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Development Center



## **Analysis of the Army Transition from LEED 2009 to LEED v4, with Updated LEED 4.1 Credits**

Annette L. Stumpf, Samuel Stidwell IV, Brent D. Panozzo,  
Charles R. Ehlschlaeger, and Megan R. Fuhler

November 2023



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Final Report

Distribution Statement A. Approved for public release: distribution is unlimited.

Prepared for Energy and Facilities Engineering Division, DAIN-ODF, Operations Directorate,  
Office of Deputy Chief of Staff (ODCS), G-9 (Installations),  
600 Army Pentagon  
Washington, DC 20310-0600

Under MIPR 11268079

## Abstract

The objective of this effort was to identify and recommend an approach for Army green building certification that ensures Army projects meet federal and Army sustainability requirements during the transition from Leadership in Energy and Environmental Design (LEED) 2009 to LEED v4.

The first Army LEED v4 project was registered for certification with the Green Building Certification Institute in 2014. Since then, over 860 Army projects were registered for LEED v4 certification. As of the third quarter of FY20, when this report was written, 2 projects achieved LEED Silver certification. Other Army projects teams documented difficulty achieving the required LEED v4 Silver certification due to difficult site conditions, budget constraints, facility types, or project requirements.

Commercial-sector project teams also had difficulty certifying with LEED v4, forcing the United States Green Building Council (USGBC) to reconsider the credits and metrics project teams found challenging. The USGBC revised the troublesome credits and now offers LEED v4.1 pilot credits that can be used for any project registered with LEED v4. To assist Army project teams, this research investigates difficult-to-achieve LEED v4 credits and their possible replacement with LEED v4.1 pilot credits.

The report concludes with guidance on implementing the updated version of the LEED rating system from v4 to v4.1.

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## Preface

This study was conducted for Energy and Facilities Engineering Division, DAIN-ODF, Operations Directorate, Office of Deputy Chief of Staff (ODCS), G-9 (Installations) under MIPR 11268079. The technical monitor was Ms. Brandy O. Reed, Headquarters, Department of the Army (HQDA), Energy and Facilities Engineering Division, DAIN-ODF, Operations Directorate, ODCS, G-9 (Installations).

The work was performed by the Installation Readiness Branch of the Infrastructure Science and Engineering Division, US Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Mr. Chuck Schroeder was branch chief; Mr. Tim Shelton was division chief; and Dr. Justin Berman was the technical director for Infrastructure Science and Engineering. The deputy director of ERDC-CERL was Ms. Michelle Hanson, and the director was Dr. Andrew Nelson.

COL Christian Patterson was commander of ERDC, and Dr. David W. Pittman was the director.

# 1 Introduction

## 1.1 Background

On 26 April 2000, the Office of the Deputy Assistant Secretary of the Army (Installations and Housing) established the US Army policy of incorporating sustainable design and development (SDD) principles into installation planning and infrastructure projects. Since that date, the Army has made an effort to construct modern, high-performance, sustainable Army facilities that are life-cycle cost effective, enhance mission effectiveness, reduce the Army's environmental impact, comply with federal sustainability policy, and provide healthy and productive work and living environments. Updates to the original Army SDD policy issued in 2000 continue to be made. The latest policy update was published on 17 January 2017 (ASA IE&E 2017b).

The Army's sustainability program builds on long-standing energy efficiency, water efficiency, waste minimization, and sustainable design mandates with the goal of enhancing resiliency at our installations. During the past 22 years, there has been a team effort and continuous process to benchmark and evaluate how well Army military construction (MILCON) and renovation sustainability goals have been met, clarify funding and technical requirements, and identify process improvements.

Engineer Research and Development Center (ERDC) Technical Report (TR)-01-3, *Planning, Engineering, and Design of Sustainable Facilities and Infrastructure: An Assessment of the State of Practice* (March 2001), describes how both the government and private-sector states of practice were moving ahead rapidly to develop and implement sustainable practices for facilities and the activities that take place within them. The report identified opportunities for the Corps of Engineers to be a major national source of expertise that implemented sustainability into engineering practice. The sustainable engineering approach recommended was to develop engineering tools that capture rapidly developing knowledge about sustainable practices that span all phases of a facility's life cycle. The facility's life-cycle phases encompass planning, design, construction, commissioning, operation and maintenance, rehabilitation, reuse, and disposal.

To help installations and designers quantify and measure the sustainability of infrastructure projects, the Army developed a self-assessment tool called the Sustainable Project Rating Tool (SPiRiT) in 2001, which was based on the Leadership in Energy and Environmental Design (LEED) version 1.0 of the US Green Building Council (USGBC) (Schneider and Fournier 2004). Unlike LEED, SPiRiT included operations and maintenance issues and flexibility in design to allow for building modifications as needs changed. It was also a self-rating tool without third-party certification.

Engineering Technical Letter (ETL) 1110-3-491 *Sustainable Design for Military Facilities* (01 May 2001) established Army sustainability as “the design, construction, operation and reuse/removal of the built environment (infrastructure as well as buildings) in an environmentally and energy efficient manner. The major tenet of sustainable design is to meet the needs of the present without compromising the ability of future generations to meet their own needs” (HQUSACE 2001). This policy also established the requirement for all military facilities to strive to achieve the SPiRiT Bronze level. All MILCON projects were originally required to strive for at least a Bronze SPiRiT rating until FY 2006, at which point a Silver rating would be required.

Army SDD policy of the time applied to MILCON, major renovations (restoration- and modernization-funded projects), and initially, Army family housing projects. Sustainment, restoration, and modernization funds were earmarked specifically for the improvement of buildings, such as barracks and libraries, as well as streetlights, roads, and infrastructure.

The Army used SPiRiT for more than five years until adopting the USGBC Leadership in Energy and Environmental Design–New Construction (LEED NC) 2.2 rating tool as its green building certification system. LEED NC 2.2 replaced SPiRiT effective with the FY 2008 Military Construction Army (MCA) program, except for Army family housing projects, which continued to be rated using SPiRiT through the FY 2012 program.

On 5 January 2006, the Office of the Assistant Secretary of the Army for Installations and Environment (OASA[I&E]) issued an update to the *US Army Strategy*, directing the transition from SPiRiT to the USGBC LEED rating system effective with the MCA program (DA 2006). This policy transition happened during the “MILCON Transformation,” when the

Army adopted process improvements recommended by the private sector to speed up construction and reduce inefficiencies. MILCON project teams transitioned from self-rating design-bid-build (DBB) projects using SPiRiT to self-rating design-build projects using LEED NC 2.2.

To support the transition from SPiRiT to LEED, the Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) conducted an assessment of Army MILCON projects that had self-rated using SPiRiT and projected the rating levels those same projects would have earned using LEED NC 2.2 while following federal mandates and Army policies (Schneider and Stumpf 2006). This assessment also reviewed private-sector successes with green buildings and what additional funding was needed as compared to conventional buildings. It was determined that private-sector green buildings cost 2%–8% more than conventional buildings. After an extensive discussion about budgets and cost estimating for MILCON projects, the Army agreed to add 2% of the program amount to MILCON project budgets to ensure the projects could meet the LEED Silver SDD requirements.

Army facility projects were registered as LEED NC 2.2 projects online with the USGBC but not required to be officially certified by the Green Building Certification Institute (GBCI). This enabled project teams to use the LEED online templates to document how they would achieve enough LEED credits to earn LEED Silver.

In FY 2009 and FY 2010, Army LEED validation teams assessed a collection of MILCON projects that had self-rated using LEED NC 2.2. The goal of the validation effort was to see how well project teams were able to follow Army SDD policy and work towards earning credits necessary for LEED Silver. As a result of that evaluation process, the Army decided to require all MILCON projects to be formally certified using LEED NC 2.2 and LEED online. LEED certification by the GBCI encouraged MILCON project delivery teams to start early and seriously consider sustainability principles during the entire planning, design, and construction process to meet the Army's LEED Silver certification mandate.

Army project delivery teams worked hard to improve the sustainability of new construction and major renovations by focusing on high-priority LEED credits during project planning, design, and construction. High-priority credits related to federal, DoD, and Army policy requirements and

mandates to conserve energy and water and reduce waste. Over time, as Army project teams, private sector architect and engineer firms, and design-build contractors gained experience, the LEED certified ratings improved for most projects. Chapter 2 contains more detailed information on the LEED certification levels for Army MILCON projects over the years. Use of the USGBC LEED NC rating tool helped the Army adopt sustainable design principles and benchmark project success.

The integrated teams who deliver Army MILCON projects make continuous process improvements to achieve higher-performance, sustainable facilities within the available budget. Project teams worked to incorporate sustainability features and principles into the 1,391 planning documents and budget to allow enough funding for project success. Installation customers advocated for building systems and features that were maintainable and appropriate for their climate and mission. Corps of Engineers teams added the technical requirements to specifications, request for proposals, Engineering Regulations, Engineering Construction Bulletins, and other guidance documents. The Tri-Service Sustainability Working Group updated guide specifications, Unified Facilities Criteria (UFCs), and other criteria. Over time, the process improved to ensure delivery of high-performance, sustainable MILCON projects meeting the federal requirements and able to meet or exceed the LEED Silver certification level required by Army SDD policy.

Green building rating tools, standards, and certification systems continue to be developed and updated to push the industry into constructing more and more sustainable buildings, infrastructure, and neighborhoods. Each time the USGBC updates LEED or ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers) updates their standards, Army MILCON project delivery practices and budgets need to be reviewed to consider more stringent requirements. Changes to criteria, standards, and policies need to be studied to update project planning, design, and construction budgets.

The 2000 Army SDD policy was updated by the Office of the Assistant Secretary of the Army, Installations, Energy and Environment (ASA IE&E) in 2010, then revised again in 2013 and 2017. These updates directed all activities on Army installations to apply the SDD policy to all infrastructure regardless of funding source, with few exceptions:

“The policy applies to all infrastructure planning, design, sustainment, restoration, modernization, and construction activities on Army installations (including government owned/contractor operated installations) regardless of funding source, with the exception of DoD Medical [DoDM] funding and privatization initiatives. This includes Army Reserve, National Guard, and Morale, Welfare, and Recreation (MWR) activities, as well as tenant activities such as commissaries, exchange service facilities (all types for all Services), and local education activity schools.” (DA 2017).

These updated policies were intended to make sure there was an Army-wide application of the SDD policy, instead of just applying the policy to MILCON projects. These policies brought new energy to the quest for high-performance sustainable buildings, infrastructure, and operations.

The DoD issued UFC 1-200-02 *High Performance and Sustainable Building (HPSB) Requirements* (01 March 2013) to provide minimum requirements and guidance to achieve high-performance and sustainable facilities that comply with the Energy Policy Act (EPA) of 2005, the Energy Independence and Security Act of 2007, Executive Order (EO) 13,423 *Strengthening Federal Environmental, Energy, and Transportation Management* (2007), EO 13,514 *Federal Leadership in Environmental, Energy, and Economic Performance* (2009), and the *Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings* (Guiding Principles). This UFC has been updated many times since (most recently in 2022) to ensure DoD buildings comply with current Executive Orders and federal mandates. The Tri-Services Sustainability Program criteria and resources are available on the Whole Building Design Guide at url: <https://www.wbdg.org/ffc/dod/tri-services-sustainability-program>.

In FY 2009, FY 2010, FY 2014, FY 2017, FY 2018, and FY 2019, Army SDD validation teams visited project sites to assess how effectively the SDD policy was implemented for facility construction. The teams reviewed both MILCON- and restoration-and-modernization-funded projects. The primary question the team sought to answer was, *Is the Army obtaining the desired results?*

Each cycle of validation reviews resulted in improvements to the SDD policy and implementation process. The most recent validation efforts in FY19 led to a recent draft of SDD policy that has not yet been finalized. Several topics are included in the draft policy, such as

- How to meet the Army's long-term resiliency goals within the programmed amount (budget) (see Section 7.1.2 of this report),
- Certification challenges the project delivery teams have using LEED v.4, and
- Increasing gaps between federal mandates and LEED requirements

The Army reports project LEED certification data every year towards the DoD's report on meeting the federally mandated *Guiding Principles for High-Performance Sustainable Buildings*. Annual DoD progress towards compliance with the Guiding Principles is recorded on the DoD OMB (Office of Management and Budget) Scorecard. DoD scorecards are available at this url: <https://www.sustainability.gov/dod.html>.

## 1.2 Objectives

The objective of this project is to prepare a report for G-9 containing the results of the process evaluation and performance improvement opportunity analysis of US Army SDD policies. The 2017 Army SDD policy requires LEED Silver certification and compliance with UFC 1-200-02 *High Performance and Sustainable Building (HPSB) Requirements* (ASA IE&E 2017b).

The report discusses observations of the Army MILCON project delivery team's challenges and successes in meeting the SDD policy and LEED certification requirements. It also mentions lessons learned based on Army validation activities and recommendations for improvement. A key part of this effort will be to assess current LEED and Guiding Principles certification rating systems to ensure Army MILCON and restoration and modernization projects comply with federal sustainability requirements.

Of particular interest to the Army is the evolution of the USGBC LEED rating tool and the eventual transition from LEED v2009 to LEED v4. The first Army LEED v4 project was registered for certification with the GBCI in 2014. Since that time, approximately 860 Army projects have been registered for LEED v4 certification. As of the third quarter of FY20, 2 of them have been certified. The National Guard Readiness Center in Davenport, Iowa, and the Easton Readiness Center in Easton, Maryland, both achieved LEED Silver certification. Several Army project teams have documented difficulty achieving the required LEED v4 Silver certification due



to difficult site conditions, budget constraints, facility types, or project requirements.

Commercial-sector project teams also had difficulty certifying their buildings using LEED v4, forcing the USGBC to reconsider the credits and metrics project teams found challenging. The USGBC revised the troublesome credits and now offers LEED v4.1 pilot credits that can be used for any project registered with LEED v4. To assist Army project teams, this research investigates difficult-to-achieve LEED v4 credits and their possible replacement with LEED v4.1 pilot credits. The pilot credits are considered more achievable in Army projects.

The main objective of this effort is to identify and recommend an approach for Army green building certification that ensures Army projects meet the federal and Army sustainability requirements.

This report assesses current project practices and the incorporation of the US Army's *Sustainable Design and Development Policy Update* memorandum (January 2017), UFC 1-200-02 *High Performance & Sustainable Building Requirements* (December 2016), recent energy and water security policies, and LEED v4 and the transition to v4.1 into MILCON projects based on SDD validation exercises and other investigations.

The report includes the following:

1. Implementation assessment of the ASA IE&E SDD policy, UFC 1-200-1, and the transition from LEED v4 and v4.1 requirements to the field
  - a. Observations of field implementation patterns based on SDD validation exercises of current Army projects
  - b. Recommendations for improved implementation of best practices for use by US Army and US Army Corps of Engineers (USACE) organizational elements
2. Identification of sustainability practices that can improve the Army's energy and water security goals and practices to support OMB Scorecard reporting requirements
3. Development of guidance on implementing the updated version of the LEED rating system from v4 to v4.1
  - a. Documentation of the changes that will most impact Army operations and identification of the most likely credits and targets

- b. Recommendations for draft implementation guidance for G-9
4. Updates on US Army LEED certification in support of federal, DoD, and Department of the Army (DA) SDD compliance to include the following:
  - a. A compilation of quarterly reports for the Office of the Assistant Chief of Staff for Installation Management (OACSIM) on US Army LEED project certifications in support of the *US Army Installation and Environment Strategic Plan*, the *Army Annual Energy Management Report (AEMR)*, and other statistical reports
  - b. A compilation of draft quarterly updates tracking energy, water, and waste reductions on US Army LEED-certified projects
5. Guidance on US Army–USGBC liaison for the maintenance of LEED standards and US Army–USGBC membership to include monitoring the ongoing development of LEED rating tools, representation of US Army interests, and support of Army members

### 1.3 Approach

This research effort corresponded to a FY20 project order titled “Process Evaluation and Performance Improvement Recommendations for the US Army Sustainable Design and Development Policy Analysis.” The CERL team is responsible for capturing and tracking the history of Army LEED project registration and certification. We also closely track recent developments and changes that the USGBC makes to the LEED rating systems and individual LEED credits. Transitioning from LEED v2009 to LEED v4 was challenging for all project teams in both the commercial and government sector. The CERL team analyzed all available literature on the newer version of LEED v4 to identify changes that made credit achievement more difficult (or easier). We assessed the available data on Army LEED v4 pilot projects, and reviewed Army LEED project waivers. Finally, we mapped out all the changes between LEED 2009 and LEED v4 and made recommendations to help project teams meet the required LEED v4 Silver certification.

## 2 Army Green Building History

The USGBC LEED rating system offers four tiers of certification for applying projects: Certified, Silver, Gold, and Platinum. Points required for each certification level can be found in Table 1. Current Army policy requires projects to achieve LEED Silver certification. Every quarter of the federal fiscal year, the USGBC reports Army LEED-certified projects to USACE ERDC-CERL. These data are then sorted, illustrated, and benchmarked to be reported to G-9 and USACE Headquarters.

Table 1. LEED certification levels.

Certification Level	Points Required
Certified	40–49
Silver	50–59
Gold	60–79
Platinum	80–100

All certified projects as of quarter three, FY 2020, had been certified with LEED v1.0, LEED v2.2, LEED v2009, and LEEDv4. This consisted of 1,028 buildings that make up 750 projects, totaling 65,246,383.56 certified square feet.

The Army primarily uses LEED for New Construction (LEED NC 2.2 or LEED NC 2009) or the newer rating tool, LEED for Building Design and Construction (LEED BD+C) v4. Over the years, Army projects have been certified using other LEED rating tools, such as Core and Shell, Schools, or Homes depending on the project scope. The USGBC issues the rating tools, and the GBCI certifies LEED projects.

Figure 1 shows the number of Army projects that were LEED certified during each fiscal year between FY 2005 and FY 2020. Table 2 shows the number of LEED-certified projects by certification level for each fiscal year between FY 2005 through the end of FY 2019.

Figure 1. Leadership in Energy and Environmental Design (LEED)-certified projects by fiscal year.

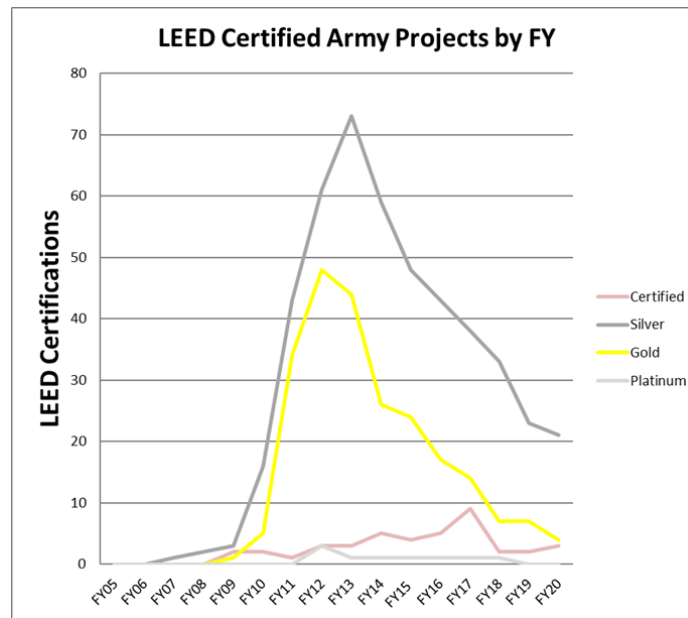
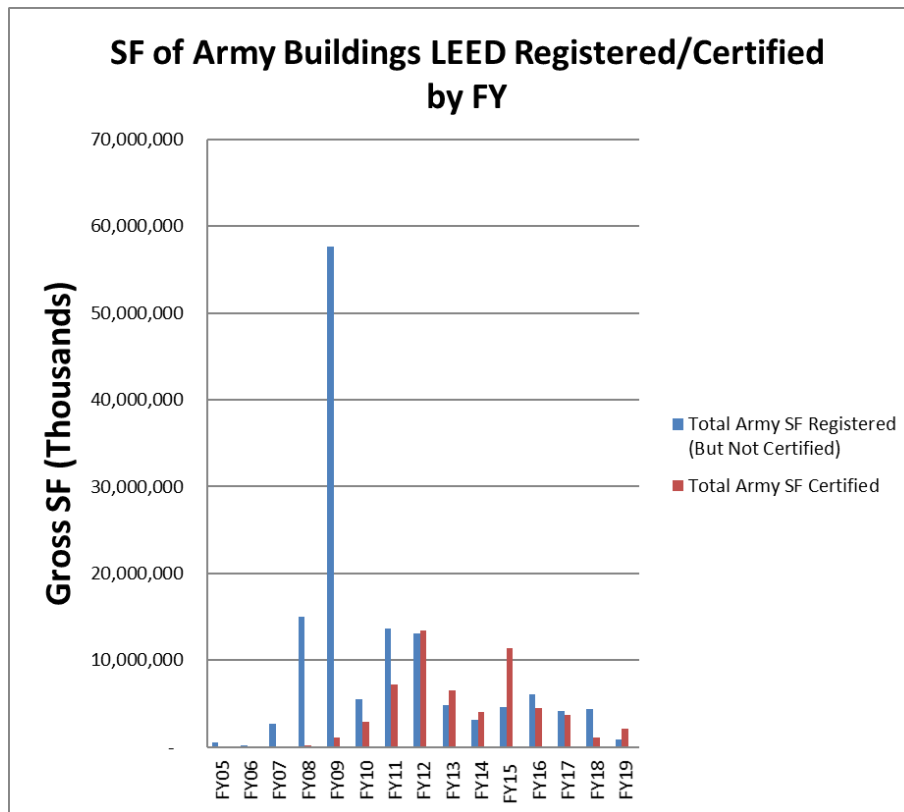


Table 2. Number of LEED-certified Army projects per fiscal year by certification level.

Certified Buildings By FY	FY05	FY06	FY07	FY08	FY09
Certified	0	0	0	0	2
Silver	0	0	2	2	5
Gold	0	0	0	0	1
Platinum	0	0	0	0	0
Estimated Total	0	0	2	2	8
	<b>FY10</b>	<b>FY11</b>	<b>FY12</b>	<b>FY13</b>	<b>FY14</b>
Certified	2	1	12	3	8
Silver	46	100	79	94	73
Gold	14	43	91	55	28
Platinum	0	0	3	1	1
Estimated Total	62	144	185	154	110
	<b>FY15</b>	<b>FY16</b>	<b>FY17</b>	<b>FY18</b>	<b>FY19</b>
Certified	7	5	9	2	2
Silver	48	44	38	33	23
Gold	67	17	14	7	7
Platinum	1	1	1	1	0
Estimated Total	123	67	62	43	34

Figure 2 shows the square footage of Army LEED projects that were certified vs. registered only between FY 2005 and FY 2019. Note the large number of Army projects that were registered but not certified during FY 2007 and FY 2008. This was when the Army SDD policy required project teams to register their projects so they could use the LEED templates to document credits showing how they would achieve Silver, but certification was not required. The next version of the Army SDD policy required all projects to be LEED certified at the Silver level.

Figure 2. Army square footage certified vs. registered only.



LEED rating systems are typically updated every three years, as shown in Table 3. Each rating system is balloted before being released as an official version. LEED v4 was released November 2013 and was mandated for Army MILCON project certification as of November 2016. The US Army participated in the pilot LEED v4 program to assess the impact of LEED v4 and ease its adoption. However, the pilot projects had difficulty with the LEED v4 certification process, as did commercial projects. Since then, there has been a considerable effort to revise problematic LEED v4 credits.

Table 3. LEED rating system dates.

Version	Launch Date	Registration Close	Certification Sunset
LEED v2.2	2005	6/27/09	6/27/15
LEED v2009	2009	10/31/16	6/30/22
LEED v4	2013	n/a	n/a
LEED v4.1 Beta	2018	n/a	n/a

Because of the COVID-19 pandemic, USGBC and GBCI extended the LEED v2009 certification deadline, which included all LEED 2009 projects, to 30 June 2022. This gave projects another year to submit for review.

## 2.1 Leadership in Energy and Environmental Design (LEED) v2.2 and LEED v2009 statistics

Between 2007 and 2016, Army LEED-certified buildings amounted to nearly 56 million square feet, with 594 certified projects. Projects were certified under two rating systems in this period, LEED v2.2 and its successor, LEED v2009. In total, 398 LEED v2.2 projects were certified between FY 2009 and FY 2016. Of the 748 Army projects certified through the third quarter of FY 2020, approximately 350 had been certified using LEED v2009. Of these, 22% surpassed the federal mandate of LEED Silver and achieved LEED Gold or Platinum. Note that multiple Army buildings can be registered as part of a LEED “project.”

Figure 3 shows the number of Army LEED v2.2–certified projects between FY 2009 and FY 2016.

Figure 3. Number of Army LEED v2.2–certified projects FY 2009–FY 2016.

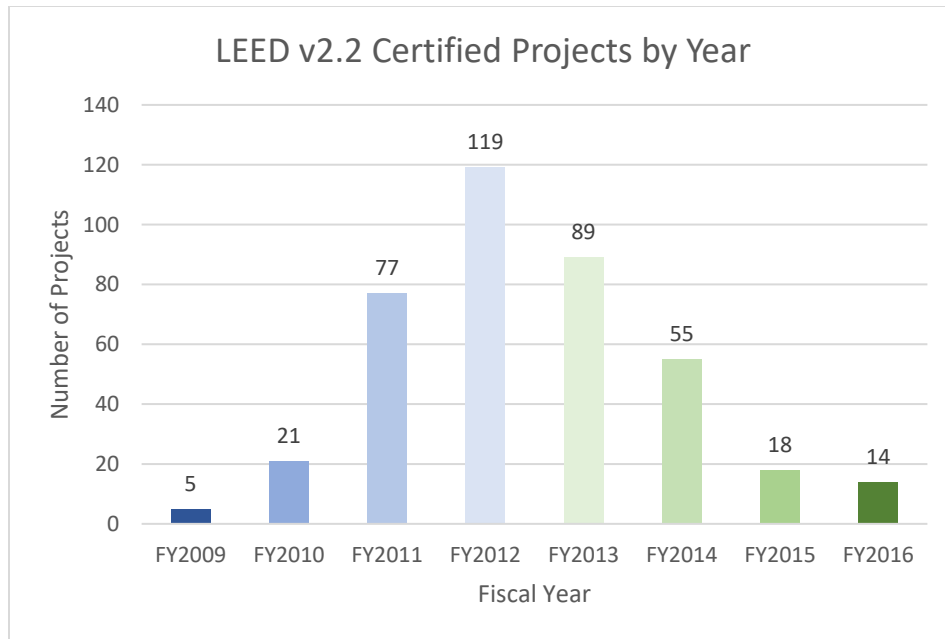


Figure 4 shows the amount of total square footage of Army LEED v2.2–certified projects between FY 2009 and FY 2016.

Figure 4. Army LEED v2.2–certified projects’ square footage FY 2009–FY 2016.

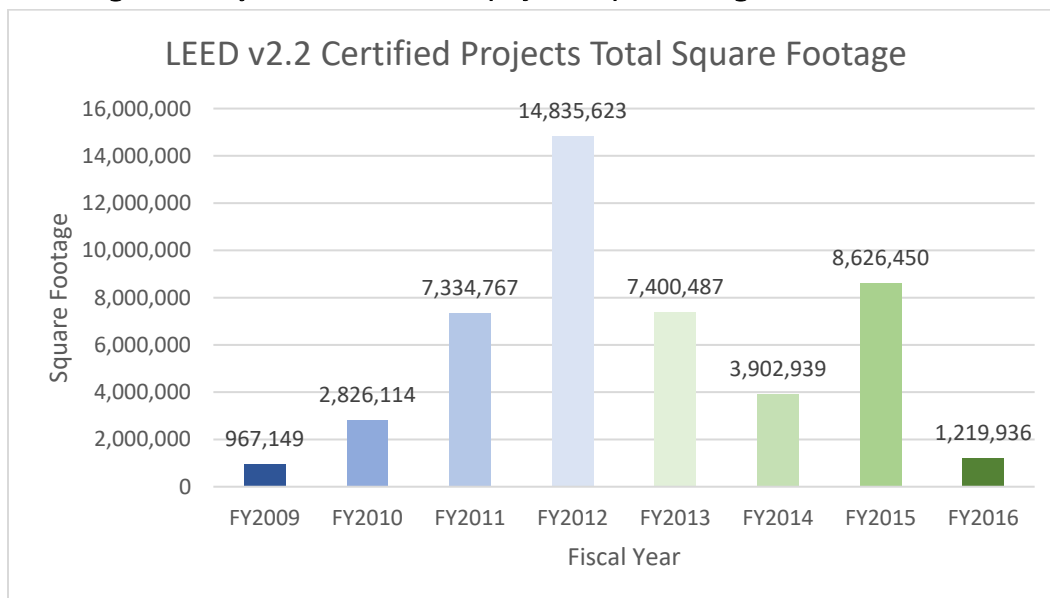


Figure 5 shows the number of Army LEED v2009–certified projects each year between FY 2011 and FY 2019.

Figure 5. Army LEED v2009–certified projects FY 2011–FY 2019.

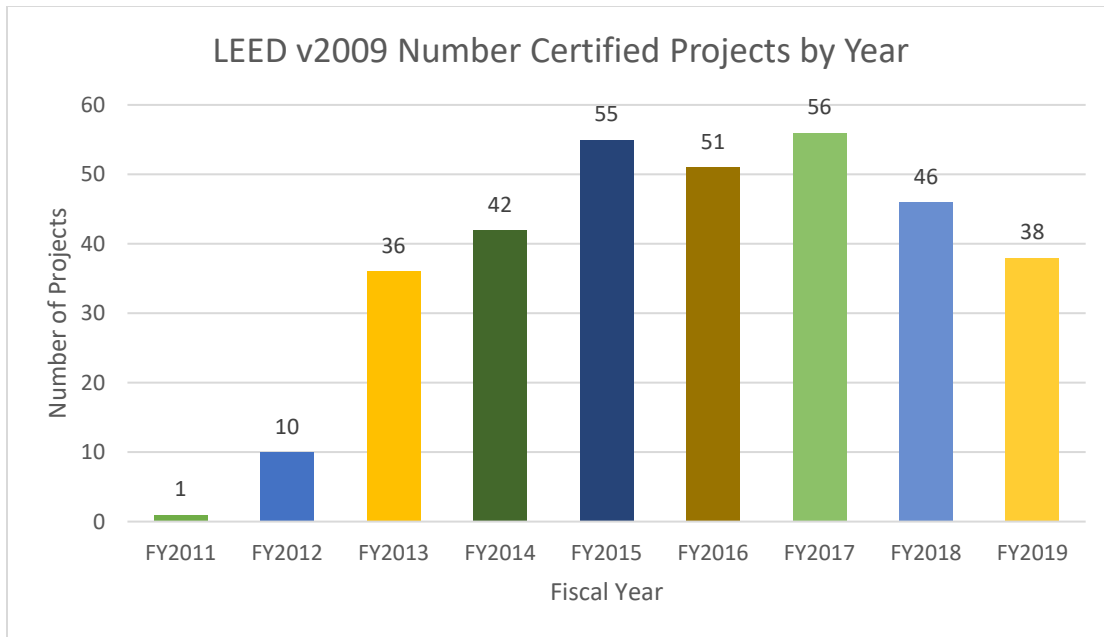
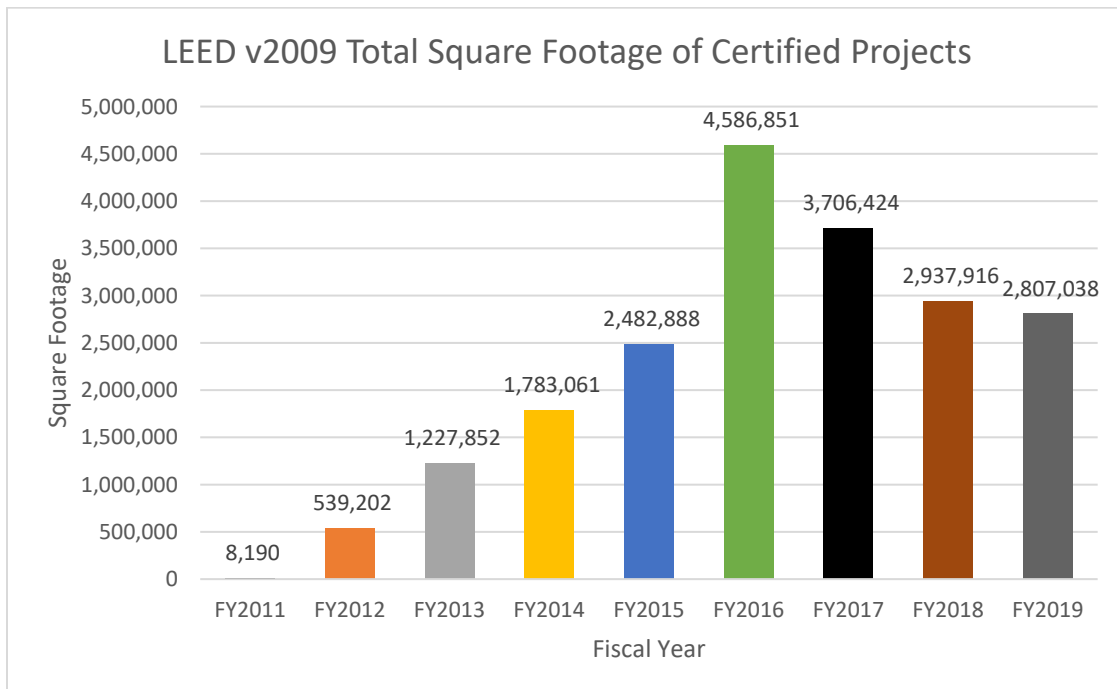


Figure 6 shows the total square footage of Army LEED v2009–certified projects between FY 2011 and FY 2019.

Figure 6. Army LEED v2009–certified projects’ square footage FY 2011–FY 2019.





## 2.2 Army benefits of using LEED

To be progressive and support modern technology, the USGBC's and Army's sustainability goals are closely aligned. LEED requirements to meet the optimal energy performance credits are consistent with Army SDD policy, UFC 1-200-02, and federal mandates. Furthermore, LEED v4.1 makes the building standards more aggressive in an effort towards achieving net-zero impact for energy efficiency, water conservation, site selection, material selection, daylighting, and waste reduction. It also directly supports the Army's installation energy and water strategic plan goals 1 and 2, which pertain to efficiency and affordability.

Energy modeling is critical in predicting and benchmarking energy use within a building. The LEED certification process involves a detailed review of energy models, which helps to ensure accuracy and consistency between projects. The Army has familiarized itself with the LEED online certification process and can effectively track progress in sustainable construction. It is helpful for the Army to have an outside review of its energy models, but addressing review comments can be difficult if they are received late in the design process.

The Army MILCON process has evolved over time to successfully embed the LEED certification requirements into project requirements and deliverables. This continuous improvement process helps ensure Army MILCON project teams meet current sustainability policy mandates.

The architectural and engineering community and large construction firms are well acquainted with LEED certification requirements in the United States and other locations. Familiarity with LEED credits and certification reduces uncertainty and risk to contractors who bid on USACE projects.

In-house and contracted project development teams who adopt an integrated design process can achieve the Army's sustainable design and development goals and meet policy requirements. An integrated design is a comprehensive holistic approach to design where all the key disciplines work together early in design to collaborate and achieve a more sustainable outcome.

## 3 Sustainability Policy

### 3.1 Policy hierarchy

Table 4 describes the sustainability policy hierarchy. Federal laws and executive orders take precedence over all other policies, followed by the Department of Defense sustainability policy, UFC for *High Performance and Sustainable Building Requirements*, *Army Sustainable Design and Development Policy*, and USACE policy guidance.

Table 4. Sustainability policy hierarchy.

Sustainable Policy Hierarchy
Federal Laws and Executive Orders
Energy Policy Act 2005
Energy Independence and Security Act (EISA) 2007
Executive Order (EO) 13423: Strengthening Federal Environmental, Energy, and Transportation Management (2007) and the HPSB Guiding Principles (2008)—Revoked by EO 13693
Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance (2009)—Revoked by EO 13693
Executive Order 13693: Planning for Federal Sustainability in the Next Decade, (2015)—Revoked by EO 13834
Executive Order 13834: Efficient Federal Operations (2018)—Revoked by EO 14057
Executive Order 13990: Climate Crisis; Efforts to Protect Public Health and Environment and Restore Science (2021)
Executive Order 14008: Tackling the Climate Crisis at Home and Abroad (2021)
Executive Order 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability (2021)
Implementing Instructions for Executive Order 14057 <a href="https://www.sustainability.gov/pdfs/EO_14057_Implementing_Instructions.pdf">https://www.sustainability.gov/pdfs/EO_14057_Implementing_Instructions.pdf</a>
Department of Defense Policy
Department of Defense <i>Sustainable Buildings Policy</i> —Memorandum (2013) <a href="https://wbdg.org/FFC/DOD/dod_sustainable_buildings_policy.pdf">https://wbdg.org/FFC/DOD/dod_sustainable_buildings_policy.pdf</a>
United Facilities Criteria
UFC 1-200-02 <i>High Performance and Sustainable Building Requirements</i> (2016, Revised 2022) <a href="https://wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-1-200-02">https://wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-1-200-02</a>
UFC 2-100-01 <i>Installation Master Planning</i> (2012, Revised 2022) <a href="https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-2-100-01">https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-2-100-01</a>
Army Policy
Army SDD Policy Update 2017 <a href="https://www.wbdg.org/FFC/ARMYCOE/POLICY/Army_SDD_Policy_Update_2017.pdf">https://www.wbdg.org/FFC/ARMYCOE/POLICY/Army_SDD_Policy_Update_2017.pdf</a>
Army Directive 2014-02 Net Zero Installations Policy

Table 4 (cont.). Sustainability policy hierarchy.

<b>Sustainable Policy Hierarchy</b>
<i>Army Directive 2020-03 (Installation Energy and Water Resilience Policy)</i> <a href="https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN21689_AD2020_03_FINAL_Revised.pdf">https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN21689_AD2020_03_FINAL_Revised.pdf</a>
USACE Engineering & Construction Bulletins (ECBs)
USACE ECB 2010-14 Directive: Improving Building Performance through Enhanced Requirements for Energy Performance and Select LEED Credits
USACE ECB 2011-1 Directive and Guidance: High Performance Energy and Sustainability Policy
USACE ECB 2017-23 Sustainable Acquisition Requirements
USACE ECB 2018-13 Lessons Learned from SDD Policy Validation Visits (Fort Leonard Wood and Fort Belvoir)
USACE ECB 2019-7 High Performing Sustainable Design Application to Renovation Projects (Lessons Learned)
USACE ECB 2020-8 Execution and Documentation Requirements for Life-Cycle Cost Analyses
USACE ECB 2021-12 Achieving Certification under LEED Version 4 (2021)
USACE ECB 2022-5 Utilizing Offline Forms for LEED Online

### 3.2 Energy standards

There are two codes that focus on energy standards for buildings:

1. ASHRAE 90.1 (2013) per UFC 1-200-02 2022
  - a. American National Standards Institute (ANSI)/ASHRAE/ Illuminating Engineering Society of North America (IESNA) Standard 90.1-2013 (ASHRAE 90.1), *Energy Standards for Buildings Except Low Rise Residential Buildings*, 2013
2. International Green Construction Code (IgCC) (formerly ASHRAE 189.1) per UFC 1-200-02 2022
  - a. ANSI/ASHRAE/USGBC/IES Standard 189.1-2014 (ASHRAE 189.1), *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*, 2014

### 3.3 Life-cycle cost analysis

The 2017 Army SDD policy requires that projects are designed and delivered to achieve the highest energy efficiency possible, provided that they are life-cycle cost effective and within the program amount. Compliance requires performance of a life-cycle cost analysis (LCCA) with a minimum of three alternatives to validate conformance. Per UFC 1-200-02, LCCA is required for systems contributing to the energy footprint of the building, renewable energy generating systems, and when life cycle cost

effectiveness is cited as a reason for not complying with a Guiding Principles requirement. Table 5 lists the policy and guidance that governs LCCA.

Table 5. Life-cycle cost analysis (LCCA) policy and guidance.

Life-Cycle Cost Analysis Policy and Guidance
SemoNOTE #22, USACE, 19 June 2019, subject: "Life Cycle Cost Analysis"
Army Sustainable Design and Development Policy Update (2017)
Unified Facilities Criteria 1-200-02, <i>High Performing and Sustainable Buildings</i> (2016, Latest Revision 2022)
CFR, Title 10 Part 433 Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High-Rise Residential Buildings. (2016) <a href="https://www.wbdg.org/ffc/fed/code-federal-regulations/10-cfr-part-433">https://www.wbdg.org/ffc/fed/code-federal-regulations/10-cfr-part-433</a> .
Engineer Regulation 1110-1-8173, Energy Modeling and Life Cycle Cost Analysis. (2017) <a href="https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-1-8173.pdf">https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-1-8173.pdf</a> .
NIST Handbook 135, Life-Cycle Costing Manual for the Federal Energy Management Program. (1995) <a href="https://www.wbdg.org/ffc/nist/criteria/nist-handbook-135">https://www.wbdg.org/ffc/nist/criteria/nist-handbook-135</a> .
USACE ECB 2014-12–MCA & SRM Building Energy and Sustainability Policy <a href="https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2014-12">https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2014-12</a> .
USACE ECB 2015-7 (Revised 2017)–Directive and Guidance: Life-Cycle Cost Analysis Requirements for the Design Phase of USACE Buildings, Central Energy Systems and Associated Supporting Facilities <a href="https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2015-07">https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2015-07</a> .
USACE ECB 2020-8–Directive and Guidance: Execution and Documentation Requirements for Life Cycle Cost Analyses <a href="https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2020-8">https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2020-8</a> .

## 4 LEED v4

### 4.1 Evolution of LEED

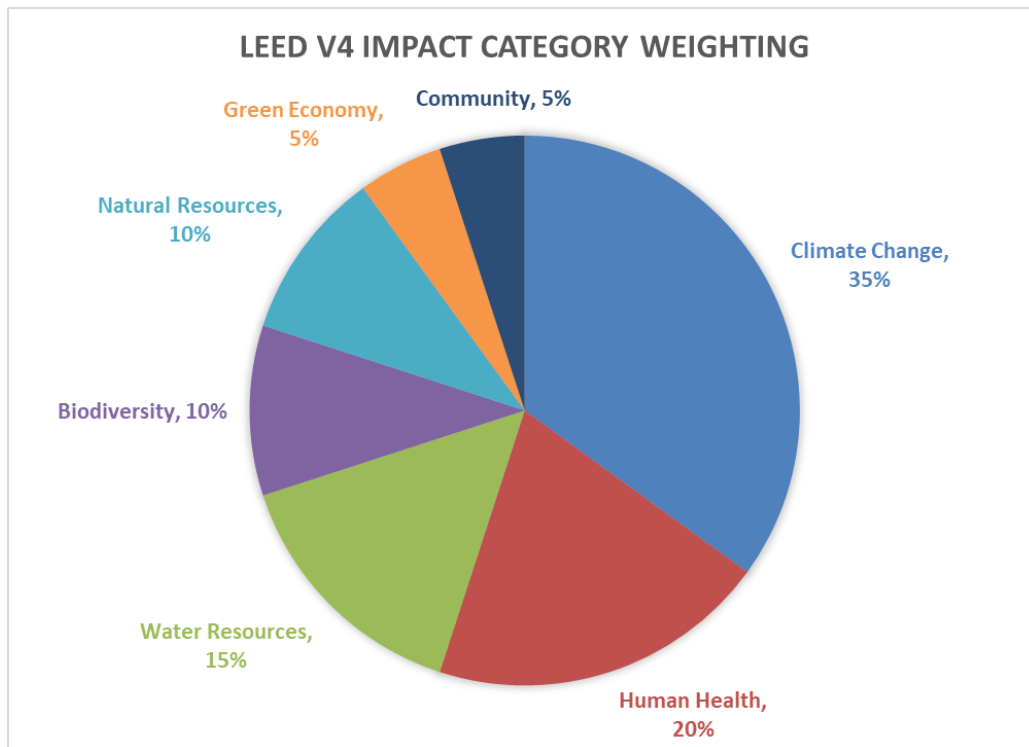
LEED aims to provide a framework for healthy, high-efficient, and cost-saving green buildings. LEED has evolved over time as each rating system version builds on the last. LEED v4 was organized around the question “What should LEED projects accomplish?” The LEED development committee established seven impact categories to answer that question as depicted in Figure 7.

Figure 7. LEED v4 impact categories. (Image reproduced from Owen et al. 2013.).



How credits perform in relation to the impact categories influence how points are distributed in the rating system. Additionally, impact categories are weighted after consideration of scale, scope, severity, and the extent to which the built environment contributes to the impact. Figure 8 shows the weighted percentage of LEED v4 impact categories. Credits that significantly contribute to the system goals of the impact categories are given more emphasis by being given more points.

Figure 8. LEED v4 impact category weighting based on scale, scope, severity, and the extent to which the built environment contributes to the impact. (Image reproduced with permission from Owen et al. 2013.).



LEED v4 launched in 2013, and the first Army building was registered for certification under that system in 2014. The project was a Pentagon metro entrance facility (MEF) for visitor screening in Arlington, Virginia. Although LEED v4 launched in 2013, projects were able to register under LEED v2009 through 31 October 2016. Projects that registered for LEED v2009 while it was open still had until 30 June 2021 to complete the certification process.

A list of the changes from LEED v2009 to LEED v4 Building Design and Construction is available on the USGBC website: <https://www.usgbc.org/resources/summary-changes-lead-2009-v4-bdc>

## 4.2 LEED v4 credit achievement trends

This report was written in the third quarter of 2020 during the early attempts by project teams to achieve LEED v4 Silver certification. Project teams had many difficulties adjusting to the changes from LEED v2009 to LEED v4. A small sample of six Army LEED v4 projects were available to assess, and only two of them had gone through the entire LEED

certification process. Figures in this section show three categories of LEED v4 credit achievement:

- Army-preferred credits
- Army difficult-to-achieve credits
- country-wide, difficult-to-achieve credits\*

Army-preferred LEED v4 credits are shown to the left of each credit type in Table 6–Table 13. A deep-blue box with “Fed Required” indicates that those LEED credits correspond to federal requirements. A light-blue box with “Preferred Credit” indicates Army buildings should prioritize receiving those credits. Army-preferred credits are those that were required in the *USACE Army LEED Implementation Guide* found on the Whole Building Design Guide site at [https://www.wbdg.org/FFC/ARMYCOE/SDP/USACE\\_ArmyLEEDImplementationGuide-v4.pdf](https://www.wbdg.org/FFC/ARMYCOE/SDP/USACE_ArmyLEEDImplementationGuide-v4.pdf).

Based on interviews and reports from Army subject matter experts (SMEs) and their projects, the team color coded LEED v4 credit names to indicate how difficult it was for the Army to receive these credits. While not comprehensive, this color-coding exercise highlights those credits that are problematic for the Army. Light orange indicated some level of difficulty in achieving the credit, while deep orange indicated a high level of difficulty. The Army should be concerned when federally required credits are difficult to achieve.

Color coding in the far-right columns of Table 6 through Table 13 shows the 2019 USGBC reporting on how often credits were achieved by all projects attempting LEED certification using LEED v4. Credits are characterized as either seldom (deep orange), moderately difficult (yellow), and often achieved (green). During discussions at the 18–22 November 2019 Greenbuild International Conference, LEED experts indicated the desire to realign the LEED credits to address environmental priorities and streamline documentation. This realignment could make the seldom-awarded LEED credits more achievable and the often-awarded credits harder to achieve.

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\* CERL researchers obtained information on the country-wide trends from USGBC staff at an all-day LEED v4 workshop held at the Greenbuild International Conference, 18–22 November 2019.

According to the USGBC, the High Priority Site and Green Vehicles credits were seldomly achieved. Army SMEs described Access to Quality Transit as very difficult to achieve and Bicycle Facilities and Green Vehicles as somewhat difficult to achieve. Table 6 shows Location and Transportation credits.

**Table 6. LEED v4 Location and Transportation credits.**

LEED v4 Location and Transportation Credits		Total Credits (up to 16)	How Often Credits were Received
Credit	LEED for Neighborhood Development Locations (new to LEED v4)		
Preferred Credit	Sensitive Land Protection	1	Often
Preferred Credit	High Priority Site (Up to 2 points)		Seldom
	Historic District	1	
	Priority Designation	1	
	Brownfield Remediation	2	
Preferred Credit	Surrounding Density and Diverse Uses (Up to 5 points)		Moderate
	Surrounding Density	2-3	
	Diverse Uses	1-2	
Preferred Credit	Access to Quality Transit	5	Moderate
Preferred Credit	Bicycle Facilities	1	Moderate
Credit	Reduced Parking Footprint	1	Moderate
Credit	Green Vehicles	1	Seldom

The USGBC stated that Site Development—Protect or Restore Habitat, Open Space, and Rainwater Management are seldom-achieved credits. Army LEED SMEs described all Sustainable Sites credits as potentially achievable. Rainwater Management and Site Assessment correspond to federal requirements. At the time this report was written, Army projects rarely achieved the Sustainable Sites credits for Open Space or Site Development—Protect or Restore Habitat, as shown in Table 7.

**Table 7. LEED v4 Sustainable Sites credits.**

LEED v4 Sustainable Sites Credits		Total Credits (up to 10)	How Often Credits were Received
Prerequisite	Construction Activity Pollution Prevention	Required	
Fed Required	Site Assessment (new to LEED v4)	1	Moderate



Table 7 (cont.). LEED v4 Sustainable Sites credits.

LEED v4 Sustainable Sites Credits		Total Credits (up to 10)	How Often Credits were Received
Preferred Credit	Site Development—Protect or Restore Habitat (Up to 2 points)		Seldom
	On-Site Restoration	1–2	
	Financial Support	1	
Preferred Credit	Open Space	1	Seldom
Fed Required	Rainwater Management (Up to 3 points)		Seldom
	Percentile of Rainfall Events	1–3	
	Natural Land Cover Conditions	2–3	
Preferred Credit	Heat Island Reduction (Up to 2 points)		Often
	Nonroof and Roof	1–2	
	Parking Under Cover	1	
Preferred Credit	Light Pollution Reduction	1	Moderate

Table 8 shows the LEED v4 Water Efficiency credits. USGBC reports that Cooling Tower Water Use was the only seldom-achieved credit in the Water Efficiency credit category. That was consistent with the Army LEED v4 projects CERL studied. Army LEED SMEs described all Water Efficiency credits as potentially achievable. All Water Efficiency credits except for Cooling Tower Water Use correspond to federal requirements.

Table 8. LEED v4 Water Efficiency credits.

LEED v4 Water Efficiency Credits		Total Credits (up to 11)	How Often Credits were Received
Prerequisite	Outdoor Water Use Reduction (new to LEED v4)	Required	
Prerequisite	Indoor Water Use Reduction	Required	
Prerequisite	Building-Level Water Metering	Required	
Fed Required	Outdoor Water Use Reduction (Up to 2 points)		Often
	No Irrigation Required	2	
	Reduced Irrigation	1–2	
Fed Required	Indoor Water Use Reduction (Up to 6 points)		Often
	Reduce by 25%	1	
Fed Required	Reduce by 30%	2	
	Reduce by 35%	3	
	Reduce by 40%	4	
	Reduce by 45%	5	

Table 8 (cont.). LEED v4 Water Efficiency credits.

LEED v4 Water Efficiency Credits		Total Credits (up to 11)	How Often Credits were Received
	Reduce by 50%	6	
Credit	Cooling Tower Water Use	2	Seldom
Fed Required	Water Metering (new to LEED v4)	1	Often

The USGBC reports that Demand Response, Renewable Energy Production, and Green Power and Carbon Offsets were seldomly achieved credits. Army LEED v4 projects seldom achieved those same credits, as shown in Table 9.

Army LEED SMEs described Demand Response and Green Power and Carbon Offsets as very difficult to achieve. Although Advanced Energy Metering was described as somewhat difficult to achieve, four out of six Army LEED v4 projects were projected to be able to earn this credit. Enhanced Commissioning, Optimize Energy Performance, and Advanced Energy Metering correspond to federal requirements.

Table 9. LEED v4 Energy and Atmosphere credits.

LEED v4 Energy and Atmosphere Credits		Total Credits (up to 33)	How Often Credits were Received
Prerequisite	Fundamental Commissioning and Verification	Required	
Prerequisite	Minimum Energy Performance	Required	
Prerequisite	Building-Level Energy Metering (new to LEED v4)	Required	
Prerequisite	Fundamental Refrigerant Management	Required	
Fed Required	Enhanced Commissioning (Up to 6 points)		Often
	No Irrigation Required	3-4	
	Reduced Irrigation	2	
Fed Required	Optimize Energy Performance (Up to 18 points)		Moderate
	Whole-Building Energy Simulation	1-18	
	Prescriptive Compliance: ASHRAE Advanced Energy Design Guide	1-6	
Fed Required	Advanced Energy Metering (new to LEED v4)	1	Often
Credit	Demand Response (new to LEED v4)	2	Seldom
Credit	Renewable Energy Production	3	Seldom
Preferred Credit	Enhanced Refrigerant Management (Up to 1 point)		Moderate
	No Refrigerants or Low-Impact Refrigerants	1	
	Calculation of Refrigerant Impact	1	
Credit	Green Power and Carbon Offsets	2	Seldom

The USGBC reports that all credits other than Construction and Demolition Waste Management were rarely achieved. Army LEED v4 projects had moderate success in achieving Building Product Disclosure and Optimization—Environmental Product Declaration. Army LEED SMEs described Building Life-Cycle Impact Reduction as somewhat difficult to achieve, as can be seen in Table 10 where almost all credits are seldom achieved. Construction and Demolition Waste Management corresponds to federal requirements and has been a consistent focus for Army waste minimization targets.

Table 10. LEED v4 Materials and Resources credits.

LEED v4 Materials and Resources Credits		Total Credits (up to 13)	How Often Credits were Received
Prerequisite	Storage and Collection of Recyclables	Required	
Prerequisite	Construction and Demolition Waste Management Planning (new to LEED v4)	Required	
Credit	Building Life-Cycle Impact Reduction (Up to 5 points)		Seldom
	Historic Building Reuse	5	
	Renovation of Abandoned or Blighted Building	5	
	Building and Material Reuse	2–4	
	Whole-Building Life-Cycle Assessment	3	
Preferred Credit	Building Product Disclosure and Optimization—Environmental Product Declarations (Up to 2 points)		Seldom
	Environmental Product Declaration	1	
	Multi-Attribute Optimization	1	
Credit	Building Product Disclosure and Optimization—Sourcing of Raw Materials (Up to 2 points)		Seldom
	Raw Material Source and Extraction Reporting	1	
	Leadership Extraction Practices	1	
Preferred Credit	Building Product Disclosure and Optimization—Material Ingredients (new to LEED v4) (Up to 2 points)		Seldom
	Material Ingredient Reporting	1	
	Material Ingredient Optimization	1	
Fed Required	Construction and Demolition Waste Management (Up to 2 points)		Often
	Diversion	1	
	Divert 75% and Four Material Streams	2	
	Reduction of Total Waste Material	2	

The USGBC reports that Enhanced Indoor Air Quality Strategies, Low-Emitting Materials, Indoor Air Quality Assessment, Thermal Comfort, Daylight, Quality Views, and Acoustic Performance were seldomly

achieved. Construction Indoor Air Quality Assessment, Thermal Comfort, and Interior Lighting correspond to federal requirements. Army LEED SMEs contacted during this study described most Indoor Environment Quality credits as potentially achievable.

The small sample of Army LEED v4 projects typically achieved Indoor Air Quality Assessment and Thermal Comfort credits, but that depended on the building type. Some Army building types such as tactical equipment maintenance facilities have spaces that are not conditioned for human comfort. The Army LEED v4 projects CERL assessed only had moderate success at getting the Interior Lighting credits. The CERL analysis showed the Army rarely got Indoor Environmental Quality—Daylight, Indoor Environmental Quality—Quality Views, and Indoor Environmental Quality—Acoustic Performance. It also showed the Army only sometimes got Indoor Environmental Quality—Enhanced Indoor Air Quality Strategies, Indoor Environmental Quality—Low-Emitting Materials, and Indoor Environmental Quality—Interior Lighting. Table 11 shows how many Army projects earned each Indoor Environmental Quality credit.

**Table 11. LEED v4 Indoor Environmental Quality credits.**

LEED v4 Indoor Environmental Quality Credits		Total Credits (up to 16)	How Often Credits were Received
Prerequisite	Minimum Indoor Air Quality Performance	Required	
Prerequisite	Environmental Tobacco Smoke Control	Required	
Preferred Credit	Enhanced Indoor Air Quality Strategies	2	Seldom
Preferred Credit	Low-Emitting Materials	3	Seldom
Fed Required	Construction Indoor Air Quality Management Plan	1	Often
Preferred Credit	Indoor Air Quality Assessment (Up to 2 points)		Seldom
	Flush-Out	1	
	Air Testing	1	
Fed Required	Thermal Comfort	1	Seldom
Fed Required	Interior Lighting (Up to 2 points)		Moderate
	Lighting Control	1	
	Lighting Quality	1	
Preferred Credit	Daylight (Up to 3 points)		Seldom
Preferred Credit	Simulation—Special Daylight Autonomy	1–3	
	Simulation—Illuminance Calculations	1–2	
	Measurement	1–3	
Preferred Credit	Quality Views	1	Seldom
Preferred Credit	Acoustic Performance (new to LEED v4)	1	Seldom

Army projects are required to have a LEED-accredited professional on the design team, which aligns with a LEED v4 Innovation credit. Because of this requirement, Army projects are often able to achieve one or two Exemplary Performance Innovation points, as shown in Table 12. Additionally, projects can pursue available Pilot and Innovation credits.

Table 12. LEED v4 Innovation credits.

LEED v4 Innovation credits		Total Credits (up to 6)
Credit	Innovation (up to 5 points)	
	Construction and Demolition Waste Management	1
	Pilot	1
	Additional Strategies, Innovation	1-3
	Additional Strategies, Pilot	1-3
	Additional Strategies, Exemplary Performance	1-2
Fed Required	LEED Accredited Professional	1

Regional Priority credits are specific to where the project is located. More information regarding Regional Priority credits can be found in the *USACE Army LEED v4 Implementation Guide* published in September 2014.

Table 13. LEED v4 Regional Priority credits.

LEED v4 Regional Priority credits		Total Credits (up to 4)
Credit	Regional Priority: Specific Credit	1
Credit	Regional Priority: Specific Credit	1
Credit	Regional Priority: Specific Credit	1
Credit	Regional Priority: Specific Credit	1

### 4.3 Army LEED v4 case studies

Data from several case studies and interviews are the foundation of this investigation. The overall question “Is LEED the best certification system for the Army?” is a difficult question to answer. Each building is unique and each team member, from design to construction, can have a variety of opinions and experiences. The following sources contributed to this information:

- LEED v.4 Silver Waiver Request per SDD Policy for FY-20, Project Number (PN) 86823/P2 472444, Army Reserve Center, Newark, Delaware, Programmed Amount=\$21.5M
- Omaha District Architects and Engineers
- USGBC's Greenbuild Conference 2019
- LEED v4 Pilot Projects: ARMY PN 71502 Advanced Individual Training (AIT) Battalion Headquarters (BNHQ), ARMY PN 71502 AIT Barracks Company Operations Facility (BCOF), ARMY PN 71502 AIT Dining Facility (DFAC)
- Aircraft Component Repair Shop (ACRS) PN 71594

As stated in the “Objectives” Section of this report, there are approximately 860 Army projects as of the third quarter of FY 2020 registered to certify with LEED v4. Of the 860 Army projects registered, only three have been certified to date.

The three Army LEED v4 pilot projects at Fort Leonard Wood have not been fully completed as of the third quarter of FY 2020. Three buildings were considered part of a LEED project campus, with each building submitting building-related credits, with the site credits common to all three buildings. The contractor for two of the campus projects (DFAC and BNHQ) filed for bankruptcy. Unfortunately, their submittals for LEED v4 construction credits were never uploaded to the GBCI website. A third campus project (BCOF) was close to LEED certification but needed a LEED credit appeal to GBCI to complete the energy credits.

#### **4.4 Challenges of using LEED for the Army**

During FY 2020, CERL researchers evaluated the differences between LEED v2009 and LEED v4 and predicted that achieving LEED Silver with the initial version of LEED v4 would be unlikely or difficult at best. This conclusion is based on (1) the LEED v2009 credits that Army projects typically do not earn, (2) the Army LEED v4 pilot projects we studied, and (3) feedback from USACE personnel and others regarding the challenges of implementing LEED v4. Fortunately, the USGBC studied those LEED v4 credits that private-sector users had difficulties achieving in their projects, and subsequently revised those credits in LEED v4.1. While LEED Silver certification is certainly going to become more demanding in the future, the Army can continue to achieve LEED Silver for some time. This can be done by strategically choosing a combination of LEED v4 and v4.1 pilot

credits for projects seeking certification through LEED v4. This will be discussed in greater detail in later sections.

#### 4.4.1 Challenging building types

Silver certification using LEED v4 (and perhaps LEED v4.1) can be more challenging to achieve with facility types that do not provide high-quality indoor environmental conditions for regular occupants, such as warehouses, aircraft hangers, or tactical equipment maintenance facilities (TEMFs). The Indoor Environmental Quality and Energy and Atmosphere credits are harder to achieve with those facility types. Warehouses typically achieve LEED Certified at best.

Projects on industrial sites with large expanses of pavement and few site amenities or green spaces nearby are less able to earn some of the easier and less expensive site credits. For example, TEMFs are difficult due to the amount of adjacent pavement that reduces the ability to manage stormwater on site. Furthermore, industrial areas on military bases may lack the neighborhood amenities that make Location and Transportation credits achievable.

Sensitive compartmentalized information facilities (SCIFs) are purposefully designed without windows, making it impossible to achieve credits for daylighting under Indoor Environmental Quality.

#### 4.4.2 Problematic LEED credits

Many LEED credits have been found to be difficult to obtain. Below is a list of those LEED credits:

- **Transportation** credits that require features like bike paths and access to quality transit must be planned by the base (in their master plan); therefore, individual building projects rarely achieve those credits if the base has not or cannot incorporate enough LEED-desired site and transportation features for projects to earn LEED Transportation credits. LEED v4.1 makes it easier to meet bike storage requirements than LEED v4, but projects will still face the challenge of connecting to an appropriate bicycle network.

LEED v4.1 has adjusted the Access to Quality Transit credit by lowering the minimum weekend trips required and by allowing projects to count private shuttle systems that allow public access.

Projects with access to public transportation may see improved performance with this credit, but projects without access to public transportation will experience no change. Many Army installations do not provide public transportation; instead, they transport troops between lodging, dining, and training as needed to conduct their mission. Army installations are focused on achieving their mission goals, not on providing public transportation to visitors or nonessential people moving around an installation. Another difference between Army communities and those outside the fence is that security is a great concern. Public transit does not cross installation boundaries. Transportation-related LEED credits have been difficult for Army projects to achieve for a long time.

Charging stations for electric vehicles (EVs) are a complex issue and incur additional cost. Right now, few electric vehicle charging stations are found at Army installations to accommodate private, mission, or tactical electric vehicles. Army policy permits making charging stations available to privately owned vehicle (POV) users on Army facilities at a cost-reimbursable basis (ASA IE&E 2020b); however, installation of EV charging infrastructure is progressing very slowly. Providing EV charging infrastructure for public use is not a mission requirement. New EV charging infrastructure for nontactical electric vehicles will need to be identified on DD1391s. The DoD and the Army are developing policies and specifications for procurement of electric vehicles and the associated charging infrastructure. The electric power distribution network and availability of reliable power sources will have to be assessed at each project location when adding EV charging infrastructure. Electric vehicles are coming to the military, and that will drive the requirement to add electric vehicle charging stations.

- Most **High Priority Site and Equitable Development** credits are difficult for Army projects to achieve. The project site must qualify as an infill location in a historic district (Option 1), be considered a brownfield (Option 3), or any of the Option 2 categories: a site listed by the EPA National Priorities List, Federal Empowerment Zone site; Federal Enterprise Community site, Federal Renewal Community site, or



Department of the Treasury Community Development Financial Institutions Fund Qualified Low-Income Community (a subset of the New Markets Tax Credit Program). It may be possible to consider a contaminated Army project site that was cleaned up before being redeveloped as a previous brownfield. Army historic districts exist, but force protection setbacks for new construction may limit new projects. The other site descriptions focus on civic objectives that are not relevant to the Army.

- In LEED v4.1, all projects must have parking that does not exceed 30% less than the base ratios listed in the Institute of Transportation Engineers's *Transportation Planning Handbook* (Meyer 2016). This change in the **Parking and Reduced Footprint** credit, compared to LEED v4, is a stricter requirement for projects that do not achieve the Surrounding Density and Diverse Uses credit. Each project team will need to look at the LEED v4.1 Parking credit to see if it can be achieved.
- The **Integrative Process** credit was introduced in LEED v4. To earn this credit, project teams need to pay attention to the requirements at the beginning of the project so they can document their findings throughout the process. This credit requires analysis by site, civil, architectural, mechanical, plumbing, and electrical disciplines during the predesign and schematic phases, similar to the mandated LCCA. In addition, the use of standard designs and a building site selection predetermined by installation master planners may hinder chances of achieving this credit.
- The design-build or construction contractor is responsible for the **Sourcing of Raw Materials**, so project specifications must include proper language to achieve this credit. Over time, most Army vendors have learned to provide the proper paperwork to meet contract requirements for this credit. Nonetheless, it would be beneficial to continue refining contract language to ensure maximum achievement of this credit.
- **Heat Island Reduction** has become very challenging to achieve, especially for projects with standing seam metal roofing. The solar reflective index (SRI) required for steep-sloped roofs increased from 29 to 39 in LEED v4.1. Bases with darker-colored roofs would need to move to a standard color that is SRI 39 or greater. Uniformity with existing

- roofs might be a concern in historic districts, but roofing can be selected to coordinate with existing buildings. Otherwise, the solution is to include highly reflective site features or covered parking. Solar photovoltaic covered parking canopies with integrated electric vehicle charging might be an ideal solution.
- The **Open Space** credit requires that the open space have features built into it, such as pedestrian-oriented paving and landscaping that accommodates social or physical activity, diverse vegetation, or restored natural habitats. In Army construction projects, building features are given funding and spatial priority over landscaping. Achieving this credit on utilitarian projects, such as warehouses, could be especially challenging.
  - The **Protect or Restore Habitat credit** is not typically pursued due to added cost. LEED v4.1 has made this credit easier to achieve, but it will likely remain a low priority for projects.
  - Additional time and training may be necessary to achieve **Acoustic Performance** for in-house acoustical design. Army projects use the required specifications for acoustical noise, vibration control, and acoustical wall and ceiling panels. The difficulty in earning this credit would be calculating or measuring sound levels and transmission between rooms as required.
  - The **Daylight** credit is often not pursued or not achieved for several reasons. While electrical engineers typically have the software necessary to perform simulations to achieve this credit, the credit requires an iterative process with project architects that is not done. Some projects can meet the daylight requirements but do not earn any points because they struggle to document and report compliance. Daylighting is important for optimizing energy use, increasing occupant health and wellness, and allowing continuity of operations during power outages. Because daylighting achieves multiple diverse objectives, the Army should consider giving priority to this LEED credit.
  - The **Quality Views** credit requires having desirable views for 75% of regularly occupied space, including special points of interest. The calculation method used to meet credit requirements has become more demanding. This credit is typically not pursued in Army projects, but it

is not out of reach for one with a favorable site and flexibility of layout to optimize views.

- The **LEED for Neighborhood Development Location** credit does not apply to projects outside a LEED Certified Neighborhood Development. Since Army projects are not sited in such developments, this credit is unattainable.

#### **4.4.3 Other problems**

Funds must be requested a least three full years prior to project execution, and program requirement changes within the intervening years. These items often resulted in inadequate funding for the Army to achieve LEED credits. Credits for brownfield remediation could be pursued, but this would require that a project be properly funded at the programming phase. Additionally, installation directorates of public works (DPWs) would need added incentives to reuse existing sites as opposed to constructing on land that has not previously been developed or polluted. Note that some Army sites are reused, so the brownfield remediation credit could be earned if project teams were able to capture the history of the site, including any past separately-funded site remediation.

Some credits, such as those earned under the Energy and Atmosphere category, are achieved using state-of-the-art technologies. Because such technologies are new or application specific, specialized training is often required to use and maintain them. For the Army, lack of training funds, inadequate staffing, and general unfamiliarity with new technologies can all be impediments to implementing advanced systems.

#### **4.4.4 Conflicting American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) versions**

The Army has a challenge when moving to newer versions of ASHRAE standards because changes affect 1391 cost estimates, designs, specifications, energy modeling baselines and requirements, system designs, and many other aspects of a project. Table 14 lists the ASHRAE standards cited by LEED v4, LEED v4.1, and the 2017 Army SDD policy .

**Table 14. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standards required under LEED v4, LEED v4.1, and Army sustainable design and development (SDD) policy (2017).**

LEED v4	LEED v4.1	Army SDD Policy (2017)
ASHRAE 90.1-2010	ASHRAE 90.1-2016	ASHRAE 90.1-2013
ASHRAE 55-2010	ASHRAE 55-2017	ASHRAE 189.1-2014
ASHRAE HVAC Applications Handbook 2011	ASHRAE HVAC Applications Handbook 2017	—
ASHRAE 62.1-2010	ASHRAE 62.1-2016	—

#### **4.4.5 Problems using Excel macros with LEED Online**

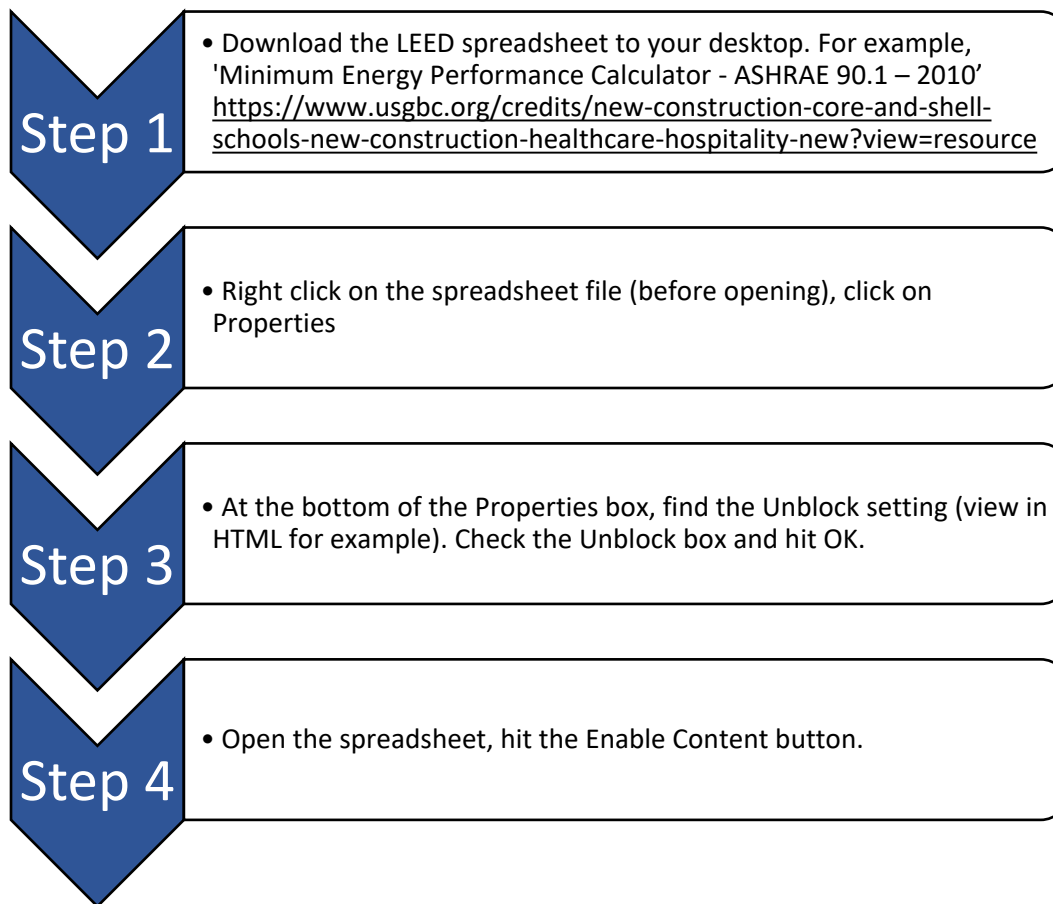
The USGBC LEED Online website is organized around project-specific directories that have multiple subareas (by credit) that designers and contractors use to submit data to GBCI for evaluation and project validation. Within these subareas are online forms—called LEED credit templates—that designers use to input project data for online calculations for the purposes of demonstrating compliance with requirements. Example credit forms include those for energy models, water reduction, landscape irrigation, lighting calculations, waste recycling, etc. These online forms are tied to other forms within the project directory and cannot be downloaded for off-line use. For DoD security policy reasons, Army information technology (IT) systems automatically disable macros in the forms, and thus, Army LEED Online users are unable to complete the forms or view the results. The Army needs a solution to resolve or circumvent this IT issue. Project teams cannot complete LEED certification without submitting all required LEED templates to GBCI.

Between October 2019 and September 2020, USACE districts and CERL submitted multiple requests for assistance thru USACE Enterprise Service Desk and also worked with local Army Corps of Engineers–Information Technology (ACE-IT) representatives and found no viable solution. As a result, there were in-house design projects being done at USACE districts that could not be loaded with data to achieve LEED certification as required by directives. We also had many projects under construction in which our in-house designers could not complete data entry on the LEED templates which affected closeout and project construction requirements. LEED certification of Army MILCON projects is required by federal law and DoD and Army directives.

Macros were disabled due to DoD security policy, so until a resolution to the problem was found, teams were unable to complete the spreadsheets or view the results. An Excel macros waiver request was submitted to ACE-IT.

One method of submitting LEED forms online that has worked for USACE Omaha District electrical engineers and architects is shown in Figure 9.

Figure 9. LEED v4 Excel macros work-around.



After the discovery of a work around process by Omaha District, USACE ECB 2022-5 *Utilizing Offline Forms* for LEED Online was published.

CERL continued to work with USACE ACE-IT, and we were able to identify a USACE-wide fix to the Excel macro problem. CEIT (Corps of Engineers Information Technology) published a self-service app portal request to enable Macros. Individuals need to open a helpdesk ticket requesting to “Enable Macros,” and the software will be pushed to their computers, resolving this problem.

## **5 LEED v4.1**

### **5.1 Introduction to LEED v4.1**

LEED v4.1 is USGBC's newest LEED rating system and is currently available in beta form. Development of the new rating system was guided by the four goals of ensuring leadership, increasing achievability, measuring performance, and expanding the market. Most relevant to this report is the changes made that increase the achievability of some credits.

Projects pursuing LEED v4 certification have the option of substituting credits for the corresponding LEED v4.1 credit without completely adopting the new system. Project teams that are facing challenges with meeting particular LEED v4 credits should investigate whether using the LEED v4.1 version of those credits would increase the likelihood of achievement. It is likely that some Army projects will more easily achieve LEED Silver certification by taking advantage of using LEED v4.1 credits.

### **5.2 Changes from LEED v4 to LEED v4.1**

One of the focuses of LEED v4.1 is to increase the achievability of difficult LEED v4 credits by adjusting achievement thresholds and creating new achievement pathways. The Materials and Resources credit category is an example where the credits were not being highly achieved in LEED v4 and were adjusted to improve achievability in LEED v4.1. Table 15 shows which credits USGBC list as having major or minor changes between LEED v4 and v4.1. Credits that did not change between the two systems are not listed.

Table 15. LEED v4 to LEED v4.1 credit changes.

Major Changes	Minor Changes
Integrative Process credit (IPc)	
IPc Integrative Process	—
Location and Transportation credit (LTc)	
LTc Reduced Parking Footprint LTc Electric Vehicles	LTc LEED for Neighborhood Development Location LTc Sensitive Land Protection LTc High Priority Site LTc Surrounding Density and Diverse Uses LTc Access to Quality Transit LTc Bicycle Facilities
Sustainable Sites prerequisite (SSp) and credit (SSc)	
SSc Rainwater Management	SSp Construction Activity Pollution Prevention SSc Site Assessment SSc Protect or Restore Habitat SSc Open Space SSc Heat Island Reduction
Water Efficiency prerequisite (WEp) credit (WEc)	
WEc Cooling Tower Water Use	WEp Indoor Water Use Reduction WEc Outdoor Water Use Reduction WEc Indoor Water Use Reduction
Energy and Atmosphere prerequisite (EAp) and credit (EAc)	
EAp Minimum Energy Performance EAc Optimize Energy Performance EAc Renewable Energy	EAp Fundamental Commissioning and Verification EAc Enhanced Commissioning EAc Grid Harmonization
Materials and Resources prerequisite (MRp) and credit (MRc)	
MRc Building Life-cycle Impact Reduction MRc Building Product Disclosure and Optimization Environmental Product Declarations MRc Building Product Disclosure and Optimization Sourcing or Raw Materials MRc Building Product Disclosure and Optimization Material Ingredients MRc Construction and Demolition Waste Management	MRp Construction and Demolition Waste Management Planning
Indoor Environmental Quality prerequisite (EQp) and credit (EQc)	
EQp Minimum Indoor Air Quality EQc Low-Emitting Materials EQc Indoor Air Quality Assessment EQc Acoustic Performance	EQp Environmental Tobacco Smoke Control EQc Enhanced Indoor Air Quality Strategies EQc Construction Indoor Air Quality Management Plan EQc Thermal Comfort EQc Daylight

### 5.3 LEED v4.1 credit categories

The following sections show LEED v4.1 credit categories. After analyzing the changes between v4.1 and v4, this report has identified the v4.1 credits, highlighted in blue, that are challenging for Army projects. The summaries below list the relevant credits and provide a short explanation of why these v4.1 credits may affect achievement for Army projects compared to their corresponding v4 credits. These credit changes may not affect every project, but they can serve as a starting point for project teams wanted to learn more about which v4.1 credit substitutions to apply.

#### 5.3.1 Location and Transportation

The Location and Transportation credit category includes eight different subcategories. Those subcategories and credits available for each are shown in Table 16.

**Table 16. Location and Transportation v4.1 credits that may affect achievability for Army projects.**

LEED v4.1 Location and Transportation Credits		Total Credits (up to 16)
Credit	LEED for Neighborhood Development Locations	
Credit	Sensitive Land Protection	1
Credit	High Priority Site	2
Credit	Surrounding Density and Diverse Uses	5
Credit	Access to Quality Transit	5
Credit	Bicycle Facilities	1
Credit	Reduced Parking Footprint	1
Credit	Electric Vehicles	1

The LEED v4.1 Location and Transportation credits that may challenge Army projects based on historical data include Access to Quality Transit, Reduced Parking Footprint, Bicycle Facilities, and Electric Vehicles. Requirements for Access to Quality Transit credit have been slightly adjusted and may be more achievable for projects that have access to a public transit system. Minor changes to the reduced Parking Footprint credit make the credit easier for projects that achieve the Surrounding Density and Diverse Uses credit and more difficult for projects that do not. The bicycle storage requirements of the Bicycle Facilities credit have been made easier to meet. The Electric Vehicles credit was previously named “green vehicles” in LEED v4. In LEED v4.1 the credit solely pertains to electric



vehicles. Projects can achieve this credit by installing electric vehicle charging stations or by installing electric vehicle charging infrastructure.

### 5.3.2 Sustainable Sites

The Sustainable Sites credit category includes seven different subcategories, of which, one is a prerequisite. These subcategories and the credits available for each are shown in Table 17.

**Table 17. Sustainable Sites v4.1 credits that may affect achievability for Army projects.**

LEED v4.1 Sustainable Sites Credits		Total Credits (up to 10)
Prerequisite	Construction Activity Pollution Prevention	Required
Credit	Site Assessment	1
Credit	Protect and Restore Habitat	2
Credit	Open Space	1
Credit	Rainwater Management	3
Credit	Heat Island Reduction	2
Credit	Light Pollution Reduction	1

LEED v4.1 Sustainable Sites credit changes that may challenge Army projects include Rainwater Management and Protect or Restore Habitat. Reduced threshold requirements for retaining on-site stormwater runoff in the Rainwater Management credit may make this credit easier to achieve. The Protect or Restore Habitat credit has a lower restoration threshold to achieve the on-site option of the credit and a lower cost to meet the option of providing financial support for off-site habitat protection or restoration. This credit is rarely attempted in Army projects, and the v4.1 changes are unlikely to change that.

### 5.3.3 Water Efficiency

The Water Efficiency credit category includes seven different subcategories, of which, three are prerequisites. These subcategories and credits available for each are shown in Table 18.

Table 18. Water Efficiency credits that may affect Army projects.

LEED v4.1 Water Efficiency Credits		Total Credits (up to 11)
Prerequisite	Outdoor Water Use Reduction	Required
Prerequisite	Indoor Water Use Reduction	Required
Prerequisite	Building-Level Water Metering	Required
Credit	Outdoor Water Use Reduction	2
Credit	Indoor Water Use Reduction	6
Credit	Optimize Process Water Use	2
Credit	Water Metering	1

The only significant Water Efficiency credit change is in the Optimize Process Water Use credit. LEED v4.1 adds an achievement pathway for projects without cooling towers or evaporative condensers.

### 5.3.4 Energy and Atmosphere

The Energy and Atmosphere credit category includes 10 different subcategories, of which, 4 are prerequisites. The subcategories and credits available for each are shown in Table 19.

Table 19. Energy and Atmosphere credits that may affect Army projects.

LEED v4.1 Energy and Atmosphere Credits		Total Credits (up to 33)
Prerequisite	Fundamental Commissioning and Verification	Required
Prerequisite	Minimum Energy Performance	Required
Prerequisite	Building-Level Energy Metering	Required
Prerequisite	Fundamental Refrigerant Management	Required
Credit	Enhanced Commissioning	6
Credit	Optimize Energy Performance	18
Credit	Advanced Energy Metering	1
Credit	Grid Harmonization	2
Credit	Renewable Energy	5
Credit	Enhanced Refrigerant Management	1

LEED v4.1 Energy and Atmosphere credits that may affect Army projects include Optimize Energy Performance, Grid Harmonization, and Renewable Energy Production. Optimize Energy Performance will now consider greenhouse gas emissions in addition to cost. Projects that are supplied by a dirty grid may need to emphasize on-site renewable production and strategies to shift energy demand to times when the grid is supplying

cleaner power if possible. The Grid Harmonization credit (previously named “demand response”) added an achievement pathway by implementing one or more listed load flexibility and management strategies. The Renewable Energy credit now has a minimum threshold of 2% of energy coming from renewable energy instead of the 1% threshold in v4. The Renewable Energy credit also now contains additional points for projects that use more than 10% renewable energy. The Energy and Atmosphere credits use a newer standard, ASHRAE 90.1-2016, in place of ASHRAE 90.1-2010.

A detailed review by USGBC into the new Energy and Atmosphere credits can be found in the “ask the experts” recordings on the USBC education webpage: <https://www.usgbc.org/education/sessions/leed-v41-ask-experts-recordings-12126387#Apr7>.

### 5.3.5 Materials and Resources

The Materials and Resources credit category includes seven different subcategories, of which, two are prerequisites. The subcategories and credits available for each are shown in Table 20.

Table 20. Materials and Resources credits that may affect Army projects.

LEED v4.1 Materials and Resources Credits		Total Credits (up to 13)
Prerequisite	Storage and Collection of Recyclables	Required
Prerequisite	Construction and Demolition Waste Management Planning	Required
Credit	Building Life-Cycle Impact Reduction	5
Credit	Building Product Disclosure and Optimization - Environmental Product Declaration	2
Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
Credit	Building Product Disclosure and Optimization - Material Ingredients	2
Credit	Construction and Demolition Waste Management	2

LEED v4.1 contains major changes to all credits in the Materials and Resources credit category. Because of the fact that these credits were difficult to achieve in LEED v4, project teams should look to these new v4.1 credits to see if they would be more achievable.

Building Life-Cycle Impact Reduction now contains an achievement pathway for conducting a life-cycle assessment of the building’s structure and

enclosure. A life-cycle assessment is a method to review environmental impacts associated with construction materials. This assessment differs from the DoD requirement for a whole building LCCA.

The Building Product Disclosure and Optimization—Environmental Product Declarations credit option 1 may be easier to achieve because the weighted value of all product declaration types was increased. Option two will be easier to achieve because LEED v4.1 reduces the cost threshold from 50% to 10% and adds the option to use “number of products” instead of “percentage of cost.” The changes in option 2 also potentially increase the number of manufacturers that would qualify for this credit.

The Building Product Disclosure and Optimization—Sourcing of Raw Materials credit may be easier to achieve in LEED v4.1 due to the decrease in cost threshold, added products that qualify for the biobased material pathway, an increased valuation of the material reuse pathway, and an increased valuation for local sourcing. One aspect of the credit that may add difficulty is that products must be sourced from at least three different manufacturers, which was not a qualification in LEED v4.

The Building Product Disclosure and Optimization—Material Ingredients credit may be easier to achieve due to reduced cost thresholds, an added pathway based on the number of products instead of cost, increased valuation for local sourcing, and an added lower-tier option for products from manufacturers that are not third-party certified but have a material ingredient screening and optimization action plan. The credit could be more difficult for some projects due to the added requirement that products must come from at least three different manufacturers.

The Construction and Demolition Waste Management credit may be easier to achieve due to achievement pathway one having a reduced number of required material streams and an added option for using certified commingled recycling facilities. Achievement pathway two may be easier due to updated waste thresholds.

### **5.3.6 Indoor Environmental Quality**

The Indoor Environmental Quality credit category includes 11 different subcategories, of which, 2 are prerequisites. The subcategories and credits available for each are shown in Table 21.

Table 21. Indoor Environmental Quality credits that may affect Army projects.

LEED v4.1 Indoor Environmental Quality Credits		Total Credits (up to 16)
Prerequisite	Minimum Indoor Air Quality Performance	Required
Prerequisite	Environmental Tobacco Smoke Control	Required
Credit	Enhanced Indoor Air Quality Strategies	2
Credit	Low-Emitting Materials	3
Credit	Construction Indoor Air Quality Management Plan	1
Credit	Indoor Air Quality Assessment	2
Credit	Thermal Comfort	1
Credit	Interior Lighting	2
Credit	Daylight	3
Credit	Quality Views	1
Credit	Acoustic Performance	1

LEED v4.1 credits that may affect Army projects include Low-Emitting Materials, Acoustic Performance, and Daylight. The Low-Emitting Materials credit has lowered required thresholds and revised product categories. The Acoustic Performance credit now allows projects to meet two of the three listed criteria (previously needed all three). The Daylight credit has revised thresholds and points available.

### 5.3.7 LEED v4.1 impact on the Army

Currently, CERL researchers do not have enough Army LEED v4 project data to fully assess how the shift to LEED v4.1 will affect Army LEED performance. USGBC has stated that one of the priorities for the new rating system was to address some of the difficult to achieve credits. After a review of the v4.1 rating system, it appears that some credits may be more achievable for Army projects. This could be especially helpful for projects that were only a few points away from achieving LEED Silver certification.

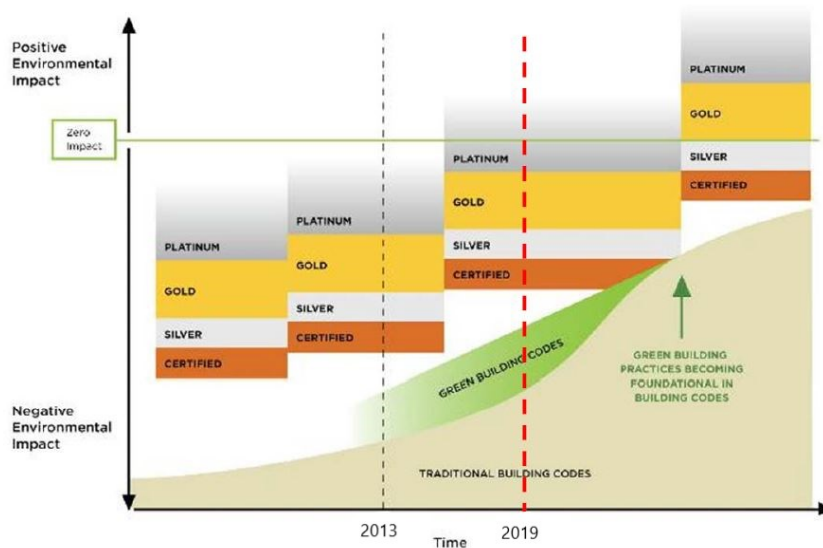
## 5.4 Future of LEED

Since LEED v4.1 is currently in beta, the rating system is expected to be adjusted based on market feedback from real-world application. Ultimately, a final version of the rating system will be approved, and a sunset date will be put in place for the previous rating system, LEED v4. Once LEED v4.1 is finalized, design teams will have to assess the implications of using the new rating system in its entirety in place of using only more

achievable LEED v4.1 credits while ignoring the credits that may have stricter standards than LEED v4.

Figure 10 shows the relationship between LEED certification levels, building codes, and environmental impact over time. Currently, LEED-certified buildings have less of an environmental impact than projects that follow traditional and green building codes. USGBC forecasts that over time green building practices will become foundational in building codes and will result in buildings having less of a negative environmental impact. As traditional building codes approach environmental impact levels similar to current LEED Silver buildings, USGBC will look to raise green building standards with a new LEED rating system.

Figure 10. LEED rating system trends captured from a United States Green Building Council (USGBC) presentation at the 2019 US Greenbuild Conference. (Image reproduced with permission from USGBC 2019a.)



U.S. GREEN BUILDING COUNCIL

## **6 Guiding Principles Compliance**

### **6.1 Guiding Principles Compliance of the Green Building Certification Institute (GBCI)**

Guiding Principles Compliance (GPC) is a third-party certification program designed for the Department of Defense's new construction and major renovation projects to assess compliance with UFC 1-200-02 *High Performance and Sustainable Building Requirements*. Projects must show compliance with each section of UFC 1-200-02 or provide justification for partial compliance or noncompliance. Acceptable justifications for partial or noncompliance include when mission precludes compliance, when location of an installation restricts or prevents compliance, when local conditions result in a requirement not being applicable to a project, or when LCCA does not support compliance.

### **6.2 Third-party certification agencies for Guiding Principles Compliance**

The two agencies offering third-party certification for GPC are GBCI and the Green Building Initiative (GBI). GBCI provides several third-party certifications, including LEED certification. GBCI's Guiding Principles assessment offers alternative compliance pathways in which showing compliance with appropriate LEED credits meet the requirements for that section. Out of the 35 sections of UFC 1-200-02, 23 sections have a compliance pathway that can be met by showing compliance with a LEED credit. Table 22 shows which of the Guiding Principles have a LEED credit compliance option in GBCI's GPC.

Projects pursuing GPC through GBCI have the opportunity to simultaneously register for LEED certification and GPC. This could provide an opportunity for projects to attempt to achieve LEED Silver certification while being able to fall back on GPC if LEED Silver ends up being unattainable.

The Green Building Initiative is an alternative third-party agency to offer GPC certification. In addition to providing GPC certification, GBI also offers a building rating system, Green Globes certification.

Table 22. The Guiding Principles of the Green Building Certification Institute (GBCI) with LEED compliance pathways.

Guiding Principles	LEED v4 Credits
2-2.1 Integrated Design	IPc Integrative Process
2-2.1.1 Integrated Planning	No LEED Compliance Pathway
2-2.1.2 Evaluation for Design Strategies	No LEED Compliance Pathway
2-2.1.3 Evaluation of the Site	No LEED Compliance Pathway
2-2.1.4 Site Integration and Design of the Building	SSc Site Assessment
2-2.2 Commissioning	EAp Fundamental Commissioning and Verification
2-3.1.1 Energy Efficiency—Commercial and Multi-Family High-Rise Residential Buildings	No LEED Compliance Pathway
2-3.1.2 Energy Efficiency—Low-Rise Residential Buildings	No LEED Compliance Pathway
2-3.1.3 Energy Efficiency—Renovations	No LEED Compliance Pathway
2-3.1.4 Energy Efficient Products	No LEED Compliance Pathway
2-3.1.5 Standby Powered Devices	No LEED Compliance Pathway
2-3.2 On-Site Renewable Energy	EAc Renewable Energy Production, minimum of 1 point and must include renewable energy generated on-site
2-3.2.1 Solar Domestic Hot Water (SDHW)	No LEED Compliance Pathway
2-3.4 Metering	EAp Building-Level Energy Metering
2-4.1 Indoor Water	WEp Indoor Water Use Reduction
2-4.1.1 Indoor Water Metering	WEp Building-Level Water Metering
2-4.2 Outdoor Water Meter	WEp Building-Level Water Metering
2-4.2.1 Outdoor Water—Landscaping	WEp Outdoor Water Use Reduction and WEc Outdoor Water Use Reduction, minimum 2 points
2-4.3 Alternative Water	No LEED Compliance Pathway
2-4.3.1 Stormwater Management	WEc Rainwater Management and SSp Construction Activity Pollution Prevention
2-5.1 Part 1 Ventilation	EQp Minimum Indoor Air Quality Performance <i>when in accordance with UFC 3-410-0</i>
2-5.1 Part 2 Thermal Comfort	EQc Thermal Comfort
2-5.2 Daylight and Lighting Controls	EQc Daylight, minimum of 2 points and/or 75% of regularly occupied areas
2-5.3.1 Indoor Air Quality—Moisture Control	No LEED Compliance Pathway
2-5.3.2 Reduce Volatile Organic Compounds (VOCs) Low-Emitting Materials	EQc Low-Emitting Materials, Option 2 Budget Calculation Method
2-5.3.3 Protect Indoor Air Quality During Construction	EQc Construction Indoor Air Quality Management Plan and EQc Indoor Air Quality Assessment



Table 22 (cont.). The Guiding Principles of the Green Building Certification Institute (GBCI) with LEED compliance pathways.

Guiding Principles	LEED v4 Credits
2-5.3.4 Environmental Tobacco Smoke Control.	No LEED Compliance Pathway
2-5.4 Occupant Health and Wellness	LTc Bicycle Facilities or Innovation credit <i>Walkable Project Site</i> or Innovation credit <i>Design for Active Occupants</i>
2-6.1.1 Recycled Content	MRc Building Product Disclosure and Optimization—Environmental Product Declarations ( <i>must use EPA-designated products to meet credit requirement</i> )
2-6.1.2 Biologically-Based Products	MRc Building Product Disclosure and Optimization—Sourcing of Raw Materials ( <i>must use BioPreferred, USDA-designated products to meet credit requirement</i> )
2-6.1.3 Ozone Depleting Substances	EAp Fundamental Refrigerant Management and EAe Enhanced Refrigerant Management
2-6.2.1 Storage and Collection of Recyclables	MRp Storage and Collection of Recyclables
2-6.2.2 Waste Diversion	MRc Construction and Demolition Waste Management, Option 1—minimum 1 point with at least a 60% diversion rate
2-7 Address Climate Change Risk	No LEED Compliance Pathway

### 6.3 DoD experience with Guiding Principles

From 2001 to 2017, the Air Force used the USGBC LEED rating system to demonstrate compliance with federal sustainability requirements. One issue noted by the Air Force is that LEED Silver certification does mean that a project completely complies with federal requirements. The Air Force has opted to instead use the GPC rating systems offered by GBCI and GBI. The Air Force made this change to better comply with federal requirements, avoid confusion about project sustainability goals, streamline HPSB Guiding Principles compliance and tracking requirements, and have a system that can be used for all new construction and major renovation projects (AFCEC 2017).

The Navy allows projects requiring third-party certification to choose which of the qualifying third-party certification programs to use. The qualifying programs include USGBC LEED, GBI or GBCI GPC, and GBI Green Globes.\*

\* Green Building Certification Systems for Federal Buildings, 10 C. F. R. 433, 435, and 436 (October 14, 2014). <https://www.govinfo.gov/content/pkg/FR-2014-10-14/pdf/2014-24150.pdf>.

## 6.4 Guiding Principles vs. LEED

Achieving GPC certification would generally be easier and more aligned with federal policy than achieving LEED Silver certification. GPC recognizes that there are situations where projects will not be able fully comply with some sections due to LCCA, mission restrictions, or project location. LEED does not have the same flexibility, causing some projects and building types to have a difficult time meeting LEED Silver certification. However, allowing projects to use GPC instead of requiring LEED Silver could result in less sustainable buildings. In pursuit of LEED Silver, projects are pushed to be as sustainable as possible. If a project is not able to achieve particular credits, the project team must focus on achieving other credits to meet the LEED Silver credit threshold. Since GPC allows for partial compliance, projects will not be pressured to find ways to compensate for a lack of compliance by improving performance in other areas.

## 7 Opportunities for Improvement

### 7.1 LEED areas for the Army to focus on

There are multiple ways to achieve LEED Silver certification. The following recommended areas to focus on may help improve projects' LEED scores while also improving performance in areas important to the Army.

#### 7.1.1 Integrative Process

LEED credit Integrative Process encourages project teams to conduct an early analysis of the interrelations between systems to support high-performance and cost-effective outcomes with an emphasis on energy and water systems. Project teams should begin this process in the predesign phase and throughout the design phases. During this process, teams will look for synergies across different building systems and disciplines that will contribute to improved energy- and water-related performances. To achieve points for this credit and take advantage of the positive outcomes, project teams must ensure that they begin these conversations as early as possible and before design decisions are made. Project teams need to document these design conversations in their project records.

This LEED credit is closely related to the UFC 1-200-02 requirement to employ integrative design strategies. UFC 1-200-02 Section 2.2 states that “Integrative design is the most important requirement in achieving a high-performance building” (NAVFAC 2020, 7). Projects must undergo integrative design, integrative planning, design strategies evaluation, site evaluation, and site integration with the design of the building.

Projects teams can incorporate the Integrative Process credit to work towards meeting federal integrative design strategies requirement and to improve energy- and water-system performances.

#### 7.1.2 Resiliency and LEED

*Army Directive 2020-03 (Installation Energy and Water Resilience Policy)* establishes energy and water resilience requirements for Army installations in support of the *2018 National Defense Strategy* and the Army's vision. To reduce mission risk, the Army will prioritize providing resilient energy and water supplies, facilities, and infrastructure that support critical missions. The Army will aim to sustain energy and water to critical

missions in the event of an extended utility outage for a duration set by the senior commander or higher headquarters, or a minimum of 14 days if a duration has not been established. The directive states, “When life-cycle cost-effective, the Army will pursue energy and water efficiency and conservation to support installation resilience by reducing demand and operating costs. Efficiency and conservation efforts include reducing overall energy and water use, maximizing efficiency, implementing energy recovery and cogeneration opportunities, recycling and reusing water by shifting to alternative sources, recharging aquifers, and striving to offset remaining demand with on-site energy generation or water sources” (Secretary of the Army 2020a, 2).

The LEED certification system aligns with base resiliency objectives by incentivizing efficiency and reductions in water and energy usage. Table 23 shows LEED v4.1 credits that relate to Army resiliency goals. Prerequisites are highlighted in blue and required for LEED certification.

**Table 23. LEED v4.1 credits related to resiliency goals.**

<b>Energy and Atmosphere Credit Category</b>	<b>Water Efficiency Credit Category</b>	<b>Other Credit Categories</b>
Fundamental Commissioning and Verification	Outdoor Water Use Reduction	Daylight
Minimum Energy Performance	Indoor Water Use Reduction	Rainwater Management
Building-Level Energy Metering	Building-Level Water Metering	Electric Vehicles
Enhanced Commissioning	Outdoor Water Use Reduction	Integrative Design Process
Optimize Energy Performance	Indoor Water Use Reduction	Pilot Credit—Assessment and Planning for Resilience
Advanced Energy Metering	Optimize Process Water Use	Pilot Credit—Design for Enhanced Resilience
Grid Harmonization	Water Metering	Pilot Credit—Passive Survivability and Backup Power During Disruptions
Renewable Energy	—	—

The Energy and Atmosphere and Water Efficiency categories contain credits that align with the Army’s goals to reduce and be more efficient with energy and water use. In addition, credits from other credit categories can impact a project’s energy and water resiliency goals. Daylight and Integrative Design Process can impact building lighting, heating, and cooling

requirements. Through building orientation and passive design, projects can take advantage of the sites local climate to reduce heating and cooling needs as well as incorporate natural lighting to reduce the need for artificial lighting during the day.

Through the Rainwater Management credit, projects in certain regions can collect rainwater that can then meet some of the project's water needs. The Electric Vehicles credit involves setting up the infrastructure for on-site charging of electric vehicles. This could be important for maintaining the operation of electric vehicles in the event of a disruption in the connection to off-site facilities.

In addition to the regular LEED credits that relate to resiliency, there are also LEED pilot credits for resilient design. LEED pilot credits for resilient design, originally introduced in 2015, are available for projects that wish to pursue them. These credits have recently been revised to improve their effectiveness, reflect feedback from LEED project teams, and harmonize the credits with RELi (USGBC's emerging resilience standard). The updated LEED Resilient Design pilot credits, which fall into the Integrative Process category, are now available to all new construction projects seeking to certify through LEED v4 or LEED v4.1. The requirements to achieve these credits include identifying potential vulnerabilities at project locations, risk mitigation, and backup power.

Army resiliency planning is enforced through documents such as those listed in Table 24.

**Table 24. Resiliency policies.**

<b>Army Resiliency Policies</b>
<i>Army Directive 2020-03 (Installation Energy and Water Resilience Policy) (2020).</i>
Department of the Army Memorandum (2017). <i>Energy and Water Goal Attainment Responsibility Policy for Installations</i>
Department of the Army Memorandum (2020) <i>Army Climate Assessment Tool Launch</i> (now called Defense Climate Assessment Tool)
ECB 2020-6–Policy and Guidance: <i>Implementation of Resilience Principles in the Engineering &amp; Construction Community of Practice</i> (2020)

LEED Resilient Design could be a point of emphasis for the Army to achieve additional LEED points while also helping projects be more resilient. There are a total of five points available with LEED Resilient Design

pilot credits that would be applied towards the Innovation credit category mentioned in Section 7.1.3 below. These credits include the following:

- IPpc98: Assessment and Planning for Resilience (one possible point)
- IPpc99: Design for Enhanced Resilience (two possible points)
- IPpc100: Passive Survivability and Backup Power During Disruptions (two possible points)

While typically earned as part of a project's initial design phase, these pilot credits can be achieved at any time during the LEED process for new construction projects.

### 7.1.3 Innovation credit category

All project teams should explore the LEED credit library to determine which pilot or Innovation credits may be applicable to the project. Projects can earn a maximum of five points through the use of pilot, Innovation, and Exemplary Performance credits, as show in Table 25.

Table 25. Innovation credit.

LEED Innovation Credits		Total Credits (up to 6)
Credit	Innovation	5
Credit	LEED Accredited Professional	1

There are many different opportunities to find project-appropriate approaches to achieve these five points. Projects that believe they may be on the borderline for achieving enough points for LEED Silver certification should emphasize achieving as many points in this category as possible.

#### 7.1.3.1 Safety First pilot credits

COVID-19 has forced the world to change the way people operate in buildings, at least for now. Along with safety of personnel and contributing to overall mitigation efforts, there is an opportunity to receive four points toward certification with LEED v4.1 Safety First pilot credits. The pilot credits include the following:

- Cleaning and Disinfecting the Space (INpc137, Possible One Point)
- Preparation for Re-Entering the Workspace (INpc136, Possible One Point)

- Water System Recommissioning (INpc139, Possible One Point)
- Managing the Indoor Air Quality during COVID-19 (INpc138, Possible One Point)

#### 7.1.3.2 Other Innovation credits

In addition to the Resilient Design credits and Safety First pilot credits mentioned above, projects may consider some of the following credits:

- Sustainable Wastewater Management
- LEED O+M (Operation and Maintenance) Starter Kit  
These credits are pulled from the operation-and-maintenance rating system to be used as new-construction Innovation credits.
  - SSp Site Management Policy
  - MRp Ongoing Purchasing and Waste Policy
  - MRp Facility Maintenance and Renovations Policy
  - EQp Green Cleaning Policy (Option 1 only)
  - EQc Integrated Pest Management
- Designing with Nature, Biophilic Design for the Indoor Environment

Innovation and pilot credits can be found on the USGBC website: <https://www.usgbc.org/innovationcatalog?Version=%22v4.1%22&Rating+System=%22New+Construction%22>.

#### 7.1.4 Planning-phase credits and construction-phase credits

To get the certification process started as early as possible, projects can elect to do a split-review application. This process involves submitting all design credits and prerequisites at the end of the design phase and then submitting the rest of the construction credits and prerequisites at the end of construction. A split review allows projects to get earlier feedback on the design phase credits to help projects figure out if they are on track to achieve the desired certification level.

## 7.2 Choosing a rating system and strategy based on project type

USGBC offers a variety of LEED rating systems that are suited to specific building types. Army projects have been certified using LEED for Building Design and Construction (BD+C), Interior Design and Construction (ID+C) for complete interior projects, LEED for Neighborhood

Development (ND), LEED for Homes, and possibly LEED for O+M. LEED for Homes offers a variety of project types including single family, multi-family, or multifamily core and shell.

LEED for BD+C rating tools include new construction and major renovation, core and shell development, schools, retail, data centers, warehouses and distribution centers, hospitality, and healthcare.

It is appropriate for project teams to look closely at their project characteristics and consider using one of the specialty LEED rating tools if it helps them achieve the Army-mandated LEED Silver certification.



## 8 Recommendations and Conclusion

### 8.1 Recommendations

Successful project teams collaborate from project planning through construction to ensure desired LEED credits are earned by the project. Each team member has a role in a variety of credits, from installation planners and DPW staff, to those who develop the 1391 (project scope and initial cost estimate), to the design team (whether in-house at a district, or at an architect/engineer [A/E] firm), and finally to the construction and commissioning teams. Conversely, it is possible for early decisions to eliminate the possibility for the project to earn a LEED credit.

For instance, LEED Transportation credits require features such as bike paths and access to quality transit that must be planned and funded by the base. Installations should be encouraged to initiate efforts to make this credit more achievable.

USACE districts may need guidance for certain credits such as the Integrative Process and Building Product Disclosure and Optimization—Environmental Product Declarations and Building Product Disclosure and Optimization—Material Ingredients credits. The flexibility to choose the best sustainable solution would be helpful in achieving this credit. Note that these credits are becoming more achievable because vendors now provide product literature needed to earn the credits.

The contractor is responsible for sourcing construction materials, components, and systems. Contractors try to avoid risk to their project and profit as much as possible. Several LEED v4 credits were difficult to earn, but revised LEED v4.1 credits are more achievable and less risky. This could possibly help contractors bid more confidently, but material shortages and COVID challenges were still problematic during the time this report was written.

If the Corps of Engineers districts have created specification language that improved project outcome, this language should be shared. The Criteria Change Program for the DoD UFC welcomes questions, comments, suggestions and recommended changes here: <https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc>.

Project teams still struggle to earn the LEED Daylight credits. Feedback from teams indicates several difficulties. First, some building types that have secure rooms just do not have enough access to windows for daylighting. Another difficulty is the effort required to model daylighting in 3D to comply with the LEED Daylight credit requirements. It would be helpful to develop a method that enables architects to perform preliminary daylighting analyses and assists electrical designers to verify the preliminary daylighting analyses. This will require some software troubleshooting, as architects and lighting designers reported that the software they previously used is no longer permitted due to cloud restrictions. There is either concern about the building model being shared over the internet, or about accessing cloud-based software that is not loaded on an Army-controlled computer. Additional investigation into this situation is necessary.

Team members should be careful not to confuse the mandated LCCA with the Building Life-Cycle Impact Reduction credit (Option (2) which addresses the environmental impact reduction of materials. ECB 2020-8 *Execution and Documentation Requirements for Life Cycle Cost Analyses* (07 July 2020) explains the requirements for LCCA.

Whole-building energy modeling can be a long process to “perfect” the energy model but is important to project success. Energy modeling requirements are clearly laid out in ER 1110-1-8173 *Energy Modeling and Life Cycle Cost Analysis* (31 December 2017). LEED energy modeling guidance is provided in the LEED reference guide and on the USGBC website. This process looks at three different system alternatives and ends up with an HVAC system design for the building.

Early-design energy analysis can be done early in the process to collaboratively work on the building layout and window configuration to maximize daylighting and reduce construction-related site work. This process can be done with integrated design tools that allow building information modeling (BIM) of the building layout to see what the energy and daylighting impacts are. This technique was used in the Army’s first LEED Platinum building: the Community Emergency Services Station that was built at Fort Liberty, North Carolina.

Training for operation and maintenance of technologies meant to enhance building performance should receive special attention and funding.

Facility trends show LEED-certified buildings underperforming due to a lack of maintenance of unfamiliar or problematic technologies.\*

Installations have the opportunity to contribute and guarantee points for projects. Resilient Design credits under the Integrative Design Process and the Location and Transportation categories are highly dependent on master planning and base policies. The Resilient Design credits offer ideas that are useful to ensuring installation facilities can continue to operate after climate events or natural disasters.

## 8.2 Conclusion

As of the third quarter of FY20, when this report was written, only two Army projects achieved LEED Silver certification using LEED v4. There was not enough data on Army buildings certified with LEED v4 to identify patterns of success and challenges for project teams. Current policy mandates require LEED certification at a Silver level and that is unlikely to change. Instead, project teams will have to figure out the most practical and cost-effective way to earn LEED Silver certification while meeting the other UFC and policy requirements.

Based on industry data, Army buildings data, and recent improvements and revisions to LEED systems, we can conclude that with LEED v4 achieving LEED Silver certification is challenging for many projects.

The introduction of and research on the improved LEED v4.1 revived optimism. LEED v4.1 introduces pilot credits that can substitute for credits in LEED v4 that may be difficult for Army projects. There are also four more points available with the introduction of the Safety First pilot credits and five more points with the revived resiliency credits. These opportunities are likely to help projects meet the mandate of LEED Silver. Two recent LEED v4 waivers—Newark Reserve (two points short of LEED Silver) and Fort Campbell, PN 69347, (six points short of LEED Silver)—would be likely to achieve LEED Silver today, especially if they began with the master planning phase.

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\* For more information, please read J. P. Miller, J. L. Vavrin, and S. Stidwell IV, 2021, *Study of Maintenance of High Performance Sustainable Buildings (HPSB)*, ERDC/CERL TR-21-10 (Champaign, IL: Construction Engineering Research Laboratory), <https://erdc-library.erdrc.dren.mil/jspui/bitstream/11681/40080/1/ERDC-CERL%20TR-21-10.pdf>.

The ACRS, PN 71594, (seven points short of LEED Silver) would have a better chance at achieving LEED Silver, but achievement is not for certain.

As more data is collected on Army projects certified with the newer versions of LEED, it might be beneficial for the Army to consider a policy that allows for more flexibility. The flexibility should emphasize LEED certification based on project characteristics (i.e., major projects and regularly occupied buildings, such as barracks, administration, schools, healthcare centers, childcare centers, dining facilities, etc.). Other building types such as aircraft hangers or tactical equipment maintenance facilities and those in industrial sites without many site amenities to help earn credits might find it difficult to earn LEED v4 Silver certification.

The GPC program is an alternate way to achieve compliance with the Guiding Principles. The Army does not currently use GPC tools like the Air Force and Navy do. It is possible the GPC tools might be more appropriate for projects that have a hard time meeting LEED Silver. Once again, that depends on the facility type, location, etc. GPC tools are more directly aligned with federal policy, without the constantly increasing difficulty that USGBC adds to each subsequent version of the LEED rating tools.

Finally, project teams need to optimize their LEED performance by starting the process as early as possible, utilizing appropriate LEED v4.1 credits, and maximizing the amount of Innovation, pilot, and Regional Priority credits to make LEED Silver certification achievable.

## Bibliography

- AFCEC (Air Force Civilian Engineer Center). 2017. *Change to AF New Construction and Major Renovation Certification Requirements*. AFCEC A-GRAM 17-01. Lackland, TX: Air Force Civilian Engineer Center. [https://www.wbdg.org/FFC/AF/POLICY/AGram\\_17-01.pdf](https://www.wbdg.org/FFC/AF/POLICY/AGram_17-01.pdf).
- ASA IE&E (Assistant Secretary of the Army [Installations, Energy and Environment]). 2006. *Sustainable Design and Development Policy Update–SPiRiT to LEED Transition*. Memorandum. Washington, DC: Department of the Army.
- ASA IE&E (Assistant Secretary of the Army [Installations, Energy and Environment]). 2017a. *Energy and Water Goal Attainment Responsibility Policy for Installations*. Memorandum. Washington, DC: Department of the Army.
- ASA IE&E (Assistant Secretary of the Army [Installations, Energy and Environment]). 2017b. *Sustainable Design and Development Policy Update*. Memorandum. Washington, DC: Department of the Army.
- ASA IE&E (Assistant Secretary of the Army [Installations, Energy and Environment]). 2020a. *Army Climate Assessment Tool Launch*. Memorandum. Washington, DC: Department of the Army.
- ASA IE&E (Assistant Secretary of the Army [Installations, Energy and Environment]). 2020b. *Policy on Charging Privately Owned/Operated Electric Vehicles in Army Installations*. Memorandum. Washington, DC: Department of the Army.
- CEQ (Council on Environmental Quality). 2019. *Implementing Instructions for Executive Order 13834 Efficient Federal Operations*. Washington, DC: Executive Office of the President.
- CEQ (Council on Environmental Quality). 2020. *Guiding Principles for Sustainable Federal Buildings and Associated Instructions*. Washington, DC: Executive Office of the President.
- DoD Climate Assessment Tool (DCAT), CONUS (+AK and HI) Installations DCAT, [https://corpsmapr.usace.army.mil/cm\\_apex/f?p=118](https://corpsmapr.usace.army.mil/cm_apex/f?p=118); ROW (rest of the world) Installations DCAT, [https://corpsmapr.usace.army.mil/cm\\_apex/f?p=119](https://corpsmapr.usace.army.mil/cm_apex/f?p=119). *This tool is common access card (CAC) enabled and is unavailable to the public.*
- Energy Independence and Security Act (EISA) of 2007, Pub. L. No. 110-140. 2007. <https://www.congress.gov/bill/110th-congress/house-bill/6>.
- Energy Policy Act (EPAct) of 2005, Pub. L. No. 109-58. 2005. <https://www.congress.gov/bill/109th-congress/house-bill/6>.
- Executive Order No. 13,834, 83 Fed. Reg. 23771–23774 (8 May 2018). <https://www.govinfo.gov/content/pkg/FR-2018-05-22/pdf/2018-11101.pdf>.

- FEMP (Federal Energy Management Program). 2016. *2016 Guiding Principles for Sustainable Federal Buildings Updates Crosswalk: New Construction and Modernization*. Guidance. DOE/EE-1403. Washington, DC: Department of Energy.
- Flanders, S. N., R. L. Schneider, D. Fournier, B. Deal, and A. L. Stumpf. 2001. *Planning, Engineering, and Design of Sustainable Facilities and Infrastructure, An Assessment of the State of Practice*. ERDC/CERL TR-01-3. Champaign, IL: Construction Engineering Research Laboratory.
- Goran W., T. Napier, R. Schneider, and A. Stumpf. 2012. "Building Green." In *Sustainability and National Security*, edited by J. Hartman, K. Butts, B. Bankus, and S. Carney, 447–482. Carlisle, PA: Center for Strategic Leadership, US Army War College.
- Green Building Certification Systems for Federal Buildings, 10 C. F. R 433, 435, and 436 (14 October 2014). <https://www.govinfo.gov/content/pkg/FR-2014-10-14/pdf/2014-24150.pdf>.
- HQDA (Headquarters, Department of the Army). 2007. *Environmental Protection and Enhancement*. Army Regulation (AR) 200-1. Washington, DC: Department of the Army.
- HQUSACE (Headquarters, United States Army Corps of Engineers). 2001. *Sustainable Design for Military Facilities*. Engineering Technical Letter (ETL) 1110-3-491, expires 31 March 2005. Washington, DC: Department of the Army. <https://apps.dtic.mil/dtic/tr/fulltext/u2/a403122.pdf>.
- HQUSACE (Headquarters, United States Army Corps of Engineers). 2014. *LEED v4 Implementation Guide*. Washington, DC: Headquarters, United States Army Corps of Engineers. [https://www.wbdg.org/FFC/ARMYCOE/SDP/USACE\\_ArmyLEEDImplementationGuide-v4.pdf](https://www.wbdg.org/FFC/ARMYCOE/SDP/USACE_ArmyLEEDImplementationGuide-v4.pdf).
- HQUSACE (Headquarters, United States Army Corps of Engineers). 2020. *Implementation of Resilience Principles in the Engineering & Construction Community of Practice*. Engineering and Construction Bulletin (ECB) 2020-6. Washington, DC: Headquarters, United States Army Corps of Engineers. <https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2020-6>.
- HQUSACE (Headquarters United States Army Corps of Engineers). 2020. *Execution and Documentation Requirements for Life Cycle Cost Analyses*. Engineering and Construction Bulletin (ECB) 2020-8 Directive and Policy. Washington, DC: Headquarters, United States Army Corps of Engineers. <https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2020-8>.
- HQUSACE (Headquarters United States Army Corps of Engineers). 2022. *Utilizing Offline Forms for LEED Online*. Engineering and Construction Bulletin (ECB) 2022-5 Directive and Policy. Washington, DC: Headquarters, United States Army Corps of Engineers. [https://www.wbdg.org/FFC/ARMYCOE/COEECB/ecb\\_2022\\_5.pdf](https://www.wbdg.org/FFC/ARMYCOE/COEECB/ecb_2022_5.pdf).

- HQ USAF (Headquarters United States Air Force). 2011. *Air Force Sustainable Design and Development (SDD) Implementing Guidance*. Memorandum. Washington, DC: Department of the Air Force. [https://www.wbdg.org/FFC/AF/POLICY/af\\_sdd\\_impl\\_guidance.pdf](https://www.wbdg.org/FFC/AF/POLICY/af_sdd_impl_guidance.pdf).
- Meyer, M. D. 2016. *Transportation Planning Handbook: Institute of Transportation Engineers*. John Wiley & Sons, Inc.
- National Research Council 2013. *Energy-Efficiency Standards and Green Building Certification Systems Used by the Department of Defense for Military Construction and Major Renovations*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/18282>.
- NAVFAC (Naval Facilities Engineering Command). 2016. *NAVFAC Sustainability and Energy Building Requirements*. Capital Improvements Engineering & Construction Bulletin (ECB) 2014-02.
- NAVFAC (Naval Facilities Engineering Command). 2020. *High Performance and Sustainable Buildings Requirements*. Unified Facilities Criteria (UFC) 1-200-02. Washington, DC: Department of Defense.
- OACSIM (Office of the Assistant Chief of Staff for Installation Management). 2017. *2017 Implementing Guidance, Army Storm Management Using Low Impact Development*. Memorandum. Washington, DC: Department of the Army.
- OASN EI&E (Office of the Assistant Secretary [Energy Installations and Environment]). 2014. *Department of Navy Sustainable Buildings Policy*. Memorandum. Washington, DC: Department of the Navy. [https://www.wbdg.org/FFC/NAVFAC/don\\_sustainable\\_bldg\\_policy.pdf](https://www.wbdg.org/FFC/NAVFAC/don_sustainable_bldg_policy.pdf).
- OUSD (Office of the Under Secretary of Defense). 2010. *DoD Implementation of Storm Water Requirements under Section 438 of the Energy Independence and Security Act (EISA)*. Memorandum. Washington, DC: Department of Defense.
- Owens, B., C. Macken, A. Rohloff, and H. Rosenberg. 2013. "LEED v4 Impact Category and Point Allocation Development Process." *United States Green Building Council*. Washington, DC: US Green Building Council. [www.usgbc.org/resources/leed-v4-impact-category-and-point-allocation-process-overview](http://www.usgbc.org/resources/leed-v4-impact-category-and-point-allocation-process-overview).
- Pinson, A. O., K. D. White, S. A. Moore, S. D. Samuelson, B. A. Thames, P. S. O'Brien, C. A. Hiemstra, P. M. Loechl, and E. E. Ritchie. 2020. *Army Climate Resilience Handbook*. Washington, DC: US Army Corps of Engineers.
- Schneider, R., and D. F. Fournier. 2004. *Sustainable Project Rating Tool (SPiRiT) version 1.4.1*. ERDC/CERL SR-04-28. Champaign, IL: Construction Engineering Research Laboratory. <https://apps.dtic.mil/sti/tr/pdf/ADA435916.pdf>.

- Schneider, R. L., and A. L. Stumpf. 2006. *Implementation of the US Green Building Council's LEED as the Army's Green Building Rating System*. Champaign, IL: Construction Engineering Research Laboratory. <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA449538>.
- Secretary of the Army. 2014. *Army Directive 2014-02, Net Zero Installations Policy*. Memorandum. Washington, DC: Department of the Army. [https://www.wbdg.org/FFC/ARMYCOE/POLICY/Army\\_NetZero\\_Installation\\_Policy.pdf](https://www.wbdg.org/FFC/ARMYCOE/POLICY/Army_NetZero_Installation_Policy.pdf).
- Secretary of the Army. 2020a. *Army Directive 2020-03 (Installation Energy and Water Resilience Policy)*. Memorandum. Washington, DC: Department of the Army.
- Secretary of the Army. 2020b. *Army Directive 2020-08 (US Army Installation Policy to Address Threats Caused by Changing Climate and Extreme Weather)*. Memorandum. Washington, DC: Department of the Army.
- Stumpf, Annette L., Julie L. Webster, Richard L. Schneider, Elisabeth M. Jenicek, Justine A. Kane, and Kelly L. Fishman. 2011. *Integration of Sustainable Practices Into Standard Army MILCON Designs*. ERDC/CERL TR-11-27. Champaign, IL: Construction Engineering Research Laboratory. <https://apps.dtic.mil/dtic/tr/fulltext/u2/a550493.pdf>.
- USGBC (United States Green Building Council). 2019a. "Driving Climate Action by Designing and Operating Greener Building through LEED v4.1 BD+C, ID+C, and O+M." Leadership in Energy and Environmental Design (LEED) V4 Workshop. Atlanta, GA.
- USGBC (United States Green Building Council). 2019b. *LEED Resilient Design Pilot Credits: How LEED Empowers Projects to Achieve a Higher Level of Resilience*. Policy Brief. Washington, DC: United States Green Building Council. <https://www.usgbc.org/sites/default/files/LEED-Resilient-Design-Pilot-Credits-Brief-FINAL.pdf>.



## Appendix A: Resources

This Appendix provides additional resources related to Leadership in Energy and Environmental Design (LEED) that can assist in further understanding the processes and versions.

- Lessons Learned from LEED v4 Pilot Projects (Fort Leonard Wood and Fort Belvoir) <https://www.wbdg.org/ffc/dod/engineering-and-construction-bulletins-ecb/usace-ecb-2016-29>
- United States Green Building Council (USGBC) LEED v4.1 Ask the Experts Recordings <https://www.usgbc.org/education/sessions/leed-v41-ask-experts-recordings-12126387#Apr7>
  - These recordings are found in the USGBC education webpage and are available to USGBC members. LEED v4.1 Energy and Atmosphere credit deep dive is recommended for a detailed look at the v4.1 changes to this credit category.
- LEED Pilot Credit Links <https://www.usgbc.org/pilotcredits?Version=%22v4.1%22&Rating+System=%22New+Construction%22>
- LEED Safety First Pilot Credits and COVID Resources <https://www.usgbc.org/about/covid-19-resources>
- Sustainable Facilities Tool Crosswalk <https://sftool.gov/learn/crosswalk>
  - This crosswalk explores how federal guiding principles relate to different standards, guidelines, and rating systems.
- Fedcenter <https://www.fedcenter.gov/programs/greenbuildings/#1.1>
  - FedCenter.gov is the federal government's home for comprehensive environmental stewardship and compliance assistance information for federal facility managers and their agencies.
- Green Infrastructure Resource of the Environmental Protection Agency (EPA) <https://www.epa.gov/green-infrastructure>
- Military Construction (MILCON) Requirements, Standardization, and Integration (MRSI) Website <https://mrsi.erdcdren.mil/>

- Resource for military construction policy, regulations, standards, and designs
- *USACE Army LEED v4 Implementation Guide* [https://www.wbdg.org/FFC/ARMYCOE/SDP/USACE\\_ArmyLEEDImplementationGuide-v4.pdf](https://www.wbdg.org/FFC/ARMYCOE/SDP/USACE_ArmyLEEDImplementationGuide-v4.pdf)
- LEED v.1 presentation and life-cycle cost analysis (LCCA) presentation from the Technical Excellence Network 2020 Fire Protection, Mechanical, Electrical, and Control Systems Communities of Practice (CoP) Meeting <https://apps.usace.army.mil/sites/TEN/ME/Pages/FP-Mech-Elec-CoP-Meeting.aspx>
  - Scroll down to the Mechanical MILCON Section to find the presentations on LEED v4.1 and LCCA. The LEED v4.1 presentation discusses DoD sustainability policy, new features of LEED v4.1, and tips and tricks to better achieve requirements. The LCCA presentation discusses a new Engineering and Construction Bulletins (ECB) on LCCA, why it is necessary, and how to do it.
- Assistant Secretary of the Army for Installations, Energy and Environment (ASA IE&E) Website <https://www.asaie.army.mil/Public/ES/index.html>
  - This website contains information and resources related to Army installation's energy and environmental policy, strategy, and guidance.
- Unified Facilities Criteria (UFC)/ARMY Sustainable Design and Development (SDD)—LEED v4 Credit Crosswalk v3

## Appendix B: Credit Changes from LEED v4 to LEED v4.1 Building Design + Construction

This appendix has been modified and reprinted with permission from the USGBC, 2023, *LEED v4.1 Building Design and Construction: Getting Started Guide for Beta Participants*, United States Green Building Council.

### B.1 Introduction

Recently, the United States Green Building Council (USGBC) has released the LEED v4.1 rating system as a beta. This new version of LEED attempts to address some of the issues that were brought up during the use of LEED v4. Projects are allowed to substitute any LEED v4 credit with a corresponding LEED v4.1 credit without having to adopt the entire 4.1 rating system. Project teams should familiarize themselves with LEED v4.1 and any credits that may be easier to achieve by using the 4.1 credit in place of the v4 credit. More can be read about the substitution process here:

<https://www.usgbc.org/articles/substitute-any-leed-v4-credit-leed-v41>.

This appendix highlights the notable changes from LEED v4 to LEED v4.1. Each credit is listed as having minor or major changes as defined by USGBC. The most significant changes occur in the Materials and Resources category which was noted as having low rates of achievement in LEED v4. In general, this credit category should be easier to achieve using LEED v4.1 due to revised thresholds, new pathways, and revised product values. For more information on LEED v4.1, visit <https://www.usgbc.org/leed/v41>.

### B.2 Credit category: Integrative Process

#### B.2.1 Integrative Process credit (IPc) 1: Integrative Process

Minor changes in the IPc1 Integrative Process include the following:

- There are now five areas to investigate, of which two must be chosen. Areas are Energy Performance, Water Performance, Site Selection, Social Equity, and Health and Wellbeing.
- Document requirements include a project team letter signed by all team members of the principal project team.

## **B.3 Credit category: Sustainable Sites**

### **B.3.1 Sustainable Sites credit (SSc) 1: Site Assessment**

Minor changes to the SSc1 Site Assessment categories include the following:

- Added impervious and pervious surfaces to the information needed for the Hydrology Section
- Removed Technical Report (TR)-55 requirement
- Added requirement for description of project's ecoregion from EPA Level III Ecoregion (or local equivalent)

### **B.3.2 SSc2: Protect or Restore Habitat**

Minor changes to the SSc2 Protect of Restore Habitat should make this credit more achievable. The changes that occurred include those listed below:

- Changed title of credit from "Site Development—Protect or Restore Habitat" to "Protect or Restore Habitat"
- Restoration credit reduced from a 30% minimum to 15% minimum
- Second threshold added at 25% for increased restoration
- Soils tests only required for imported soils, instead of all soils
- Added new vegetation section
- Option 2 Financial Support is no longer offered.

### **B.3.3 SSc4: Rainwater Management**

Major changes made to the SSc4 Rainwater Management credit were made to reduce runoff volume and improve water quality through two options.

Option 1 is related to rainfall event percentages and includes the following changes:

- Added new percentile reduction thresholds—80th, 85th, and 90th percentile (previous thresholds were 95th and 98th)
- Added requirement to treat runoff from pollution-generating hard surfaces using low-impact-development (LID) practices
- Eliminated the use of the term "manage" on-site runoff and replaced with "retain (i.e., infiltrate, evapotranspire, or collect and reuse)"

- Redefined zero-lot-line (ZLL)
- Added a requirement for ZLL projects to retain a minimum 70th percentile storm event for one point via LID or green infrastructure (GI) practice. Additional points can be earned if 75th percentile and 80th percentile retainage is met.

Option 2 provides points for retaining runoff on site equal to the difference between the projected runoff volume under proposed design conditions and undisturbed natural land cover conditions.

Additional changes to the Rainwater Management credit include the following:

- New exemplary performance for all projects has been added for both Options 1 and 2.
- Excess drainage is allowed off site for ZLL projects if appropriate (built to accommodate project).
- Detention is prohibited unless included within a holistic LID system.

#### **B.3.4 SSc5: Heat Island Reduction—minor changes**

There are two options for obtaining the SSc5 Heat Island Reduction credit. Option 1 includes nonroof and roof requirements with the following changes:

- Added language referencing new American National Standards Institute (ANSI)/Cool Roof Rating Council (CRRC) S100 standard for “Rapid Ratings”
- Roof area that consists of functional, usable spaces may meet the requirements of nonroof measures.

Option 2 is related to Parking Under Cover and now must include off-street parking that is owned or leased by the project. On-street parking in public rights-of-way is excluded from these calculations.

## **B.4 Credit category: Location and Transportation**

### **B.4.1 Location and Transportation credit (LTc) 3: High Priority Site and Equitable Development**

In order to more accurately convey the intent of the LTc3 High Priority Site and Equitable Development credit, the following minor changes were made:

- Added Federal Promise Zones to list of high-priority site locations
- Updated Federal Empowerment Zone, Federal Enterprise Community, and Federal Renewal Community sites to Qualified Opportunity Zones in list of high-priority site locations
- Added an option for Equitable Development with two paths
  - Path 1 requires the development and implementation of an equity plan.
  - Path 2 requires either affordable residential housing or mixed-use projects.

### **B.4.2 LTc4: Surrounding Density and Diverse Uses**

The minor changes within LTc4 Surrounding Density and Diverse Uses credit include the following:

- Combined Data Centers with Warehouse and Distribution Centers pathway
- Clearly defined that surrounding existing density is within a 1/4-mile offset of the project boundary
- Option 1 includes a new path for school projects.
- Another option was added with a focus on walkable locations.

### **B.4.3 LTc5: Access to Quality Transit**

Minor updates to the LTc5 Access to Quality Transit credit were meant to help with the challenges related to pervasive limitations to weekend transit requirements. Those updates include the following:

- Allows privately-run shuttles only when open to the public
- Added intermediate thresholds at two and four points
- Reduced lowest weekend minimum from 40 to 30 trips

- Allowed projects to only count the weekend day with the higher number of trips in calculations rather than using an average (i.e., Saturday for most US projects)

#### **B.4.4 LTc6: Bicycle Facilities**

The following minor changes to LTc6 Bicycle Facilities should make this credit more achievable for diverse project types:

- Long-term bicycle storage for residential projects revised to a requirement of 15% of regular building occupants rather than 30%
- Allows on-site bicycle sharing stations to count for 50% of the long-term and short-term bicycle storage space for all projects
- A LEED interpretation about showers was adopted to adjust shower needs for projects with a high occupancy count.
- Extends the distance to short-term storage to 200 ft (60 m) and long-term storage to 300 ft (90 m)
- Allows indoor storage if it meets the distance requirement. Exempts vertical distance traveled by elevator from walking distance requirements

#### **B.4.5 LTc7: Reduced Parking Footprint**

In order to achieve the intent of the LTc7 Reduced Parking Footprint credit, the following major changes occurred:

- Removed Cases 1 and 2
- Requires 30% parking reduction for all projects
- Updated to 5th edition of *Parking Generation Manual* from the Institute of Transportation Engineers (ITE)
- Removed carpool preferred parking requirement
- Added four new options, which should allow for flexibility depending on project type. The new options include the following:
  - Option 1. No Off-Street Parking
  - Option 2. Reduce Parking
    - \* Minimum local code requirements must be met.
    - \* A 30% reduction below base ratios recommended by Parking Consultants Council
  - Option 3. Carshare

- \* Dedicated parking for carshare vehicles must be provided. Documentation requires projects to show legal agreement between carshare company and project.
- Option 4. Unbundling Parking
  - \* Parking must be sold separately from all property sales or leases.
  - \* Daily parking fee at cost equal to or greater than the daily cost of municipal public transit must be implemented.

#### **B.4.6 LTc8: Electric Vehicles**

Because the electric vehicle (EV) market has grown at a much higher rate than other alternative fuels, the LTc8 Electric Vehicle credit title was changed to reflect that green vehicles are only EV. The following are additional changes made to the credit:

- Removed preferred parking requirements
- Removed Option 2. Liquid, Gas, or Battery Facilities and replaced with Option 2. Electric Vehicle Ready Infrastructure
- For warehouse and distribution center projects, changed Option 1 to Electric Vehicle Charging

### **B.5 Credit category: Water Efficiency**

#### **B.5.1 Water Efficiency credit (WEc) 3: Optimize Process Water Use**

This credit was previously named Cooling Tower Water Use within LEED v4. There are three options for obtaining the Optimize Process Water Use credit focused on conservation of low-cost potable water resources used for mechanical processes. Any changes to these options are outlined below.

##### *B.5.1.1 Option 1: Cooling Tower and Evaporative Condenser Cycles of Concentration*

- Updated requirements to allow projects to earn two points if conditions are met to earn one point and
  - increase the number of cycles by at least 25%, or
  - use a minimum 20% recycled nonpotable water.



### *B.5.1.2 Option 2: Optimize Water Use for Cooling*

- Only projects that use water-cooled systems compliant with American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 90.1-2016, Appendix G, Table G3.1.1 (systems 7, 8, 11, 23, or 13) qualify for this option.
- The project design case does not include a cooling tower.
- The design case mechanical system does not use the latent heat of the evaporative cooling of water.
- The project does not receive any cooling from a district cooling system.

## **B.6 Credit category: Energy and Atmosphere**

Updated standards include the following:

- ASHRAE 90.1-2016 for energy performance
- ASHRAE Guideline 0-2013 for commissioning
- ASTM E2947-16: *Standard Guide for Building Enclosure Commissioning*

### **B.6.1 Energy and Atmosphere credit (EAc) 2: Optimize Energy Performance**

The major changes listed below are based on updated reference standards:

#### *B.6.1.1 Option 1: Energy Performance Compliance*

- Now uses two metrics based on greenhouse gas (GHG) emissions and cost
  - Points are earned if a project can demonstrate a performance cost index (PCI) below the performance cost index target (PCI<sub>t</sub>) using the metrics of cost and GHG emissions.
  - On-site renewables permitted for cost and GHG emissions
  - New off-site renewables permitted for GHG emissions metric

#### *B.6.1.2 Option 2: Advanced Energy Design Guide*

- Added advanced-energy design guide for grocery stores and revised options for Core and Shell (CS)

### B.6.1.3 Option 3 (New): Systems Optimization

- Up to four points for demonstrated improvement in building systems: interior and exterior lighting, daylight controls, building envelope, HVAC and service water heating equipment efficiency, and equipment and appliances

### B.6.2 EAc4: Grid Harmonization (previously named Demand Response)

Minor changes within this credit are meant to address projects where the local utility does not have a demand response program available. While a majority of this section remains the same, some changes have been made and are listed below:

- To earn points within Case 1, the demand response program and all installed technologies must be included in the building systems manual.
- All projects must install interval recording meters with communications and have a building automation system capable of accepting an external signal in Case 2.
- A new case (Case 3) was added related to load flexibility and management strategies. In this case, one or more of the load flexibility and management strategies described below must be accomplished:
  - Peak Load Optimization: demonstrate that strategy reduces on-peak load by at least 10% as compared to peak electrical demand (one point)
  - Flexible Operating Scenarios: demonstrate that strategy moves at least 10% of peak load by a time period of two hours (one point)
  - On-site Thermal and/or Electricity Storage: demonstrate that strategy reduces on-peak load by at least 10% as compared to peak electrical demand (one point)
  - Grid Resilience Technologies: project served by utilities with resilience programs in place, which leverage strategies such as islanding and part-load operation, automatically achieve this credit (one point)

### B.6.3 EAc5: Renewable Energy

New to LEED v4.1, this credit combines the LEED v4's EAc7 Green Power and Carbon Offsets and EAc5 Renewable Energy Production into one credit. This credit both updates performance requirements and adds new

categories of renewables. Although this is a new credit, the LEED v4 credit options that were combined offer much of the same information. Changes to each of these portions of the new credit are listed below:

#### *B.6.3.1 Changes in Renewable Energy Production*

- Added the consideration of off-site renewable energy in addition to on-site generation
- Threshold to achieve one point with on-site generation increased from 1% renewable energy to 2%
- Additional points available for producing more than 10% renewable energy (four points for 20%, five points for 40%, exemplary performance for 60%)

#### *B.6.3.2 Changes in Green-e Climate certification or equivalent carbon offsets*

- Thresholds are twice the amounts from LEED v4.
  - One point for 100% total annual emissions offset (previously was 50%)
  - Two points for 200% total annual emissions offset (previously was 100%)

## **B.7 Credit category: Materials and Resources**

### **B.7.1 Materials and Resources credit (MRc) 1: Building Life-Cycle Impact Reduction**

The major changes to MRc1 Life-Cycle Impact Reduction credit are focused on reducing embodied carbon in building structures and enclosures. What were once four credit options have been reduced to two with pathways for achievement of each option. The list below reflects the changes:

- LEED v4.1 credit Option 1 is a combination of LEED v4 credit Options 1, 2, and 3. This credit provides two paths that can be combined for points:
  - Path 1 requires that the project maintain existing structural elements, including walls, floors, roofs, and envelope.
  - Path 2 requires that the project use existing interior non-structural elements, like interior walls, doors, floor coverings, and ceiling systems, for at least 30% of the entire completed building.

- LEED v4 credit Option 4 is now credit Option 2 and provides four paths to achieve points:
  - Path 1 requires a life-cycle assessment of the project's structure and enclosure.
  - Path 2 requires a life-cycle assessment of the project's structure and enclosure that demonstrates a minimum of 5% reduction compared with a baseline building in at least three of the six impact categories, one of which must be global warming potential.
  - Path 3 remains the same as LEED v4.
  - Path 4 must meet the requirements of Path 3 with increased reductions.

LEED v4.1 makes credit Options 1 and 2 easier to achieve. Option 1 contains two new pathways that separate maintaining existing building structures and envelopes and existing interior nonstructural elements. Option 2 includes two new easier-to-achieve pathways. One point is awarded for conducting a life-cycle assessment of the project's structure and enclosure. Two points are awarded for achieving a minimum 5% reduction in building life-cycle impacts (previously a 10% reduction was the only option). Projects should be able to achieve at least one point for conducting a life-cycle assessment of the project's structure and enclosure.

### **B.7.2 MRc2: Building Product Disclosure and Optimization—Environmental Product Declarations (EPDs)**

Major changes were made to the MRc2 Environmental Product Declarations (EPDs) credit to better meet the original intent. Changes to Options 1 and 2 are listed below:

#### *B.7.2.1 Option 1: EPD*

Adjustments to project weightings were made as follows:

- Product-specific declarations are counted as one product in LEED v4.1. LEED v4 considered them to be one-fourth of a product.
- Third-party-verified, industry-wide (generic) EPDs are counted as one product in LEED v4.1. LEED v4 considered them to be one-half of a product.

- Third-party-verified, product-specific EPDs are counted as one and a half products in LEED v4.1. LEED v4 considered them to be one product.

#### *B.7.2.2 Option 2: Embodied Carbon/Life-Cycle Assessment (LCA) Optimization*

Reductions to cost requirements and the addition of new pathways for this option are listed below:

- LEED v4 required the use of products that met the criteria for this option to be 50%, by cost, of the total value of permanently installed products in the project. LEED v4.1 reduced the requirement to 10%.
- Added the alternative pathway to use at least 10 products from three different manufacturers instead of meeting the cost requirement
- Added new pathways for meeting the product criteria
- All pathways require a narrative that explains how life-cycle optimization is or will be achieved.

Option 1 will be easier to achieve because the weighted value of all product-declaration types was increased from LEED v4 to 4.1. Option 2 will be easier to achieve because LEED v4.1 reduces the cost threshold from 50% to 10% and adds the option to use the number of products instead of percentage of cost. The changes in Option 2 also potentially increase the number of manufacturers that would qualify for this credit.

#### **B.7.3 MRc3: Building Product Disclosure and Optimization—Sourcing of Raw Materials**

Due to the complexity and lack of available information of credit Option 1 from LEED v4, it was moved to the pilot credit library. Since Option 1 was moved, Option 2 became the only part of MRc3 Sourcing Raw Materials and is worth two points. The additional changes that were made to this credit are listed below:

- Cost threshold changed from 25% to 15%
- Added that products must be sourced from at least three different manufacturers
- Added an additional lower-tier valuation (50% of cost) to biobased material pathway

- Now, biobased products that meet the listed criteria but do not meet the Sustainable Agricultural Network's Sustainable Agricultural Standard can be counted.
- Added a higher threshold of 30% of cost from five manufacturers for two points
- Increased the valuation of material reuse pathway from 100% to 200% of cost
- Products sourced within 100 miles of the project site are valued at twice their base contributing cost (or number of products) up to a maximum of 200% of cost or two products.

This credit will be easier to achieve in LEED v4.1 due to the decrease in cost threshold, added products that qualify for the biobased material pathway, an increased valuation of the material reuse pathway, and increased valuation for local sourcing. One aspect of the credit that may add difficulty is that products must be sourced from at least three different manufacturers, which was not a qualification in LEED v4. Projects will have the opportunity to earn an additional point if they are able to comply with the higher threshold option.

#### **B.7.4 MRc4: Building Product Disclosure and Optimization—Material Ingredients**

Major changes were made to MRc4 Material Ingredients in order to reduce barriers for achievement while still maintaining the overall approach as listed below:

- Warehouses and distribution centers have a lower number of product requirements (10 instead of 20).
- Reduced cost threshold from Option 2
- Added an alternative pathway based on number of products instead of cost
- Added the requirement that products must come from at least three different manufacturers
- Added a lower-tier option for products from manufacturers that are not third-party certified but have a material ingredient screening and optimization action plan
- Added that products sourced within 100 miles of the project site are valued at twice their base contributing cost (or number of products) up to a maximum of 200% of cost or two products

- Moved Option 3 to the pilot credit library

Credit Option 1 is now easier to achieve for warehouses and distribution centers. Credit Option 2 may be easier to achieve due to USGBC reducing of the cost threshold, adding a pathway based on number of projects instead of cost, increasing the valuation for local sourcing, and adding a lower-tier option for products from manufacturers that are not third-party certified but have a material ingredient screening and optimization action plan. This option could be more difficult for some projects due to the added requirement that products must come from at least three different manufacturers.

### **B.7.5 MRc5: Construction and Demolition Waste Management**

To make the MRc5 Construction and Demolition Waste Management credit more achievable, the requirement for diversion through multiple material streams has been removed. This requirement has been replaced with a more flexible way to prevent and divert waste as described below:

#### *B.7.5.1 Option 1: Diversion*

- Added additional pathways for using a certified commingled recycling facility
  - Divert 50% requires no additional material stream.
  - Divert 75% requires one waste stream to the certified commingled facility and one additional material stream.
- For the noncertified commingled recycling facility pathways
  - Divert 50% and two material streams (previously required three streams)
  - Divert 75% and three material streams (previously required four)

#### *B.7.5.2 Option 2. Waste Prevention*

- Updated thresholds and clarified that the waste generation target only applies to new construction waste
  - Waste from new construction activities must be less than 7.5 lb/ft<sup>2</sup> (previously was 2.5 lb/ft<sup>2</sup>).

- Demolition or renovation waste must be 75% diverted or more but does not count against total generated waste target.

Both options of this credit should be easier to achieve. Option 1 has reduced the number of required material streams and included pathways for using certified commingled recycling facilities. Option 2 has updated the waste thresholds so now waste from new construction activities must be less than 7.5 lb/ft<sup>2</sup>, which is easier than the 2.5 lb/ft<sup>2</sup> threshold from LEED v4.

## **B.8 Credit category Indoor Environmental Quality**

### **B.8.1 Indoor Environmental Quality credit (EQc) 1: Enhanced Indoor Air Quality Strategies**

Minor changes to EQc1 Enhanced Indoor Air Quality Strategies include the following updates to referenced standards:

- ASHRAE 52.2-2010 to ASHRAE 52.2-2017 for Option 1, Strategy C, Filtration
- European norm (EN) 779-2002 to International Organization for Standardization (ISO) 16890-2016 for Option 1, Strategy C, Filtration
- ASHRAE 62.1-2010 to ASHRAE 62.1-2016 for Option 2, Strategy C

### **B.8.2 EQc2: Low-Emitting Materials**

EQc2 Low-Emitting Materials updates were made to make this credit more straightforward. The changes include the following:

- Deleted credit Option 2. Credit achievement is only based on number of compliant product categories (no longer an option to consider percentage of budget).
- Revised thresholds for each product category (ranging from 75% to 90%). This results in a lower threshold value to meet in all product categories.
- Revised product categories. Split category for ceilings, walls, thermal, and acoustic insulation into three product categories: (1) ceilings, (2) wall panels, and (3) insulation
- Removed requirement for reporting range of total VOCs after 14 days
- Updated referenced standards



### **B.8.3 EQc3: Construction Indoor Air Quality Management**

Most of the EQc3 Construction Indoor Air Quality Management credit changes pertained to updating reference standards. Those updates are listed below:

- ASHRAE 52.2-2010 updated to ASHRAE 52.2-2017
- EN 779-2002 updated to ISO 16890-2016
- Facility Guidelines Institute (FGI) 2010 updated to FGI 2018

Beyond standard updates, this credit also changed smoking prohibition to include any building openings (not just entrances).

### **B.8.4 EQc4: Indoor Air Quality Assessment**

Although no changes were made to Option 1 of EQc4 Indoor Air Quality Assessment, Option 2 has major changes as shown below:

- Option 2 divided into two pathways. Path 1 involves testing for particulate matter and inorganic gases, and Path 2 involves testing for VOCs.
- Added and revised allowed testing methods
- Some changes to allowed concentration limits

### **B.8.5 EQc5: Thermal Comfort**

Minor changes to EQc5 Thermal Comfort are due to updated referenced standards. The referenced standard updates are listed below:

- ASHRAE 55-2010 updated to ASHRAE 55-2017
- *ASHRAE Applications Handbook* 2011 edition updated to 2015 edition
- EN 15251 updated to ISO 17772-2017

### **B.8.6 EQc7: Daylight**

In order to make the three options for the EQc7 Daylight credit clearer, more detailed, and achievable, the following minor changes were made:

- Revised Option 1. Annual sunlight exposure (ASE) is required to be calculated but specific 10% ASE threshold was removed
- Revised Option 1 to require spatial daylight autonomy (SDA) to be calculated for each individual space in addition to an average for all regularly occupied floor area
- Revised thresholds and points for Options 1, 2, and 3

- Option 1 now contains an option for one point at a lower threshold of 40% (Lowest threshold in LEED v4 was 55% for two points).
- Options 2 and 3 now have an option to achieve one point at a threshold of 55%. The 75% and 90% thresholds are worth an additional point compared to LEED v4.
- Added reference to Illuminating Engineering Society (IES) LM-83-12 for SDA and ASE
- Added exceptions for 3,000 lux value if view-preserving, automatic (with manual override) glare-control devices are used

### **B.8.7 EQc9: Acoustic Performance**

Major changes to the EQc9 Acoustic Performance credit are outlined below:

- Revised to allow for two of three criteria for one point. Achievement of all three criteria earns an extra exemplary performance point.
- *2011 ASHRAE Handbook—HVAC Applications* updated to *2015 ASHRAE Handbook—HVAC Applications*
- Added additional option for sound measurements: IEC 61672-1:2013
- Added the option to consider noise isolation class (NIC) for measuring sound transmission instead of composite sound transmission class (STCc)
- Revised sound transmission Table 1: added NIC option for compliance, revised adjacency combinations and associated STCc ratings
- Added option for using reduced STCc ratings or NIC values if sound masking is used
- Deleted sound reinforcement and sound masking requirements and revised reverberation timetable

## Abbreviations

ACE-IT	Army Corps of Engineers-Information Technology
ACRS	Aircraft component repair shop
AEMR	Annual Energy Management Report
A/E	Architect/engineer
AFCEC	Air Force Civilian Engineer Center
AIT	Advanced individual training
ANSI	American National Standards Institute
AR	Army Regulation
ASA IE&E	Assistant Secretary of the Army for Installations, Energy and Environment
ASE	Annual sunlight exposure
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BCOF	Barracks company operations facility
BIM	Building information modeling
BNHQ	Battalion headquarters
CAC	Common access card
CEIT	Corps of Engineers Information Technology
CEQ	Council on Environmental Quality
CERL	Construction Engineering Research Laboratory
CoP	Community of practice
CRRC	Cool Roof Rating Council
CS	Core and Shell

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DA	Department of the Army
DBB	Design-bid-build
DCAT	DoD Climate Assessment Tool
DFAC	Dining facility
DoDM	DoD Medical
DOE	Department of Energy
DPW	Directorate of Public Works
EAp	Energy and Atmosphere prerequisite
EAc	Energy and Atmosphere credit
ECB	Engineering and Construction Bulletin
EISA	Energy Independence and Security Act
EN	European norm
EO	Executive Order
EOc	Indoor Environmental Quality credit
EOp	Indoor Environmental Quality prerequisite
EPD	Environmental Product Declaration
ERDC	Engineer Research and Development Center
ETL	Engineering Technical Letter
EV	Electric vehicle
FEMP	Federal Energy Management Program
FGI	Facility Guidelines Institute
GBCI	Green Building Certification Institute
GBI	Green Building Initiative

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GHG	Greenhouse gas
GI	Green infrastructure
GP	Guiding Principles
GPC	Guiding Principles Compliance
HPSB	High Performance and Sustainable Building
HQDA	Headquarters, Department of the Army
HQUSACE	Headquarters, United States Army Corps of Engineers
HQ USAF	Headquarters United States Air Force
IES	Illuminating Engineering Society
IESNA	Illuminating Engineering Society of North America
IgCC	International Green Construction Code
IPc	Integrative Process credit
ISO	International Organization for Standardization
IT	Information technology
ITE	Institute of Transportation Engineers
LCA	Life-cycle assessment
LCCA	Life-cycle cost analysis
LEED	Leadership in Energy and Environmental Design
LEED BD+C	LEED for Building Design and Construction
LEED ID+C	LEED for Interior Design and Construction
LEED NC	Leadership in Energy and Environmental Design for New Construction
LEED ND	LEED for Neighborhood Development
LEED O+M	LEED for Operation and Maintenance

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LID	Low-impact development
LTc	Location and Transportation credit
MCA	Military Construction Army
MEF	Metro entrance facility
MILCON	Military construction
MRC	Materials and Resources credit
MRp	Materials and Resources prerequisite
MRSI	MILCON requirements, standardization, and integration
MWR	Morale, Welfare, and Recreation
NAVFAC	Naval Facilities Engineering Command
NIC	Noise isolation class
OACSIM	Office of the Assistant Chief of Staff for Installation Management
OASA(I&E)	Office of the Assistant Secretary of the Army for Installations and Environment
OASN EI&E	Office of the Assistant Secretary [Energy Installations and Environment
OUSD	Office of the Under Secretary of Defense
ODCS	Office of the Deputy Chief of Staff
OMB	Office of Management and Budget
PCI	Performance cost index
PCI <sub>t</sub>	Performance cost index target
POV	Privately owned vehicle
SCIF	Sensitive compartmentalized information facility

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SDA	Spatial daylight autonomy
SDD	Sustainable design and development
SDHW	Solar domestic hot water
SME	Subject matter expert
SPiRiT	Sustainable Project Rating Tool
SRI	Solar reflective index
SSc	Sustainable Sites credit
STCc	Composite sound transmission class
TEMF	Tactical equipment maintenance facility
TR	Technical Report
UFC	Unified Facilities Criteria
USACE	United States Army Corps of Engineers
USGBC	United States Green Building Council
WEc	Water Efficiency credit
ZLL	Zero-lot-line

## REPORT DOCUMENTATION PAGE

<b>1. REPORT DATE</b> November 2023		<b>2. REPORT TYPE</b> Final Report		<b>3. DATES COVERED</b>	
				<b>START DATE</b> FY20	<b>END DATE</b> FY21
<b>4. TITLE AND SUBTITLE</b> Analysis of the Army Transition from LEED 2009 to LEED v4, with Updated LEED 4.1 Credits					
<b>5a. CONTRACT NUMBER</b>		<b>5b. GRANT NUMBER</b>		<b>5c. PROGRAM ELEMENT</b>	
<b>5d. PROJECT NUMBER</b>		<b>5e. TASK NUMBER</b>		<b>5f. WORK UNIT NUMBER</b>	
<b>6. AUTHOR(S)</b> Annette L. Stumpf, Samuel Stidwell IV, Brent D. Panozzo, Charles R. Ehlschlaeger, and Megan R. Fuhler					
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> US Army Engineer Research and Development Center Construction Engineering Research Laboratory (CERL) 2902 Newmark Drive Champaign, IL 61822				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b> ERDC/CERL TR-23-26	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Energy and Facilities Engineering Division, DAIN-ODF, Operations Directorate, Office of Deputy Chief of Staff (ODCS), G-9 (Installations), 600 Army Pentagon Washington, DC 20310-0600			<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>		<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>
<b>12. DISTRIBUTION/AVAILABILITY STATEMENT</b> Distribution Statement A. Approved for public release: distribution is unlimited.					
<b>13. SUPPLEMENTARY NOTES</b> MIPR 11268079					
<b>14. ABSTRACT</b> <p>The objective of this effort was to identify and recommend an approach for Army green building certification that ensures Army projects meet federal and Army sustainability requirements during the transition from Leadership in Energy and Environmental Design (LEED) 2009 to LEED v4.</p> <p>The first Army LEED v4 project was registered for certification with the Green Building Certification Institute in 2014. Since then, over 860 Army projects were registered for LEED v4 certification. As of the third quarter of FY20, when this report was written, 2 projects achieved LEED Silver certification. Other Army projects teams documented difficulty achieving the required LEED v4 Silver certification due to difficult site conditions, budget constraints, facility types, or project requirements.</p> <p>Commercial-sector project teams also had difficulty certifying with LEED v4, forcing the United States Green Building Council (USGBC) to reconsider the credits and metrics project teams found challenging. The USGBC revised the troublesome credits and now offers LEED v4.1 pilot credits that can be used for any project registered with LEED v4. To assist Army project teams, this research investigates difficult-to-achieve LEED v4 credits and their possible replacement with LEED v4.1 pilot credits.</p> <p>The report concludes with guidance on implementing the updated version of the LEED rating system from v4 to v4.1.</p>					
<b>15. SUBJECT TERMS</b> Military construction operations; Sustainable engineering; Sustainability; Military bases; United States. Army					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>		<b>18. NUMBER OF PAGES</b>
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified	SAR		96
<b>19a. NAME OF RESPONSIBLE PERSON</b>			<b>19b. TELEPHONE NUMBER (include area code)</b>		