the Next Decade*. EO 13693. https://www.epa.gov/greeningepa/executive-order-13693-planning-federal-sustainability-next-decade. Revoked by EO 13836 (2018). *Efficient Federal Operations*.

Acronyms and Abbreviations

Term	Definition
AAR	After Action Report
AEE	Association of Energy Engineers
AESIS	Army Energy Security Implementation Strategy
AFI	Air Force Instruction
AFPD	Air Force Policy Directive
AMC	U.S. Army Materiel Command
AMO	Ability, Motivation, Opportunitys
AR	Army Regulation
ASA(IE&E)	The Office of the Assistant Secretary of the Army for Installations, Energy and Environment
BCxA	Building Commissioning Association
BECC	Behavior Energy and Climate Change
BEM	Building Energy Monitor
BTU	British Thermal Unit
CBECS	Commercial Buildings Energy Consumption Survey
CERL	Construction Engineering Research Laboratory
CSA	Chief of Staff of Army
CT	Current Transformer
DASA E&S	Deputy Assistant Secretary of the Army, Energy and Sustainability
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DPW	Directorate of Public Works
EEI	Energy Efficiency Initiative
EISA	U.S. Energy Independence and Security Act of 2007
ERDC	U.S. Army Engineer Research and Development Center
ES	Energy and Sustainability
ESTCP	Environmental Security Technology Certification Program
EUI	Energy Use Intensity
FAQ	Frequently Asked Questions
FEMP	Federal Energy Management Program
FTE	Full-Time Employee
FY	Fiscal Year
HCEP	Human-Centered Efficiency Process
HQ	Headquarters
HQDA	Headquarters, Department of the Army
HQUSACE	Headquarters, United States Army Corps of Engineers
HVAC	Heating, Ventilating, and Air-Conditioning

Term	Definition
IDIQ	Indefinite Delivery/Indefinite Quantity
IEE	Installations, Energy and Environment (Strategy)
IEWP	Installation Energy and Water Plan
IMCOM	U.S. Army Installation Management Command
ISO	International Organization for Standardization
ISSP	Installation Strategic Sustainability Plan
JBER	Joint Base Elmendorf-Richardson
JBLM	Joint Base Lewis-McChord
KSF	thousand square feet
LBNL	Lawrence Berkeley National Laboratory
LED	Light Emitting Diode
MATOC	Multiple Award Task Order
MCAS	Marine Corps Air Station
MDMS	Maintenance Data Management System
MMBTU	million BTU
MMBTU/KSF	Million BTU per Thousand Square Feet
MWR	Morale, Welfare, and Recreation
NREL	National Renewable Energy Laboratory
O&M	Operations and Maintenance
OEI	Office of Energy Initiatives
OPSEC	Operational Security
OTA	Other Transaction Authority
PNNL	Pacific Northwest National Laboratory
RCT	Randomized Control Trial
RRT	Rules, Roles, and Tools
SAIC	Science Applications International Corporation, Inc.
SECARMY	Office of the Secretary of the Army
SESC	Senior Energy and Sustainability Council
SMA	Sergeant Major of the Army
SOP	Standing Operating Procedure
SOW	Statement of Work
TDA	Table of Distribution and Allowances
UECO	Unit Energy Company Officer
UEM	Unit Energy Manager
UESC	Utility Energy Savings Contract
UMCS	Utility Monitoring and Control System
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USMC	U.S. Marine Corps
WG	Wage Grade

Appendix A: Detailed Analysis of Interviews and Questionnaires

Investigation of the human side of facilities energy management included interviews and questionnaires of a wide range of facility stakeholders. (Section 2.7.1 [p. 41] includes a detailed list of those stakeholders.) This section amplifies the observations listed in section 2.7.2, supported with associated graphical results.)

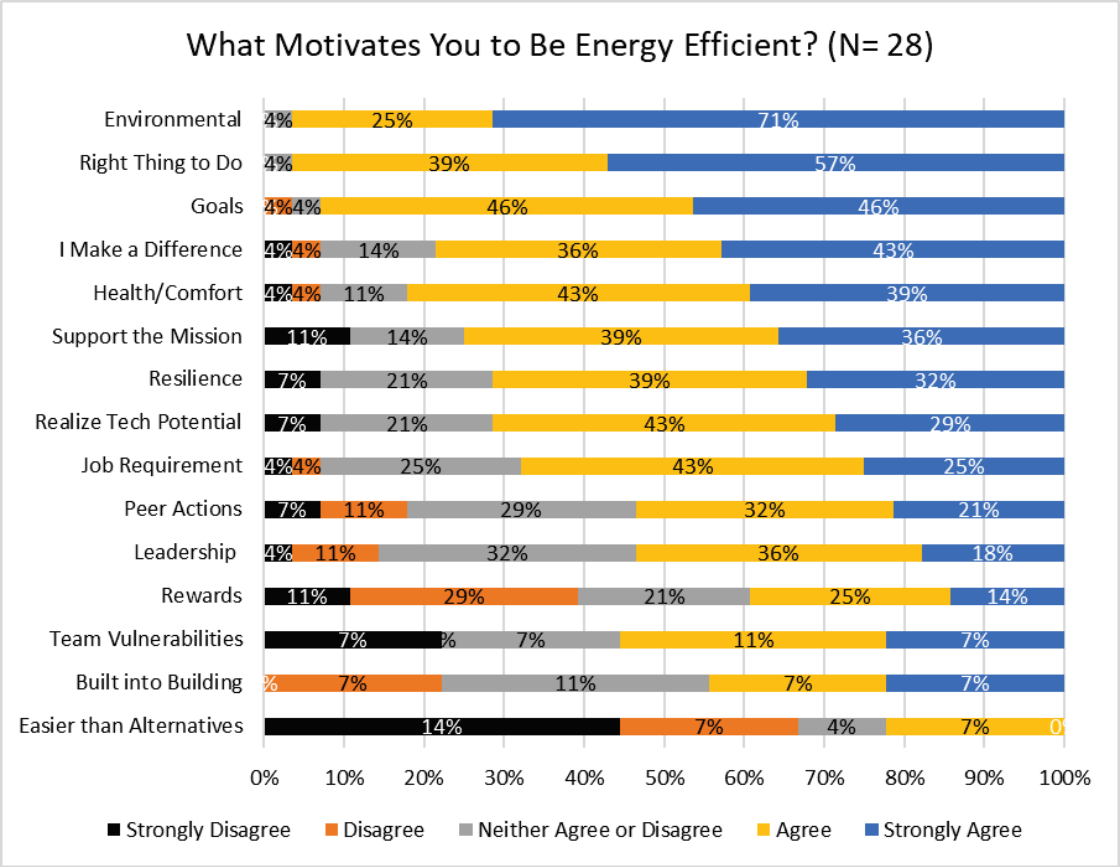
An analysis of the elements of the energy culture assessment elicited the following important points.

Human Interactions with Technology are Pivotal. All administrators and facility management personnel easily expressed agreement that there is a need for appropriate use of technology by people to achieve desired efficiency. They saw human choices and actions as being able to make or break efficiency efforts.

Electric Grid Resilience is a Top Concern. Installation facility/resource management personnel were keenly concerned about energy resilience to endure and quickly recover from pull-the-plug electricity disconnection exercises, and often mentioned that their primary energy concern was redundant generation and micro-grid capability to direct electricity to critical loads. This aspect of energy management was not reflected in the pilot questionnaires.

Efficiency is a High Priority. Administrators, teachers, researchers, and facility support staff universally expressed a keen interest in improving efficiency to attain energy goals and to alleviate environmental concerns, as well as to satisfy more general altruistic goals (i.e., “it’s the right thing to do” and “I can make a difference”). Supporting the mission also ranked highly; 79% of respondents identified it as a motivator (Figure A-1).

Figure A-1. Efficiency motivations per facility support staff and researchers.



Researchers further asked participants to assess their peers' perceptions and actions toward energy efficiency, as well as their own personal willingness to take energy efficiency actions. Just under half of respondents felt their commands/groups encouraged them to be more efficient, but 83% believed their peers valued being efficient, indicating there is a perceived interest at a personal level more than an organizational level. Accordingly, all but one respondent reported personally valuing efficiency (Figure A-2).

The researcher group's valuation of efficiency can further be explored by identifying which efficiency actions they are willing to take. The research group, at a minimum, expressed a willingness to try most suggested actions (Figure A-3). The action most reported as currently being done was encouraging others to develop energy saving habits, followed by suggesting innovative energy savings ideas to leadership. Respondents were most skeptical of participating in communities of practice and participating in competitions. This supports the previously identified concept that efficiency actions are currently at the personal than at the organizational level.

Figure A-2. Peers valuing efficiency.

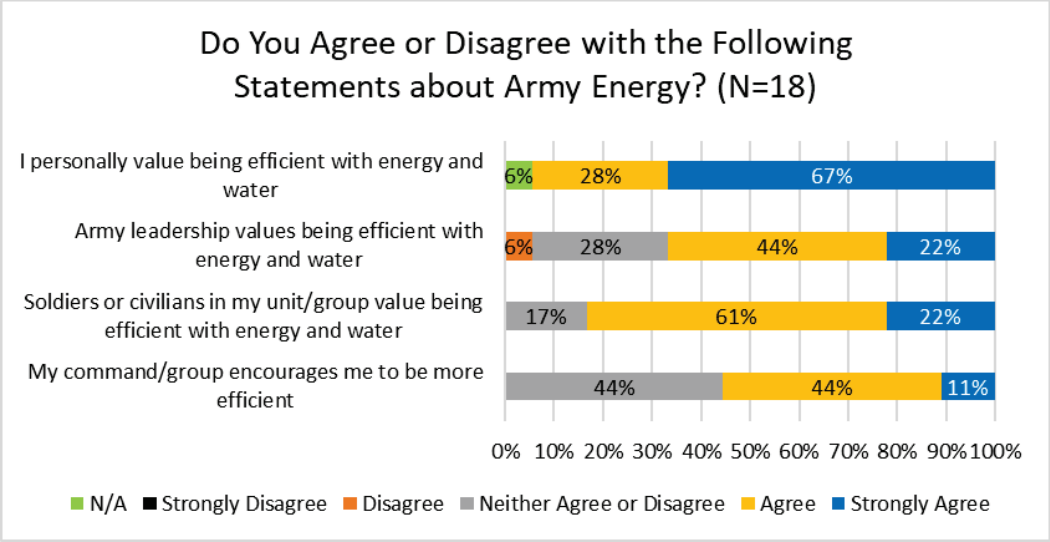
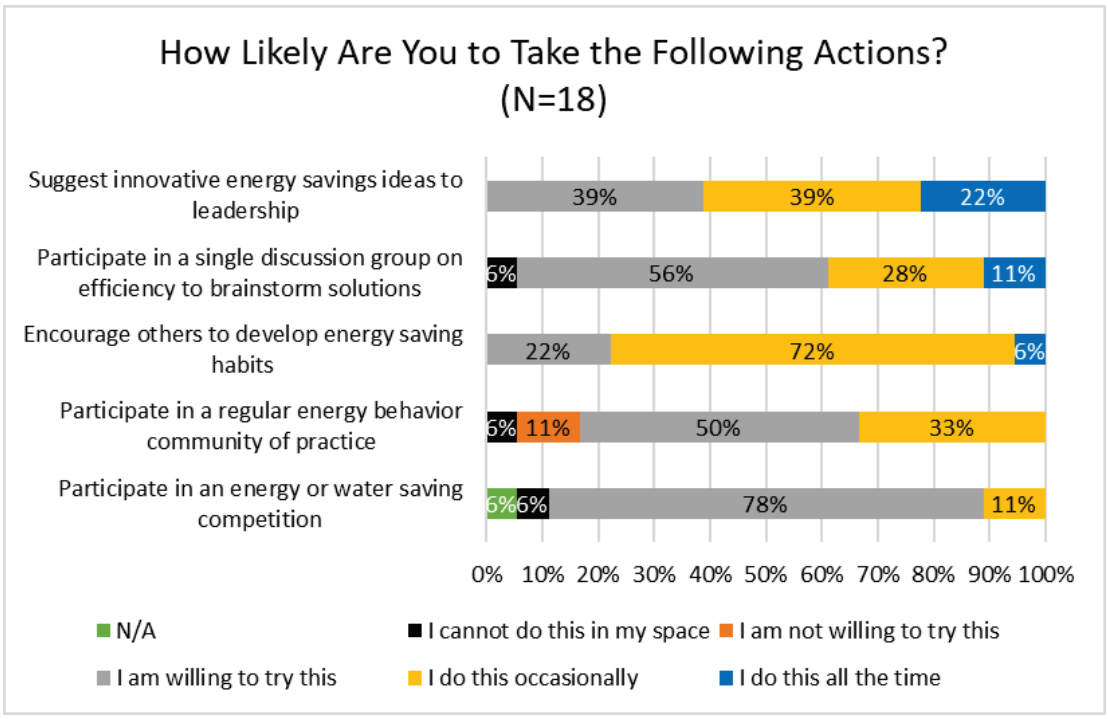


Figure A-3. Efficiency actions.



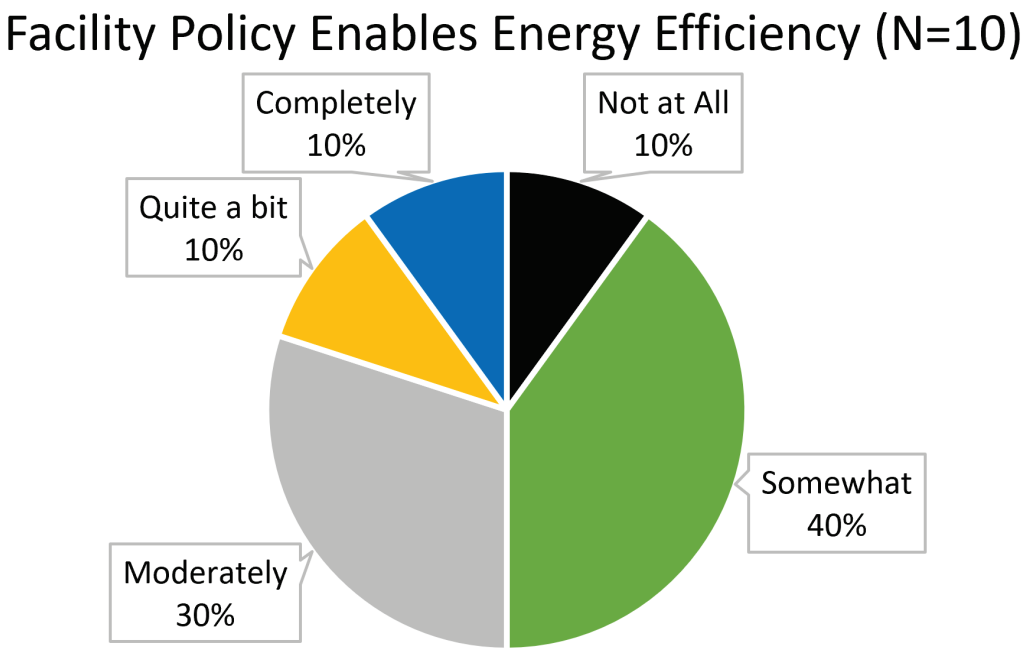
Staff Are Willing To Support Efficiency. Although the facility energy researchers indicated a willingness to take action to support efficiency, only about 20% regularly suggest savings ideas to leadership, and less than 10% regularly collaborate on solutions or encourage others to be efficient.

Facility HVAC Operators Are Ambivalent about Efficiency. The HVAC operators expressed a mixture of enthusiasm for efficiency; their stated focus was more on facility functionality and comfort than efficiency, and they expressed some skepticism regarding how efficiency measures might impact their comfort. Some facility operators stated that they had discovered successful approaches to efficiency and expressed enthusiasm about solving the puzzle of making systems work more efficiently.

Soldiers Are Not Engaged on Efficiency. All who commented on the attitude of young and transient Soldiers reported that this group displayed a widespread obliviousness to energy consumption and was apparently not invested in the site efficiency goals, likely based on the assumption that young Soldiers were personally not yet accustomed to paying for energy. Some countered with the observation that Soldiers are sufficiently challenged with training and they are entitled to some creature comforts afforded by energy use. Others simply expressed the opinion that Soldiers were wasteful in their energy practices, or that they should practice austerity for readiness purposes.

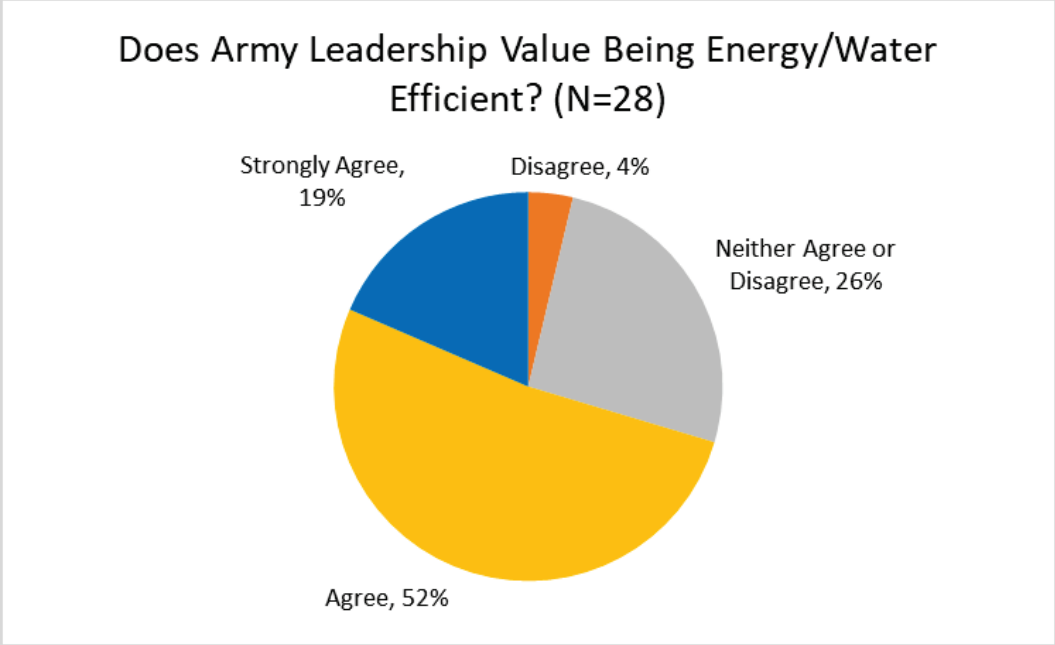
Policy Supports Efficiency. Overall, facility policy was seen as enabling efficiency (Figure A-4).

Figure A-4. Facility policy enables efficiency per facility support staff.



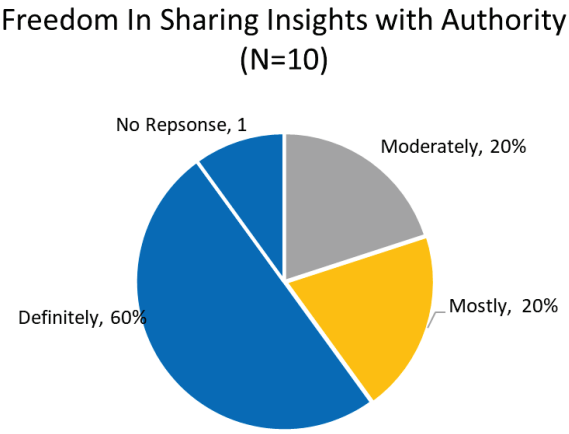
Leadership Actions Support Efficiency. The culture questionnaire respondents perceived leadership as largely supporting efficiency (Figure A-5) with 70% indicating that leadership supported and demonstrated a culture of efficiency. In other words, leadership "walks the talk," which is a very positive sign for the organization. A respondent from military leadership indicated that efficiency is not tied to unit performance (of company, battalion, brigade), and not a criterion that leaders are evaluated on.

Figure A-5. Leadership actions support energy efficiency.



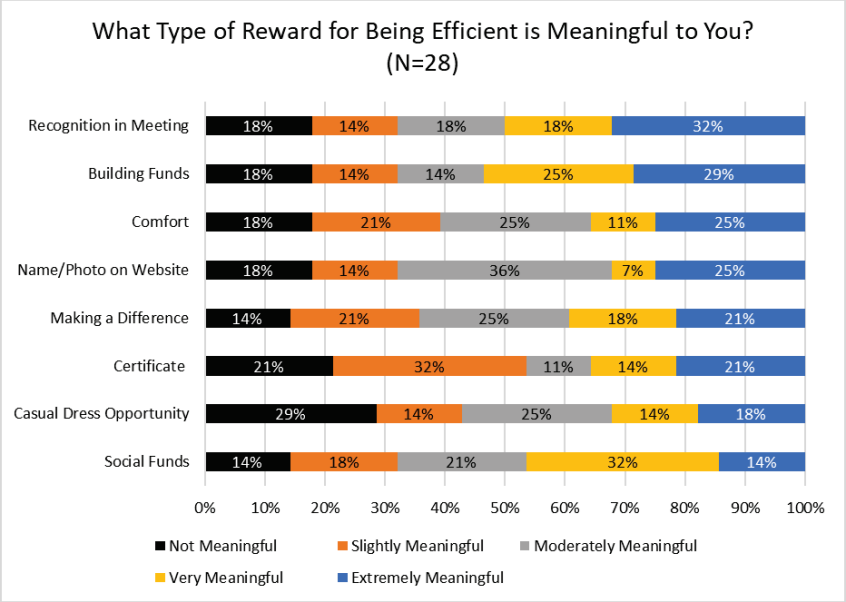
Support Staff Feel Free to Share Ideas. The respondents to the culture questionnaire expressed the opinion that they were largely free to share ideas about efficiency with authority (Figure A-6). It will be instructive to see if that is also reflected in the larger population, especially the military population that has a hierarchical culture that typically is not open to ideas from subordinates.

Figure A-6. Freedom to share insights with authority per facility support staff.



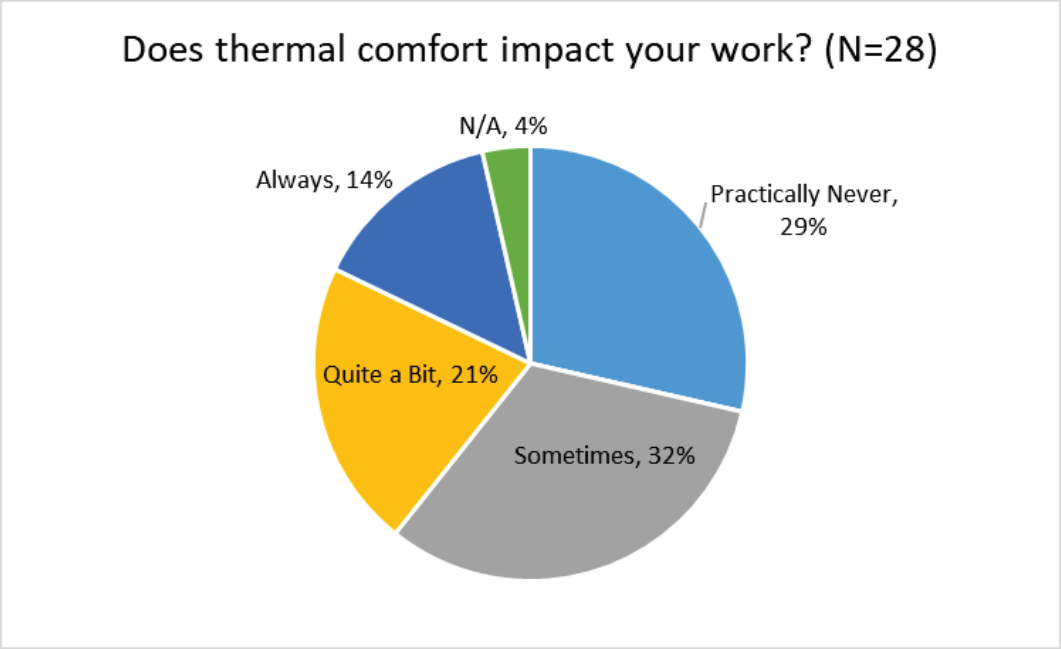
Practical and Intrinsic Rewards Are Meaningful. The facility support staff and researchers expressed the belief that practical and intrinsic rewards, including funds for building upgrades, social funds (e.g., Morale, Welfare and Recreation [MWR] funds used for team building events) and recognition in meetings, were meaningful to them (Figure A-7).

Figure A-7. Meaningful efficiency rewards per facility support staff.



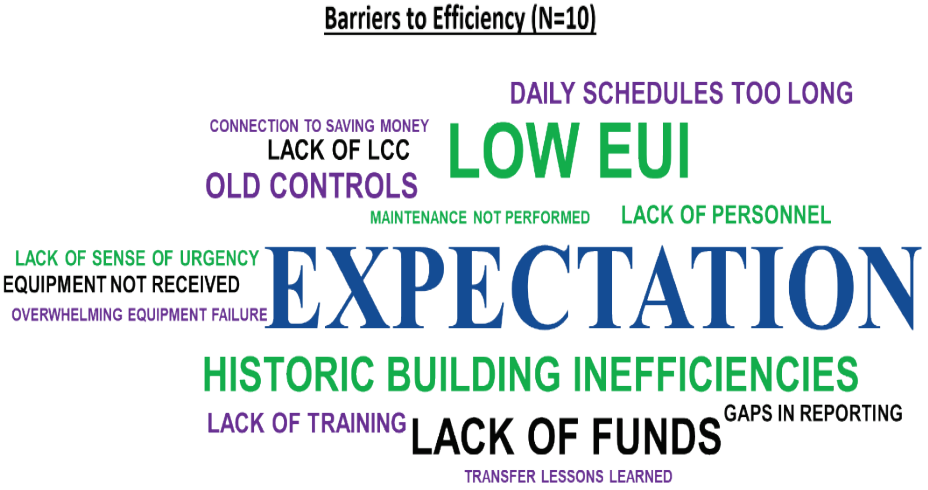
Comfort Issues are Common. About 35% of respondents expressed the opinion that they had significant challenges with comfort in their work or living spaces, while 32% stated that they were challenged to a lesser degree (Figure A-8).

Figure A-8. Interruptions due to thermal comfort per facility support staff.



Barriers to Energy Efficiency Range from Funding to Differing Expectations. An open response question to respondents identified a wide range of concepts that are barriers to energy efficiency, depicted in the word cloud shown in Figure A-9. Words with higher frequency are displayed in larger font. Here expectations, including conventional wisdom on building efficiency and status quo methods appear most frequently in these open responses.

Figure A-9. Barriers to efficiency – open response question "word cloud."



Responses to this line of questioning indicate that repeated challenges included funding, staffing, training, and coordination (Figures A-10 to A-12).

- Insufficient funding leads to inefficient facility operations.
  - Funding was reported as insufficient to adequately staff for and maintain building equipment and operations. Low funding was identified as the greatest barrier to efficiency in the culture questionnaire for both facility construction and facility operations by both facility support personnel and facility researchers. Current funding levels result in inefficient operations of equipment and significantly shortened equipment life. One respondent pointed to the 2015 Federal Budget Control Act, when the government chose to take a risk by reducing installation funding to accommodate budget shortfalls. They observed that the effort to maintain facility operations with current funding, which meets 50% to 70% or less of current needs, was a losing battle.
  - Supporting that position, the screening review of about 50 IMCOM installations revealed that the condition of facility controls and mechanical HVAC equipment is not good for efficiency. Of the approximately 14K buildings that are candidates for centralized networked controls (buildings sufficiently large or important), approximately 50% of facilities (7K buildings) need significant controls tuning or adjustments, about 20% (2.2K buildings) need major controls upgrade, and about 15% (2K buildings) need major mechanical overhaul/replacement. A rough estimate of the needed investment is $400M in backlogged facility controls maintenance/repair/upgrade, and $3.4B in backlogged mechanical system upgrades. The condition of the equipment used to heat, cool, and ventilate our buildings is preventing effective, efficient energy operations.
  - Additionally, funding levels make it challenging to attract and retain needed talent, as salaries do not keep up with other employment alternatives for capable personnel.
- Facility support staffing is inadequate.
  - Getting sufficient numbers of the appropriately trained people to support the physical buildings infrastructure is very challenging. Existing staff are overworked and overwhelmed with requirements and are forced to limit time spent on essential tasks for efficient operations such as managing the Utility Monitoring Control System. Results of the IMCOM controls questionnaire indicate that only 15% of installations have, in our opinion, minimally sufficient staff

to attend to facility related controls systems. The broadly held believe that automated controls are self-supporting and do not require human interaction is incorrect. Completely unattended controls are typically underperforming controls.

- We heard a few reports that a large percentage (~50%) of systems are running "in hand" at some locations, meaning that installed equipment controls are not used at all, and that systems are performing at far less than their potential technical efficiency. Getting these systems to run "full on," all the time would offer a significant savings opportunity that would justify the needed staffing investments. The Army's Meter Data Management System (MDMS) does have some capability to flag systems that run 24/7 and may be a platform for further exploring this saving opportunity.
- Overall staffing levels for HVAC operations appear to be only a fraction (maybe 20%) of the quantity that we estimate is needed for robust operations. At one location reported having 1 FTE per 60+ buildings. We estimate that 1 FTE (of combined skills from administration to wrench turning) is needed to support HVAC systems in 12 buildings.

Figure A-10. Barriers to efficiency in facility construction per facility support staff.

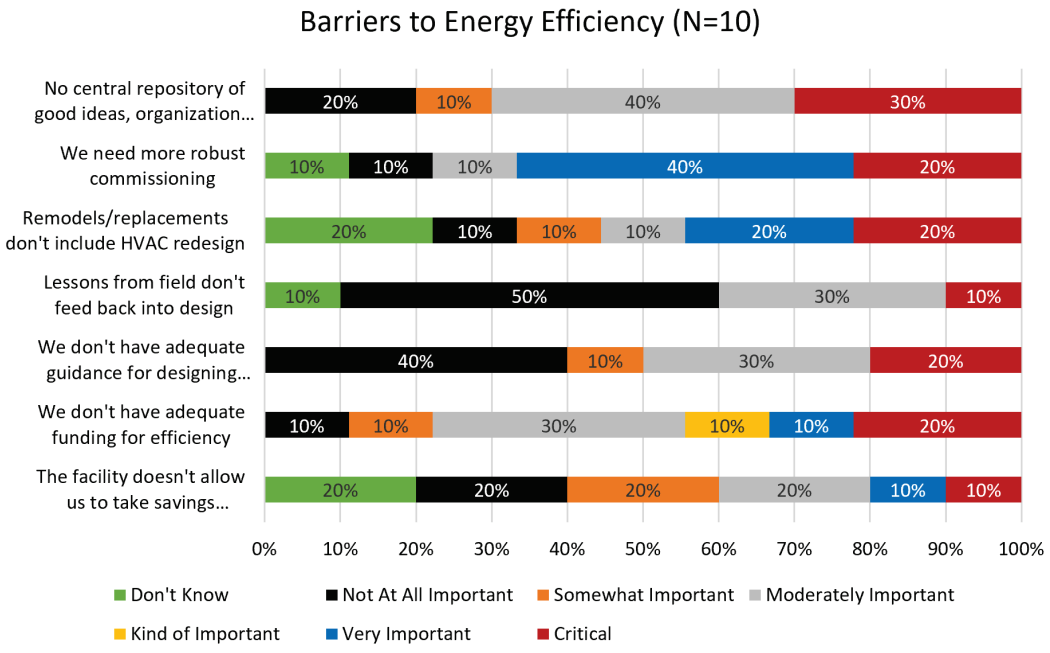


Figure A-11. Barriers to efficiency in facility construction per facility energy researchers.

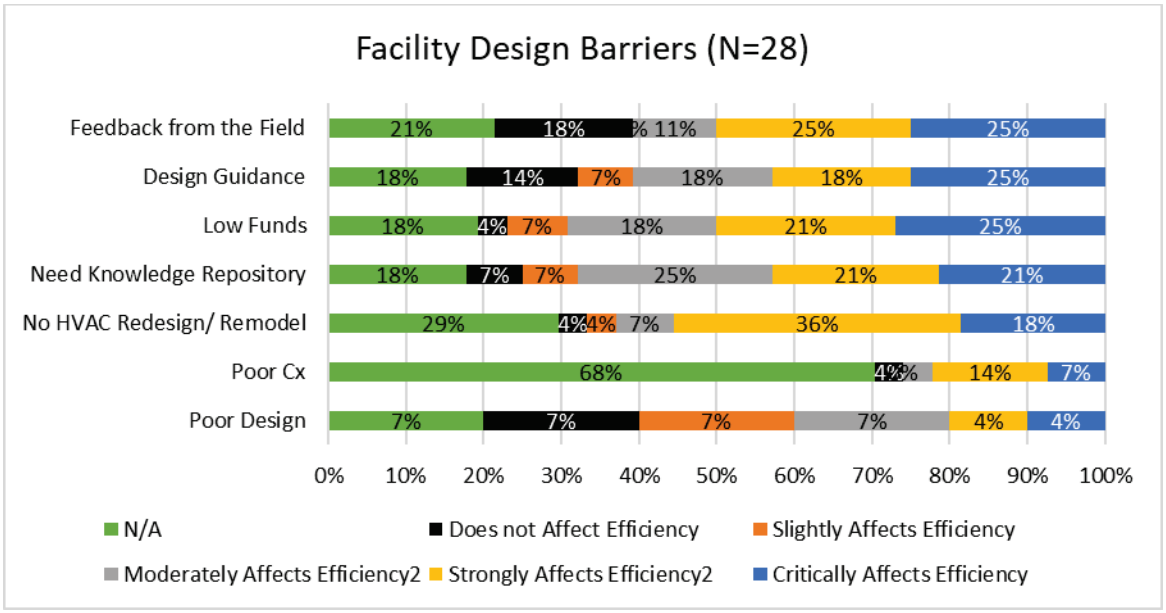
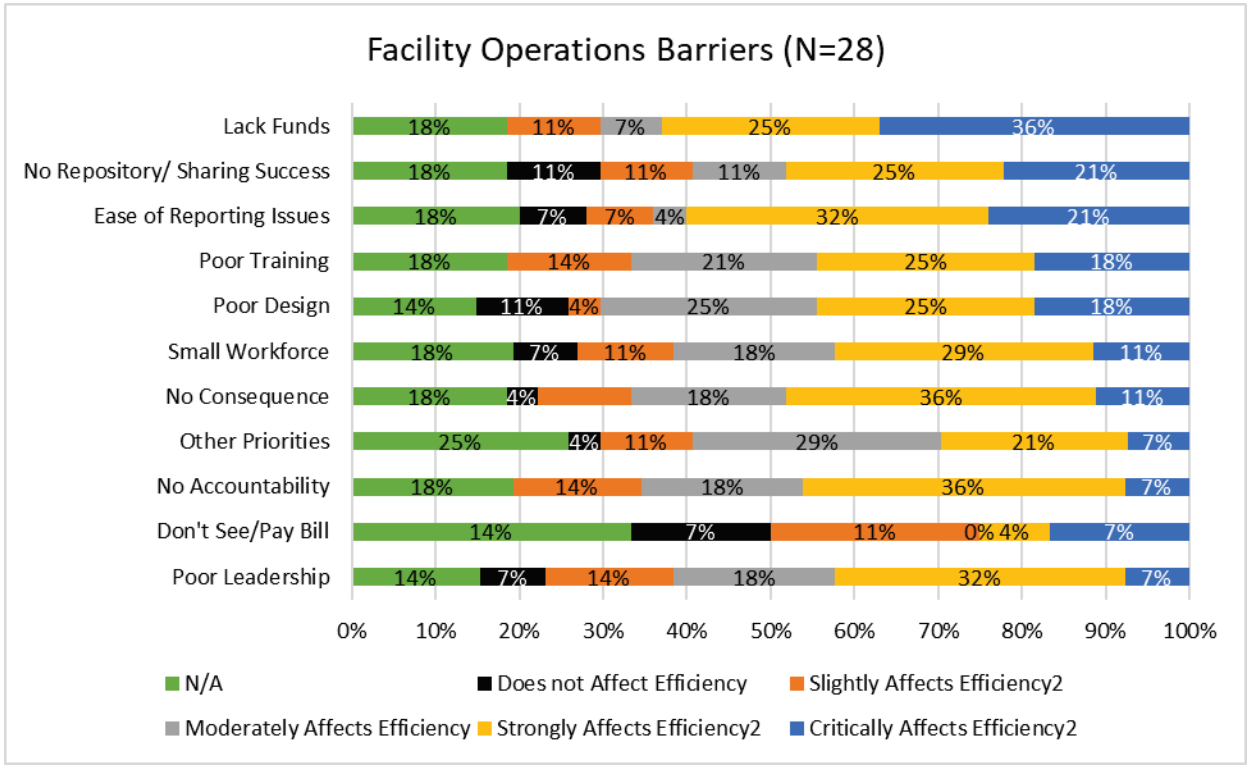
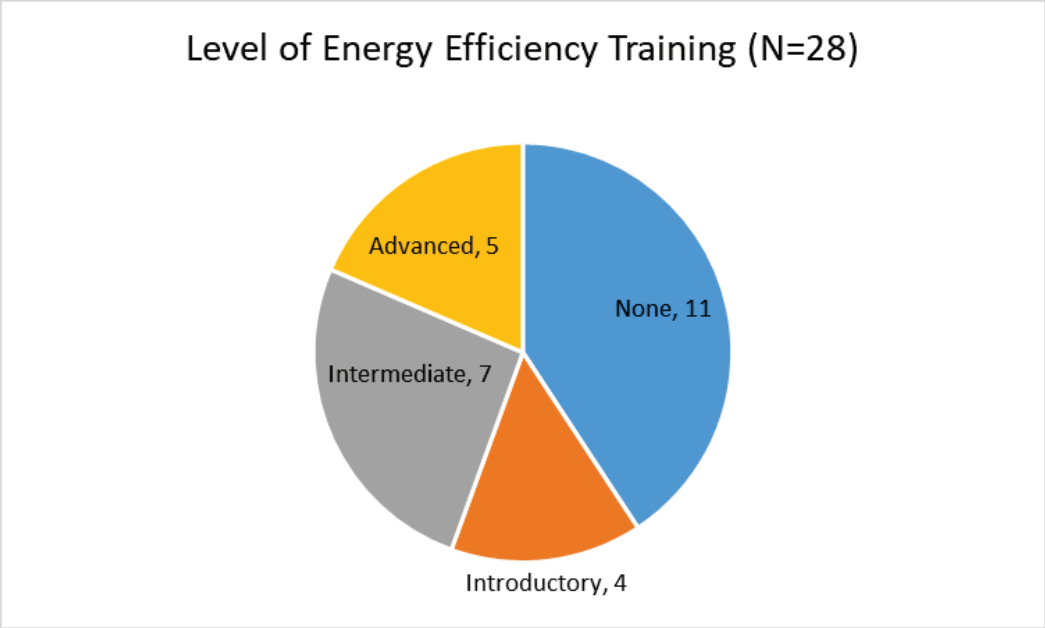


Figure A-12. Efficiency barriers in facility operations.



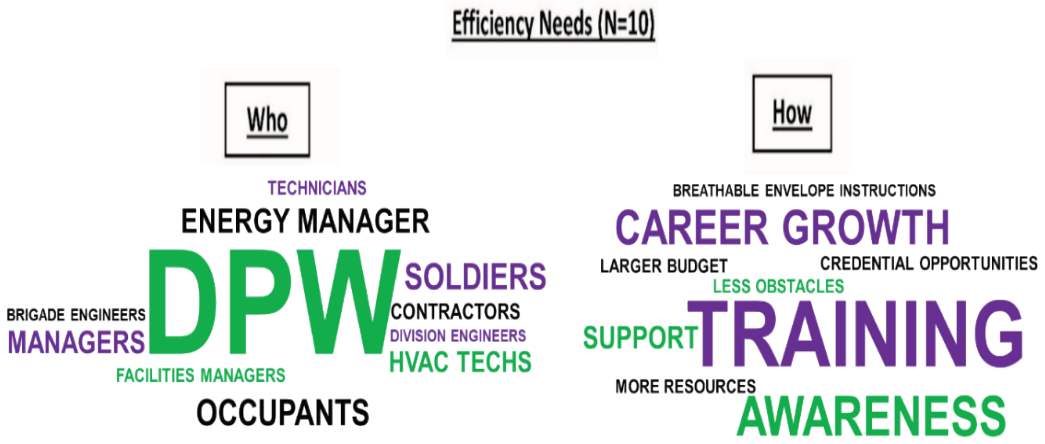
- Training is limited.
  - A common issue raised by installations in the controls questionnaire is lack of training. Half of facility support staff indicated that there was “barely any” or “no” funding for training. Another third indicated that training funds are only somewhat available. (Note that although those observations mainly applied to Control Techs and HVAC Mechanics, they are also applicable to other roles.) While training is —in theory— available, the reality is different. A number of factors conspire to limit training:
  - Scheduling and Funding: A common observation is that there really are no funds for training, or that there are so many constraints on use of the funding that as a practical matter funds are not available. For example, at one installation, training could only occur during the 2nd or 3rd quarter of the fiscal year. Uncertainties in funding availability often further constrain training opportunities.
  - There is a lack of clearly defined training goals and objectives, tied to job performance and career advancement.
  - Many HVAC workers appear to lack incentives to be trained. In the interviews it was observed that promotion opportunities are largely non-existent for many WG employees. Inflexibility in position classification in many cases makes it difficult to distinguish between different skill-levels of workers.
  - Specifically, we heard concrete suggestions that DPWs should be able to hire both Series 5306 HVAC Equipment Mechanics and Series 2606 Controls Technicians.
  - Management expressed the opinion that it is not cost effective to train staff; that trained staff will simply then qualify for jobs outside of government and leave the installation. This reinforces the notion that workers have little incentive to be trained.
  - Approximately 40% of both facility support staff and facility energy researchers report receiving no training on energy efficiency in the energy culture questionnaire (Figure A-13). Of those who have received training, 25% have received only introductory training, while 31% have received advanced training. The researchers had the most training with over half receiving intermediate or advanced efficiency training.

Figure A-13. Energy efficiency training received per facility support staff.



- Respondents were broadly asked "who needs what help" to be more efficient. (The word cloud in Figure A-14 summarizes the responses; responses that occurred more often are shown in larger font.) In the respondent group, the DPW was identified as the facility stakeholder most in need of support. Training was most often identified as the needed method of support. One DPW we spoke with was strongly committed to training of HVAC staff, and established individual development plans for facilities employees. This theme of needed training was common among responses.

Figure A-14. Groups Needing Support and How.



- Assess/Coordination of information is challenging.
  - Information sharing was identified as the second largest barrier to efficiency after funding. The organization is so large that we do not know how others are addressing efficiency concerns and what leads to success. A repository of institutional knowledge on efficiency seems quite worthwhile.
  - For facilities personnel, communications are difficult to coordinate. One key instance is the access to construction documents. In the controls questionnaire, only a third of respondents indicated that construction documents and equipment manuals are "mostly" or "always" available and organized. Several HVAC operators said they have trouble getting as-built construction documents, even for *new* facilities. This may be a potentially easy fix opportunity to make document handoff to the operational staff part of the acceptance/commissioning process. (These may be redlined documents if full as-builts were not developed.) Coordination procedures for system modifications were only "barely" or "not at all" in place for 40% of respondents, indicating a large opportunity for improvement.

Appendix B: Detailed Analysis of Gaps in Efficiency and Opportunities for Improvement in HVAC Controls

Figures B-1 through B-4 show the results of the building controls questionnaire in the area of best practices related to HVAC controls including technician sustainment practices, computer front-end utilization by the controls expert, management of the computer system and data, and control system manager tasks. Approximately 50 IMCOM installations participated in this detailed questionnaire. These practices were self-reported by the installation teams. The black dots show the average response regarding each practice. Our hope is that all activities are in the green bands indicating that they are mostly or absolutely practiced. The upper rows where averages are in the green indicate strengths, where the lower rows, where averages are in the yellow or red indicate opportunities for improvement.

Strengths for HVAC technicians (Figure B-1) are that they routinely troubleshooting malfunctioning equipment; they get contracted support; and they have assigned buildings that they get to know well. Opportunities include the need to improve accessibility and organization of construction documents and equipment manuals; the need to establish logging procedures for system modifications; the need to routinely inspect and calibrate equipment controls; the need to make training resources available; and the need posting equipment maps in mechanical rooms so that technicians can see which equipment serves which area of a building.

Figure B-1. HVAC controls/building automation technicians' best practices.

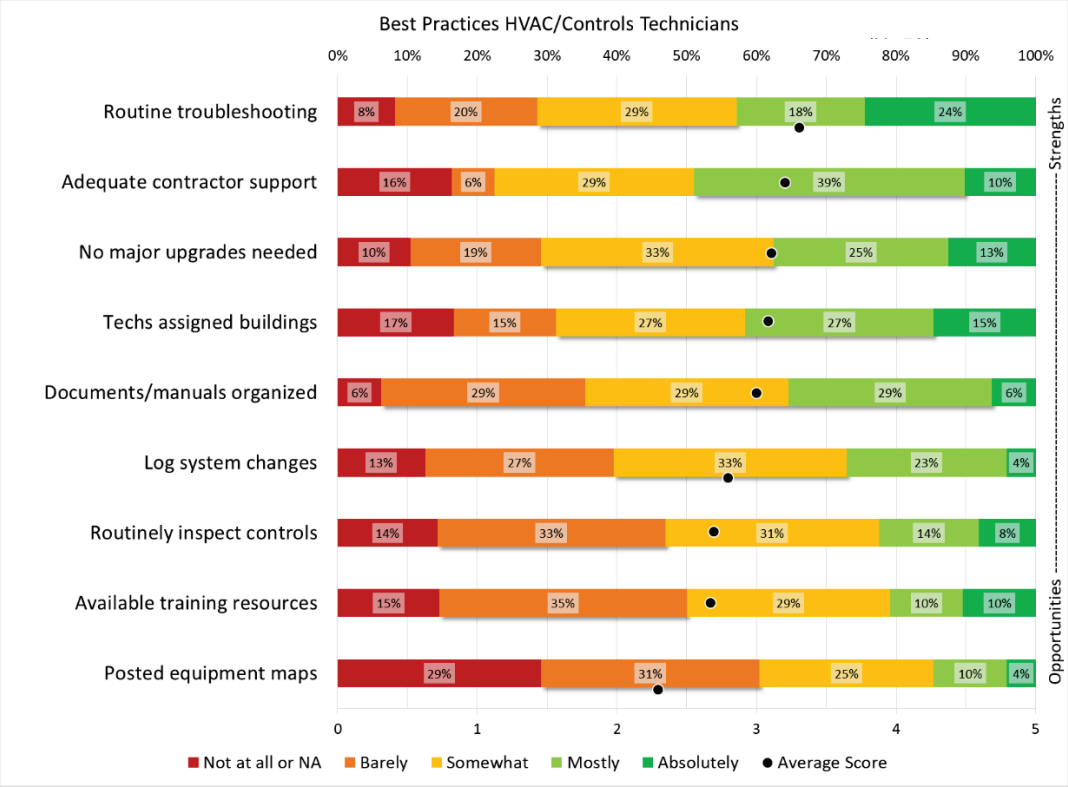


Figure B-2 shows the extent of the use of centralized controls capabilities for HVAC controls. Self-reporting indicated good use of front ends. Strengths include the ability to change operational parameters centrally, to troubleshoot with system graphics, to schedule systems, to review data trends, and to detect faults. Opportunities for improvement include the need to better manage system alarms, to employ proactive maintenance evaluations, and to use centralized energy use reporting and analysis.

Figure B-2. Building automation front-end feature utilization best practices.

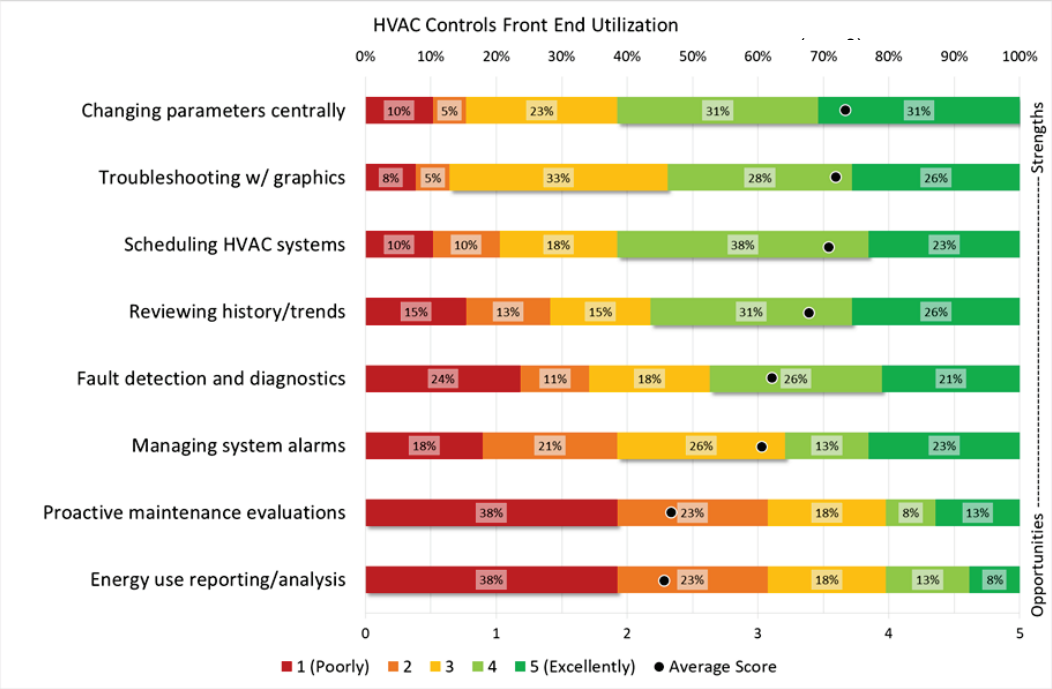


Figure B-3 shows practices for managing the controls computer system. Reported strengths include the ability to use of temporary overrides, to use intuitive and accurate graphics, to appropriately delegate authority for system corrections, and to perform regular database backups. Opportunities for improvement include the need to establish ready operator procedures for common front-end tasks (cheat sheets), to manage server disk space to avoid potential crashes due to filled disks, to organize documents, and to establish remote access to improve use of the system.

Figure B-4 shows HVAC controls manager task best practices. They identify needing support in procurement, conflict resolution, and establishing accountability of facility performance.

Figure B-3. Centralized HVAC controls computer system management best practices.

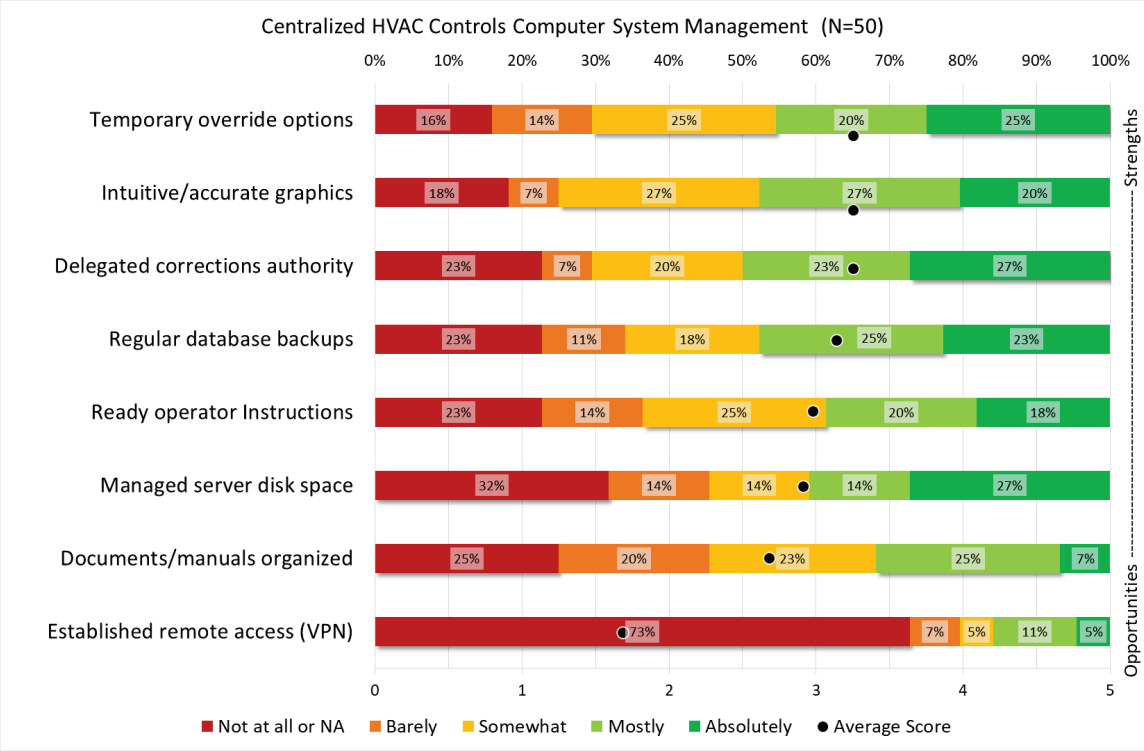
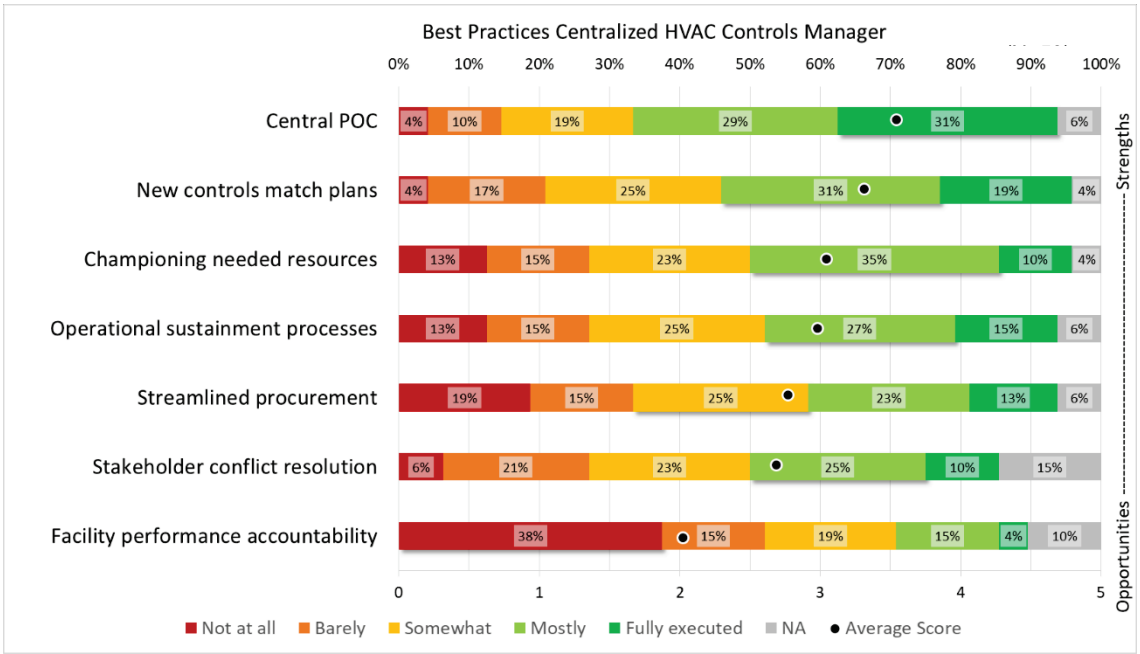


Figure B-4. HVAC controls manager tasks best practices.



Appendix C: Demonstration Project Overview

One of this report's recommendations is to conduct behavioral demonstration projects to establish ground level methods and impacts. (See section 3.2.2, number 7 [p. 51]). This section describes the steps of that process.

The objective of a behavior demonstration project is to validate the use of an energy behavior campaign at select buildings to impact individual behaviors in order to reduce energy costs at Army facilities. The effort will develop and demonstrate a holistic approach to energy efficiency by actively supporting people to make choices and to act in ways that increase energy resilience at an individual level. This four-phase, on-the-ground investigation will inform methods to increase installation energy resiliency through energy efficiency behavior.

> Leadership at Fort Bragg was impressed by the potential increase in resiliency and savings of an energy behavior demonstration project and has already expressed enthusiastic support for conducting the demonstration project at facilities on the installation.

C.1 Phase 1: Research

The research phase will collect and analyze data to identify the best location for the effort, to inform planning, and to establish a baseline to measure success. The team will work with key Army offices to evaluate potential installations. This effort will consider energy use, diversity of facility types, infrastructure investments, logistics, and potential onsite partners. Upon selection, the team will identify stakeholders at the targeted installation that engage with facility energy, including the energy manager, Directorate of Public Works (DPW), facilities and/or barracks managers (typically in uniform), maintenance staff that deal with energy-related work tickets, and others. The team will then identify sources of energy data, including metered data, utility bills, and records of energy projects and retrofits in facilities. Additionally, the team will collect existing energy-related communications, policy, and outreach materials, and identify all training opportunities associated with installation facilities.

Depending on the total number and position of stakeholders, interviews, focus groups or surveys will be used to identify barriers to and motivations

behind efficient behavior in those who interact with high energy consuming technologies. The team will analyze all available energy data to identify opportunities, and will set a baseline from which to measure success of the pilot. Communications, policy, and training will be assessed to determine existing messaging. All this content will be used to create a gap analysis and identification of opportunities to frame a proof of concept pilot.

C.2 Phase 2: Plan

The planning phase will use research outcomes to develop an approach for the proof of concept pilot and any associated materials. The team will select target facilities, develop a timeline and milestones, and determine end states for the stakeholders. Once the structure and location of the pilot is decided, standard processes can be developed to track and share information and to identify and course-correct challenges throughout. Depending on the research data received and selected facilities, a priority list of inefficient behaviors will be used to tailor outreach materials and education. All these outcomes will be combined into a project plan for the pilot.

Depending on the installation and outcome of the research, the plan can take several shapes. There may be opportunities for gamification, pitting units or facilities against each other to reduce energy consumption. Depending on the energy data infrastructure, consumption can be tracked in near-real time to encourage a competitive nature. If installation operational units are less motivated to engage, the pilot can focus on training initiatives and the development of new processes for staff already engaged in energy or facility management, to include one-way outreach to Soldiers occupying facilities.

C.3 Phase 3: Implement

The implementation phase will center on the team working with identified installation stakeholders to execute the Proof of Concept Pilot Plan. The pilot will kick off with necessary briefings and policy announcements to begin the effort. In behavioral work, it is critical to share feedback with participants; to this end, energy consumption data will be shared periodically with Soldiers and stakeholders. The pilot will be monitored actively, using resources on hand to develop additional materials or to adjust plans based on challenges encountered.

C.4 Phase 4: Evaluate

The evaluation phase will include qualitative and quantitative analysis to assess the effectiveness of the pilot, and to contribute to wider Army energy behavior planning. This evaluation will mirror the research phase, using the same questions and methods from pre-pilot surveys, and using focus groups to measure change. Energy data analysis will be used to compare the pilot energy consumption data against the baseline. Findings will be compiled into an AAR that reflects the proof of concept and informs recommendations for how to expand the effort across other installations.

Appendix D: Energy Culture Assessment Template

Assess the Energy Culture at specific installations using one-on-one interviews, small group focus groups, and surveys to understand current values and practices related to efficiency, and opportunities to better support people to use technology effectively and efficiently. In general, engineering details of facility design and operations is best gathered from people associated with the DPW.

D.1 Interview questions for DPW or Energy Manager

1. Is energy efficiency important? To whom?
2. Does leadership demonstrate commitment? Who champions efficiency?
3. Why is efficiency important? What makes it worthwhile? Why should you care? What circumstances (requirements, staffing, and tools) and values drive motivation? Is motivation external or internal?
4. How is energy behavior tied to mission? Does energy behavior connect to saving lives?
5. What requirements, processes, people, tools support efficiency?
6. Would you please review and comment on the stakeholder support tactics table?
7. What are ways to improve each aspect of human performance?
8. Individual behavior is a product of ability, motivation, and opportunity. Organizational behavior the sum of rules, roles, and tools. Have we provided the individual all the needed aspects for change? Have we embedded structures to sustain change over time? Have we employed FEMP's evidenced-based methods for change?
9. Who needs help and how?
10. Can all participate? Are you free to give suggestions? Will they be taken seriously? Will they be acted upon?
11. Do you have ideas to share?
12. What prevents efficiency? What are the gaps that separate us from our optimally efficient selves?
13. What can we do better? Where are opportunities for improvement?
14. How does Army differ from other services in terms of opportunities, obstacles?
15. How do drivers/barriers differ between civilians and service members?
16. How can we scale this up?

D.2 Focus group questions

1. What role, if any, do you play in helping others be energy efficient? (e.g., I am part of an installation sustainability team, I encourage other to dress in seasonally appropriate clothing.)
2. What requirements, roles or tools are you aware of that support facility energy/water efficiency? (e.g., building construction specifications and criteria support designers/engineers; or a facility energy competition at the office engages building occupants in efficiency.)
3. What practices are you aware of that are a barrier to optimal facility energy efficiency? (e.g., an informal policy by a facility administrator of "If it ain't broke, don't fix it," where "broke" meant totally inoperative, tolerates many underperforming, failing HVAC systems.)
4. Considering all the people that interact with our facilities (such as designer, administrator, purchaser, builder, technician, resource manager, staff member, occupant), who could benefit from additional support and how?

D.3 Survey questions for wider population

Energy Culture Enhancement Investigation V5.1

Purpose: The Army is actively working to increase its energy resilience by fostering a culture of energy stewardship and energy efficiency. We know that technology can only take us part of the way to our energy use goals, and we need to work together to use that technology effectively and efficiently to go farther. We are seeking your insights and ideas on how to get to the next level of efficiency! Please take about 15 minutes to share your thoughts with us! Thank you!

1. Where is your location? (installation or lab name?)

2. How long have you been working with the Army in some capacity?

- ◯ 0-2 years
- ◯ 3-5 years
- ◯ 6-10 years
- ◯ 11-20 years
- ◯ >20years

3. What is your primary role with regard to Army facilities and their energy/water systems?

- ◯ Facility Engineer (Designer or Specifier or Facility Project Developer)
- ◯ Builder or Commissioning Representative
- ◯ Purchaser (Contract Officer or Acquisition Specialist or Credit Card Holder)
- ◯ Building Manager
- ◯ Resource Manager (Energy or Environmental Manager or Consultant, UMCS Manager, or Strategic Planner)
- ◯ Building Technician (including Trades, Controls, Operations and Maintenance)
- ◯ Other (please specify)
- ◯ Building Maintenance (not HVAC)
- ◯ Other Building Staff (e.g. instructor, office worker)
- ◯ Occupant
- ◯ Administrator or Supervisor
- ◯ Researcher

4. Are you a designated Building Energy Monitor?

- ◯ Yes
- ◯ No

5. Are you a Service member or a civilian?

- ◯ Service member
- ◯ Civilian & Former Service member
- ◯ Civilian, not a Former Service member

6. In your opinion, to what extent do you agree or disagree with the following statements about Army energy?

	Strongly agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I personally value being efficient with energy and water	○	○	○	○	○
Soldiers or civilians in my unit/group value being efficient with energy and water	○	○	○	○	○
Army leadership values being efficient with energy and water	○	○	○	○	○
My command/group encourages me to be more efficient	○	○	○	○	○

7. Please rate how likely you are to take the following actions regarding energy and water:

	I do this all the time	I do this occasionally	I am willing to try this	I am not willing to try this	I cannot do this in my space
Suggest innovative energy savings ideas to leadership	○	○	○	○	○
Encourage others to develop energy saving habits	○	○	○	○	○
Participate in an energy or water saving competition	○	○	○	○	○
Participate in a single discussion group on efficiency to brainstorm solutions	○	○	○	○	○
Participate in a regular energy behavior community of practice	○	○	○	○	○

8. To what degree do you personally agree or disagree with the following motivations for how you use energy?
I'm motivated to use energy efficiently ...

	1 Strongly Agree	2 Agree	3 Neither Agree nor Disagree	4 Disagree	5 Strongly disagree
... to support the Army's mission	○	○	○	○	○
... to extend the mission's reach	○	○	○	○	○
... to support resilience goals	○	○	○	○	○
... to minimize environmental impact	○	○	○	○	○
... to helps us (unit, team, base, or Army) meet our energy reduction goals	○	○	○	○	○
... to help us save money	○	○	○	○	○
... to reach out technical potential w/ efficiency investments	○	○	○	○	○
... because it's part of my job	○	○	○	○	○
... to earn rewards	○	○	○	○	○
.. because I can make a difference	○	○	○	○	○
... because others on my team are taking action	○	○	○	○	○
... because my leadership cares	○	○	○	○	○
.. because I don't want to put my team at risk	○	○	○	○	○
... to improve health/comfort of our facility	○	○	○	○	○
... because it's the right thing to do	○	○	○	○	○

Other (please specify)

9. What type of "reward" for efficiency is meaningful to you?

	1 extremely meaningful	2 very meaningful	3 moderately meaningful	4 slightly meaningful	5 not meaningful
Name/photo recognition on website	○	○	○	○	○
Opportunity to wear less formal uniform/clothes at work (e.g. casual Friday)	○	○	○	○	○
Mention in high visibility meeting	○	○	○	○	○
Certificate of Appreciation	○	○	○	○	○
Social funds for a party	○	○	○	○	○
Funds for building improvements	○	○	○	○	○
Knowing I made a difference	○	○	○	○	○
Improving facility thermal comfort and air quality	○	○	○	○	○

Other (please specify)

10. Facility Construction Challenges.

If you have some opinions/experience regarding facility design and construction and its affect on energy efficiency at your location, please answer the following question. If not, Skip to the next question.

In your opinion, to what extent do the following factors in facility design/construction affect optimal levels of efficiency?

	1: Does not affect efficiency at all	2: Slightly affects efficiency	3: Moderately affects efficiency	4 Strongly affect efficiency	5: Critically affects efficiency	6: n/a
The inclusion of accessible well labeled controls that allow occupants to take savings actions (e.g. an accessible light switch or thermostat)	○	○	○	○	○	○
Funding levels that support greater first costs for efficient equipment	○	○	○	○	○	○
Guidelines for designers on efficiency that incorporate local climate conditions or local design practices	○	○	○	○	○	○
Feedback from field on challenges with existing equipment, layout, and operations	○	○	○	○	○	○
Consideration of HVAC re-design in all building remodels/replacements	○	○	○	○	○	○
Commissioning Practices	○	○	○	○	○	○
Knowledge sharing on efficiency across the military	○	○	○	○	○	○

What else?

11. Facility Operational Challenges:

If you have opinions/ experience related to facility operations and its effect on energy efficiency, please answer the following question. If you don't please skip to the next question.

In your opinion rate how the following factors affect optimal levels of energy efficiency?

	1: Doesn't affect efficiency at all	2: Slightly affects efficiency	3: Moderately affects efficiency	4: Strongly affects efficiency	5: Critically affects efficiency	n/a
Knowing who to call to report observed inefficiencies (e.g. leaking faucet, steam leak)	○	○	○	○	○	○
Accessible controls that make it easy to take savings actions (e.g. accessible light switches)	○	○	○	○	○	○
Job performance requirements that include efficiency metrics	○	○	○	○	○	○
Leadership demonstration of efficiency support	○	○	○	○	○	○
Information of actual energy usage and comparison with be expectations	○	○	○	○	○	○
Consequences for not meeting energy reduction targets.	○	○	○	○	○	○
Size of workforce to address efficiency.	○	○	○	○	○	○
Funding for efficient operations	○	○	○	○	○	○
Training for efficiency	○	○	○	○	○	○
Multiple priorities that compete with efficiency for attention	○	○	○	○	○	○
Sharing of efficiency strategies that work across the military	○	○	○	○	○	○

What else?

12. Does the thermal comfort (temperature, humidity, drafts) or air quality of your workspace/living space ever get in the way of your ability to work, learn, or enjoy life?

Practically never	Sometimes	Quite a bit	All the time
○	○	○	○

Optional: What is your gender?

13. What level of training have you received to support facility energy efficiency?

None	Introductory (ad hoc, local training)	Intermediate (vendor led)	Advanced (professional certification)
○	○	○	○

Do you feel it is adequate? Any recommendations for additional training?

14. What energy saving initiatives are you aware of at your installation?

15. Considering all the people that interact with our facilities (such as: designer, administrator, purchaser, builder, technician, resource manager, staff member, occupant) who could benefit from additional support and how?

16. Do you have any suggestions on policies, procedures, habits or attitudes that could be changed to increase energy efficiency?

17. Optional. If you are willing to discuss your responses if we have questions, or participate in a discussion group, please provide an email address.

Appendix E: Details of FEMP Rules, Roles, and Tools Methodology

The Federal Energy Management Program (FEMP) construct of organizational behavior frames lasting change as a function of rules, roles, and tools. This appendix provides some insights into those elements.

E.1 Rules

What are the policies, procedures, and norms that support the present behaviors and the principles that apply to changing those rules?

Setting a clear goal is the first step in the process of achieving higher-order sustainability goals. Once the goal is established, it is important to assess the institutional context within which that goal is to be achieved (4.2).

E.2 Roles

What/whose behavior matters with regard to that problem? What needs to change?

It is extremely important to differentiate the roles that are involved in the behaviors targeted for change, and to engage the pivotal roles first — those with the leadership, authority, resources, and influence to initiate and maintain changes that will lead to reaching sustainability and building performance goals, as well as those whose "buy-in" is necessary. Once pivotal roles are aligned and individuals are motivated, a comprehensive change program can be developed (4.4).

- Building managers and O&M staff have perhaps the largest role in saving energy. They know the building systems and can uncover technological issues and observe occupant behavior that works against reduced resource use.
- Occupants, who, in the course of performing their jobs or using buildings, may increase resource use by resetting temperature controls, blocking vents, adding personal small appliances or lights, and so on. Because of the focus on occupants in many sustainability programs, there are many potential behaviors that could be changed. However, it is important to make sure that (1) occupants can control resource use in the ways specified ("tools"); (2) their legitimate needs for comfort,

indoor air quality, and lighting are achieved; (3) their job-related needs are met; and (4) new or modified behaviors become embedded as "normal" so that they persist and remain effective as situations change (e.g., new responsibilities, technologies, or staff members).

- Leaders, from top management to staff champions, who visibly advocate and set examples of energy saving behavior. Leaders and champions may overlap with other roles.
- Managers and technical representatives, who approve purchases and thus can specify ENERGY STAR®, Federal Energy Management Program-approved, or other resource-efficient products. These individuals may have the authority to limit the number and types of personal equipment, as well as the (sometimes conflicting) responsibility to provide workspaces that enhance productivity and comfort.
- Contracting officers and procurement personnel (e.g., major "back office" players on the actual products and services purchased), who can also limit their purchases to those that conform to energy, water, materials, and indoor air quality standards.
- Information technology specialists, who can set defaults for "sleep" modes, double-sided printing, etc., and encourage overnight shutdown of equipment (e.g., by applying patches at start-up or shut down), while assuring these practices align with other organizational responsibilities (e.g., cybersecurity).
- Administrators who set building policies such as hours of operation, lighting protocols, and office assignments (considering such factors as occupancy rates).

E.3 Tools

What technologies, processes, and systems are in place or needed to support desired behavior changes and outcomes?

Some modifications to existing rules, roles, and tools (RRT) are particularly suited for institutionalizing change. Examples include rewriting position descriptions and performance standards, requiring the reporting of progress toward goals, instituting required training of new rules and strategies, changing the organizational structure, and adding budget lines to highlight costs/savings or to support initiatives. These types of strategies promote a shift from implicit or short-term expectations about sustainability to explicit, long-term ways of doing business (4.5).

Information and *outreach i*nvolve systematic attempts to provide important knowledge beyond standard norms to particular segments of a community, with the intent of initiating change (5.1):

- Provide vivid, concrete, and personalized information.
- Use credible, trustworthy sources to convey messages.
- Use clear, concise, and concrete language to increase understanding and memorability.
- Use multiple methods and settings and deliver content over multiple sessions rather than during a one-time effort.
- Tailor the information to the specific context.
- Circulate information through social networks.

Feedback techniques provide information on how well an individual or group is performing relative to a specified goal, how current behavior outcomes compare to past outcomes, or how personal behavior outcomes compare to those of other individuals or groups (5.3).

- Provide more frequent (daily, real time) versus less frequent (weekly, monthly) feedback.
- Make data available in an unobtrusive manner when and where needed.
- Combine feedback with specific actions to reduce energy consumption (or other sustainability outcomes).
- Provide feedback on how well people are doing, such as progress toward goals and goal achievement.
- Reinforce or reward successful resource-saving behaviors, which can include verbal praise or visual methods that translate impacts of behavior into environmental benefits (more trees, growing gardens).
- Combine feedback with prompts, reminders, or other triggers to help promote and maintain desired behaviors (5.4).

Persuasion is the influence of beliefs, attitudes, intentions, motivations, or behaviors. Persuasion techniques go a step beyond information and outreach in that they explicitly aim to convince people to take certain actions. With persuasion, there is no assumption that "the data speak for themselves," i.e., that information will lead to action.

- **Reciprocity:** the strong cross-cultural norm of returning favors. Can reciprocity be used to encourage resource conservation? The current focus is on

competition between groups rather than reciprocity to achieve environmental goals (see, for example, Metzger et al. [2011], and numerous relevant papers from past *Behavior, Energy and Climate Change* conferences*).

- **Commitment and Consistency:** the tendency to honor an idea or goal that has been committed to orally or in writing, even if the original incentive is removed. Commitment strategies have been used since the 1970s oil embargo to reduce energy consumption.
- **Social Proof:** the tendency for people to do things that others are doing. This driver relates to social norms and conformity to group behavior. Social norms are increasingly used to generate behavioral change in organizations and communities.
- **Authority:** the tendency to obey authority figures, which is relevant to organizational change and the role of leadership in motivating and sustaining change.
- **Liking:** the tendency for individuals to be easily convinced by people they like, which is relevant to the selection of "messengers" in a behavioral change program.
- **Scarcity:** in marketing research, scarcity tends to generate demand ("limited time only"). Of relevance here is how scarcity of environmental resources can be used to *diminish* demand and lead to more efficient use (such as reduced electrical use during high-demand periods).

Rewards and incentives serve to induce or motivate behavioral change.

- **Changing defaults:** How building space is configured and how options are presented can make huge differences in the choices people make (5.6).
- **Commitments** are oral or written pledges to change behavior (5.7).

Social norms are the explicit or implicit rules specifying what behaviors are acceptable within a society or group (5.8).

- **Community-based social marketing** is a programmatic approach focused on barriers to and benefits of changing behavior at the community or group level (5.8).
- **Urgency** is a quality or condition suggesting immediate or pressing importance.

* The *Behavior, Energy and Climate Change Conference* website contains "Archive" links to a host of related materials: https://beccconference.org/

- **Habits** are actions or activities that are carried out automatically, with little conscious effort, and are often cued by factors in the environment.
- **Motivation** refers to a process that elicits, controls, and sustains certain behaviors.

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Eileen T. Westervelt, Paul M. Loechl, Sarah A. Clark, and Courtney E. DuPont

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14. ABSTRACT

Facility energy efficiency efforts too often underperform because of people's choices and actions in their use of technology. Recognizing this challenge, Army energy guidance calls for establishing an informed energy-conscious culture of stewardship to meet mission resilience requirements. However, the details for implementing that guidance have not been established. This report provides two primary products to address these needs: (1) a Human-Centered Efficiency Process (HCEP), which is a coordinated nine-step process to use best practices in energy behavior, and (2) an outline of a strategy to build a culture of efficiency. The practical HCEP is synthesized from energy management, change management, and Army processes (After Action Report [AAR] and Commander's Intent), as well as insights from federal personnel. It is built around an organizational framework and a continuous improvement process that systematically enables people to use technology effectively and efficiently. The culture strategy consists of a method of assessing the current status of the Army's energy culture; a vision of a desired end state; and a path toward change.

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