

Department of Defense
High Performance and Sustainable
Buildings
Report to Congress



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Under Secretary of Defense for Acquisition and Sustainment

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Introduction

This report responds to a request in House Report 115-673, page 5, accompanying H.R. 5786, the Military Construction, Veterans Affairs and Related Agencies Appropriations Bill, 2019 directing the Secretary of Defense to work with universities, public agencies, and experienced nonprofit organizations to develop a plan to expand the application of the innovative technologies in future military construction (Milcon) projects, and to report to Congress on how the Department will implement this plan.

Expansion of high performance and sustainable buildings is a primary opportunity for the Department of Defense (DoD) to incorporate innovative technologies into Milcon. Therefore, this report discusses the DoD policies and guidance that encourage the construction of high performance and sustainable buildings, provides examples of where DoD is partnering with universities, public agencies, and experienced nonprofit organizations on high performance and sustainable buildings and innovative technologies, offers examples of DoD's use of innovative technologies, and details DoD's challenges and plans to expand the application of innovative technologies in Milcon.

The DoD has policies in place to support sustainable building efforts and works to integrate sustainable materials and innovative technologies into Milcon, where possible. Additionally, DoD is engaging with universities, public agencies, nonprofit organizations, and industry to develop and review new innovations and materials in sustainable design and construction. DoD continues to make progress in increasing the performance and sustainability of its buildings to the extent possible given its constrained budgets and limited funding for sustainment, restoration, and modernization.

Background on High Performance and Sustainable Building Requirements

There are numerous Federal laws, regulations, and executive orders (EOs) that apply to Milcon and building performance, both directly and indirectly connected to sustainability and efficiency (e.g., energy security, new construction, and infrastructure upgrades).

- *Energy Independence and Security Act* (EISA) of 2007 directs Federal agencies to increase the efficiency of buildings, promote research on alternative fuels, and improve the energy performance of the Federal government in order to increase U.S. energy security and independence.
- EO 13834, *Efficient Federal Operations*, tasks Federal agencies with increasing energy efficiency, optimizing facility performance, and enhancing the resilience of Federal infrastructure and operations.
- The Council for Environmental Quality's *Guiding Principles for Federal Sustainable Buildings* outlines principles for new construction, modernization, and modifications to existing buildings (e.g., optimizing energy performance, environmental impact reduction from materials).

These requirements are the basis for DoD-specific policies that encourage sustainable building planning, design, and construction.

DoD-Wide Policies and Guidance

Across the DoD, there are several directives, instructions, and criteria that outline sustainable building requirements and provide guidance for engaging with universities, public agencies, nonprofit organizations, and industry¹. Policy instruments like these are the primary way that DoD executes the incorporation of innovative technologies and sustainable materials into Milcon. These policies encourage DoD to construct sustainable buildings, where feasible and cost-effective, that employ innovative technologies that meet DoD's requirements. Per Department of Defense Directive 4270.5, *Military Construction*, the DoD Components must follow applicable unified facilities criteria (UFCs) and unified facilities guide specifications (UFGSs) in Milcon.

UFCs provide planning, design, construction, sustainment, restoration, and modernization criteria, and apply to all the DoD Components. UFC 1-200-02, *High Performance and Sustainable Building Requirements*, provides guidance for planning, designing, constructing, renovating, and maintaining high performance and sustainable buildings and establishes compliance with the minimum requirements of the EISA, EO 13834, and industry building standards. For example, UFC 1-200-02 specifies that new buildings must be designed to achieve at least a 30% energy consumption reduction from the ASHRAE 90.1 baseline². It emphasizes the importance of designing and integrating high performance and sustainable systems (e.g., heating, ventilation, and air conditioning (HVAC), plumbing, water heating systems, lighting systems, control systems, elevators, building envelope and fire protection systems) into the overall building. UFC 1-200-02 requires the procurement of environmentally preferable products that are composed of recycled content and have a lesser effect on human health and the environment. Additionally, UFC 1-200-02 encourages building design solutions that more resilient to climate vulnerabilities. By incorporating innovative technologies into its building design, planning, and construction activity, DoD can potentially increase the resilience of both new and existing buildings.

Other UFCs that support high performance and sustainable buildings are UFC 3-210-10, *Low Impact Development*, which encourages stormwater management on installations, UFC 4-010-06, *Cybersecurity of Facility-Related Control Systems*, and UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*. When employing innovative technologies, DoD must ensure its facilities are physically and cybersecurity safe. UFC 4-010-06 describes requirements for incorporating cybersecurity into the design of all facility-related control systems to mitigate vulnerabilities to an acceptable level. UFC 4-010-01 establishes required minimum engineering standards that incorporate antiterrorism based mitigating measures. If sustainable materials and innovative technologies cannot meet the standards and requirements in UFC 4-010-06 and UFC 4-010-01, their use in DoD will be limited.

DoD updates UFGSs, the basis for military facility construction, to provide guidance on the use of new and innovative building materials, technologies, and methodologies. In many instances, nonprofits and industry groups are involved in developing suggestions for content or providing peer reviews prior to publication. Examples of UFGSs that have included input from

¹ For more information on DoD Component specific policies related to sustainable building and use of innovative technologies, see Appendix A.

² American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

outside groups are: UFGS 07 17 19 *Cross-Laminated Timber*, UFGS 32 01 16.74 *In Place Hot Reused Asphalt Paving*, and UFGS 32 12 22.00 10 *Polymer Concrete-Micro-Overlay for Fuel and Abrasion Resistant Wearing Surfaces*. As part of the development process for UFGSs, individual Discipline Working Groups are established across all the Military Services to develop unified DoD criteria for the specific materials in the UFGSs. The criteria incorporate input from outside groups (e.g., universities, public agencies, nonprofit organizations, and industry), when possible. These working groups ensure that the DoD criteria neither endorse nor prohibit individual products, but rather confirms that products are selected solely on performance. The Military Service Discipline Working Groups also seek to include industry and nonprofit organizations (e.g. Woodworks.org, American National Standards Institute) and other agencies (e.g., the U.S. Department of Agriculture’s Forest Products Lab) in the development of new content for or to provide peer reviews of documents and criteria. The specialized industry expertise and recommendations provide DoD with ideas on new approaches and potential uses for innovative technologies.

Department of Defense Instruction (DoDI) 4170.11, *Installation Energy Management*, is the overarching policy guidance document for the DoD on installation energy use and requires that all large capital energy investments in existing buildings use the most energy efficient sustainable designs for systems and use innovative technologies. Additionally, DoDI 4170.11 requires that the DoD Components design new Milcon to a Leadership in Energy and Environmental Design (LEED) silver level or better. DoDI 4105.72, *Sustainable Procurement*, includes specifications on using sustainable building products and provides guidance to DoD on procurement of these products.

In 2013, DoD released the *Department of Defense Sustainable Buildings Policy* to ensure compliance with the EISA, and the various EOs related to sustainable buildings. The policy states that DoD will sustainably design, build, operate, maintain, re-use and demolish facilities, where possible. The policy further requires the DoD Components to establish processes to ensure that applicable new buildings will meet the requirements in UFC 1-200-02 and can achieve green building certifications.

Examples of Recent Innovations and Partnerships

Engaging with Universities, Public Agencies, and Nonprofit Organizations

The Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) are the primary pathways for new innovative technologies to be tested for their applicability to DoD and subsequently fielded for DoD use. SERDP is DoD’s environmental science and technology research program that invests in basic and applied research, while ESTCP promotes the transfer of successful innovative technologies to field or production use. Leveraging research and technology from industry strengthens partnerships between the DoD and industry and encourages the use of innovative technologies. SERDP and ESTCP projects involve partnerships with universities, other Federal Agencies (e.g., U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency), nonprofit organizations, and industry to test new approaches and innovative technologies for use within DoD. Through the SERDP and ESTCP’s Installation Energy and

Water program³, DoD installations serve as test cases for innovative technologies and methodologies developed by researchers from universities, Federal Agencies, nonprofit organizations, and industry. Some of these include:

- Testing cost-effective aerosol sealing application methods for sealing building shells to meet the requirements for DoD facilities;
- Employing modified atmosphere insulation to reduce energy consumption in DoD facilities;
- Expanding the use of High-Efficiency Dehumidification Systems (HEDS);
- Incorporating solar, thermal electric systems with above sheathing ventilation, and rainwater harvesting into roof construction or retrofitting; and
- Developing tools to improve the transfer of energy conservation and efficiency technology from demonstration/validation to deployment on installations.

The Department of the Army through the U.S. Army Corps of Engineers (USACE) maintains multiple national memberships and partnerships with universities, public agencies⁴, and nonprofit organizations that work to advance the sustainability and efficiency of building technology and materials. USACE partnerships with public agencies and nonprofit organizations include: the Building SMART Alliance through the National Institute of Building Sciences, the Construction Industry Institute, the U.S. Green Building Council, and the National Academy of Sciences Roundtable. USACE incorporates knowledge gained through these partnerships into its Milcon projects for DoD facilities. USACE is collaborating with the Center for Integration of Composites into Infrastructure (CICI), a multi-university National Science Foundation Industry/University Cooperative Research Center. CICI originates from a merger of the efforts of four universities: West Virginia University, the University of Texas Arlington, the University of Miami, and North Carolina State University.

The USACE Engineer Research and Development Center Construction Engineering Research Laboratory (ERDC-CERL) routinely collaborates with universities and national labs (e.g., DOE's Pacific Northwest National Lab and the Lawrence Berkeley National Lab) on new innovative building technologies. The ERDC-CERL Energy Branch partners with several universities, Federal Agencies, and industry via ESTCP projects focused on enhancing building energy efficiency. These efforts include: cost analysis of a building retrofit using high-performance insulation; HEDS; intelligent building management with holistic digital lighting; and nanofiber-based low energy consuming HVAC air filters.

Naval Facilities Engineering Command (NAVFAC), who plans, builds, and maintains sustainable facilities for the Department of the Navy (DON), participates in the DOE's Sustainable Working Groups to encourage the building industry to adopt the stricter Federal building requirements as standards, which could lower DoD's Milcon costs. New and innovative materials must be vetted to ensure they meet DoD building standards and requirements prior to their widespread use in Milcon. Therefore, NAVFAC's Expeditionary Warfare Center assesses and validates the performance of new technologies and innovative building materials for their potential use in Milcon and updates industry on their findings.

³ The Installation Energy and Water program invests in technologies that support sustainable building design and operations, including innovative energy efficient lighting and HVAC systems.

⁴ Including National Laboratories

The Air Force Civil Engineer Center partnered with Karagozian and Case, Inc., a science and engineering consulting firm, and the University of Maine through a cooperative research and development agreement to explore the use of innovative materials in Milcon. The multi-year effort successfully validated the full-scale blast resistance of cross-laminated timbers.

Examples of Innovative Technologies

The USACE ERDC-CERL is working with several different universities on multiple projects that use innovative technologies and materials in sustainable buildings. Specifically, the ERDC-CERL Materials and Structures Branch is working with the University of Illinois and Southern Mississippi University on advanced paints/coatings to improve corrosion resistance and energy efficiency of military structures. The Branch is also working with the University of Illinois on the use of geopolymer materials for various construction-related purposes, including 3-D printing, rehabilitation and replacement of deteriorated railroad ties, and soil stabilization as a replacement for concrete pads.

In addition, the USACE ERDC-CERL Materials and Structures Branch is currently working with West Virginia University on innovative polymer matrix composite materials to replace, rehabilitate, and repair civil infrastructure. These materials are a low-maintenance, corrosion-resistant, and rot-resistant alternative to traditional construction materials (i.e., steel and wood). The team has had success replacing wooden wicket gates on the Illinois River with polymer composite wicket gates. The success of these materials has the potential to cross over to vertical building construction.

Separately, the ERDC-CERL team has recently scaled up efforts in additive manufacturing, or 3-D printing, to develop a portable printer that can print custom-designed structures on-demand in the field, using concrete with large aggregate, which could potentially reduce construction time. The team demonstrated the first full-sized building to be printed in-place using concrete in the United States. They also provided a printing demonstration at the Maneuver Support, Sustainment, Protection and Integration Experiment at Fort Leonard Wood, Missouri. ERDC-CERL team will work closely with the DoD Components on testing this technology taking note of any challenges resulting from cleaning and equipment maintenance requirements which cause delays. Additionally, ERDC successfully printed a 32-foot reinforced concrete footbridge and continues to explore using 3-D printing for expeditionary structures. Once the technology is fully vetted and is applied to Milcon, 3-D printing has the potential to reduce building construction time and resources in forward-deployed settings. For example, for the concrete footbridge, construction time decreased from 4-5 days to 1 day, personnel required from approximately 8 to 3 per structure, and material shipped from 5 tons to less than 2.5 tons. Most importantly, these achievements have the potential to reduce logistics and exposure to risk.

The Office of the Assistant Secretary of Defense (Sustainment) and the National Defense Center for Energy and Environment are demonstrating a sustainable door system at various DoD installations. High performance door openings from the company ASSA ABLOY have been found to deliver certified energy savings to DoD facilities, giving the government agency a trusted sustainable building component to comply with energy efficiency requirements. DoD and third-party agency GreenCircle Certified LLC examined several standard exterior door openings at Joint Base San Antonio, Texas and at Fort Bragg, North Carolina and compared the performance of these doorways against the ASSA ABLOY doorways. In all cases, the Trio-E

doorways from ASSA ABLOY outperformed the existing doorways and produced an annual certified energy savings average of \$100 per year per doorway.

Opportunities to Expand the Use of Innovative Technologies in Military Construction

Identifying Impediments & Challenges

Limited Facilities Sustainment, Restoration and Modernization (FSRM) resources, Federal Acquisition Regulation guidance, and security requirements all present a consistent challenge in expanding innovative technology in Milcon. Although DoD policy requires new construction and major renovations to adhere to UFC 1-200-02, the sheer magnitude of DoD's facility inventory to which the UFC applies (e.g., nearly 46,000 eligible buildings) presents challenges in achieving this requirement.

Using innovative materials for sustainable new construction is often possible, but it must still be cost-effective within the scope of the project. The Code of Federal Regulation and Federal Acquisition Requirements (FAR) direct the Federal government to use systems, components, and products that are life-cycle cost-effective, non-proprietary, reasonably available, and meet all required specifications. These requirements may inhibit the opportunity to incorporate innovative building materials and new technology into Milcon projects. For example, while cross laminated timber is a very promising material, lightweight steel stud construction is more economical for low-rise construction, which makes up the majority of military facilities. Availability of innovative materials may also pose a challenge when there is an insufficient number of competitive vendors in the market to meet open competition requirements, or when a product's availability is limited to particular regions. Additionally, many new technologies and building products use proprietary control systems to control HVAC, lighting, and other systems or rely on proprietary products making them incompatible with the FAR.

DoD has specialized operations and maintenance requirements that are military-specific. This can pose additional challenges to the integration of innovative materials. Material used on installations must suit DoD's military mission and be able to withstand the military environment (e.g., stricter building codes, DoD's requirements for sealed buildings). While DoD currently has numerous criteria guides with specifications for sustainable materials, other new and innovative technologies must be vetted to ensure they comply with DoD installation use. DoD's installation requirements can be quite specific, leading to limitations on the types of available material that can be used. Lastly, with new technologies, particularly in building control systems, it can be challenging to ensure compliance with DoD cyber-security and anti-terrorism standards.

Identifying Opportunities

DoD already engages with partners to incorporate innovative technologies into Milcon to the extent possible. The following are examples of areas where DoD can explore expanding its ongoing efforts.

- Milcon offers a significant opportunity for the DoD to continue to implement its sustainable practices and innovative technologies at the beginning of a project, especially for new construction. The DoD Components' master planning efforts prioritize the

expansion of sustainable materials and innovative technologies into installation buildings, where feasible. For example, in FY 2015 the Army added 122 buildings to its high-performance sustainable buildings inventory, making a total of 790 buildings.⁵

- Contracting is a mechanism DoD can continue to use to increase sustainable design and the use of innovative material. Additionally, DoDI 4105.72, *Procurement of Sustainable Goods and Services*, encourages contract actions to include sustainable procurement language, provisions, specifications, and clauses. In order for these efforts to be successful, DoD will need to continue to educate its contracting officers and installation personnel on sustainable design and innovative technologies. DoD will continue to ensure that its contracts address additional maintenance requirements or service contracts/agreements from the use of innovative technologies to avoid creating a maintenance cost burden for an installation.
- As SERDP and ESTCP projects and USACE ERDC-CERL efforts continue to provide proof of concept and validation of the innovative technologies, these efforts can be replicated at DoD installations. While there can be delays or hurdles in incorporating new or innovative technologies into policies, contracts, and standard Milcon practices due to cost-effectiveness concerns, DoD can work on expanding its efforts to encourage installation deployment of SERDP/ESTCP and USACE ERDC-CERL projects using sustainable design and innovative technologies. For example, if ERDC-CERL's polymer matrix composite materials can be used for vertical building construction and can produce cost savings, DoD Components will be more apt to deem it useful for Milcon, thus potentially avoiding the usage limitations associated with other innovative materials.
- Another opportunity for DoD to expand its sustainability efforts is for the Department to continue to update policies related to sustainable design and use of innovative technologies. For example, DoD continues to work with industry groups to update the UFGSs, which are used as the basis for military facility construction. Updates cover the inclusion of new and innovative building materials and technologies. As the Military Services replace and update criteria documents for hazardous material abatement and handling (e.g., lead, asbestos, mold), there is an opportunity for incorporation of industry innovations, innovative technologies, and unified guide specifications.

Conclusion

The DoD has policies in place to support the integration of innovative materials into its sustainable building efforts. For decades, DoD has partnered with other organizations, as appropriate, on the research and development of new technologies. Through its efforts in the SERDP, the ESTCP, and the individual engagements of the DoD Components, DoD will continue to collaboratively work with universities, public agencies, and nonprofit organizations to develop and apply innovative technologies for high performance buildings into its Milcon. DoD will continue to make progress in increasing the performance and sustainability of its buildings to the extent possible given regulation and resourcing constraints.

⁵ Department of the Army. (2016). *Sustainability Report*.

Appendix A: DoD Component-Specific Policies & Guidance

The Army requires new construction to follow LEED green building standards. The use of LEED standards in Army construction results on an average of 30% energy efficiency improvements above industry standard buildings. LEED standards also encourage the use of rapidly renewable materials such as bamboo, for floors and cabinets.

The DON established the NAVFAC ECB 2011-01, *Navy Shore Energy Building Standards*, which requires repairs and renovations to comply with UFC 1-200-02, and that sustainable design principles are incorporated into all new construction and major renovation projects. Additionally, through the Secretary of the *Navy Shore Policy Memorandum*, the DON will build to LEED gold standards and EnergyStar certification criteria, where possible, for new Milcon projects.

The Department of the Air Force Resilient Energy Demonstration Initiative guides the development and deployment of innovative technologies and business models to enhance energy resilience at buildings on Air Force installations, build a more resilient energy grid, and mitigate cyber threats to critical infrastructure. As part of this effort, the Air Force gives preference to Milcon projects with the highest return on investment.

The Defense Logistics Agency (DLA) in its installation management, facilities and equipment memorandum, *DLA Sustainability and Energy Efficiency Policy*, sets goals to reduce the environmental impact and total ownership cost of new and renovated facilities by reducing energy, water usage, maintenance requirements, and resources needed to provide safe, healthy, and environmentally sustainable facilities.

Acronyms

Acronym	Definition
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CICI	Center for Integration of Composites into Infrastructure
DLA	Defense Logistics Agency
DoD	Department of Defense
DoDI	Department of Defense Instruction
DOE	Department of Energy
DON	Department of Navy
EISA	Energy Independence and Security Act
EO	Executive Order
ERDC-CERL	Engineer Research and Development Center Construction Engineering Research Laboratory
ESTCP	Environmental Security Technology Certification Program
FAR	Federal Acquisition Regulations
FY	fiscal year
HEDS	High-Efficiency Dehumidification Systems
HVAC	heating, ventilation, and air-conditioning
LEED	Leadership in Energy and Environmental Design
MILCON	Military Construction
NAVFAC	Naval Facilities Engineering Command
SERDP	Strategic Environmental Research and Development Program
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specifications
USACE	United States Army Corps of Engineers