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Study Highlights: Characterizing Plug Load Energy Use and Savings Potential in Army Buildings

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Study Highlights: Characterizing Plug Load Energy Use and Savings Potential in Army Buildings

Overview

A recent study of plug load devices in Army buildings has identified opportunities to save over 83 million kWh of electricity valued at over $5 million per year. These savings may be conservative and were identified by inventorying and monitoring plug load and miscellaneous electric load (MEL) equipment within representative Army buildings. The objective was to better understand the energy consumed by these devices and identify approaches for reducing it while enhancing resilience. This summary highlights the findings, lessons learned, and recommendations identified by the study.

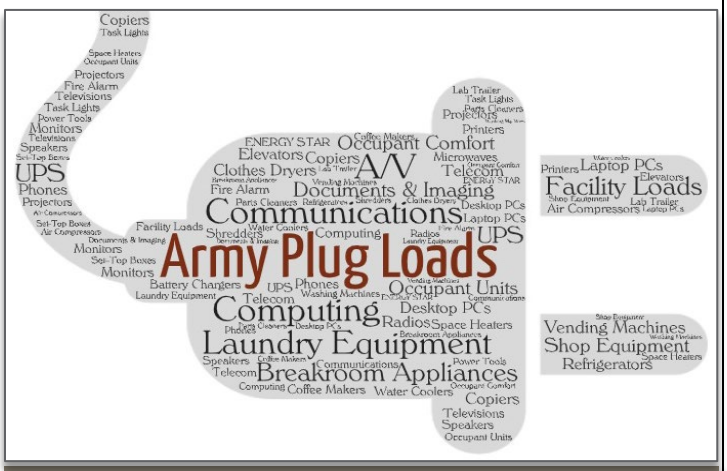
What are Plug Loads?

Plug loads and MELs represent the electricity used by appliances and devices that are plugged in or hardwired and serve functions outside of a building's core end uses. Common plug loads include computers, printers, copiers, networking devices, refrigerators, vending machines, and electronic devices such as televisions, smart phones, and gaming systems. Hardwired MELs include elevators, air compressors, and security and fire alarm systems.

As the number of plug load devices grows, so does their contribution to building energy use and costs. A better understanding of the magnitude and nature of these loads is important to develop and maintain sound policy and practices to manage energy use across the Army, and to support efforts to enhance the energy efficiency and resilience of installations. The main goal of the study was to evaluate plug load and MEL energy use and inform sensible actions and policies towards their improved management at Army garrisons.

Study Approach

Nearly 900 plug load devices were inventoried within five representative Army buildings whose broader categories comprise one-fifth of total Army floor area. The devices were grouped into eight categories and a sampling of each device type was selected for monitoring via a combination of plug load and select electrical panel metering. Table 1 presents a summary of building characteristics, the number of devices inventoried and monitored, plug load energy use, and the contribution to total building energy consumption. In addition to electricity, each building uses natural gas for space and water heating. Metering activities were performed between May 2019 and March 2020, in two phases, and augmented with building-level interval-meter data. Each phase lasted between 18 and 22 weeks.



Study Highlights

- A variety of plug load equipment supports the Army mission and on average comprises 25% of electricity use and 11% of total energy use within typical buildings.
- Laundry equipment is the highest-consuming category, with the UEPH clothes dryers using the most electricity of any type of equipment. The next categories are computing (e.g., laptops, monitors, and desktop PCs), and breakroom equipment (vending machines, refrigerators, coffee makers).
- Refrigerated vending machines are the first, second, and fifth highest-consuming individual devices. The others in the top five are the TEMF air compressor and BN HQ elevator.
- Strategies for managing plug load energy consumption include policies and best practices focused on equipment purchase, setup, operation, monitoring, and review, plus staff engagement.
- Ten priority measures are identified that together can save the Army over 83 million kWh and $5 million per year. Many of these focus on purchasing more efficient equipment and setting devices to power down when not in use.
- Monitoring plug load equipment is critical to understanding energy use under operating conditions, identifying savings potential, and verifying that controls remain effective.

Table 1. Building Characteristics and Plug Load Findings

Building	Floor Area (sf)	Vintage	Total EUI (kBtu/sf)	Device Count	Devices Metered	Energy Use (kWh/yr)	Energy Intensity (kWh/ksf)	Percent of Total Electricity	Percent of Total Energy
Admin General Purpose (Admin)	14,300	1988	64.7	394	55%	34,300	2,410	30%	13%
Battalion HQ (BN HQ)	14,000	2013	60.9	227	34%	26,200	1,870	21%	10%
Company Operations Facility (COF)[a]	32,300	2010	39.9	126	0%	18,000	560	9%	5%
Tactical Equipment Maintenance Facility (TEMF)	18,100	2010	109.6	88	58%	30,700	1,690	16%	5%
Unaccompanied Enlisted Personnel Housing (UEPH)[b]	63,800	2009	45.9	43	48%	139,300	2,180	39%	16%
TOTAL	**142,500**		**56.0**	**878**	**39%**	**248,500**	**1,740**	**25%**	**11%**

[a] No metering was performed in the COF; plug load energy estimates were developed using the detailed inventory and typical device-level energy use compiled based on metering of similar equipment and applications in other buildings.
[b] The device inventory and monitoring in the UEPH was limited to common areas; occupant space plug loads were captured via electrical panel metering and subtracting estimated lighting loads.

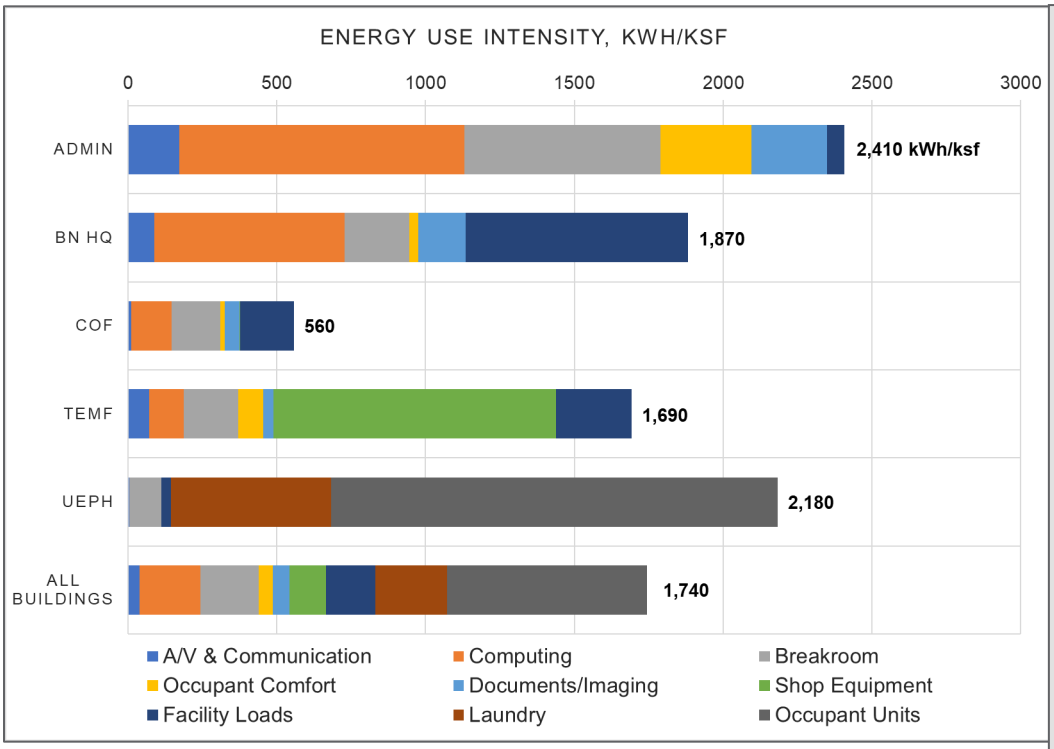


Figure 1. Plug Load Energy Intensity by Device Category and Building

Building Energy Contribution

On average, plug loads contribute 25% of the electricity use in the studied buildings and 11% of total building energy use. This is highest in the UEPH (39%/16%) and lowest in the COF (9%/5%). The Admin has the highest plug load energy intensity at 2,410 kWh/ksf, followed by the UEPH and BN HQ. The TEMF has the highest plug load energy use per occupant at 2,040 kWh/occ, with all other buildings significantly lower; the next highest is the UEPH at 1,040 kWh/occ. Figure 1 presents the total plug load energy intensity by device category, in annual kWh per thousand square feet, for each building and for all buildings combined. Examples of devices identified within each category are listed at the right.

Device Categories

A/V & Communications: TVs, cable boxes, projectors, phones, radios, communications terminals

Computing: Desktop PCs, laptops, monitors, UPS devices, network switches, external hard drives, dock stations, computer speakers

Breakroom: Vending machines, refrigerators, coffee makers, water coolers, microwaves, toasters, electric kettles

Occupant Comfort: Space heaters, fans, task lights, air purifiers, standup desks

Documents/Imaging: Copy/print devices, printers, shredders, plotters, scanners

Shop Equipment: Lift cranes, air compressors, air dryers, power tools, parts cleaners, battery chargers, ground power units, lab trailer, portable shop lights

Facility Loads: Telecom/networking infrastructure, elevators, fire/security systems, plumbing fixture controls, hand dryers

Laundry: Washing machines, dryers

Occupant Units: Aggregate UEPH living quarter loads

Largest Energy Consumers

The UEPH living quarters consume the most plug load energy of all categories across the studied buildings. However, a detailed inventory and monitoring of equipment within these private spaces was not possible; the energy use is from a mix of kitchen appliances, computers, televisions, and other personal electronic equipment that, if known, would be allocated to other categories. Excluding the UEPH living quarters, the five categories with the highest energy use in the five studied buildings are:

1. **Laundry Equipment**
2. **Workstation Computing**
3. **Breakroom Appliances**
4. **Facility Loads**
5. **Shop Equipment**

The types of devices with the largest contribution (Figure 2) include clothes dryers, laptop PCs, networking loads, vending machines, and computer monitors. The highest-consuming individual loads use up to 3,600 kWh per year (Figure 3). These include the combined networking loads in the BN HQ, two refrigerated vending machines in the UEPH, and the TEMF shop air compressor.

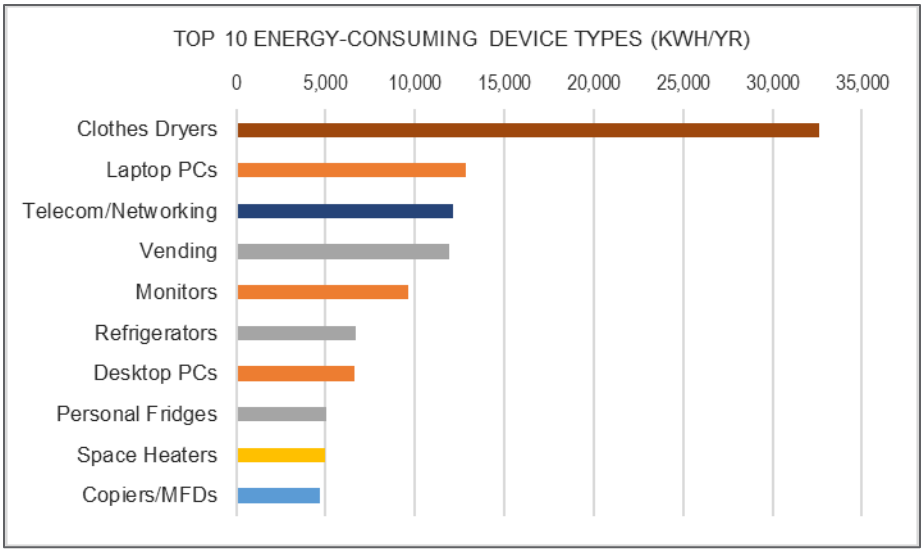


Figure 2. Top 10 Energy-Consuming Device Types

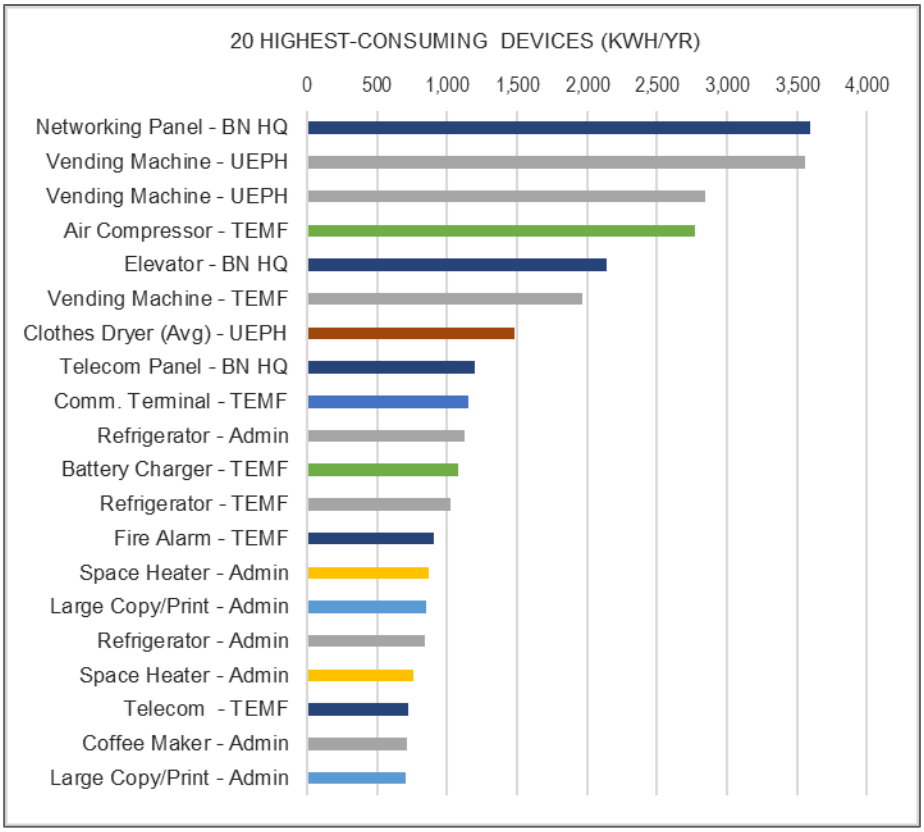


Figure 3. 20 Highest-Consuming Individual MELs within the Study Buildings

Energy Saving Measures

Significant energy savings are possible with relatively simple steps, including enabling power management features, replacing old and inefficient equipment, and turning equipment off or down when not in use. Existing policies prescribe many of these steps, and new policies may be considered for others. Table 2 lists the ten priority savings measures identified by the study. Collectively, these recommendations can save 51% of average device-level energy and more than 83 million kWh and $5 million per year across the Army within the evaluated building categories—likely more when extended to other buildings.

Energy Management Best Practices

Successful plug load energy management processes incorporate the following steps: ***purchase, setup, operate, monitor, review***. Best practices focus on key elements throughout the equipment life cycle to ensure the purchase is necessary and meets the intended need, the features are understood and set properly, the device is operated as intended and monitored regularly, and, when it is time to add to or replace the equipment, the needs and characteristics are reviewed prior to purchase. ***Engagement*** with Army personnel who operate and interact with the devices is critical to support significant and sustained results. Fostered energy awareness and behaviors will extend outside of the workplace to installation housing and the broader community.

Table 2. Priority Plug Load Savings Opportunities and Scale of Potential Savings Across the Army

Savings Measure	Average Device-Level Savings (%)	Annual Energy Savings (million kWh/yr)[a]	Annual Utility Cost Savings ($K/yr)[b]	Measure Type
Implement Sustainable Computer Policy: Power Systems Down Each Night	46%	31.6	$1,900	Policy Implementation
Refrigerated Vending Machines: Energy Star with Custom Settings	57%	31.2[c]	$1,870	Contracting Policy
Improve Power Save Settings: Large Copy Print Devices	47%	7.6	$456	Power Mgmt.
Refrigerators: Replace 20+ Year Old Units with New Energy Star Models	39%	6.3	$378	Replacement Policy
Computer Purchase Policy: Purchase Laptop PCs over Desktops + UPS	46%	3.2[d]	$192	Purchasing Policy
Commercial Coffee Makers: Add Timer or Similar Controls	43%	2.6	$156	Power Mgmt.
Space Heaters: Review Policy Enforcement and Exceptions for Reasonable and Responsible Use	50%	1.1	$66	Policy Implementation
Printers: Enable Sleep Mode	14%	0.93	$56	Power Mgmt.
Projectors: Turn Off When Not in Use	41%	0.75	$45	Power Mgmt.
Elevators: Review and Remove or Adjust Hydraulic Fluid Heaters	62%	0.25	$15	System Design Review
TOTAL	**51%**	**82.9**	**$4,970**	

[a] Army-wide savings are estimated based on savings per sf for each studied building multiplied by the total floor area within the studied building's category. Applying the measures to additional building categories would increase the savings.
[b] Total Army dollar savings (thousands of dollars per year), assuming a $0.06/kWh average electric rate.
[c] Savings estimates for refrigerated vending machines are extrapolated to the entire Army floor area, and not only the building categories assessed in this study.
[d] Savings are estimated only for general Admin buildings and assume that a sustainable solution to allow computers to power down nightly (measure 1) has been implemented.

About the Study

This summary highlights results from a study to examine plug load equipment operation and energy use within typical Army buildings. The findings are intended to raise awareness, inform policy, and encourage actions to drive savings. In addition to this overview, four separate equipment-focused fact sheets detail best practices for the following devices: computing equipment, vending machines, office equipment, and breakroom appliances. Additional detail regarding the study methods and findings may be found within the technical report.

For more information, contact:
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[1] **Characterizing Plug Load Energy Use and Savings Potential in Army Buildings. PNNL-29914. December 2022.**

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