ESTCP

EXECUTIVE SUMMARY

Energy Management and Information Systems Technology Transfer

Building Technology and Urban Systems Division
Lawrence Berkeley National Laboratory

Construction Engineering Research Laboratory
U.S. Army Corps of Engineers

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ESTCP Project # EW22-7299

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ACRONYMS AND ABBREVIATIONS

ASO	Automated System Optimization
ATO	Authority to Operate
CUI	Controlled Unclassified Information
DDC	Direct Digital Control
DoD	Department of Defense
DODIN	DoD Information Network
EBCS	Enterprise Building Control System
EIS	Energy Information System
EM	Energy Manager
EMIS	Energy Management and Information System
ERCIP	Energy Resilience and Conservation Investment Program
ESCO	Energy Services Company
ESPC	Energy Savings Performance Contracts
ESTCP	Environmental Security Technology Certification Program
FCS	Field Control Systems
FDD	Fault Detection and Diagnostics
FRCS	Facility-Related Control System
HVAC	Heating, Ventilation and Air Conditioning
IoT	Internet of Things
IP	Internet Protocol
LCCA	Life-cycle Cost Assessment
MDMS	Meter Data Management System
MILCON	Military Construction

O&M	Operations and Maintenance
RMF	Risk Management Framework
SRM	Sustainment, Restoration, and Modernization
UESC	Utility Energy Services Contract
UFC	Unified Facilities Criteria
UMCS	Utility Monitoring Control System
UP	Utilities Privatization

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1.0 BACKGROUND

Energy management and information systems (EMIS) are a class of building data analytics and control software technology that have shown significant potential for reducing energy waste, improving occupant comfort, and streamlining operations and maintenance (O&M) practices. EMIS products have been demonstrated through the Environmental Security Technology Certification Program (ESTCP). In the commercial buildings sector, the value of EMIS has been proven at scale, most recently through the largest ever assessment of technology costs and benefits, covering over 6,500 public and private sector commercial buildings, representing over half a billion square feet of floorspace. Findings showed that on average, fault detection and diagnostics (FDD, a type of EMIS) users saved 9% in whole-building energy use, with a two-year payback. Smart meter analytics were shown to save 3%, also with a two-year payback. Federal energy-related mandates and associated Department of Defense (DoD) efforts such as advanced metering adoption are well-aligned with the capabilities and potential for EMIS, supporting powerful energy management processes such as monitoring-based commissioning (MBCx). Figure ES-1 illustrates the possible data inputs for EMIS and their capabilities. The left side of Figure ES-1 shows that building operations data are available from many sources, and with the proliferation of new technologies (e.g., Internet of Things [IoT] devices, distributed energy resources) the volume of data has increased exponentially in recent years. EMIS has emerged to enable building owners to extract accurate and actionable insights from large amounts of data.

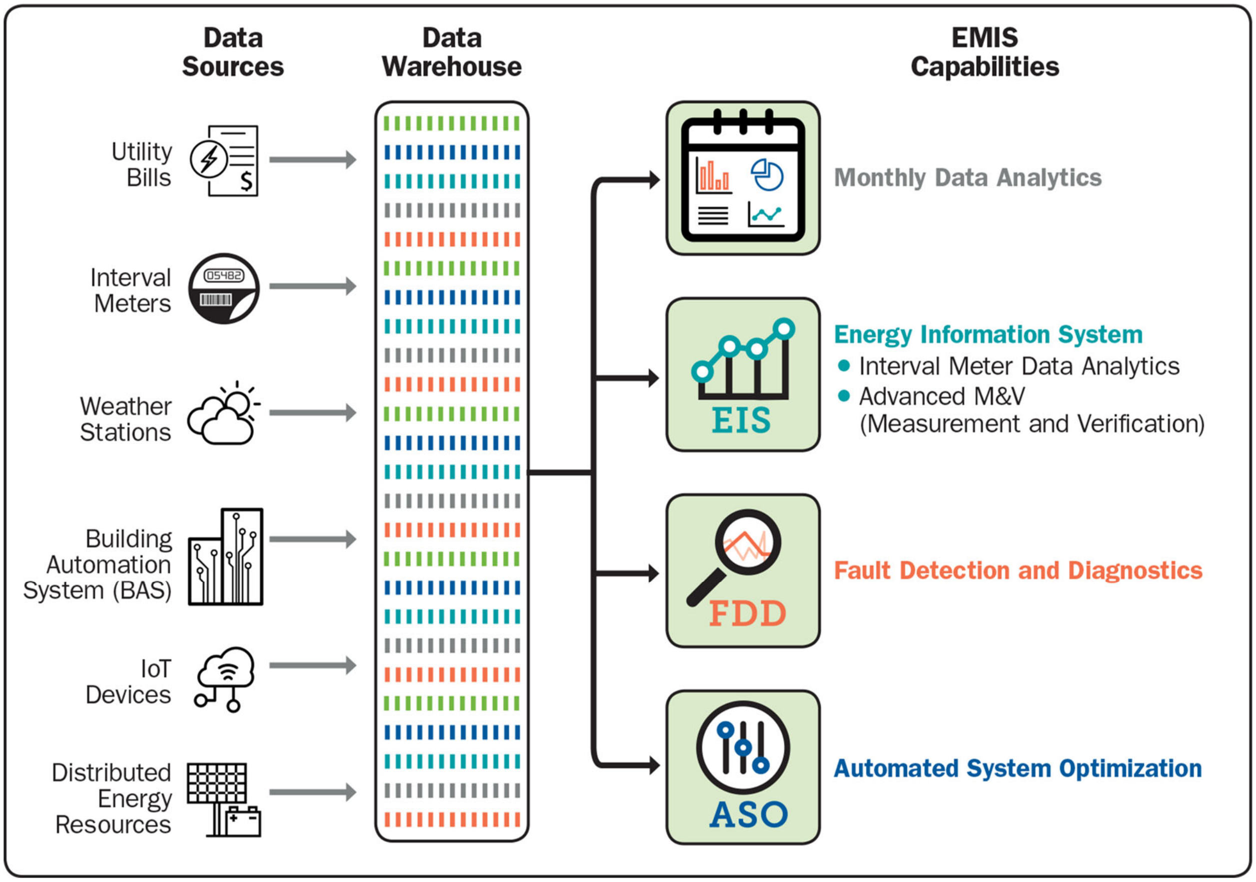

Figure ES-1. EMIS Framework - Data inputs and EMIS capabilities

Adoption of EMIS is rapidly increasing across a wide range of commercial property types, however DoD facilities present particular implementation challenges, as evidenced through past and ongoing ESTCP demonstration projects. Examples of these challenges include:

- IT resource bottlenecks that delay Risk Management Framework (RMF) and Authorization to Operate (ATO) process
- Despite DoD-level support for cost-effective, innovative technologies such as EMIS, funding shortfalls and sustainment processes constrain enterprise-level implementation
- Separation of departmental responsibilities between the construction, O&M, and network management silos result in disconnects in EMIS implementation process
- Existing resources to support EMIS deployment (e.g., model specifications, best practice guides) may be unknown to DoD users or require further customization to meet their needs

DoD has seen the potential from EMIS, as evidenced by its selection for ongoing ESTCP demonstration projects; however, these projects have also revealed the ways in which DOD's internal processes are not yet aligned to take advantage of high value EMIS opportunities at scale. Addressing the barriers listed above is particularly challenging given DoD's organizational complexity, but the opportunity is substantial. With energy costs accounting for approximately 2% of DoD's annual budget, and with DoD managing over 560,000 buildings, the savings potential is significant. Further, EMIS are an ideal complement to other high-potential technologies such as distributed energy resources, advanced building controls, and advanced energy security strategies.

1.1 PURPOSE AND ACHIEVEMENTS

The goal of the EMIS Technology Transfer Project (EW22-7299) was to overcome critical process and technical barriers impeding scaled adoption of EMIS within DoD installations. This was achieved by documenting and disseminating technology transfer solutions that provided a set of "work-through" pathways. With an initial focus on Army installations and stakeholders, the project successfully achieved the following:

- Development of Needs, Barriers, and Opportunities Assessment
- Completion of U.S. Army Building Stock EMIS-Readiness Analysis
- Composition of ESTCP Playbook – guidance for implementing smart building data analytics
- Engagement of stakeholders

The following sections of this Executive Summary provide an overview of these achievements.

2.0 NEEDS, BARRIERS AND OPPORTUNITIES ASSESSMENT

The Needs, Barriers and Opportunities Assessment provided an overview of challenges and opportunities related to the implementation of EMIS within the U.S. Army and DoD. The findings are based on stakeholder interviews and literature review, highlighting key areas that need improvement to facilitate EMIS adoption.

2.1 CHALLENGES TO EMIS IMPLEMENTATION

Several challenges that inhibit EMIS adoption and implementation were identified. The primary challenges are described in the subsections below.

2.1.1 Authority to Operate (ATO) Process

The Authority to Operate (ATO) process, mandated by the NIST RMF, presents significant challenges in terms of complexity, time requirements, and cost. This has led to documented instances where ATO-related delays have caused projects to stall, with some cases necessitating complete resubmission of documentation. The situation is further complicated by limited information technology (IT) expertise at the installation level, where many IT staff members lack sufficient understanding of Operational Technology (OT) requirements. In response to these challenges, the continuous ATO (cATO) framework was introduced in 2022, as one potential strategy designed to enhance the efficiency of ATO approvals through the implementation of ongoing cybersecurity monitoring measures.

2.1.2 Operational Challenges

Staffing shortages at installation sites make it difficult to maintain an EMIS system because energy managers (EMs), maintenance teams, and IT personnel often lack the resources to oversee ongoing EMIS operations. Many installation sites do not have a dedicated EM, making it difficult to integrate EMIS into daily workflows. Budget constraints hinder not just EMIS deployment but also basic building maintenance – if HVAC systems and controls are in poor condition, EMIS analytics will have limited value. Existing procurement contracts (e.g., Base Operations and Support Services [BOSS] contracts) prioritize low-cost solutions, leaving little room for advanced analytics and energy optimization tools.

2.1.3 Lack of Awareness and Technical Resources

Facility managers often lack familiarity with EMIS capabilities and their potential for energy savings. While the Army Reserve Enterprise Building Control System (EBCS) represents one of the few existing EMIS deployments, it suffers from limitations including non-user-friendly analytics and the need for dedicated staff to manage it. Similarly, although the Meter Data

Management System (MDMS) is widely adopted for basic energy tracking, its effectiveness is constrained by the absence of advanced FDD features.

2.2 OPPORTUNITIES FOR EMIS ADOPTION

Despite the challenges, there are viable opportunities to employ EMIS adoption and implementation. Some strategies that offer solutions to the challenges previously described are presented in the subsections below.

2.2.1 Packaged EMIS Implementation Approaches

To overcome installation-level challenges, EMIS solutions should be tailored to specific building characteristics for optimal implementation. For newer buildings equipped with advanced control systems, a comprehensive EMIS implementation combining Energy Information Systems (EIS) and FDD is recommended. In contrast, older buildings with basic HVAC controls would benefit most from a simplified EIS monitoring approach that focuses on tracking energy usage and generating alerts for significant deviations. Buildings featuring central HVAC plants should utilize FDD analytics capabilities to optimize their load-based temperature and pressure control systems. For facilities primarily served by packaged rooftop units (RTUs), implementing networked thermostat controls with cellular gateway technology offers an effective solution to bypass potential network restrictions while maintaining system functionality.

2.2.2 Strategic Policy Alignment

Integration with key Army initiatives is essential, encompassing coordination with the Control Systems Governance Office (CSGO) to ensure EMIS is incorporated into long-term cybersecurity and control systems planning. Additionally, the Energy Resilience and Conservation Investment Program (ERCIP) and Energy Savings Performance Contracts (ESPCs) provide critical financial pathways for EMIS implementation.

3.0 U.S. ARMY BUILDING STOCK ANALYSIS

The Building Stock Analysis evaluates the readiness of U.S. Army buildings for EMIS deployment using a data-driven assessment methodology. The goal is to identify buildings best suited for EMIS implementation and estimate the potential energy savings.

3.1 DATA ANALYSIS METHODOLOGY

Under this project the research team conducted a comprehensive analysis of 56,622 Army buildings' suitability for EMIS, using data from the Army's custom-developed "Builder" database. Through filtering based on the presence of Direct Digital Controls (DDC), researchers identified a relevant subset of 3,858 buildings for further examination. To systematically evaluate these facilities, the team employed a rules-based decision tree model that classified buildings into three categories using key criteria: building size, with larger buildings being more suitable for EMIS; HVAC Condition Index (CI), where higher CI scores indicated better potential for FDD and EIS; and Energy Use Intensity (EUI) classifications, which were determined based on specific building types as defined by their Category Codes (CATCODEs).

3.2 CLASSIFICATION OF EMIS READINESS

The data-driven methodology when applied to the subset of buildings revealed the findings summarized in Table ES-1 below.

Table ES-1. EMIS readiness classification of Army buildings

Classification	EMIS Recommendation	Number of Buildings	Potential Energy Savings
High Readiness	FDD + EIS	458 (12%)	9% savings
Medium Readiness	EIS (borderline FDD)	499 (13%)	3%–9% savings
Low Readiness	EIS only	2,901 (75%)	3% savings

The Building Stock Analysis revealed that buildings that lack DDC systems should prioritize upgrading to DDC before implementing EMIS. This foundational step ensures the building has the necessary infrastructure to fully utilize advanced energy management tools. Additionally, while smaller buildings with low HVAC CI typically may not be ideal candidates for FDD, they can still derive value from implementing basic EIS features to monitor and optimize their energy usage.

3.3 RECOMMENDATIONS AND NEXT STEPS

To effectively implement EMIS systems across Army facilities, priority should be given to buildings demonstrating high readiness based on EMIS classification results for initial pilot projects. The EMIS deployment timeline should be coordinated with scheduled DDC system upgrades to maximize efficiency and minimize disruption. Additionally, standardized procurement language needs to be developed for seamless integration of EMIS requirements into future Army contracts, ensuring consistency and compliance across all installations.

4.0 EMIS PLAYBOOK: GUIDANCE FOR IMPLEMENTING SMART BUILDING DATA ANALYTICS

The *'EMIS Guidance for implementing smart building analytics,'* subsequently referred to as the "Playbook" in this document, provides guidance for implementing an EMIS, a key tool for meeting DoD sustainability goals. The Playbook is intended to help DoD building operators and facility managers overcome the most critical process and technical barriers that impede scaled adoption of EMIS within DoD installations. The Playbook was organized into sections that aim to address specific questions as follows:

- **How do I select an EMIS configuration to suit my building?** Section 2 provides different EMIS architecture options, each with different installation, cybersecurity, and sustainment implications.
- **How can I assess whether my building is ready for an EMIS?** Section 3 presents factors that can be used to assess when a site is ready for EMIS procurement and installation.
- **How can I navigate the funding and procurement of an EMIS?** Section 4 provides the context and resources to prepare a business case to secure funding for the procurement of an EMIS.
- **What are the cybersecurity issues I need to be aware of when installing an EMIS?** Section 6 presents potential cybersecurity issues to consider.

The Playbook is applicable to all DoD building energy projects. The Defense Logistics Agency Energy Office and the Services Energy Offices are the starting point for most energy projects. The DoD depends on the private sector to provide the vast majority of energy projects and has special legislative authorization for the acquisition of energy projects. These acquisition mechanisms include ESPCs, Utility Energy Services Contracts (UESCs), Utilities Privatization (UP), ERCIP, and other contract or program vehicles. The Playbook explores the barriers to acquiring energy projects and presents multiple pathways to effectively implement EMIS. Key concepts from the Playbook are summarized in the subsections below.

4.1 EMIS ARCHITECTURE OPTIONS

EMIS can be installed and configured in different ways, with various benefit alternatives, each described as an 'architecture option' in this document. The installation and integration of an EMIS within DoD requires the selection of an appropriate architecture option that aligns with the existing Field Control System (FCS) and its Utility Monitoring and Control System (UMCS) front-end integration options, outlined in Unified Facilities Criteria (UFC) 3-470-01 (Utility Monitoring and Control System Front End and Integration, 2018), and the five-level Control System Architecture, outlined in UFC 4-010-06 (Unified Facilities Criteria: Cybersecurity of Facility-Related Control Systems, 2023). As illustrated in Figure ES-2, the UMCS network architecture supports four fundamental FCS cases, and consists of a base-wide internet protocol (IP) network connected to one or more field control systems through a field point of connection (FPOC) device, which provides an interface between the UMCS IP network and the field control network (FCN). On the other hand, in the five-level control system architecture (shown in Figure ES-3), each level represents a collection of field control system components that are logically grouped together by function, and which generally share a cybersecurity approach (note, the FCS shown in Figure ES-2 is segmented into Levels 0, 1, and 2 in the five-level control system architecture). This architecture is defined as a general architecture suitable for a wide range of field control systems, and there are some key considerations when integrating EMIS at different field control system levels, because it is rare that EMIS exert control capabilities. In addition, not every implementation of a control system will make use of every level, or every type of component shown at a level.

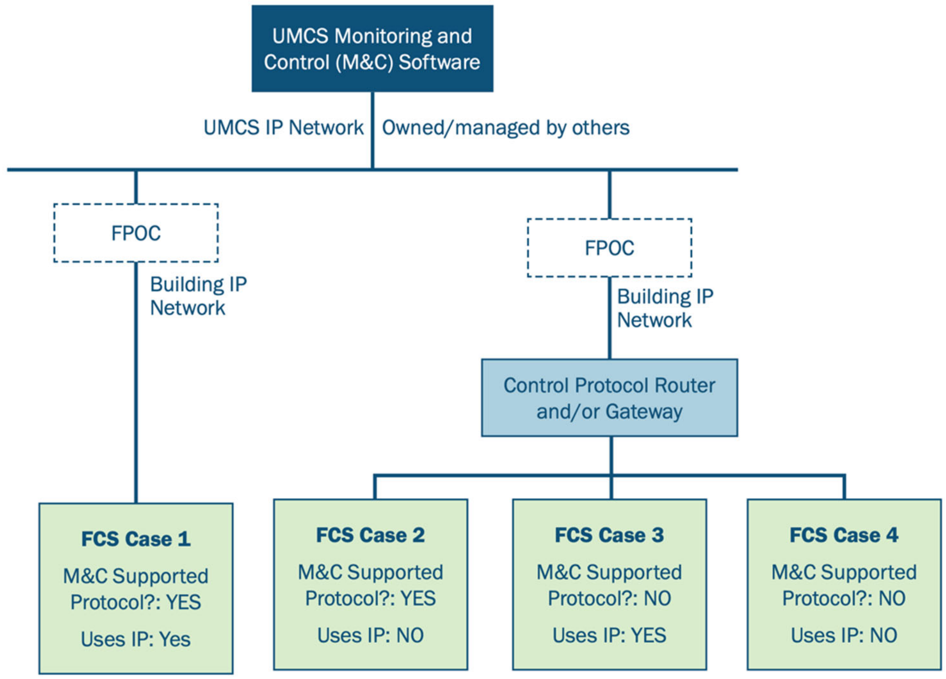

Figure ES-2. UMCS Architecture

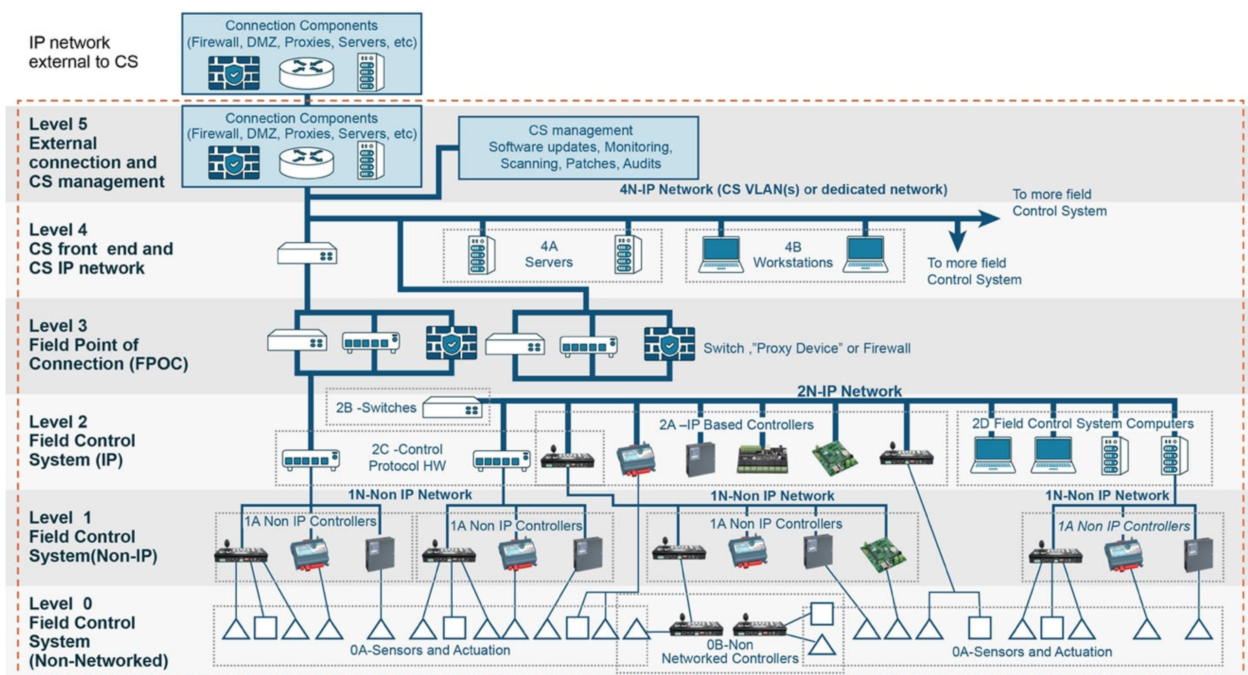

Figure ES-3. Five-level Reference Architecture from UFC 4-010-6

The Playbook outlines five EMIS deployment options, ranging from basic fault detection to fully integrated cloud-based analytics, summarized in the table below.

Table ES-2. Summary of EMIS Architecture Options

Architecture Option	Description	UMCS Front End changes required?	Architecture Level?
EMIS-lite	Basic function on existing UMCS	Yes	4
EMIS as UMCS add-on	UMCS add-ons or on-premise EMIS without cloud services	Yes	1, 2, and 4
Cloud EMIS with configuration changes only	Simplest cloud option	No	2 and 5
Cloud EMIS with software changes	Cloud option with some EMIS continuously running at the front end	Yes	2, 4 and 5
Cloud EMIS with hardware changes only	Cloud option with some EMIS continuously running on an added EMIS hardware	No	2 and 5

4.2 EMIS BUSINESS CASE DEVELOPMENT

When developing a business case for adding EMIS at a DoD facility, it is important consider alignment with strategic goals, gap analysis, alternative analysis, and project management. A critical component of the business case is a Cost-Benefit Analysis, which involves formal requirements analysis, sensitivity testing, and financial projections like net present value. Estimating savings can be complex due to varying building inefficiencies, but industry metrics (e.g., 9% savings from fault detection data analytics) and datasets such as energy usage models can provide planning-level estimates. The document also emphasizes Life-Cycle Cost Assessment (LCCA), which evaluates all costs associated with owning, operating, maintaining, and disposing of a project. LCCA is particularly useful for assessing alternatives in building systems or renovations. Tools such as NIST Handbook 135 and the Building Life-Cycle Cost (BLCC) tool are recommended for federal projects.

Project funding mechanisms include:

1. Military Construction (MILCON): Supports integration of EMIS during new construction or major renovations, including energy-saving initiatives under programs like ERCIP.

2. Sustainment, Restoration, and Modernization (SRM): Funds maintenance and upgrades to facilities.
3. Third-Party Financing: Includes ESPCs and UESCs, which finance projects through energy savings over time.

An example of ESPC implementation illustrates how the DoD collaborates with Energy Service Companies (ESCOs) to upgrade infrastructure while ensuring performance optimization through EMIS. These long-term agreements are tailored to site-specific needs and involve comprehensive audits, design, financing, and construction phases.

4.3 CASE STUDIES OF SUCCESSFUL EMIS DEPLOYMENT

There are several instances of successful EMIS deployment that demonstrate how EMIS can be implemented and used successfully with the architecture options presented in Table ES-1. Examples of successful deployments are highlighted in case studies described in the following subsections.

4.3.1 EMIS at Marine Corps Air Station Beaufort and Hanscom Air Force Base

A pilot project focused on HVAC fault detection within the DoD delivered promising preliminary results in 2024, aiming for a 15% reduction in energy use with a payback period of under two years. Cimetrics' Analytika platform was deployed at Marine Corps Air Station Beaufort and Hanscom Air Force Base, using a hardware appliance to extract data from existing building control systems. The vendor managed most of the configuration, minimizing workload for DoD personnel. The project, categorized as "Cloud EMIS with hardware changes," involved migrating analytics to AWS GovCloud for enhanced security. The “Cache Poller” hardware, responsible for data collection and upload, was required to undergo the ATO process. The scalable solution, initially planned for six buildings, expanded to over 100, analyzing 2 million square feet. The EMIS/FDD system identified thousands of faults and energy-saving opportunities, demonstrating significant potential for the project and broader DoD adoption.

4.3.2 EMIS at Fort Leavenworth

Fort Leavenworth is conducting a study on energy management effectiveness, deploying an EMIS across eight facilities to assess FDD. The evaluation considers facility energy use, system economics, implementation rate, and perceived operational benefits. The project follows the "EMIS as a UMCS add-on" approach, integrating fault detection notifications into the UMCS front end. This initiative serves as a model for future DoD-wide expansions, enhancing energy management strategies.

4.3.3 EMIS at CERL Champaign

The Modius OpenData platform was demonstrated as a middleware solution for centralized utility and facility data management across DoD service branches. By integrating diverse systems and smart meter data, the platform improved energy usage insights and metering system efficiency. The solution enhances operations, supports the DoD’s 5% energy reduction goal, and incorporates machine learning for automated oversight. This initiative aligns with security and operational standards while optimizing decision-making for maintenance teams.

4.3.4 EMIS CERL FDD Pilot

Johnson Controls' OpenBlue platform was installed at CERL Champaign, IL, to evaluate installation, data ingestion, and fault detection. A network-scanning hardware bridge identified Tridium JACE devices, auto-populating BACnet objects into the cloud. The system applied over 800 predefined fault detection rules, categorizing faults into Energy, Maintenance, and Comfort for corrective action. Integration with maintenance management systems like Maximo and ArMA was tested. The project, fitting the "Cloud EMIS with hardware or software changes" category, utilized Azure Cloud with a Palo Alto firewall for security, demonstrating the potential for large-scale DoD energy management improvements.

4.4 CYBERSECURITY AND ATO COMPLIANCE

The integration of cybersecurity requirements is crucial for ensuring secure and cyber-resilient EMIS infrastructures within DoD. Systems connecting to the DoD Information Network (DODIN) must undergo the RMF process, while standalone contractor-owned projects must follow RMF procedures and manage their own ATO internally. Third-party energy service providers are contractually required to meet cybersecurity standards to protect DODIN and Controlled Unclassified Information (CUI).

To meet these demands, project teams should include experienced contractor Cybersecurity Subject Matter Experts who will develop the Cybersecurity Basis of Design. In the Army, oversight by the United States Army Corps of Engineers ensures compliance with cybersecurity controls, enabling the delivery of RMF-accreditable and low-risk EMIS solutions. Collaboration with IT groups is essential in the successful implementation and long-term operation of EMIS. Requiring the establishment of Service Level Agreements and training on EMIS integration with front-end UMCS will help to establish an effective collaboration.

5.0 STAKEHOLDER WORKSHOP

An EMIS workshop held at Fort Hood on July 27th, 2023, aimed to elicit first-hand feedback from a cross-section of stakeholders working at a single installation, to better understand the baseline conditions, challenges, and perceived benefits of EMIS across stakeholders. The workshop focused on implementing EMIS solutions to better utilize existing HVAC controls infrastructure and improve energy management efficiency. The workshop covered three main EMIS implementation pathways: EMIS/FDD Lite with configuration changes only, cloud EMIS with existing UMCS/ATO, and new UMCS/ATO with integrated EMIS. Each pathway presented different levels of complexity, cost, and potential benefits, with considerations for cybersecurity requirements and FedRAMP compliance. The event facilitated detailed discussions on building analytics implementation challenges, including: IT resource bottlenecks, funding shortfalls, and departmental responsibility separation. Participants explored various EMIS functionalities, including FDD, EIS and ASO, with median energy savings potential of 3-9% and implementation costs ranging from $0.01 to $0.06 per square foot. The workshop concluded with practical sessions on building stock analysis, EMIS resource needs, and implementation challenges, particularly focusing on cybersecurity and training requirements.

Following the successful Fort Hood workshop, outreach was conducted to identify potential opportunities for one to two more workshops, either in-person or virtual. Additional workshop locations were not secured within the project timeline, but the Fort Hood workshop, in combination with the Needs Assessment interviews, provided a valuable mix of first-hand and secondary information across a range of DoD stakeholder roles.

6.0 DEVELOPMENT OF EMIS RESOURCE PACKAGE

The EMIS resource package consists of fact sheets, the Playbook, and training videos. Case studies from EMIS projects were condensed into one-page fact sheets summarizing their value and made available online alongside other project materials like the Playbook. Additionally, a three-part *EMIS Process Playbook* training video series was developed to support EMIS implementation in the DoD. The series provides guidance on quantifying the business case, addressing network security concerns, managing implementation, and showcasing real-world case studies. It categorizes EMIS capabilities and configurations, helping DoD facility managers customize solutions to their needs. The training materials are hosted on the Whole Building Design Guide website (www.wbdg.org).

7.0 CONCLUSION

EMIS has significant potential but must be implemented properly to address challenges and ensure a secure system. Challenges to implementation include resource constraints, outdated infrastructure, and departmental silos. Utilizing tools offered in the EMIS playbook and resource package can help to successfully incorporate EMIS into DoD energy projects. The EMIS resource package provides actionable guidance to identify the optimal level of EMIS functionality, develop a feasible business case, and navigate cybersecurity for DoD facility management and energy management staff. The analysis of 56,622 Army buildings revealed that 12% of buildings have high readiness for EMIS, with potential energy savings of 9%, while 13% have medium readiness and 75% have low readiness. The pilot project at Marine Corps Air Station Beaufort and Hanscom Air Force Base demonstrated the potential for EMIS to reduce energy use by 15% with a payback period of under two years.

Overall, it has been demonstrated that EMIS can be a valuable tool for the DoD to improve energy efficiency and reduce energy consumption. Thoughtfully implementing EMIS in accordance with the guidance presented is expected to result in significant cost and energy savings. Further research into increasing the readiness level of buildings is recommended to fully realize the potential of EMIS across the broadest variety of facilities.