Incremental Costs of Meeting ASHRAE Standard 189.1 at Air Force Facilities

An Evaluation of Four AF MILCON Projects



June 2011

Executive Summary

The US Air Force Center for Engineering and the Environment (AFCEE) wishes to know the incremental upfront construction cost of adhering to American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 189.1, released in 2009. ASHRAE Standard 189.1 is a holistic high-performance and sustainable building standard intended to conserve energy and water resources, and to advance other sustainability goals.

The intent of this evaluation is to identify aspect of ASHRAE Standard 189.1 that could be included in Air Force (AF) construction criteria. The results of this evaluation and other management factors will likely influence the degree to which the AF encourages or mandates compliance with this standard.

To facilitate its assessment, AFCEE tasked TEAM-IE/LMI to study existing AF facilities or ones under construction. TEAM-IE/LMI conducted case studies at four such locations chosen to represent different types of facilities and climate zones:

1. Tyndall Fitness Center, Tyndall Air Force Base (AFB), FL (climate zone 2A: hot-humid)

2. C-17 Hangar, Travis AFB, CA (climate zone 3B: hot-dry)

3. HQ, AF Weather Agency Headquarters, Offutt AFB, NE (climate zone 5A: cold)

4. FY09 Dormitory, Minot AFB, ND (climate zone 7A: very cold)

In each case, TEAM-IE/LMI determined the added design or material requirements to meet the standard, estimated their first cost, and totaled the amounts. The results appear in Table ES-1. The estimates show both the total incremental cost and the added cost to meet the renewable energy requirement, the single biggest cost component.

Table ES-1. Incremental Costs of Meeting ASHRAE 189.1 Standard

Building	Total initial cost	Added cost of standard	Added cost of renewable energy requirement	LEED status
Offutt Weather Agency	$27 million	7.1%	4.0%	Gold
Tyndall Fitness Center	$18 million	1.3%	1.0%	Platinum

Table ES-1. Incremental Costs of Meeting ASHRAE 189.1 Standard

Building	Total initial cost	Added cost of standard	Added cost of renewable energy requirement	LEED status
Travis C-17 Hangar	$25.4 million	2.8%	1.7%	Silver
Minot Dormitory	$22.9 million	2.3%	1.9%	Silver

It is important to note that ASHRAE Standard 189.1 is a code standard, and as such does not grant exceptions to its requirements. In other words, if a facility does not meet all of the stated requirements, it is not in compliance with the standard. Because AF buildings already are constructed to meet the Guiding Principles for High Performance Sustainable Buildings, meet at least LEED silver requirements, and other federal sustainable building requirements, the added initial cost of meeting ASHRAE 189.1 is fairly modest, at least as a percentage of total building construction costs. For three of the buildings the added cost falls in the 1–2.8 percent range; only for the Offutt Weather Agency Headquarters facility is it somewhat higher, at 7.1 percent. However, some of the requirements listed in ASHRAE Standard 189.1 would require fundamental changes to the implementation of the energy and metering programs.

Offutt has higher added costs for two reasons. First, it is a very large building, with almost 189,000 square feet of space. Because the requirements for renewable energy are tied to the amount of a building's conditioned space, and because the renewable requirement is the single largest cost component, Offutt shows the largest incremental cost. And second, Offutt made use of a runway for parking space, but this runway likely did not meet the ASHRAE Standard 189.1 for shading or reflectivity, so a costly concrete overlay would have been necessary.

Other AF considerations besides cost might interfere with meeting the ASHRAE Standard 189.1. For example, one part of the standard requires being able to reduce a building's energy demand by 10 percent at peak load times. However, if a building provides mission-critical functions, the building would be exempted from base-wide load shedding management. Also, under ASHRAE Standard 189.1, electricity, gas, and water meters must have remote reading capability. The AF requires advanced meters for new construction, but it has ordered a strategic pause in connecting new meters to existing remote meter reading systems due to security concerns and the pursuit of a standardized platform. Furthermore, the AF currently does not have the ability to manage the data collected by the meters (or sub-meters on some systems). Lastly, in one case a building did not meet a window (fenestration) area requirement but would have done so were it oriented differently to face a direction other than west.

Clearly some of the ASHRAE Standard 189.1 requirements overlap with what the AF is already doing from a HPSB perspective, while others like renewable energy (RE) drive a very large capital investment that may not align with the AF's corporate RE strategy, and still others may be in conflict with how individual programs are implemented in the AF. The Army took exception to the RE requirement because it makes more sense for military bases to use their size and footprint to tackle that problem rather than looking at individual building applications where the numbers simply aren't life cycle cost effective. Furthermore, the AF will consider those best practices from ASHRAE Standard 189.1 that complement its program the most and include them in applicable design requirement documents (e.g., UFC, ETLs, AFIs).

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Chapter 1
Introduction

In January 2004, seventeen federal government agencies signed a Memorandum of Understanding (MOU) committing to leadership in the design, construction, and operation of High-Performance and Sustainable Buildings (HPSB). A major element of this strategy is the implementation of common strategies for planning, acquiring, siting, designing, building, operating, and maintaining these facilities. Consistent with and in addition to Federal policy, statutes, executive orders and supplemental agency policies and guidance, the signatories collaboratively established and are now following a common set of sustainable Guiding Principles for integrated design, energy performance, water conservation, indoor environmental quality, and materials aimed at helping Federal agencies and organizations:

- Reduce the total ownership cost of facilities
- Improve energy efficiency and water conservation
- Provide safe, healthy, and productive built environments
- Promote sustainable environmental stewardship

At that time, the federal government owned approximately 445,000 buildings with total floor space of over 3 billion square feet, in addition to leasing an additional 57,000 buildings comprising 374 million square feet of floor space.

> These structures and their sites affect our natural environment, our economy, and the productivity and health of the workers and visitors that use these buildings. Therefore, the Federal government is committed to designing, locating, constructing, maintaining, and operating its facilities in an energy efficient and sustainable manner that strives to achieve a balance that will realize high standards of living, wider sharing of life's amenities, maximum attainable reuse and recycling of depletable resources, in an economically viable manner, consistent with Department and Agency missions. In doing so and where appropriate, we encourage the use of life cycle concepts, consensus-based standards, and performance measurement and verification methods that utilize good science, and lead to sustainable buildings.

As is the case with all federal agencies, the Air Force (AF) and other Department of Defense (DoD) components are already required to meet HPSB standards. DoD policy also requires the components to achieve LEED Silver (40 percent of the points in energy/water) for all new construction. These requirements alone set a fairly high standard. In addition, the Navy requires LEED Gold certification for

their applicable facilities beginning in FY13[1], and the Army moved forward and required compliance with certain sections of the new 2009 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 189.1, shortly after its release.

These developments resulted in the AF further evaluating the ASHRAE Standard 189.1. In particular, the US Air Force Center for Engineering and the Environment (AFCEE) wishes to know the incremental upfront construction cost of adhering to the new standard. ASHRAE Standard 189.1 is a high performance, sustainable building standard intended to conserve energy and water resources, make efficient use of natural light, encourage the use of renewable materials, and advance other sustainability goals. In its own words, ASHRAE Standard 189.1 provides a

> "total building sustainability package" for those who strive to design, build and operate green buildings. From site location to energy use to recycling, this standard sets the foundation for green buildings by addressing site sustainability, water use efficiency, energy efficiency, indoor environmental quality, and the building's impact on the atmosphere, materials and resources.

The intent of this evaluation is to identify aspects of ASHRAE Standard 189.1 that could be included in AF construction criteria. The results of this evaluation and other management factors will likely influence the degree to which the AF encourages or mandates compliance with this standard.

To facilitate the assessment, AFCEE tasked TEAM-IE/LMI to undertake case studies involving existing Air Force facilities or ones under construction. TEAM-IE/LMI conducted four such case studies, to see how construction costs at the facilities involved would have been impacted had they been built to conform to applicable sections of the ASHRAE Standard 189.1. This report describes how the case studies were performed and the results.

The four case studies were chosen to represent different types of facilities and different climate zones. They are:

1. Tyndall Fitness Center, Tyndall Air Force Base (AFB), FL (climate zone 2A: hot-humid)

2. C-17 Hangar, Travis AFB, CA (climate zone 3B: hot-dry)

3. HQ, AF Weather Agency, Offutt AFB, NE (climate zone 5A: cold)

4. FY09 Dormitory, Minot AFB, ND (climate zone 7A: very cold)

[1] "Navy Buildings Must be Certified Green Starting in Fiscal 2013, Top Official Says," *Environment Reporter*, Bureau of National Affairs, Vol. 42, No. 19, p. 1054.

In each case, TEAM-IE/LMI determined the incremental design or material requirements to meet ASHRAE Standard 189.1, estimated their cost, and totaled these for the facility. Note, however, that this study focused solely on incremental initial construction costs. Proper analysis of alternative sustainability standards requires life cycle cost and benefits analysis, which would have required greater depth of analysis and considerably more data than was immediately available. Further, the annual AF MILCON budget is limited and greater initial costs to achieve a sustainability standard imply fewer resources would be available to achieve other desirable building objectives.

The next chapter of this report lays out the approach in more detail. Subsequent chapters provide the results of our analysis for each of the four facilities. A final chapter summarizes our findings and conclusions.

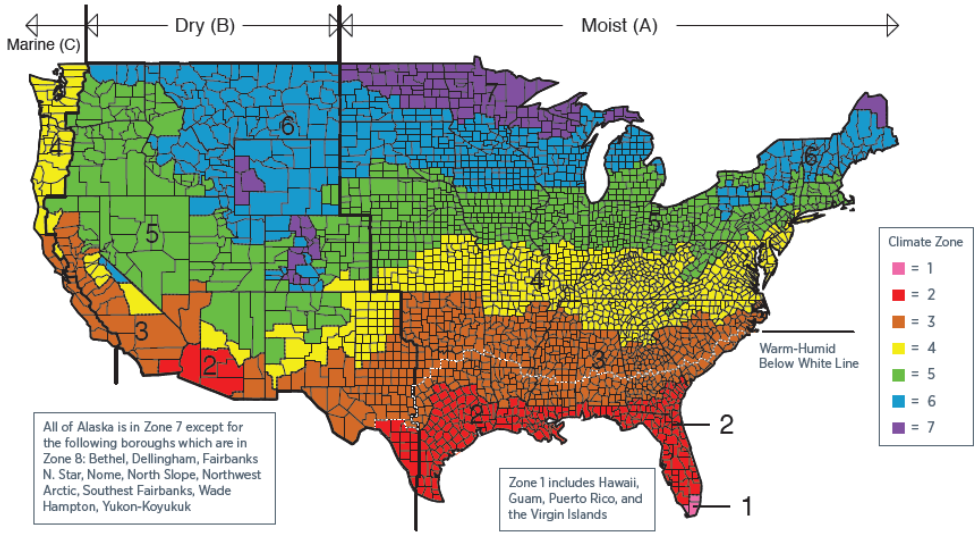
Chapter 2
Approach

FACILITY TYPES

The case studies herein involve four different facility types. At Offutt AFB, the weather agency headquarters is an office building with a large parking area surrounding it. The Tyndall AFB fitness center is a gymnasium along with an exercise room, dressing rooms, and a few offices. At Travis AFB, we analyzed an aircraft hangar, a large building with considerable open space and floor areas for tools and specialized repair work and a few offices. The building at Minot AFB is a dormitory with multiple living quarters for base personnel. In each case the question is the same: what additional up front or initial costs would have had to be borne to make this particular facility consistent with ASHRAE Standard 189.1?

CLIMATE ZONES

As mentioned in the Introduction, we selected the four case studies to represent different climate zones. The US Department of Energy (DOE) illustrates the eight climate and three moisture zones as follows:



The degree-day measurement is the difference in temperature between the mean (average) outdoor temperature over a 24-hour period and a given base temperature for a building space, typically 65°F. In terms of cooling degree days (CDD) and heating degree days (HDD), the thermal criteria zones are defined as follows:

ZONE NUMBER	THERMAL CRITERIA	
	IP Units	SI Units
1	9000 < CDD50°F	5000 < CDD10°C
2	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤ 5000
3A and 3B	4500 < CDD50°F ≤ 6300 AND HDD65°F ≤ 5400	2500 < CDD10°C ≤ 3500 AND HDD18°C ≤ 3000
4A and 4B	CDD50°F ≤ 4500 AND HDD65°F ≤ 5400	CDD10°C ≤ 2500 AND HDD18°C ≤ 3000
3C	HDD65°F ≤ 3600	HDD18°C ≤ 2000
4C	3600 < HDD65°F ≤ 5400	2000 < HDD18°C ≤ 3000
5	5400 < HDD65°F ≤ 7200	3000 < HDD18°C ≤ 4000
6	7200 < HDD65°F ≤ 9000	4000 < HDD18°C ≤ 5000
7	9000 < HDD65°F ≤ 12600	5000 < HDD18°C ≤ 7000
8	12600 < HDD65°F	7000 < HDD18°C

For SI: °C = [(°F)-32]/1.8.

The case studies here involve four climate zones as follows:

- Offutt AFB—Zone 5A
- Tyndall AFB—Zone 2A
- Travis AFB—Zone 3B
- Minot AFB—Zone 7A.

ASHRAE STANDARD 189.1

The ASHRAE Standard 189.1 details 72 primary requirements, which fall into six areas:

- Site sustainability
- Water use efficiency
- Energy efficiency
- Indoor air quality
- Impact on atmosphere, materials, and resources
- Construction and operation impacts.

Each area comprises numerous requirements, which can be met by following either the “prescriptive” or “performance” options that the standard specifies. A performance option allows for different ways to achieve a particular end result, while a prescriptive option describes a particular way that if followed will meet that part of the standard. However, analysis of performance standards would have required in-depth understanding of the relevant alternatives. Though investiga-

tions of these performance standards might have revealed instances in which less expensive means could have been used to accomplish a given objective, such investigations would have required more time and other resources than available to complete the study in timely fashion. Accordingly, the TEAM-IE/LMI analysis assumes that the AF follows the prescriptive options in each instance. The 72 primary requirements of ASHRAE Standard189.1 are the basis of comparison for all four case study sites we analyzed.

ALTERNATIVE STANDARDS

Though the AF does not presently require its buildings to meet ASHRAE Standard189.1, it adheres to other green building standards that present various degrees of rigor in their requirements. These include the federal government's High Performance and Sustainable Buildings (HPSB) Guiding Principles as stipulated by Executive Orders 13423 and 13514, DoD policy regarding building design, Unified Facilities Criteria (UFC), and the Leadership in Energy and Environmental Design (LEED) rating system as established by the US Green Building Council, ASHRAE 90.1 (a less restrictive standard than 189.1). Although not required by the AF, our analysis includes the International Green Construction Code, which is a model code being developed by the International Code Council focused on new and existing commercial buildings addressing green building design and performance.

Overall, LEED offers four certification levels (certified, silver, gold, and platinum) that are based on a point scoring system, to which certain building attributes affecting energy efficiency, water use efficiency, and other sustainable metrics contribute. In general, attaining the LEED Silver certification means that a building has met a good number of sustainability attributes, and attaining gold or platinum even more. The rating system, with a 1998 inception, was the first of its kind and is the foundation for most, if not all, related standards and guidelines. For example, the HPSB Guiding Principles and ASHRAE Standard189.1 took their shape from the LEED rating system which explains why there are so many similarities and overlaps exist. The AF, as part of the DoD, is required to comply with the Guiding Principle requirements, achieve LEED Silver certification for all new construction, and meet other green building requirements. This includes achieving 30 percent better energy efficiency and 40 percent water use reduction than is required by ASHRAE 90.1-2007 and LEED Silver, respectively. Current policy and compliance efforts drive the AF to site, design, construct and operate facilities that perform at or exceed industry standards.

When ASHRAE Standard 189.1 was under development, a goal was to design a standard that would result in facility that operates 30 percent more efficiently than one built to the 2007 ASHRAE Standard 90.1. A July 2010 evaluation of the ASHRAE Standard 189.1 by the National Renewable Energy Laboratory stated the following conclusions:

The energy impacts analysis of Standard 189.1-2009 is not overly complicated or detailed; rather, it is an order-of-magnitude analysis. Several conclusions, which would likely persist in a more detailed analysis, can thus be drawn from the results. The most important conclusions are:

- Standard 189.1-2009 goes much further in terms of energy savings over Standard 90.1-2007 than Standard 90.1-2007 does over its 2004 counterpart. This analysis shows that the weighted average savings seen in the former comparison are roughly 8 times those seen in the latter.
- Results vary significantly by building type.
- Except for hotels and warehouses, buildings in very cold climate zones (6A, 7, 8) show significantly higher savings than those in climate zones 1–5.
- About two-thirds of the savings of Standard 189.1-2009 over Standard 90.1-2007 come from energy efficiency measures, and about one-third from the renewable energy requirement in Standard 189.1-2009.
- Low-EUI sectors, such as offices and warehouses, show large energy savings because the 4.0 kBtu/ft^2 (45 MJ/m^2) renewable energy savings constitute a larger percentage of the total building EUI than for high-EUI sectors.
- Lodging buildings dominated by guest room space, as in the small hotel model, show significant additional savings. These savings come from the Standard 189.1-2009 requirements to setback lighting, plug loads, and HVAC when rooms are unoccupied.
- Healthcare buildings see smaller savings because medical plug loads constitute such a large portion of their energy consumption, yet standard methods for reducing their intensity (ENERGY STAR) have not been written.
- Generally, as Standard 189.1-2009 pushes the boundaries of efficiency for lighting and HVAC equipment, as well as some plug loads, the "other" process loads become more critical to a building's potential for energy savings. Future research needs to address these loads.

FOUR-STEP ANALYTIC PROCESS

Our analysis followed four steps. The first was to crosswalk the requirements of the ASHRAE Standard189.1with those of ASHRAE Standard 90.1 (2010 version), LEED requirements, the High Performance Sustainable Buildings (HPSB) Guiding Principles, DoD policy, UFC, and the International Green Construction Code (see Appendix A for the detailed crosswalk results). The idea was to isolate the ASHRAE Standard189.1 requirements that are more strict than those of all of the other green building standards.

The second step was to identify the incremental ASHRAE Standard189.1 requirements that apply at each of the facilities under study. This involved completing a detailed examination of facility specifications, design drawings, and LEED submission documents, and then comparing these to the ASHRAE Standard189.1 requirements to determine whether a facility already met or exceeded them. For each of the facilities, this resulted in a list of requirements that would entail a different design or added materials.

Step 3 was to develop cost estimates[1] for the requirements identified in step 2 that a particular facility did not meet. This step focused particularly on requirements thought to impose substantial costs. Some judgment was required, because ASHRAE Standard 189.1 contains many detailed specifications that exceed the other green building standards but would impose relatively small additional costs. To be sure about these, however, we undertook a number of cost investigations. For example, ASHRAE Standard 189.1 imposes a water closet flow standard of 1.28 gallons per flush (gpf), whereas the standard followed for the Offutt weather agency headquarters was 1.6 gpf. We determined that 1.28 gpf water closets are readily available in the same $100–$1,000 price range as the 1.6 gpf versions, and reasoned from this that any additional cost of the stricter requirement likely would have been low. More generally, since building construction costs in our four case studies ranged from $18 million to $25 million, we treated cost increments of less than $5,000 as minimal for our purposes.

However, some requirements deemed to have little to no cost may have resulted in programmatic changes at the installation - these were not considered since the intent of this study was to understand the first cost increase to these specific facilities. Those requirements affecting how entire programs are executed (e.g., energy, metering) are discussed in the conclusions, however if the facility meets the requirements then no cost was associated with that requirement.

We also looked to see whether some element other than cost might have prevented a particular building from meeting ASHRAE Standard 189.1. For example, in one case we found that the building orientation was such that it would not meet the standard, but we did not try to estimate what it would have cost to reorient the building in a different direction. In another, ASHRAE Standard 189.1 requires remote meter reading capability; however, while enhanced metering capability is required for new buildings, the AF currently is requesting a strategic pause in connecting new meters to existing remote meter reading systems due to security concerns and the pursuit of a standardized platform. This pause may make it temporarily impossible for a building to fully meet ASHRAE Standard 189.1.

[1] For most cost estimates we used 2011 RSMeans facility, interior, and mechanical construction data. For pavement and landscaping costs we used a combination of 2011 RSMeans and FY11 USACE unit cost factors. For RE we used cost factors based on Solar Power Authority data and Solar Panels Plus direct solar insolation data. For remote meters we primarily used equipment cost data from Submeter Solutions, Inc. Additional details are provided throughout this report.

The final step was to sum the incremental costs for full compliance with all requirements that we ascertained to be of relatively major importance. We compared that sum with the actual facility construction cost to express the increase as a percentage of the original construction cost. The results illuminate how this increase varies by the type of building, its location, and the standard already followed in its initial construction.

PREVIOUS WORK

We were unable to discover comparable studies of the incremental initial costs of meeting ASHRAE Standard189.1 vis a vis other green building standards. The closest was a two-sheet numerical analysis done for the US Army Corps of Engineers (USACE) that compared the energy and water system portions of ASHRAE Standard189.1 to those of the Energy Independence and Security Act of 2007 (EISA) 2007 (low energy model) for a single climate zone.[2] This analysis offered two alternative incremental costs: with and without a renewable energy component fulfilled by using a 30 kW photovoltaic (PV) system. Without such a system, the analysis showed a 3.0 percent increase in costs from a baseline of $6.5 million; with it, a 15.4 percent increase.

Those percentage increases are greater than the ones we found. One possible reason is the baseline used. All of the AF buildings studied herein attained at least LEED Silver certification, and in one case LEED Gold and in another LEED Platinum. With AF buildings starting from a higher level of sustainability, the incremental costs of achieving yet a higher standard may be less. Regardless, we have confidence in this report's findings based on our in-depth analysis of four projects with differing facility types and climate zones.

The costs shown for a PV system in the USACE analysis also are higher. We are uncertain as to the reason. We compared our costing method for PV systems against other data sources, however, and found that our estimates are generally similar to the other sources.

[2] "Comparison to ASHRAE 189.1 – TEMF (Site) Climate Zone 2A." Unpublished analysis.

Chapter 3
Offutt AFB Weather Agency Headquarters

BACKGROUND

The Offutt Air Force Weather Agency Headquarters (HQ) facility was constructed as a new single building for initial occupancy in 2008. It has three levels comprising 188,930 square feet (sq ft). The building footprint is 52,850 sq ft, and it sits on a property of 749,814 sq ft, a little over 17 acres. The building is scheduled for year-round occupancy for about 800 people.

The facility grounds contain 842 surface parking spaces. The project was able to take advantage of a previously built concrete aircraft runway for parking, thereby saving substantial costs.

Offutt AFB is about 10 miles south of Omaha in eastern Nebraska. The entire base comprises more than 4,000 acres and has 12,000 employees. Compared with the rest of the United States, the installation experiences average precipitation and sunlight, and more than average wind. It is in DOE climate zone 5A, which tends to be somewhat colder than average.

The cost of building the Weather Agency Headquarters, including site grading and preparation, was slightly over $27 million. In addition, $4 million was budgeted for furniture, fit-out, and equipment.

REQUIREMENTS THAT ADD SIGNIFICANT COST

As noted in Chapter 2, ASHRAE Standard 189.1 identifies 72 primary building requirements. Our analysis of the design specifications and LEED submission for the Offutt Weather Agency Headquarters facility indicated that it already exceeds or meets (or could meet with little or no incremental cost) 64 of those requirements. The last two columns of the spreadsheet in Appendix B explain these similarities. In addition, at the end of this chapter we summarize a number of instances where we assumed that even if the facility did not fully meet the ASHRAE Standard 189.1, it could have done so at minimal additional cost.

One reason why the facility already complied with many ASHRAE Standard 189.1 requirements is that it was built to achieve a LEED Gold certification. A building achieving LEED Gold can be expected already to have many features consistent with energy and water use efficiency and other sustainability measures.

The seven ASHRAE Standard 189.1 requirements that were not met needed additional analysis to determine what the incremental cost would have been to incorporate them into the final constructed facility. Table 3-1 summarizes these requirements.

Table 3-1. ASHRAE Standard 189.1 Requirements Needing Further Cost Analysis for Offutt Weather Agency Headquarters facility

Reference	Requirement summary	Type
5.3.2.1	Requires at least 50 percent of site hardscape (roads, sidewalks, courtyards, and parking lots of the building project) to be shaded or have high reflectivity	Mandatory
6.3.3	Extensive metering and submetering requirements and remote reading capabilities for both potable and reclaimed water	Mandatory
7.3.3.1, 7.3.3.2, 7.3.3.3	Requires consumption data recording with remote communication capabilities for electricity, gas, and district heat for main systems and some subsystems	Mandatory
7.4.1.1	Mandates on-site renewable energy systems with production of not less than 6.0 kBtu/sq ft., or 4 kBtu/sq ft if building equipment is Energy Star	Prescriptive
7.4.2.9	Provides fenestration orientation requirement based on formula $1/3(A_n*SHGC_N + A_s*SHGC_N + A_e*SHGC_N) \geq 1.1(A_wSHGC_N)$ $1/3(A_n*SHGC_N + A_s*SHGC_N + A_e*SHGC_N) \geq 1.1(A_wSHGC_N)$	Prescriptive
7.4.3.8	Requires exhaust air energy recovery systems with at least 60 percent energy recovery effectiveness	Prescriptive
9.4.1.3	Biobased products must make up at least 5 percent of the cost of the building materials	Prescriptive

The following sections provide additional detail on our assessment of each of these requirements.

Mitigation of Heat Island Effect - ASHRAE Standard 189.1, Section 5.3.2.1 Requirement

5.3.2.1 Site Hardscape. The *site hardscape* includes roads, sidewalks, courtyards and parking lots but not the constructed building surfaces and not any portion of the *site hardscape* covered by photovoltaic panels generating electricity or other *solar energy systems* used for space heating or water heating. At least 50 percent of the *site hardscape* shall be provided with one or any combination of the following:

a. existing trees and vegetation or new *bio-diverse plantings* of *native plants* and *adapted plants* located to provide shade within 5 years of issuance of the final certificate of occupancy. The effective shade coverage on the *hardscape* shall be the arithmetic mean of the shade coverage calculated at 10 a.m., noon, and 3 p.m. on the summer solstice.

b. paving materials with a minimum initial *SRI* of 29. This also applies to *porous pavers (open-grid pavers)* and *open-graded (uniform-sized) aggregate materials*. A default *SRI* value of 35 for new concrete without added color pigment is allowed to be used instead of measurements.

c. shading through the use of structures, provided that the top surface of the shading structure complies with the provisions of 5.3.2.3.

d. parking under a building, provided that the *roof* of the building complies with the provisions of 5.3.2.3.

e. buildings or structures that provide shade to the *site hardscape*. The effective shade coverage on the *hardscape* shall be the arithmetic mean of the shade coverage calculated at 10 a.m., noon, and 3 p.m. on the summer solstice.

Exception: *Building projects* in *climate zones 6*, *7*, and *8*.

ANALYSIS

The sidewalks and ramps at the facility are new concrete that has a default SRI of 35. Since this is greater than (>) 29, those components meet the standard. The 34,725 square yard (sq yd), 842-space parking lots are old concrete airfield runways that likely do not have an SRI >29. Accordingly the alternative means to bring that area into compliance would be to build a completely new concrete parking lot (assumes that the airfield pavement would not require demolition); build an underground parking garage; install trees to shade 50 percent of the existing parking lot (not viable, given existing 24-inch-thick reinforced concrete pad); install a completely new parking lot made of permeable pavers; or install a 2-inch-thick bonded overlay of fiber reinforced concrete over the existing parking

lot. Cost estimates for these alternatives are shown in Table 3-2 (see Appendix F for cost estimate details).

Table 3-2. Alternatives for Mitigating Heat Island Effect

Alternative	Estimated cost	Cost per parking space
New concrete parking lot	$1,225,422	$1,491
New parking garage	$15,408,600	$18,300
New permeable paver lot	$5,309,652	$6,306
Bonded 2-inch concrete overlay ($15.66/sq yd)	$543,794	$646

FINDING

In view of the foregoing, adding a 2-inch bonded overlay of fiber reinforced concrete would be the most cost-effective way to meet the requirement and also make use of the existing airport runways, with an incremental cost of about $544,000.

Water Consumption Measurement - ASHRAE Standard 189.1, Section 6.3.3 Requirement

6.3.3.1 Consumption Management. Measurement devices with remote communication capability shall be provided to collect water consumption data for the domestic water supply to the building. Both potable and reclaimed water entering the *building project* shall be monitored or submetered. In addition, for individual leased, rented, or other tenant or subtenant space within any building totaling in excess of 50,000 sq ft (5,000 sq meters), separate submeters shall be provided. For subsystems with multiple similar units, such as multi-cell cooling towers, only one meter is required for the subsystem. Any project or building, or tenant or subtenant space within a project or building, such as a commercial car wash or aquarium, shall be submetered where consumption is projected to exceed 1,000 gal/day (3,800 liters/day [L/day]).

Measurement devices with remote capability shall be provided to collect water use data for each water supply source (e.g., *potable water*, reclaimed water, rainwater) to the *building project* that exceeds the thresholds listed in Table 6.6.3A. Utility company service entrance/interval meters are allowed to be used.

Table 6.3.3A. Water Supply Source Meter Thresholds

Water source	Main metering threshold
Potable water	1,000 gal/day (3,800 L/day)
Municipally reclaimed water	1,000 gal/day (3,800 L/day)
Alternate sources of water	500 gal/day (1,900 L/day)

Provide submetering with remote metering to collect water use data for each of the following building subsystems, if such subsystems are sized above the threshold levels listed in Table 6.3.3B.

Table 6.3.3B. Subsystem Water Metering Thresholds

Subsystem	Sub-metering threshold
Cooling towers (meter on make-up water)	Primary flow through tower > 500 gpm (30 L/second)
Evaporative coolers	Makeup water > 0.6 gpm (0.04 L/second)
Steam and hot-water boilers	> 500,000 Btu/h (50 kW) input
Irrigated landscape area with controllers	> 25,000 ft 2 (2,500 m 2)
Separate campus or project buildings	Consumption > 1,000 gal/day (3,800 L/day)
Separately leased or rental space	Consumption > 1,000 gal/day (3,800 L/day)
Any large water-using process	Consumption > 1,000 gal/day (3,800 L/day)

6.3.3.2 Consumption Data Collection. All building meters, monitoring systems, and sub-meters installed to comply with the thresholds limits in 6.3.3.1 shall be configured to communicate water consumption data to a meter data management system. At a minimum, meters shall provide daily data and shall record hourly consumption of water.

6.3.3.3 Data Storage and Retrieval. The meter data management system shall be electronically storing water meter, monitoring systems, and submeter data; and creating user reports showing calculated hourly, daily, monthly, and annual water consumption for each measurement device and submeter and provide alarming notification capabilities as needed to support the requirements of the Water User Efficiency Plan for Operation in 10.3.2.1.2.

ANALYSIS

The existing facility incorporates a water meter with an electric contacting register and remote cumulative counter in each chiller makeup water line to provide input on water usage by the chemical treatment system. It also incorporates a domestic water service meter for the entire building. The meter is equipped with a pulse generator, remote readout register, and all necessary wiring and accessories for connection to the building Energy Modeling and Control System (EMCS).

In addition to the above metering, the standard would require installation of remote readout water meters on each of the two cooling towers and each of the three boilers. The cooling towers and boilers all have 10-inch cold water supply lines. Hence to comply with the standard would have required installation of five remote readout water meters in the 10-inch supply lines.

FINDING

A purchase price for water meters was available for a nearby state effective May 1, 2011. Those data reflect the cost of a 10-inch turbine water meter with a 10-inch bypass at $23,235 each, including installation (but not connection to a remote monitoring station). The five needed meters would have cost an estimated total of $116,175 (see Appendix F for cost estimate details).

Consumption Data Recording with Remote Communication Abilities for Electricity, Gas, and District Heat - ASHRAE Standard 189.1, Section 7.3.3.1, 7.3.3.2, and 7.3.3.3 Requirements

7.3.3.1. Consumption Management. Measurement devices with remote communication capability shall be provided to collect energy consumption data for each energy supply source to the building, including gas, electricity, and district energy, that exceeds the thresholds listed in Table 7.3.3.1A. The measurement devices shall have the capability to automatically communicate the energy consumption data to a data acquisition system.

Table 7.3.3.1A. Energy Source Thresholds

Energy source	Threshold
Electrical service	> 200 kVA
On-site renewable electric power	All systems > 1 kVA (peak)
Gas and district services	> 1,000,000 Btu/h (300 kW)
Geothermal energy	> 1,000,000 Btu/h (300 kW) heating
On-site renewable thermal energy	> 100,000 Btu/h (30 kW)

For all buildings that exceed the thresholds in Table 7.3.3.1A, subsystem measurement devices with remote capability (including current sensors or flow meters) shall be provided and shall measure energy consumption data of each subsystem for each use category that exceeds the thresholds listed in Table 7.3.3.1B.

Table 7.3.3.1.B. System Energy Use Thresholds

Use (total of all loads)	Subsystem threshold
HVAC system	Connected electric load > 100kVA
HVAC system	Connected gas or district services load > 500,000 Btu/h (150 kW)
People moving	Sum of all feeders > 50 kVA
Lighting	Connected load > 50 kVA
Process and plug process	Connected load > 50 kVA
Process	Connected gas or district services load > 250,000 Btu/h (75 kW)

The energy consumption data from the subsystem measurement devices shall be automatically communicated to the data acquisition system.

7.3.3.2. Energy Consumption Data Collection. All building measurement devices shall be configured to automatically communicate the energy data to the data acquisition system. At a minimum, measurement devices shall provide daily data and shall record hourly energy profiles. Such hourly energy profiles shall be capable of being used to assess building performance at least monthly.

7.3.3.3. Data Storage and Retrieval. The data acquisition system shall be capable of electronically storing the data from the measurement devices and other sensing devices, for a minimum of 36 months, and creating user reports showing hourly, daily, monthly, and annual energy consumption.

Exception: Portions of building used as *residential.*

ANALYSIS

Specification section 15951, paragraph 1.3.4, page 10, requires that the facility incorporate the existing Offutt AFB-wide EMCS/Heating, Ventilation and Air Conditioning (HVAC) Direct Digital Control (DDC) system, which is a Honeywell Excel 5000 System using programmable controllers and associated operating software. Specification section 15951, paragraph 1.3, page 8, requires installation of a DDC system to control the HVAC systems and all other building-level systems. Specification section 15195N, paragraph 2.5, page 8, requires a gas meter that conforms to ANSI B109.2 or B109.3. The meter must have a pulse totalizer for connection to EMCS, and the EMCS must indicate cubic feet of gas used.

Given the facility's design specifications, the only part of this requirement that applies is the additional installation of gas submeters that can be remotely connected to the EMCS for each of the three boilers. Based on the LEED submission documentation, average monthly gas usage does not exceed 25 tons per hour or 2,500 cubic feet per hour on any single boiler. Accordingly, per prices quoted on the Submeter Solutions, Inc. website (http://esubmeter.com/store) the 3,000 CFH Actaris Dattus Gas Meter w/Pulser (Model GMI-FM2-3M) meets the necessary specifications, at a cost of $2,586. If installation adds another $500, we could assume a purchase and installation cost of about $3,000 each, so that the total estimated cost for the gas meters would be $9,000.

FINDING

We treat this requirement as imposing an additional cost of $9,000 on the construction of the facility. As mentioned earlier, however, while advanced meters can be installed on new buildings, it currently is requesting a strategic pause in connecting new meters to existing remote meter reading systems due to security concerns and the pursuit of a standardized platform. Thus, aside from the incremental cost, the strategic pause may cause Offutt not to comply with this particular portion of ASHRAE Standard 189.1. Our interpretation of the design, however, is that it has sufficient remote meter reading capability within a Local Area Network (LAN) to meet the standard.

On-Site Renewable Energy Systems - ASHRAE Standard 189.1, Section 7.4.1.1 Requirement

7.4.1.1. On-Site Renewable Energy Systems. *Building projects* shall contain *onsite renewable energy systems* that provide the annual energy production equivalent of 4.0 kBtu/sq ft/yr (45 megajoulessq meter/yr) of *conditioned space*. The annual energy production shall be the combined sum of all *on-site renewable energy systems.*

Exception: Buildings that demonstrate compliance with both of the following are not required to contain *on-site renewable energy systems*:

1. An annual daily average incident solar radiation available to a flat plate collector oriented due south at an angle from horizontal equal to the latitude of the collector location less than 4.0 kWh/m^2/day, accounting for existing buildings, permanent infrastructure that is not part of the *building project*, topography, and trees, and

2. Purchase of renewable electricity products complying with the Green-e Energy National Standard for Renewable Electricity Products of at least 7 kWh/ft^2 (75 kWh/m^2) of conditioned space each year until the cumulative purchase totals 70 kWh/ft^2 (750 kWh/$m^{2)}$.

ANALYSIS

The federal government is required to purchase such Energy Star equipment where possible, so it is likely that the facility meets the requirement. Hence we assume the renewable standard at that facility would have required only 4 kBtu/sq ft/year.

There was no indication in the facility's project design of a free-standing flat plate solar collector facing due south, so we disregard the exception listed above.

There are several options for renewable energy supply, including geothermal, wind, waste to energy, and solar. To date, geothermal energy has not been exploited in Nebraska, though there are indications that resources may exist in the western part of the state. The use of geothermal energy at Offutt probably would require that geothermal energy is present under the base itself, something that has not been proven.

In an August 2010 study, the Pacific Northwest National Laboratory (PNNL) completed a feasibility study that evaluated potential application of biomass and waste to energy, wind, solar, and geothermal technologies at Offutt AFB. That study concluded that Offutt AFB had no potential economic opportunities for renewable energy projects, and recommended that the AF take no further action at that time.

Offutt AFB is in a fairly windy area, above the U.S. average, and it is conceivable that windmills could supply some if not all of the renewable energy requirement under ASHRAE Standard 189.1. However, windmills are not an attractive alternative for an Air Force base, because they can interfere with flight paths and radar readings and pose a degree of danger for aircraft. Hence we did not examine this option for Offutt further.

Waste to energy involves extracting methane from waste sites to power the production of steam for generating electricity, or the direct burning of waste for this purpose. This option is renewable to the extent that waste itself is continuously regenerated, but we do not have data on the waste stream at Offutt nor how much of it would be suitable for this application.

Instead, we investigated the use of photovoltaic cells for the facility. This option involves a renewable resource and a readily applicable technology. As with the other ASHRAE Standard 189.1 requirements, however, we investigated only the upfront costs, not those of maintenance nor the net returns.[1]

The first step was to calculate the amount of PV cells necessary to meet the Btu requirement, given that 1 watt = 3.4 Btu. This equivalence implies that it is necessary to produce 1.18 kW of power per square foot of conditioned space annually. The facility contains more than 188,000 sq ft. of building space. The number was rounded to 188,000 to account for loading docks or the like that would not be conditioned space. Thus, to meet the standard would require 221,184 kW of power annually.

According to one reference (see footnote link), PV cell power production capacity is about 10 W/sq ft.[2] Nebraska averages about 4.5 hours of useable sunlight per day,[3] so a square foot of PV cells can produce 10 watts × 4.5 hrs × 365 days = 16,425 watts of power per year, or 16.425 kW. To meet the requirement, Offutt would have needed 13,466 sq ft of PV cells.

The next step was to estimate the installed cost of PV. This cost currently ranges up to about $9/watt, but may be lower with large-scale installation. To be conservative, we assumed a cost of $8/watt in the case of the facility, yielding an installed cost of $80/sq ft.

[1] Evidently no renewable energy source was found to be cost-effective at Offutt. A cursory analysis of PV cells at Offutt indicated that at their present cost the payback period would be a few decades.

[2] http://solarpowerauthority.com/how-much-does-it-cost-to-install-solar-on-an-average-us-house/.

[3] Solar Panels Plus, “Solar Direct Insolation Chart,” http://www.solarpanelsplus.com/solar-panels/large-insolation-map.html.

FINDING

Given the cost per square foot, the total cost of solar PV at the Offutt Weather Agency Headquarter facility would have been about $1,077,300. This is about 4 percent of the total realized cost of construction. In other words, had the ASHRAE Standard 189.1 requirement for 4 kBtu/sq ft/yr been met through this approach, building construction costs would have been more than $1 million, or about 4 percent, higher than they were.

Had building equipment not met Energy Star standards, this additional cost would have been 50 percent higher, or about $1,616,000. However, as noted earlier, the facility very likely qualified because of the federal government's Energy Star requirement; in any case it would have been cheaper to purchase Energy Star facility equipment than to add another $500,000 in construction cost.

Fenestration Orientation - ASHRAE Standard 189.1, Section 7.4.2.9 Requirement

7.4.2.9. Fenestration Orientation. To reduce solar gains from the east and west in *climate zones 1 through 4* and from the west in *climate zones 5 and 6* the *fenestration area* and *SHGC* shall comply with the following requirements:

a. For *climate zones 1, 2, 3, and 4*:

$$(A_N*SHGC_N + A_S*SHGC_S) \geq 1.1*(A_E*SHGC_E + A_W*SHGC_w)$$

b. For *climate zones 5 and 6*:

$$1/3*(A_N*SHGC_N + A_S*SHGC_S + A_E*SHGC_E) \geq 1.1*(A_W*SHGC_W)$$

where:

$SHGC_x$ = the *SHGC* for orientation x
A_x = *fenestration area* for orientation x
N = north (oriented less than 45 degrees of true north)
S = south (oriented less than 45 degrees of true south)
E = east (oriented less than or equal to 45 degrees of true east)
W = west (oriented less than or equal to 45 degrees of true west)

ANALYSIS

The facility design shows its front to be oriented 324 degrees from north, or facing northwest. The design drawings identify the west side as the front of the building.

We obtained window areas from the design specifications, as follows:

Table 3-3. Weather Agency Headquarters Facility Window Area

Building face	Estimated total window area (sf)
North	2,525
South	2,400
East	1,665
West	5,925

Applying the first of the above formulas, and assuming SHGC is a constant equal to 0.26 for all windows, the left side would equal 1,280.5, the right side 2,170.7. Thus, the facility does not meet this requirement.

FINDING

If the window areas were to stay as they are, then it appears that the requirement could have been met by rotating the building to face in another direction, e.g., to the south. It may be that the facility was oriented as it was to take maximum advantage of the preexisting airport runway, or perhaps for aesthetic purposes. In any case, we do not estimate a cost of orienting the building differently from what was done.

Exhaust Air Energy Recovery - ASHRAE Standard 189.1, Section 7.4.3.8 Requirement

7.4.3.8 Exhaust Air Energy Recovery. Each fan system shall have an energy recovery system when the system's supply air flow rate exceeds the value listed in Table 7.4.3.8 based on the climate zone and percentage of *outdoor air* at design conditions. Where a single room or space is supplied by multiple units, the aggregate supply cfm (L/s) of those units shall be used in applying this requirement.

Energy recovery systems required by this section shall have at least 60% energy recovery effectiveness. Sixty percent energy recovery effectiveness shall mean a change in the enthalpy of the *outdoor air* supply equal to 60 percent of the difference between the *outdoor air* and return air enthalpies at design conditions. Provisions shall be made to bypass or control the energy recovery device to permit air economizer operation as required by Section 7.4.3.4.

Table 7.4.3.3. Energy Recovery Requirement

Energy Recovery Requirement (I-P)								
Zone	% Outside Air at Full Design Flow							
	≥10% and <20%	≥30% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Flow (cfm)							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	≥5,000	≥5,000
1B, 2B, 5C	NR	NR	NR	NR	≥26,000	≥12,000	≥5,000	≥4,000
6B	NR	≥22,500	≥11,000	≥5,500	≥4,500	≥3,500	≥2,500	≥1,500
1A, 2A, 3A, 4A, 5A, 6A	≥30,000	≥13,000	≥5,500	≥4,500	≥3,500	≥2,000	≥1,000	≥0
7.8	≥4,000	≥3,000	≥2,500	≥1,000	≥0	≥0	≥0	≥0
Energy Recovery Requirement (SI) (For Zone 5A only)								
Zone	% Outside Air at Full Design Flow							
	≥10% and <20%	≥30% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Flow (cfm)							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	≥2,360	≥2,360
1B, 2B, 5C	NR	NR	NR	NR	≥12,271	≥5,663	≥2,360	≥1,888
6B	NR	≥10,619	≥5,191	≥2,596	≥2,124	≥1,652	≥1,180	≥708
1A, 2A, 3A, 4A, 5A, 6A	≥14,158	≥6,135	≥2,596	≥2,124	≥1,652	≥944	≥472	>0
7.8	≥1,888	≥1,416	≥1,180	≥472	>0	>0	>0	>0

Note: NR=not recommended

ANALYSIS

One way to meet this requirement is to run cold water and air flow lines through the heat exhaust system, thus heating the water and air and relieving the HVAC system of a portion of its load. However, the facility was not designed to recover heat in this way. An alternative is to install energy and heat recovery ventilators to recover the escaping heat. From the design specifications, we calculated that total exhaust air would be as follows:

Table 3-4. Building Exhaust Riser Aggregate Flow Rates

Riser	Calculated total exhaust flow rate (cfm)
South	6,070
North	8,735
East	4,640
Auditorium	855

We obtained unit cost data from 2011 RSMeans Facility Construction Data for heat recovery ventilators, page 383. The numbers represent installed costs and so include ancillary equipment. Costs were $7,575 for a 1,000 cfm system and $15,900 for a 10,000 cfm system.

FINDING

The facility would require one 1,000 cfm and three 10,000 cfm systems to fully capture the exhaust heat. The installed cost to meet the requirement if done in this way would be $15,900 × 3 + $7,575 × 1 = $55,275. We round this to $55,000 for purposes of this analysis.

Use of Renewable Construction Materials - ASHRAE Standard 189.1, Section 9.4.1.3 and 9.4.1.3.1 Requirement

9.4.1.3 Biobased Products. A minimum of 5 percent of building materials used, based on cost, shall be *biobased products*. *Biobased products* shall comply with the minimum biobased contents of the USDA's Designation of Biobased Items for Federal Procurement, contain the "USDA Certified *Biobased Product*" label, or be composed of solid wood, engineered wood, bamboo, wool, cotton, cork, agricultural fibers, or other biobased materials with at least 50 percent biobased content.

ANALYSIS

Per the USDA's BioPreferred Program product categories listing, the two principal biobased products for building construction are wood (used for panels, doors, acoustical protection, flooring, etc.) and soy-based foam insulation. Of the two, wood imposes a lower incremental cost and is more likely to be used to fulfill the requirement.

For building construction, wood is considered more expensive than steel because of the labor cost of installation. Overall, wood appears to be about 20 percent more expensive, though this varies with the particulars of a project.[4] Also, the incremental cost of ASHRAE Standard189.1 in this instance would depend on the type of wood already planned for the project. Project design plans specify some wood content for the roof, and it is plausible that many interior doors and cabinets would be made of wood as well. Thus, at most this ASHRAE Standard 189.1 requirement would have added a 1 percent cost increment for building materials (20 percent more costly × 5 percent of building costs), or about $120,000. We note, however, that since wood frame construction is generally not allowed, meeting this requirement will be a continuing challenge.

FINDING

After subtracting wood already contained in ceiling joists, interior doors, and other building components, we believe the cost increment likely would have been considerably less than 1 percent of building materials. However, because we do not have data for estimating the number precisely, we are assuming half of $120,000, or $60,000, for rough estimation purposes. This amount is included in summary Table 3-6 below.

REQUIREMENTS THAT ADD MINIMAL COST

Our analysis found that the facility already met many of the ASHRAE Standard 189.1 requirements, probably because the facility was built to meet the LEED gold standard as well as other green building standards. In addition, we identified a number of requirements which we assume the building could have met at minimal additional cost. These are shown in Table 3-5. In each case we identify the requirement and explain why, even if not fully met, it would have added little to costs.

Table 3-5. Requirements That Add Minimal Cost

ASHRAE Standard189.1 requirement	Assumption
5.3.2.2. - 30 percent of walls must be shaded on east and west of building based on shade angle at 10 and 3 on summer solstice.	Assuming it would not violate existing architectural compatibility regulations, this requirement can be met by simply choosing outside wall color/material with SRI ≥ 29. We assume minimal cost. However, if certain colors are forbidden or required at Offutt such that SRI ≥ 29 cannot be attained, a more expensive solution would be necessary.

[4] http://www.selfstoragetalk.com/construction-development-financing/233-steel-vs-wood-frame-construction.html.

Table 3-5. Requirements That Add Minimal Cost

ASHRAE Standard189.1 requirement	Assumption
6.3.2 - requires 50 percent water use reduction in plumbing fixtures; the building complies but uses 1.6 gpf water closets, while ASHRAE Standard 189.1 requires 1.28 gpf.	Both 1.6 gpf and 1.28 gpf water closets are readily available in the $100–$1,000 cost range. Therefore we assume that the more efficient ones could have been installed at little or no additional cost.
6.6.3 - Extensive water metering and submetering requirements and remote reading capabilities cover both potable and reclaimed water.	Design specifications indicate the requirement has been met. However, for security reasons, USAF policy is not to utilize remote meter reading capability. This could prevent the Weather Agency Headquarters facility or other buildings from fully meeting ASHRAE Standard 189.1.
7.4.2.5 - Requires that vertical fenestration on west, south, and east sides be shaded by permanent projections in some climate zones.	Per the LEED submission, windows have sun shades, light shelves, and high-efficiency window glazing that reduces energy use by 50 percent. We assume this combination meets the ASHRAE Standard 189.1.
7.4.4 - Requires compliance with ASHRAE 90.1 plus additional requirements regarding water heating system efficiency and insulation.	Design specifications indicate small instantaneous electric heaters and several 30 gal electric heaters, all at point of use. This meets energy efficiency ratings of ASHRAE 90.1. We assume this fulfills the requirements of ASHRAE Standard189.1.
7.4.5.1 - Mandates automatic load reduction of at least 10 percent for all building projects during peak load times.	All electrical systems are connected to the EMCS and can be controlled from there. We assume it can be programmed to achieve a 10 percent reduction when needed.
8.3.1.5 - Entry mats are required at all regularly used entrances.	We assume that additional entry mats, if required, could be secured at minimal cost.
8.3.3 - Building projects should meet exterior and interior acoustical controls.	Building specs require STC 48 and 50 wall insulation and acoustical ceiling tiles with minimum ceiling attenuation class of 30. We assume these enable the facility to meet the ASHRAE Standard 189.1.
8.4.1.1 - Sets minimum effective aperture area for day lighting for office spaces and classroom.	Specification requires that insulated glass have 41 percent visible light transference rating. Windows make up at least 40 percent of outside wall area on west face, so the effective aperture is at least 0.16. However, the window area on other walls is less than 40 percent, so effective apertures will be less than the 0.15 required by ASHRAE Standard189.1. We assume that increasing the window area on those walls would have increased construction cost little, if at all.
10.3.2.3 - Mandates service life plan for structural, building envelope, and hardscape materials and a transportation management plan with varying mandates based upon ownership or leasing arrangements.	These plans do not exist, but could have been put together by building staff and presumably would not be very costly to produce.

Table 3-5. Requirements That Add Minimal Cost

ASHRAE Standard189.1 requirement	Assumption
9.4.1.3.1 - Certified wood must make up at least 60 percent of total wood used in the project.	Certified wood appears to impose a small price premium over regular wood. One source indicates that certified wood companies have been able to obtain a premium of about 5 percent in the United States.[a] The requirement is that 60 percent of wood product be made up of certified wood, so at most this requirement would add 0.03 percent to the cost of building materials (60% × 5% × 1%).

[a] http://www.californiagreensolutions.com/cgi-bin/gt/tpl.h,content=1849.

We assume for each of these 11 requirements that they could be met at minimal cost not to exceed $5,000. We note, however, that collectively this could amount to almost $55,000, which is a significant additional cost that should be added to the overall incremental cost estimate.

CONCLUSION

Table 3-6 summarizes our estimate of the total additional costs to build Offutt Weather Agency HQ facility to ASHRAE Standard 189.1. As shown there, our estimate of the total cost is about $1.92 million, or roughly 7 percent of the $27 million total cost of construction. Of this, by far the biggest element is the cost of renewable energy production, which alone would have added about 4 percent. The next biggest cost pertains to the reflectivity of the parking area, which would have added $544,000, or about 2 percent. Various other requirements would have added another 1 percent or so. The building did not meet a fenestration orientation requirement, but we did not attempt to estimate the cost, if any, of orienting the building in a different direction.

Table 3-6. Summary of Additional Costs at Offutt Weather Agency Headquarters Facility Imposed by ASHRAE Standard189.1

Requirement	Summary	Added cost
5.3.2.1	Requires at least 50 percent of site hardscape (roads, sidewalks, courtyards and parking lots of the building project) to be shaded or have high reflectivity.	$544,000
6.3.3	Extensive metering and submetering requirements and remote reading capabilities cover both potable and reclaimed water.	$116,000
7.3.3.1, 7.3.3.2, 7.3.3.3	Requires consumption data recording with remote communication capabilities for electricity, gas, and district heat for main systems and some subsystems.	$9,000
7.4.1.2	Mandates on-site renewable energy systems with production of not less than 6.0 kBtu/sq ft.	$1,077,000

Table 3-6. Summary of Additional Costs at Offutt Weather Agency Headquarters Facility Imposed by ASHRAE Standard189.1

Requirement	Summary	Added cost
7.4.3.8	Requires exhaust air energy recovery systems with at least 60 percent energy recovery effectiveness.	$55,000
9.4.1.3	Biobased products must make up at least 5 percent of the cost of the building materials.	$60,000
Various	Aggregate “minimal cost” requirements.	$55,000
Total additional cost		$1,916,000
Increase over base cost of $27 million		7.1%

Chapter 4
Tyndall AFB Fitness Center

BACKGROUND

Tyndall Air Force Base is about 12 miles east of Panama City on the panhandle of northwest Florida. The land area of the base is about 15 square miles.

The Tyndall Fitness Center, completed in 2010, comprises 72,666 sq ft of building space and a footprint of 60,360 sq ft. The property that includes the fitness center is 379,276 sq ft, or about 8.7 acres. The building is occupied about 100 hours per week, or roughly 60 percent of the time.

The facility's cost was $18 million, not counting furniture and other equipment installed within the building. The building is in DOE climate zone 2A, a warm-humid weather zone, which reduces heating requirements relative to the US average but increases cooling requirements, especially because the fitness center was built to promote strenuous physical exertion within its confines.

The center was built to attain a LEED Platinum certification, the highest level awarded under the LEED rating system—implying that it contains many features to promote efficient use of energy and water, take advantage of light and other natural resources, make more efficient use of heat and cooling, etc. Because of this, the additional cost of meeting ASHRAE Standard 189.1 requirements could be expected to be less than that of a comparable type of building in a similar climate zone that meets a less demanding green building standard.

REQUIREMENTS THAT ADD SIGNIFICANT COST

Table 4-1 below lists the ASHRAE Standard 189.1 requirements that were not met in the Tyndall facility's construction and would have a noticeable effect on up-front construction costs.

Table 4-1. ASHRAE Standard 189.1 Requirements with Cost Implications at Tyndall Fitness Center

Reference	Requirement summary	Type
5.3.2.1	Requires at least 50 percent of site hardscape (roads, sidewalks, courtyards and parking lots of the building project) to be shaded or have an SRI ≥29	Mandatory
7.4.1.1	Mandates on-site renewable energy systems with production of not less than 4.0 kBtu/sq ft (with additional requirements for Energy Star)	Prescriptive
8.3.4	Mandates minimum daylighting by toplighting for buildings 3 stories or less	Mandatory

Mitigation of Heat Island Effect - ASHRAE Standard 189.1, Section 5.3.2.1 Requirement

This requirement specifies shading or high reflectivity of the paved surfaces associated with a new building (parking lots, walkways, etc.). It is explained in its entirety in Chapter 3, because it applies also at the Offutt AFB Weather Agency Headquarters facility.

ANALYSIS

The parking area at Tyndall consists of new construction (165 new parking places for cars, 21 for motorcycles) and 101 preexisting parking places in two segments that originally were to be removed but instead were kept for fitness center patrons. Our cost estimate for meeting ASHRAE Standard 189.1 treats the two areas separately.

Several options would have been available to meet the standard for the new parking area, including shade trees, a new parking structure with an SRI $\geq$ 29, an asphalt base with a bonded concrete overlay, a concrete lot, or stone pavers. By far the least expensive means of achieving the standard for this area would have been shade trees. We assume the use of American sycamore, laurel oak, or live oak, because these are native to Florida. Of them, sycamores grow the most rapidly but thrive best around water. Oaks grow more slowly and so would have to be bigger to provide the necessary shade within the prescribed time. We estimate that 40 trees 10 feet tall would have been sufficient, and that the installed cost of such trees is $700 per tree, for a total cost of $28,000.

Modification to the existing parking area also must be considered. For that area there are two options: (1) lay a bonded concrete overlay on the existing asphalt or (2) plant sufficient trees around the lot to meet the standard. The estimated cost of

bonded overlay is $15.66 per sq yd[1]. We estimate a space requirement of 34 sq yds per parking space, or 3,434 sq yd for 101 spaces. Hence the cost of this alternative would have been around $54,000. Alternatively, we estimate that 24 newly planted trees 10 feet tall would have been sufficient to meet the standard. This alternative would have cost around $17,000 (see Appendix F for cost estimate details).

FINDING

We assume the least expensive method would have been used for each segment of the parking lot—planting shade trees. The total estimated cost of meeting the ASHRAE Standard189.1 requirement would have been about $45,000.

On-Site Renewable Energy Systems - ASHRAE Standard189.1, Section 7.4.1.1 Requirement

As explained in Chapter 3, ASHRAE Standard189.1 requires building projects to have on-site renewable energy systems that provide the annual energy production equivalent of 4.0 kBtu/sq ft/yr for conditioned space. An exception applies if certain minimum amounts of renewable energy are produced via a flat plate collector facing due south and purchased off-site from renewable sources. Chapter 3 discusses this requirement in its entirety.

ANALYSIS

In a July 2010 study, the Pacific Northwest National Laboratory (PNNL) completed a feasibility study that evaluated potential application of biomass and waste to energy, wind, solar, and geothermal technologies at Tyndall AFB. That study concluded that Tyndall AFB has good potential for a waste-to-energy project utilizing MSW, biomass, or a combination of the two, further noting that while regional MSW may not be available, biomass appears to be, and the opportunity merits further investigation. Only one WTE or biomass plant is needed to produce sufficient electricity to supply Tyndall's demand.

The recommended next steps included continuing discussions regarding a small-scale demonstration project, starting discussions with regional authorities to determine availability of MSW and biomass, and talking with installation personnel to gain internal support and educate key players about the potential projects. PNNL further recommended that each project be re-evaluated for economic feasibility once the additional data are collected, and new paths forward should then be determined.

[1] Cost estimate is based on FY11 USACE unit cost factors for concrete pavement adjusted to include surface preparation of the existing pavement.

Tyndall Fitness Center's original plans did not include renewable energy production onsite as defined for purposes of ASHRAE Standard 189.1. These plans did feature a solar hot water heater system installed on the roof and a chiller heat recovery system as the primary sources of hot water for the building, with an electrical resistance heating coil as the fail-safe backup.

The original building plans indicated that the facility intended to purchase at least 70 percent of its power from renewable sources. The solar water heating and chiller heat recovery systems reduce the facility's electric bill, but they do not produce renewable energy. While the renewable power purchase might have been sufficient to trigger an exception to the onsite production requirement, the plans showed no indication of installation of a flat plate solar energy collector facing due south.

On the other hand, Tyndall later modified its building plan to incorporate the installation of solar photovoltaic cells on its roof. According to the design modifications, a grid-connected PV system consisting of 30 kW of roof-mounted amorphous silicon laminate film was installed, which fulfills a portion of the ASHRAE Standard 189.1 requirement.

The facility would have to install sufficient solar photovoltaic cells to achieve the full ASHRAE Standard 189.1 requirement of 4 kBtu/sq ft/yr for conditioned space. The fitness center contains 72,666 square feet of conditioned space, which means it would have to generate 85,746 kW of renewable power annually to meet the standard.

PV cell power production capacity is about 10 W/sq ft.[2] the facility was built to include 30 kW of capacity, and about 3,000 sq ft of roof space was used for that purpose. Roof space was also used for the solar hot water system, but the building's effective roof area is more than 40,000 sq ft, so there should have been plenty of room to house both.

The installation's location in the Florida panhandle averages about 4.5 hours of useable sunlight per day,[3] so a square foot of PV cells can produce 10W × 4.5 hrs × 365 days = 16,425 watts of power per year, or 16.425 kW/yr.[4] To meet the ASHRAE Standard 189.1 requirement, Tyndall would have to install 5,220 sq ft of PV cells.

[2] http://solarpowerauthority.com/how-much-does-it-cost-to-install-solar-on-an-average-us-house/.

[3] Solar Panels Plus, "Solar Direct Insolation Chart," http://www.solarpanelsplus.com/solar-panels/large-insolation-map.html.

[4] The LEED submission for the fitness center (p. 861) contains a table asserting that a square meter of PV cells can produce about 5kW/day at the site. This is clearly erroneous. At that rate, PV cells would return their capital investment within 5 years, and it would be economical for private as well as public entities to invest in such cells without subsidy. That particular calculation is off by a factor of 10.

FINDING

We assume an installed cost of $8/watt, so the installed cost would be $80/sq ft. At this cost per square foot, the total cost at the fitness center would have been about $417,636. After subtracting the cost for the PV cells already in place, the incremental cost to meet the standard would be $177,600. This is about 1.0 percent of the total realized cost of building the facility.

Daylighting by Toplighting - ASHRAE Standard 189.1, Section 8.3.4 Requirement

8.3.4 Daylighting by Toplighting. There shall be a minimum *fenestration area* providing daylighting by *toplighting* for large enclosed spaces. In buildings 3 stories and less above grade, conditioned or unconditioned enclosed spaces that are greater than 20,000 ft^2 (2,000 m^2) directly under a *roof* with finished ceiling heights greater than 15 ft (4 m) and that have a *lighting power allowance* for general lighting equal to or greater than 0.5 W/ft^2 (5.5 W/m^2) shall comply with the following:

Exceptions to 8.3.4:

1. Buildings in *climate zones 7* or *8*.
2. Auditoria, theaters, museums, places of worship, and refrigerated warehouses.

8.3.4.1 Minimum Daylight Zone by Toplighting. A minimum of 50 percent of the floor area directly under a *roof* in spaces with a lighting power density or *lighting power allowance* greater than 0.5 W/ft^2 (5.5 W/m^2) shall be in the *daylight zone.* Areas that are daylit shall have a minimum toplighting area to daylight zone area ratio as shown in Table 8.3.4.1. For purposes of compliance with Table 8.3.4.1, the greater of the space lighting power density and the space *lighting power allowance* shall be used.

Table 8.3.4.1. Minimum Toplighting Area

Lighting Power Density or Lighting Power Allowances in Daylight Zone W/ft2 (W/m2)	Minimum Toplighting Area to Daylight Zone Area Ratio
1.4 W/ft2 (14 W/m2) < LPD	3.6%
1.0 W/ft2 (10 W/m2) < LPD < 14 W/m2 (1.4 W/ft2)	3.3%
0.5 W/ft2 (5 W/m2) < LPD < 1.0 W/ft2 (10 W/m2)	3.0%

8.3.4.2 Skylight Characteristics. *Skylights* used to comply with 8.3.4.1shall have a glazing material or diffuser that has a measured haze value greater than 90%, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the *AHJ*.

Exceptions:

1. *Skylights* with a measured haze value less than or equal to 90% whose combined area does not exceed 5% of the total *skylight* area.
2. *Tubular daylighting devices* having a diffuser.
3. *Skylights* that are capable of preventing direct sunlight from entering the occupied space below the well during occupied hours. This shall be accomplished using one or more of the following:
    a. orientation.
    b. automated shading or diffusing devices.
    c. diffusers.
    d. fixed internal or external baffles.
4. Airline terminals, convention centers, and shopping malls.

ANALYSIS

ASHRAE Standard 189.1 specifies that buildings of 3 stories or less must have certain minimum ratios of toplighting area relative to daylight zone area. Though the Tyndall fitness center is only 1 story over most of its area, it is a very high story, higher than many buildings of 4 stories or more. Nevertheless, we conclude that the requirement applies.

Determining the daylight zone area to make the necessary calculation would involve projecting the skylight footprint to the floor below, measuring out from all four sides of the skylight footprint a distance equal to 0.7 times the height from floor to ceiling, and then calculating the ratio as the skylight footprint area divided by the area of the larger footprint.

We did not have the data to apply this approach, so we used an alternate method. The Tyndall building has an average lighting power allowance of 0.55 watts per sq ft. Per ASHRAE Standard 189.1, this implies a minimum toplighting area to daylight zone area ratio requirement of 3.0 percent. The facility's LEED documentation indicates that rooftop skylighting through the roof structure provides indirect solar lighting in the gymnasium, group training rooms, and main lobby areas, with a total skylight-roof ratio of 2.8 percent. For this alternative approach, we assume the skylight-roof ratio is roughly equivalent to the toplighting area to

daylight zone area ratio. Given that, the 2.8 percent skylight-roof ratio at Tyndall is a little less than the ASHRAE requirement.

Per RSMeans 2011 Interior Cost Data, page 154, line item 2300 (Insulated Safety Glass with Aluminum Frame), the cost of skylighting is $98.60/sq ft installed. The effective roof area is 40,210 sq ft, and 3 percent of that equals 1,206 sq ft. The existing skylights comprise 1,134 sq ft, leaving a shortcoming of 72 sq ft. At $98.60/sq ft, the cost to upgrade the fitness center skylights to the ASHRAE Standard 189.1 would have been about $7,000.

FINDING

Our estimate of $7,000 is only approximate, because we did not have sufficient data concerning roof heights and other factors to precisely calculate the additional daylighting that might be needed. However, in the context of an $18 million project, inexactitude of a few thousand dollars is inconsequential.

REQUIREMENTS THAT ADD MINIMAL COST

As discussed above, we found that the Tyndall fitness center differed with the ASHRAE Standard 189.1 standard on only three requirements that would add noticeable costs. In addition, we identified three instances where the facility did not comply but could have done so at minimal additional cost. These are shown in Table 4-2. In each case we identify the requirement and explain why it would have added little to costs.

Table 4-2. Requirements That Add Minimal Cost

ASHRAE Standard 189.1 requirement	Assumption
5.3.2.2 - Requires 30 percent of walls to be shaded on east and west of building, based on shade angle at 10 and 3 on summer solstice.	Windows have awnings to provide shade, but not for 30 percent of wall area. Assuming it would not violate existing architectural compatibility regulations, the fitness center could have simply chosen an outside wall color or material with SRI ≥ 29, at minimal cost.

Table 4-2. Requirements That Add Minimal Cost

8.3.3 - Building projects should meet exterior and interior acoustical controls.	The fitness center windows meet the exterior envelope acoustical standard, and we assume the rest of the structure's exterior also meets it. The interior standard requires a sound transmission class (STC) rating ≥ 50 for wall and floor-ceiling assemblies. The center's design specifications include attenuators over light fixtures and other ceiling penetrations; acoustical blanket insulation adjacent to partitions and acoustical panels with minimum STC = 40; and partitions with minimum STC = 42. The insulation, joint sealing, roof, masonry, and other specifications suggest the STC requirement for the building envelope probably is met. If not, more expensive building tiles or wallboard would have been required, but given the small number of interior offices, the total cost would have been minimal.
10.3.2.3 - Mandates a service life plan for structural, building envelope, and hardscape materials. Also mandates a transportation management plan, with varying requirements based upon ownership or leasing arrangements.	These plans appear not to exist but could easily have been prepared in-house at minimal cost.

There is one other consideration. We assume that the fitness center met the ASHRAE Standard 189.1 metering and submetering remote reading requirements for electricity, gas, and water by using connections to a LAN. However, as mentioned earlier, while advanced meters can be installed on new buildings, the AF has ordered a strategic pause in connecting new meters to existing remote meter reading. If the connections at the facility were insufficient to meet the ASHRAE Standard 189.1 then the standard probably could not be completely met while the pause is in place.

CASE STUDY CONCLUSION

As shown in Table 4-3, building the Tyndall fitness center to ASHRAE Standard 189.1 requirements would have increased costs by only about 1.3 percent. Of this the renewable energy requirement accounts for 1.0 percent.

Because the facility was built to LEED Platinum standards, this result is not entirely surprising. However, as mentioned above, if the AF strategic pause on remote reading of onsite electricity, gas, and water meters for new buildings would have prevented the fitness center from completely fulfilling that aspect of the standard, then even with this relatively small cost increase the facility still would not have reached full compliance.

Table 4-3. Summary of Additional Costs at Tyndall Fitness Center Imposed by ASHRAE Standard 189.1

Requirement	Summary	Added cost
5.3.2.1	At least 50 percent of site hardscape (roads, sidewalks, courtyards, and parking lots of the building project) must be shaded or have high reflectivity.	$45,000
7.4.1.1	On-site renewable energy systems with production of not less than 4.0 kBtu/sq ft/yr.	$178,000
8.3.4	Minimum daylighting by toplighting for buildings 3 stories or less.	$7,000
Total cost increment		$230,000
Increase in base cost of $18 million		1.3%

Chapter 5
Travis AFB C-17 Hangar

BACKGROUND

Travis AFB is 3 miles east of Fairfield, CA, in Solano County. Solano borders Napa County and is northeast of the San Francisco Bay Area and southwest of Sacramento. The weather is temperate, with more heating than cooling degree days. Travis is in DOE climate zone 3B.

The building at Travis AFB is a two-bay hangar primarily intended for repair and maintenance of C-17 airframes and KC-10s. It contains offices and support spaces for maintenance personnel. These consist of administration and general offices, a documents library, a set of toilets and shower, janitor spaces, a mechanical room, an electrical room, and additional storage areas.

The hangar is a 1-story building with windows on its west, north, and south sides. It is about 102,000 sq ft in all, but its conditioned floor area is only 83,028 sq ft. The building faces due west.

The hangar was part of a brownfield redevelopment project at Travis AFB. It opened on January 15, 2010, and has been LEED silver certified. Among other things, its construction included highly reflective paving and a high percentage of certified wood. The base is also purchasing green power the total of which will likely exceed the expected consumption of the hangar.[1] The total cost of the hangar was around $25.4 million.

REQUIREMENTS THAT ADD SIGNIFICANT COST

Table 5-1 below summarizes the ASHRAE Standard 189.1 requirements that were not met in the hangar's construction and would have had more than a minimal effect on up-front construction costs.

Table 5-1. Requirements That Add Significant Cost

Reference	Requirement summary	Type
7.3.3.1, 7.3.3.2, 7.3.3.3	Energy consumption measurement	Mandatory
7.4.1.1	Renewable energy production	Prescriptive

[1] Kit M. Wong, "Case Study of LEED Silver Project, C-17 Hangar, Travis AFB, CA". https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_ww_pp/navfac_navfacsw_pp/engfrm/07-Silver.pdf

Table 5-1. Requirements That Add Significant Cost

Reference	Requirement summary	Type
7.4.3.8	Exhaust air recovery	Prescriptive
8.3.4	Daylighting	Mandatory
9.4.1.3	Biobased products	Prescriptive

Energy Consumption Measurement - ASHRAE Standard 189.1, Section 7.3.3.1., 7.3.3.2, and 7.3.3.3 Requirement

This requirement, spelled out in its entirety in Chapter 3, involves measuring energy consumption (electricity and natural gas) and connecting metering systems to a remote reading capability.

ANALYSIS

The ASHRAE Standard 189.1 standard requires sub-meters for natural gas HVAC systems > 500,000 Btu/hour. Thus sub-meters would be required for both of the 1,900,000 Btu/hour gas-fired hangar bay heaters. Per design drawing PO.01, the hangar natural gas meter is American Meter Company model RPM 3.5MG65, 4,300 CFH/122 CFM, installed on a 2-inch gas line. Per the Submeter Solutions, Inc. website (http://esubmeter.com/store) the 5,000 CFH 5.5M American gas meter, which costs $2,500, is comparable. Assuming an additional $500 for installation, each meter installed would cost $3,000, for a total estimated cost of $6,000.

FINDING

Fulfilling this ASHRAE Standard 189.1 requirement would have added about $6,000 to the initial cost. We again assume that the remote readability requirement would have been fulfilled by connecting to a LAN. If not, the hangar would not have been able to meet this part of ASHRAE Standard 189.1 while the AF strategic pause regarding connection to remote meter reading remains in effect.

On-Site Renewable Energy Systems - ASHRAE Standard 189.1, Section 7.4.4.1 Requirement

In a July 2010 study, the Pacific Northwest National Laboratory (PNNL) completed a feasibility study that evaluated potential application of biomass and waste to energy, wind, solar, and geothermal technologies at Travis AFB. That study concluded that Travis AFB has three potential opportunities for renewable energy projects, and these options should be further investigated. These include landfill gas (LFG), regional waste to electricity, and wind. The economics of the LFG and WTE projects were similar, but their size and practicality differed. A WTE project could be sized to provide all of Travis AFB's electricity consumption, while a

LFG project would provide only about 11% of the base need. Obtaining the MSW and LFG for these projects presents challenges that may or may not be able to be overcome. The wind resource onsite needs to be verified because there is conflicting data for the region, but if the higher resource is available, one turbine could generate over 3% of Travis AFB's electricity.

PNNL proposed next steps that include discussions with Hay Road Landfill to verify gas availability and the potential for a partnership, regional waste haulers to determine availability of MSW, wind resource experts to site a met tower, and installation personnel to gain internal support and educate key players about the potential projects. PNNL further recommended that each project be reevaluated for economic feasibility once additional data are collected, and new paths forward should then be determined.

The requirement for renewable energy production, discussed in its entirety in Chapter 3, would require on-site production of 4 kBtu/sq ft/yr of power for conditioned space. Exceptions allow for purchased green energy combined with deploying flat plate solar energy collectors facing due south. Though there is indication that Travis purchased some green energy, the design specifications give no indication of solar collectors facing due south. Hence, we assume that ASHRAE Standard 189.1 would have required Travis to produce on-site 4 kBtu/sq ft/yr of power for the hangar's conditioned space. For the reasons given earlier, we assume this would have been done with photovoltaic cells.

ANALYSIS

Given the conversion parameters used in this report, the Travis hangarwould have had to produce 83,028 × 1.18 = 97,973 kW of power per year to meet the ASHRAE Standard 189.1 renewable energy power requirement. Travis AFB averages about 5 hours of usable sunlight per day,[2] so 1 sq ft of roof space can produce 10W × 5 × 365 = 18,250 watts or 18.250 kW per year. This implies that 5,368 sq ft of roof space would have had to be devoted to PV cells to meet the requirement. At an installed cost of $80/sq ft, this would have cost $429,470.

FINDING

We estimate that meeting the renewable energy requirement would have cost $429,000. Possibly this requirement could have been met at a lower cost by both installing solar collectors facing due south and purchasing renewable energy on the open market. The hangar apparently did commit to purchase renewable energy, but whether these purchases met the minimum ASHRAE Standard 189.1 requirement on this score is unclear, and the building plans have no indication that it was erecting solar collectors facing due south. For now, therefore, we assume the rooftop PV approach would have been the best available at the time.

[2] See note 3, p. 3-8.

Exhaust Air Recovery - ASHRAE Standard 189.1, Section 7.4.3.8 Requirement

The requirement for exhaust air recovery, discussed in full in Chapter 3, relates to recovering the energy associated with a building's exhaust air heat.

ANALYSIS

The Travis facility does not have energy recovery ventilators (ERVs). Under the standard, because split air conditioning system exhaust fans have flow rates of 2,000 CFM drawing 45 percent outside air, ERVs are not required. However, the two gas-fired HVAC system exhaust fans have flow rates of 6,500 CFM drawing 100 percent outside air, so ERVs are required.

FINDING

The estimated cost of an installed 8,000 CFM ERV per 2011 RSMeans Mechanical Cost Data, page 383, line 4050, is $13,400, so the two together would cost $26,800. We round the estimate to $27,000 in Table 5-3 below.

Daylighting by Toplighting - ASHRAE Standard 189.1, Section 8.3.4 Requirement

The ASHRAE Standard 189.1 requirement for daylighting via toplighting is spelled out in full in Chapter 4. It defines a minimum for lighting via skylights, with the amount of required skylight area determined by a formula involving the height of the building and other parameters.

ANALYSIS

The design specifications for the Travis hangar indicate that no skylights were installed. We used the formula included in ASHRAE Standard 189.1 to determine what the area of such skylights would have had to be to meet the minimum requirement. This involved multiplying 0.7 times the height of the building and combining it with the standard's required ratio of skylight area to skylight floor footprint (0.033, or 3.3 percent based on LPD–1.295 W/sq ft) to derive the required skylight size. It seemed logical to put one skylight above each bay, so for calculation purposes the floor area was divided into two. Given that, the calculation for a single skylight yielded an edge of 24.92 ft on each side, or 621 sq ft in total. According to 2011 RSMeans Interior Cost Data, page 154, line 2300, the installed cost of skylighting as of 2011 is $98.60 per sq ft. Thus, each skylight (or multiple smaller skylights totaling the same gross area) would have cost $61,231, and the two together would have cost $122,462 (see Appendix F for cost estimate details).

FINDING

Because the Travis hangar is a very large building, the amount of skylighting needed to meet the ASHRAE Standard 189.1 requirement also is large. Our approach of one skylight above each bay seemed logical, in that such an arrangement would have gained the most light for those working on aircraft below. As Travis did not actually install skylights, meeting the ASHRAE Standard 189.1 requirement would have cost as much as $122,000.

Biobased Products - ASHRAE Standard 189.1, Section 9.4.1.3 Requirement

This requirement, spelled out in full in Chapter 3, mandates that at least 5 percent of building materials, based on cost, be biobased products.

ANALYSIS

The data for the hangar were insufficient for estimating the percentage of materials, by cost, that were biobased. We assume some wood would have been used for doors, panels, or other features, and that perhaps some other biobased products were used as well. The LEED application for the hangar indicates that it did meet another part of the biobased materials standard, namely that 60 percent of the wood used was certified wood. But that application did not specify an overall cost for wood at the facility.

As we cannot determine whether the 5 percent standard was reached, and given the industrial nature of the building, we instead assume that only 1 percent of materials were biobased, so that another 4 percent would have had to be purchased to meet the standard. No cost figure was given for total materials at Travis, so we assumed the LEED default ratio of materials to total construction costs as at Offutt, 45 percent. That extrapolation indicated total materials costs at Travis of $11.4 million. By assumption, then, the additional 4 percent of materials would have cost 20 percent more than other materials, adding $91,200 in all to the cost of construction ($11.4 million × 0.04 × 0.2), which we round to $91,000.

FINDING

Based on the assumptions stated, we add $91,000 to the incremental cost of meeting ASHRAE Standard 189.1 at the hangar. Because of the number of assumptions that underlie the estimate, it is only a rough approximation; but since it adds only 0.2 percent to total building costs, little bias is added by including it.

REQUIREMENTS THAT ADD MINIMAL COST

We identified a number of ASHRAE Standard 189.1 requirements with which we assume Travis could have complied at minimal additional cost. These are shown

in Table 5-2. In each case we identify the requirement and explain why we assume that it would have added little to costs.

Table 5-2. Requirements That Add Minimal Cost

ASHRAE Standard 189.1 requirement	Assumption
5.3.2.2 - Requires 30 percent of walls to be shaded on east and west of building, based on shade angle at 10 and 3 on summer solstice.	Windows do not have awnings and there are no trees to provide shade for 30 percent of wall area. However, the light exterior wall color likely has an SRI ≥ 29. Thus, assuming it would not violate existing architectural compatibility regulations, the requirement could be met by choosing an outside wall color or material with SRI ≥ 29. Cost would be minimal.
5.3.2.3 - Requires a minimum of 75 percent of the roof to have an SRI of 78 for low-sloped roof or SRI of 29 for steep-sloped roofs, or to be covered by Energy Star roof products.	Per design specifications, the hangar has a low-sloped roof that requires an SRI ≥ 78. The existing roof color is too dark to meet this requirement. However, roof products may have been Energy Star or, assuming it would not violate existing architectural compatibility regulations, the requirement could have been met by choosing a roof color or material with an SRI ≥ 78. The cost of that option would be minimal.
7.4.2.5 - Requires vertical fenestration on west, south, and east sides to be shaded by permanent projections in some climate zones.	Should be able to meet this requirement by using low-E insulated glass, window blinds, light boxes, etc., which should be relatively inexpensive.
7.4.5.1 - Mandates automatic load reduction of at least 10 percent for all building projects during peak load times.	Per basis of design specification, all controls for the HVAC system will be direct digital controls (DDC). There are extensive such controls, involving air conditioners, economizer dampers, gas heating, air handlers, filters, exhaust fans, etc. We assume the DDC system can selectively reduce peak demand load throughout the facility when required. However, because of mission requirements, USAF may not wish to subject it to a 10 percent load reduction during peak load times.
7.4.7 - In addition to compliance with ASHRAE 90.1 standards, ASHRAE Standard 189.1 requires performance standards for electric motors, heat recovery on supermarket refrigeration equipment, and an Energy Star mandate for most appliances and electronics.	National Electrical Manufacturers Association (NEMA) MG 1 (2006) standard for motors and generators applies throughout design specifications. NEMA MG-1 and ASHRAE Standard 189.1 Table C-13 are identical. Hence, it is likely that this standard was met or nearly met, and if not could have been met at little incremental cost.

Table 5-2. Requirements That Add Minimal Cost

ASHRAE Standard 189.1 requirement	Assumption
8.3.3 - Building projects must meet exterior and interior acoustical controls.	Per ASHRAE Standard 189.1, an STC ≥ 50 is required. Travis design specifications indicate that the contractor must provide a ceiling system with a ceiling attenuation class (CAC) of 35 determined in accordance with ASTM E 1414, provide fixture attenuators over light fixtures and other ceiling penetrations, and provide acoustical blanket insulation adjacent to partitions, as required to achieve the specified CAC. The design specification also requires the contractor to provide sound insulated door and frame assemblies in rooms requiring sound insulated wall assemblies. The STC rating for the door and frame assembly may not be less than the wall assembly STC rating. These specifications are assumed to have met the ASHRAE requirements or nearly so, so that the incremental cost of meeting it would have been nominal.
10.3.2.2 - Mandates a maintenance plan for mechanical, electrical, plumbing, and fire protection systems in accordance with ASHRAE 180.	Design specification section 08.11.13, paragraph 1.2, requires that the contractor submit operation and maintenance data. We assume this would constitute the needed inputs for an O&M plan.
10.3.2.3 - Mandates a service life plan for structural, building envelope, and hardscape materials, and a transportation management plan, with varying mandates based upon ownership or leasing arrangements.	We assume that the cost to prepare these plans in-house would be minimal.

We assume for each of these 8 requirements that they could be met at minimal cost not to exceed $5,000. We note, however, that collectively this could amount to almost $40,000, which is a significant additional cost that should be added to the overall incremental cost estimate.

CONCLUSION

As shown in Table 5-3, initial construction costs for the Travis hangar would have increased by about 2.8 percent had it been built to ASHRAE Standard 189.1. Most of the incremental cost (about 1.7 percent) would have come from installing a renewable energy production capability in the form of PV cells. Installing skylights would have accounted for most of the rest.

These would not have been the only items necessary at Travis to fulfill ASHRAE Standard 189.1, however. Some of the items mentioned in Table 5-2 also would have required attention, though they would not have added much to costs. One of these—systems to execute a 10 percent energy demand reduction during peak load times—might conflict with other USAF objectives: namely, to maintain full operations at mission-critical facilities. If so, many AF facilities would not meet

this part of the ASHRAE Standard 189.1, even though the direct money cost of doing so would be relatively minor.

Table 5-3. Summary of Additional Costs at Travis Hangar Imposed by ASHRAE Standard 189.1

Requirement	Summary	Additional cost
7.3.3.1, 7.3.3.2, 7.3.3.3	Consumption data recording with remote communication capabilities for electricity, gas, and district heat for main systems and some subsystems	$6,000
7.4.1.1	On-site renewable energy systems with production of not less than 4.0 kBtu/sq ft/yr	$429,000
7.4.3.8	Exhaust air energy recovery systems with at least 60 percent energy recovery effectiveness	$27,000
8.3.4	Minimum daylighting by toplighting for buildings 3 stories or less	$122,000
9.4.1.3	Biobased products must make up 5 percent or more of total materials costs	$91,000
Various	Aggregate “minimal cost” requirements	$40,000
Total cost increment		$715,000
Increase over base cost of $25.4 million		2.8%

Chapter 6
Minot AFB Dormitory

BACKGROUND

The city of Minot is in the north central part of North Dakota. Minot AFB is located 13 miles north of the city. The base comprises 7.6 square miles, of which 7.2 square miles are land, the rest water. Minot is in DOE climate zone 7A, with an average year-round temperature (day and night) of 41.6°F. Average snowfall is just short of 2 feet per year. On average, Minot experiences 9,275 heating degree days and 526 cooling degree days per year.

The Minot AFB dormitory is under construction at this time. It is planned to house 168 single residents, each in a small suite, and to accommodate a staff of five. The dormitory is a 3-story building planned to last for 50 years. Each suite will consist of a bedroom and private bath, and every four suites will share a kitchenette, living room, and washer and dryer. In addition, the building will house storage space plus room for vending machines. Total planned floor space over the 3 stories is 69,215 sq ft, though the planned building footprint is only 24,376 sq ft. The building sits on a 3.8-acre site that includes green space and parking areas.

The project team has set a goal to achieve a LEED Silver certification. The design includes ground source heat pumps for heating and cooling, with vertically installed heat exchangers connected to multiple heat pumps. Solar hot water heating was considered but rejected as not cost-effective at the site. According to building design documents, various construction and control features will enable the dormitory to achieve energy savings of 47 percent relative to ASHRAE Standard 90.1 (1994). Building construction is estimated to cost $22.9 million.

REQUIREMENTS THAT ADD SIGNIFICANT COST

Table 6-1 below summarizes ASHRAE Standard 189.1 requirements not met by the building's design and that would significantly increase construction costs.

Table 6-1. Requirements That Add Significant Cost

Requirement	Summary	Type
5.4.1.2, 6.3.1	Per 5.4.1.2, for greenfield sites 20 percent of the site should contain native or adapted plants. Per 6.3.1, 60 percent of building site landscaping must be bio-diverse plants, with additional requirements for irrigation systems and controls.	Prescriptive

Table 6-1. Requirements That Add Significant Cost

Requirement	Summary	Type
7.4.1.1	Mandates on-site renewable energy systems with production of 4 kBtu/sq ft for conditioned space, assuming building equipment is Energy Star.	Prescriptive
7.4.3.8	Mandates use of economizers on HVAC systems that exceed 33,000 Btu/hr in cooling mode.	Prescriptive

Effective Pervious Area and Water Use Efficiency/Landscape Design - ASHRAE Standard 189.1, Section 5.4.1.2 and 6.3.1 Requirement

5.4.1.2 Greenfield Sites. On a *greenfield site*:

a. where more than 20% of the area of the predevelopment *site* has existing *native plants* or *adapted plants*, a minimum of 20% of the area of *native plants* or *adapted plants* shall be retained.

b. where 20% or less of the area of the predevelopment *site* has existing *native plants* or *adapted plants*, a minimum of 20% of the *site* shall be developed or retained as vegetated area. Such vegetated areas include bioretention facilities, rain gardens, filter strips, grass swales, vegetated level spreaders, constructed *wetlands*, planters, or open space with plantings. A minimum of 60% of such vegetated area shall consist of *bio-diverse planting* of *native plants* or *adapted plants*.

Exception to 5.4.1.2.b: Locations with less than 10 in (250 mm) of average annual rainfall per year.

6.3.1 Site Water Use Reduction: 6.3.1.1 Landscape Design. A minimum of 60% of the area of the *improved landscape* shall be in *bio-diverse planting* of *native plants* and *adapted plants* other than *turfgrass*.

ANALYSIS

At Minot, most of the area proposed to be developed is grassed, with some trees. The proposed improvements, including the parking area expansion, brings a significant reduction in green area. As a result, the dormitory would not meet this portion of the ASHRAE Standard 189.1.

To meet the standard, it would be necessary to plant native and adaptive plants in place of most of the grass planting. Admittedly a number of plant options exist. Our cost estimate is based on what appears to us a reasonable approach, but de-

pending on the aesthetic qualities sought there could be more or less expensive alternatives. All cost data is taken from 2011 RSMeans Facility Construction Data, and includes both labor and materials (see Appendix F for cost estimate details). Our proposed plant combination to meet the standard is as follows:

Access road shrubs:
600 linear feet; assume 1 shrub every 5 feet = 120 shrubs
60 snowberry shrubs × $38/shrub
60 gray dogwood shrubs × $95/shrub
(60 × $38) + (60 × $95) = $7,980

Trees and shrubs around dormitory:
10 red dogwood × $199 = $1,990
10 birch × $253 = $2,350
10 green ash × $410 = $4,100
250 gray dogwood × $95= $23,750
250 snowberry × $38= $9,500

Total cost of meeting the standard: $49,670

FINDING

The plantings proposed in this example would fulfill the requirements of both 5.4.1.2 and 6.3.1. For purposes of this exercise, we round the estimate to $50,000. Though other plantings could meet the standard at somewhat lower or greater cost, this total is only 0.2 percent of the total cost of the Minot dormitory; slight variation in one direction or another would not much affect our results.

On-Site Renewable Energy Systems - ASHRAE Standard 189.1, Section 7.4.1.1 Requirement

The requirement for on-site renewable energy is discussed in full in Chapter 3. The exceptions listed there for purchased green energy plus solar collectors facing due south do not appear to apply at Minot. Hence, as with the other sites we reviewed, under ASHRAE Standard 189.1 the facility would have been required to produce on-site 4 kBtu/sq ft/yr of power for conditioned space. We examined the cost of providing such power with photovoltaic cells.

ANALYSIS

In a September 2010 study, the Pacific Northwest National Laboratory (PNNL) completed a feasibility study that evaluated potential application of biomass and waste to energy, wind, solar, and geothermal technologies at Minot AFB. That study concluded that although Minot AFB has the resource potential for a wind project, the economic potential is marginal, even for large-scale turbines, due to Minot's low cost of marginal electricity. If a wind project is implemented, about

2% of Minot's electricity consumption could be supplied by each large-scale turbine installed.

PNNL recommended that if economic conditions change, Minot AFB should consider a wind energy project. Next steps would include gaining support for the project and assessing mission conflicts. If a project still seems viable at that point, a site visit should be arranged for more discussion and to identify a location for a met tower and turbines.

For the PV cell alternative, we estimated that final conditioned space would equal the planned building floor space (69,215 sq ft). Given the conversion parameters used in this report, this implies a requirement for 81,674 kWh of renewable power per annum at the site. On average, Minot receives about 4.2 hours of usable sunlight per day; this implies that roof space there can produce 10W × 4.2 × 365 = 15,330 watts or 15.33 kW/sq ft/yr. Thus, the Minot dormitory would have had to devote 5,328 sq ft of roof space to meet the ASHRAE Standard 189.1 renewable power generation requirement. At a price of $80/sq ft for PV installation, this would have cost $426,218.

FINDING

Installing renewable energy via rooftop PV cells would have cost around $426,000 at Minot. A cheaper alternative might have been to purchase green energy and to erect solar collectors facing due south, but the ASHRAE Standard 189.1 exception requires fairly large quantities of purchases and collectors, so it is unclear whether this could have been done in that locality and what it would have cost. Minot might have been able to take advantage of local wind resources to fulfill part of this requirement, but doing so would have required erecting windmills and other infrastructure, a questionable approach at an AFB. For now, therefore, we use the $426,000 estimate for PV cells as our best approximation of the cost to meet the renewable energy production requirement. Minot is currently exploring the feasibility of using a waste-to-energy (WTE) plant to help meet this requirement.

EXHAUST AIR ENERGY RECOVERY - ASHRAE STANDARD 189.1, SECTION 7.4.3.8 REQUIREMENT

The requirement for exhaust air recovery, discussed in full in Chapter 3, relates to recovering the energy associated with a building's exhaust air heat.

ANALYSIS

The Minot facility does not have energy recovery ventilators (ERVs). The two HVAC systems generate 140,000 Btu/hr in cooling mode, which exceeds the 33,000 Btu/hr threshold under the standard, thus ERVs are required. The HVAC system's exhaust fans have variable flow rates (MAU 1 = 4,200-4,800 CFM; MAU 2 = 4,260-5,000 CFM). Therefore, ERVs are selected with a maximum flow rate of 6,000 CFM.

FINDING

The estimated cost of an installed 6,000 CFM ERV per 2011 RSMeans Mechanical Cost Data, page 383, line 4040, is $12,100, so the two together would cost $24,200. We round the estimate to $24,000 in Table 6-3 below.

REQUIREMENTS THAT ADD MINIMAL COSTS

In several instances we assume Minot could have complied with ASHRAE Standard 189.1 requirements at minimal additional cost. These are shown in Table 6-2. In each case we identify the requirement and explain why it would have added little to costs.

Table 6-2. Requirements That Add Minimal Cost

ASHRAE Standard 189.1 requirement	Assumption
7.4.2 - Requires compliance with ASHRAE 90.1 regarding insulation, fenestration, permanent projections, vestibules, and continuous air barriers.	Per final design submittal document, roof insulation is R-30; the vertical fenestration is <40 percent of wall area; and the permanent projection requirement can be met with low-emissivity insulated glass, blinds, and window boxes. The SGHC of bedroom windows is 0.72, core area is 0.42, and entry foyer is 0.55. The fenestration orientation does not apply, since the building is adjacent to an existing building on at least one side.
7.4.2.5 - Requires vertical fenestration on west, south, and east sides to be shaded by permanent projections in some climate zones.	No permanent projections exist. However, using low-emissivity insulated glass coupled with interior blinds and light boxes would likely meet this requirement at minimal cost.
9.3.4.2 - Requires buildings with residential space to have an area serving the building to be dedicated to the collection and reuse of materials.	Designating such space can be done at little or no cost, especially if the existing dormitory already has such dedicated space.
9.4.1.3 - Biobased products must make up at least 5 percent of the cost of the building materials.	The contractor is supposed to supply data showing biobased materials costs and total materials costs, but we were unable to discover it. However, Minot involves residences that presumably would have wooden doors, cabinets, interior floors, and trim, so it is likely that this requirement was met or nearly met for the Minot project.
9.4.1.3.1 - Certified wood must make up at least 60 percent of total wood used in the project.	Existing plan calls for using at least 50 percent of all wood-based materials to come from Forest Stewardship Council (FSC)-certified sources. The cost for increasing the share to 60 percent would be minimal.
10.3.2.3 - Mandates a service life plan for structural, building envelope, and hardscape materials. Also mandates a transportation management plan, with varying mandates based upon ownership and leasing arrangements.	We assume that the cost of preparing these plans in-house would be minimal.

We assume for each of these 6 requirements that they could be met at minimal cost not to exceed $5,000. We note, however, that collectively this could amount to almost $30,000, which is a significant additional cost that should be added to the overall incremental cost estimate.

CONCLUSION

As shown in Table 6-3, initial construction costs for the dormitory would have increased by about 2.3 percent had it been built to ASHRAE Standard 189.1 requirements. As with the other buildings in this study, most of the incremental cost—about 1.9 percent of the total increase of 2.3 percent—would have come from installing a renewable energy production capability in the form of PV cells. Landscaping would have accounted for most of the rest.

In addition, items mentioned in Table 6-2 would have required attention, though they would not have added much to costs. Overall, other than the renewable energy requirement, it appears that the Minot dormitory could have met the ASHRAE Standard 189.1 standard at relatively low incremental cost.

Table 6-3. Additional Costs at Minot Dormitory Imposed by ASHRAE Standard 189.1

Requirement	Summary	Additional cost
5.4.1.2, 6.3.1	20 percent of the site to contain native or adaptive plants; 60 percent of landscaping must be bio-diverse plants plus required irrigation system controls	$50,000
7.4.1.1	On-site renewable energy systems with production of not less than 4.0 kBtu/sq ft/yr	$426,000
7.4.3.8	Economizers for exhaust air energy recovery	$24,000
Various	Aggregate “minimal cost” requirements	$30,000
Total cost increment		$530,000
Increase over base cost of $22.9 million		2.3%

Chapter 7
Conclusions

In this study, we have focused on four recently constructed AF buildings in four different weather zones to assess the incremental costs of meeting the ASHRAE Standard 189.1 for sustainable buildings. Table 7-1 presents our bottom-line conclusions, from two perspectives: the total added cost for each of the four buildings, and the added cost just to produce renewable energy on-site.

Table 7-1. Summary of Incremental Costs of Meeting ASHRAE Standard 189.1

Building	Total initial cost	Added cost of standard	Cost increase to meet renewable energy requirement	Comment
Offutt Weather Agency Headquarters	$27 million	7.1%	4.0%	LEED gold, climate zone 5A
Tyndall Fitness Center	$18 million	1.3%	1.0%	LEED platinum, climate zone 2A
Travis Hangar	$25.4 million	2.8%	1.7%	LEED silver, climate zone 3B
Minot Dormitory	$22.9 million	2.3%	1.9%	LEED silver, climate zone 7A

Several conclusions emerge from these data. First, because USAF buildings already meet at least LEED silver requirements (if not gold or platinum) plus other sustainable building standards, the added costs to meet ASHRAE Standard 189.1 are fairly modest, at least as a percentage of total building construction costs. For three of the buildings, these incremental costs fall in the 1–2.8 percent range; only for the Offutt weather station are they somewhat higher, more than 7 percent.

Why are the Offutt Weather Agency Headquarters facility incremental costs that much higher? There are two reasons. First, it is a very large building, with almost 189,000 sq ft of covered space. Since the requirements for renewable energy are tied to the amount of conditioned space and the renewable requirement is the largest cost component, the facility shows the largest incremental cost. Second, the Offutt facility is unusual in that it uses a large former runway for parking space, but this runway likely did not meet the ASHRAE Standard 189.1 for shading or reflectivity, so a costly concrete overlay on that area would have been necessary. Also, because of its orientation, the facility was unique among the four buildings in not meeting a fenestration requirement; however, we did not estimate what it would have cost to orient the building in a different direction.

In each case, our cost estimate for the supply of renewable energy assumed that a rooftop PV system would be used. It may be that other, cheaper means could have been available in some instances (e.g., wind energy, methane extraction from waste, geothermal), or that the exceptions allowed under ASHRAE Standard 189.1—which entail purchasing a minimum quantity of renewable energy and producing a minimum amount via solar collectors facing due south—would have been less costly. However, none of the four sites indicated that they were considering a solar collector, though two indicated that they were purchasing renewable energy from elsewhere.

For each building we also identified provisions of ASHRAE Standard 189.1 that would have required only minimal extra costs. Therefore, although it is possible that we have slightly underestimated incremental costs in some instances, we believe the estimates in Table 7-1 are reasonably close to what would have actually occurred.

In a few cases, other USAF considerations besides cost might have interfered with meeting the ASHRAE Standard 189.1. For example, the standard requires being able to reduce a building's energy usage by 10 percent at peak load times. However, if a building provides mission-critical functions, USAF might choose not to build such a usage reduction into its energy management systems. Also, under ASHRAE Standard 189.1, electricity, gas, and water meters must have remote reading capability, but AF has ordered a strategic pause in connecting new meters to existing remote meter reading systems due to security concerns and the pursuit of a standardized platform. Finally, in one case a building did not meet a window area requirement, but would have done so were it oriented differently. Possibly the reasons for the building's orientation were such that they would have precluded meeting this requirement.

Appendix A
Complete Crosswalk

This appendix summarizes and compares the high performance sustainable building requirements of ASHRAE 189.1, ASHRAE 90.1, applicable DoD directives, Unified Facilities Criteria, and the International Green Construction Code, and identifies instances where ASHRAE 189.1 is more stringent.

ASHRAE 189.1 Reference	Subject	Summary (requirement met or requirement not met)	Mandatory, Prescriptive, or Performance	LEED 2009 (NC)	LEED meets AF Energy and Water Criteria	HPSB (12/2008)	DoD Policy Directives	ASHRAE 90.1 (2010)	ASHRAE 90.1 (2007)	ASHRAE 90.1 (2004)	Unified Facilities Criteria (as of 3/2011)	International Green Construction Code (v2.0, Nov 2010)
ASHRAE 189.1 Section 5.3 Site Sustainability												
Section 5.3.1: Site Selection												
5.3.1.1 and 5.3.1.2	Site Selection	Building site must be on brownfield, greyfield, or greenfield with certain restrictions (such as within 1/2 mile of pedestrian services, public transit, or other developed lands). This requirement also includes specific prohibitions against building too close or within wetlands, wildlife habitat areas, protected areas, or flood zones.	Mandatory	SS Credit 5.1: Protect or Restore Habitat Limit habitat impacts on greenfield sites, or restore or protect a portion of the area for a previously developed site. 1 point		GPIII-EISA Sec 438: Employ strategies that reduce storm water runoff and discharges of polluted water offsite. Where redevelopment affects site hydrology, use site planning, design, construction, and maintenance strategies to maintain hydrologic conditions during development, or to restore hydrologic conditions following development, to the maximum extent that is technically feasible.	None Identified beyond those already considered.	N/A	N/A	N/A	UFC 4-030-01 (C-2.1): Give preference to sites that: do not include sensitive site elements and restrictive land types (e.g., wetlands, prime farmland); were previously occupied (e.g., brownfields, existing buildings); and are located in urban areas, near mass transportation systems or conform to the desired development density.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
				SS Credit 2: Development Density and Community Connectivity Construct or renovate on a previously developed site in areas of high sq ft/acre density, or construct/renovate on a previously developed site near basic commercial services with access to those services. 5 points		N/A						
				SS Credit 1: Site Selection Requirements limiting and restricting development locations, including primary farmland, within floodplains, wildlife habitat areas, or near wetlands or waterways. 1 point		N/A						
				SS Credit 5.2: Maximize Open Spaces Site must provide open space (amount determined by zoning ordinances) 1 point		N/A						
				SS Credit 3: Brownfield Redevelopment Develop on a site that is documented as contaminated or defined as a brownfield. 1 point		N/A						
Section 5.3.2: Mitigation of Heat Island												
5.3.2.1	Mitigation of Heat Island Effect	Requires at least 50% of site hardscape (roads, sidewalks, courtyards and parking lots of the building project) to be shaded by trees and vegetation or some other structure, to be made up of at least 29 SRI paving material, or should provide for parking under the building. Building projects in climate zones 6, 7 and 8 are exempted.	Mandatory	SS Credit 7.1: Heat Island Effect---Nonroof Requires at least 50% of hardscape (sidewalk, roads, parking lots, etc)to be shaded by trees and vegetation or some other structure, to be made up of at least 29 SRI paving material, or built with specific pervious materials. 1 point	Meets AF Energy and Water Criteria	N/A	None Identified beyond those already considered.	N/A	N/A	N/A	UFC 4-030-01 (C-2.6): Minimize heat islands by minimizing building footprint, reducing paving and walkways, and using landscaping and exterior building design methods, which include cool roofs and vegetated roofs. UFC 3-201-02 (B-3.3.2): To effectively reduce such effects and increase energy savings, materials used in parking lots should be highly reflective over the life of the product. Specify highly reflective materials for non-vehicular areas including walkways and plazas.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
5.3.2.2	Mitigation of Heat Island Effect	Requires 30% of walls shall be shaded on east and west of building based on shade angle at 10 and 3 on summer solstice. Exception for SRI minimum 29. Exceptions exists for climate zones 5,6,7 and 8.	Mandatory	N/A		N/A		N/A	N/A	N/A	UFC 4-030-01 (C-2.6.1): Consider covering or replacing walkways, parking lots, and other open areas that are paved or made with low reflectivity materials with high reflectivity materials or vegetation to reduce heat absorption.	
5.3.2.3	Mitigation of Heat Island Effect	Requires a minimum of 75% of the roof to be SRI of 78 for low-sloped roof or SRI of 29 for steep-sloped roofs, or to be covered by Energy Star Roof Products	Mandatory	SS Credit 7.2: Heat Island Effect - Roof Require 75% of the roof to be SRI of 78 for low-sloped roof or SRI of 29 for steep-sloped roofs, or 50% of the roof be vegetated, or a combination of the two as defined. 1 point	Meets AF Energy and Water Criteria	N/A		5.5.3.1.1 Roof Solar Reflectance and Thermal Emittance Roofs in Climate Zones 1,2, & 3 are required to have a minimum solar reflectance and/or roof insulation levels.	N/A	N/A	UFC 4-030-01 (C-2.6.2): Use a roofing product that meets or exceeds ENERGY STAR® roofing criteria and has an emissivity of at least 0.9.	
Section 5.3.3: Reduction of Light Pollution												
5.3.3	Reduction of light pollution.	Requires exterior lighting system comply with section 9 of ASHRAE Std 90.1. Sets requirements for backlight, glare and up light ratings based upon lighting zone. Exceptions based on various lighting zones and specific provisions	Mandatory	SS Credit 8: Light Pollution Reduction Interior lights must be limited within the hours of 11pm and 5am, AND Exterior lights must meet ASHRAE 90.1 2007 for classified zones and exterior lighting. 1 point	Meets AF Energy and Water Criteria	N/A	None Identified beyond those already considered.	9.4.1.7 Exterior Lighting Control Requires lights be controlled by an automatic device and off during daylight hours. Building facade and landscaping lights are off at night, and other lighting power needs will be reduced by 30% under certain conditions.	9.4.1.3 Exterior Lighting Control Lighting for exterior applications shall have controls capable of turning off exterior lights when there is sufficient daylight. Lighting not designated for dusk to dawn operations shall be controlled by photosensors and a time switch or an astronomical time switch.	9.4.1.3 Exterior Lighting Control Lighting for exterior applications shall have controls capable of turning off exterior lights when there is sufficient daylight. Lighting not designated for dusk to dawn operations shall be controlled by an astronomical time switch.	UFC 4-030-01 (C-2.4.1): Design the exterior lighting system to light only the desired area. Use full cut-off fixtures that do not shine any light above the horizon line. For parking lots rarely used at night, consider providing a low constant light level supplemented by occupancy-type sensors to light up the area when a pedestrian or vehicle is detected. Avoid using occupancy-type sensors with low pressure sodium and metal halide fixtures due to start-up delays. UFC 3-530-01 (3-1): Provide sustainable design to achieve the required LEED or other agency certification level in accordance with UFC 4-030-01	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
Section 5.4: Prescriptive Options												
5.4.1.1	Site Development	Requires a minimum of 40% of entire site shall be planted; or requires the use of permeable pavers; or requires a green roof. Exceptions are provided if certain percentage of rainfall is captured on site.	Prescriptive	SS Credit 5.2: Maximize Open Spaces Site must provide open space (amount determined by zoning ordinances) 1 point		N/A		N/A	N/A	N/A	UFC 4-030-01 (C-2.4):	Section 302 (1)

ASHRAE 189.1 Reference	Subject	Summary (requirement met or requirement not met)	Mandatory, Prescriptive, or Performance	LEED 2009 (NC)	LEED meets AF Energy and Water Criteria	HPSB (12/2008)	DoD Policy Directives	ASHRAE 90.1 (2010)	ASHRAE 90.1 (2007)	ASHRAE 90.1 (2004)	Unified Facilities Criteria (as of 3/2011)	International Green Construction Code (v2.0, Nov 2010)
5.4.1.2	Effective Pervious Area for All Sites	Greenfield sites should have at least 20% of the entire site to contain native or adapted plants	Prescriptive	SS Credit 5.2: Maximize Open Spaces Site must provide open space (amount determined by zoning ordinances) Assumes that all DoD facilities fall into Case 2 (Sites with No Zoning Requirements): Vegetate open space area equal to area of the building footprint. 1 point		N/A	None identified beyond those already considered	N/A	N/A	N/A	When planning a project, keep land disturbance to a minimum to allow retention of prime vegetation and the natural habitats of birds and animals.	Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
Section 5.5: Performance Options												
5.5.1	Site Development	At a minimum, buildings must manage the following amount of rainfall through infiltration, reuse, or evapotranspiration: Existing envelopes should manage >= 20%; brownfield or greyfield developments should manage >=40%; all other sites should manage >=50%.	Performance	SS Credit 5.2: Maximize Open Spaces Site must provide open space (amount determined by zoning ordinances) Case 2 (Sites with No Zoning Requirements): Vegetate open space area equal to area of the building footprint. Depending upon rainfall, open space, and development type, the ASHRAE requirement could be met. 1 point		GPIII-EISA Sec 438: Employ strategies that reduce storm water runoff and discharges of polluted water offsite. Where redevelopment affects site hydrology, use site planning, design, construction, and maintenance strategies to maintain hydrologic conditions during development, or to restore hydrologic conditions following development, to the maximum extent that is technically feasible.	EISA Section 438: The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow. TR-55 Curve Number Methodology (SCS 1986), Chapter 2: "Estimating Runoff"	N/A	N/A	N/A	UFC 4-030-01 (C-2.5): Use low impact development (LID) technologies (e.g., bio-retention cells, permeable paving) and natural or man-made site features (e.g., roofs of buildings, parking lots, and other horizontal surfaces) to infiltrate, treat/filter, store, evaporate, and detain runoff close to its source to the maximum extent feasible.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
ASHRAE 189.1 Section 6.3: Water Use Efficiency												
Section 6.3.1:												
6.3.1	Water Use Efficiency-Landscape Design	Landscape Design:60% of the site's improved landscape shall be bio-diverse plants other than turf grass, requirements for irrigation system design and controls.	Mandatory	N/A	Meets AF Energy and Water Criteria	HPSB GPIII--Outdoor Water: Use water efficient landscape and irrigation strategies, such as water reuse, recycling, and the use of harvested rainwater, to reduce outdoor potable water consumption by a minimum of 50% over that consumed by conventional means (plant species and plant densities). The installation of water meters for locations with significant outdoor water use is encouraged.	None identified beyond those already considered.	N/A	N/A	N/A	UFC 3-201-02 (8-5.5.1) Select water-efficient plants. Installations should populate their plant lists with native plants that have demonstrated long-term landscape value through hardiness, availability, and minimal maintenance and water requirements. UFC 4-030-01 (C-3.1): Design landscape for water efficiency through xeriscaping or use of native plants tolerant of local soil and rainfall conditions, eliminating the need for permanent irrigation systems.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
6.3.2	Water Use Efficiency-Building water use requirements:	Places water flow requirements on plumbing fixtures	Mandatory	WE Credit 2: Innovative Wastewater Technologies Option 1: Reduce potable water use for sewage by 50% with water -conserving fixtures or nonpotable water OR Option 2: Treat 50% onsite waste-water These requirements could be met with low-flow plunbing fixtures. 2 points		HPSB GP III--- Indoor Water: Employ strategies that in aggregate use a minimum of 20 percent less potable water than the indoor water use baseline calculated for the building, after meeting the EPAct 1992, Uniform Plumbing Codes 2006, and the International Plumbing Codes 2006 fixture performance requirements. The installation of water meters is encouraged to allow for the management of water use during occupancy. The use of harvested rainwater, treated wastewater, and air conditioner condensate should also be considered and used where feasible for nonpotable use and potable use where allowed.	Per Executive Order 13423, employ strategies that in aggregate use a minimum of 20% less potable water than the indoor water use baseline calculated for the building after meeting the Energy Policy Act of 1992, Uniform Plumbing Code 2006, and the International Plumbing Code 2006 fixture performance requirements.	N/A	N/A	N/A	UFC 3-420-01 (9-1.1): Per Executive Order 13423, employ strategies that in aggregate use a minimum of 20% less potable water than the indoor water use baseline calculated for the building after meeting the Energy Policy Act of 1992, Uniform Plumbing Code 2006, and the International Plumbing Code 2006 fixture performance requirements. UFC 4-030-01 (C-3.1): Use ultra water-efficient plumbing fixtures including dual flush toilets and waterless urinals, and integrate other water-saving devices into the buildings.	
6.3.2.2 and 6.3.23	Water Use-Appliances and HVAC Systems	Requires Energy Star appliances, and makeup and blow down meters, conductivity controllers and subsystem water meters based on threshold flows for HVAC systems. Requires condensate from AC units with a capacity of greater than 65,000 BTU (5.4 tons) and from all steam systems shall be recovered for reused.	Mandatory	N/A		N/A	None identified beyond those already considered.	N/A	N/A	N/A	UFC 4-711-01 (8-1.5): New and replacement building products and appliances should be Energy Star® qualified and labeled. UFC 4-030-01 (C-4.2.4.1-3): Use ENERGY STAR® approved products or products that meet or exceed Department of Energy Federal Energy Management Program (FEMP) standards.	
6.3.3	Water Consumption Measurement	Mandatory Provision-Meter with remote communication capability both potable and reclaimed water usage. Proved sub metering for each subsystem above 1000 gal/day (see table 6.3.3A). Meters equipped to provide daily and hourly consumption data by	Mandatory	WE Prerequisite1: Water Use Reduction Calculate baseline and employ strategies to reduce water use by 20%. WE Credit 3: Water Use Reduction Calculate baseline water consumption from estimates and then reduce by either 30, 35, or 40%.	Meets AF Energy and Water Criteria	HPSB GP III-- Indoor Water: The installation of water meters is encouraged to allow for the management of water use during occupancy. Outdoor Water: The installation of water meters for locations with significant water use is encouraged.	Per A7C Memorandum, DoD Facilities Metering Installation Initiative (27 April 2006), all new construction should install potable water meters.	N/A	N/A	N/A	UFC 4-030-01 (C-3.1): Establish a water use baseline; meter water usage; employ measurement and verification methods; comply with the Department of Energy's International Performance Measurement and Verification Protocol (IPMVP) for water use.	
Section 6.4: Prescriptive Options												
6.4.1	Site Water Use Reduction	Golf courses and driving ranges can only use municipally reclaimed or alternative on-site water sources. For landscaped areas, only 1/3 of irrigation water can come from potable sources.	Prescriptive	WE Credit 1: Water Efficient Landscaping Reduce potable water consumption for irrigation by 50%; or No potable water for irrigation 2-4 points	Meets AF Energy and Water Criteria	HPSB GPIII--Outdoor Water: Use water efficient landscape and irrigation strategies, such as water reuse, recycling, and the use of harvested rainwater, to reduce outdoor potable water consumption by a minimum of 50% over that consumed by conventional means (plant species and plant densities).	None identified beyond those already considered.	N/A	N/A	N/A	UFC 4-030-01 (C-3.2): Use roof water, groundwater from sump pumps, and non-sewage wastewater for on-site activities such as landscape irrigation, cooling tower make-up and other industrial and processes, fire sprinkler systems, and sewage conveyance. Ensure non-potable water usage is permissible in the city or county in which the base is located.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
6.4.2	Building Water Use Reduction	Specific requirements for water use in cooling towers, food operations, and medical facilities.	Prescriptive	N/A		N/A		N/A	N/A	N/A	UFC 4-030-01 (C-3.1): Install water-conserving cooling towers designed with delimiters to reduce drift and evaporation. Reduce evaporation through scheduled irrigation at dawn and dusk.	
6.4.3	Special Water Features	Prescriptive options for ornamental fountains or water features, pools, and spas.	Prescriptive	N/A		N/A		N/A	N/A	N/A	N/A	
Section 6.5: Performance Options												
6.5.1	Site Water Use Reduction	Potable water can not make up more than 35% of total water demand for landscaping	Performance	WE Credit 1: Water Efficient Landscaping Reduce potable water consumption for irrigation by 50% (2 points); or No potable water for irrigation (4 points). 2-4 points	Meets AF Energy and Water Criteria	HPSB GPIII--Outdoor Water: Use water efficient landscape and irrigation strategies, such as water reuse, recycling, and the use of harvested rainwater, to reduce outdoor potable water consumption by a minimum of 50% over that consumed by conventional means (plant species and plant densities).	None identified beyond those already considered.	N/A	N/A	N/A	N/A	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
6.5.2	Building Water Use Reduction	Building project water use shall be less than or equal to what would be achieved through compliance with 6.3.2, 6.4.2, and 6.4.3.	Performance	WE Credit 2: Innovative Wastewater Technologies Option 1: reduce potable water use for sewage by 50% with water-conserving fixtures or nonpotable water. 2 points Unclear if ASHRAE is more strenuous		HPSB GP III--- Indoor Water: Employ strategies that in aggregate use a minimum of 20 percent less potable water than the indoor water use baseline calculated for the building, after meeting the EPAct 1992, Uniform Plumbing Codes 2006, and the International Plumbing Codes 2006 fixture performance requirements. The installation of water meters is encouraged to allow for the management of water use during occupancy. The use of harvested rainwater, treated wastewater, and air conditioner condensate should also be considered and used where feasible for nonpotable use and potable use where allowed.		N/A	N/A	N/A	N/A	

ASHRAE 189.1 Reference	Subject	Summary (requirement met or requirement not met)	Mandatory, Prescriptive, or Performance	LEED 2009 (NC)	LEED meets AF Energy and Water Criteria	HPSB (12/2008)	DoD Policy Directives	ASHRAE 90.1 (2010)	ASHRAE 90.1 (2007)	ASHRAE 90.1 (2004)	Unified Facilities Criteria (as of 3/2011)	International Green Construction Code (v2.0, Nov 2010)
ASHRAE 189.1 Energy Efficiency												
7.3	Mandatory Provisions for Energy Efficiency	Makes mandatory for Building Projects ASHRAE Standard 90.1-2010 sections 5.4, 6.4 7.4, 8.4, 9.4, and 10.4.	Mandatory	N/A		N/A	None identified beyond those already considered.	Comply with 5.4 Mandatory Provisions on Building Envelope: Insulation, Fenestration and Doors, and Air Leakage 6.4 Mandatory Provisions on Heating, Ventilating, and AC: Equipment Efficiencies, Calculations and Controls 7.4 Mandatory Provisions on Water Heating: Load Calculations, Equipment Efficiencies, Piping Insulation, Heating System controls, and Pools 8.4 Mandatory Provisions on Power: Voltage Drop 9.4 Mandatory Provisions on Lighting: Lighting Controls, Tandem Wiring, Exit Signs, Exterior Building Grounds Lighting, Exterior Building Lighting Power10.4 Mandatory Provisions on Other Equipment: Electric Motors, Service Water Pressure Booster System, and Elevators	Comply with 5.4 Mandatory Provisions on Building Envelope: Insulation, Fenestration and Doors, and Air Leakage 6.4 Mandatory Provisions on Heating, Ventilating, and AC: Equipment Efficiencies, Verification and Labeling Requirements 7.4 Mandatory Provisions on Water Heating: Load Calculations, Equipment Efficiencies, Service Hot Water Piping Insulation, Service Water Heating System Controls 8.4 Mandatory Provisions on Power: Voltage Drop 9.4 Mandatory Provisions on Lighting: Lighting Controls, Tandem Wiring, Exit Signs, Exterior Building Grounds Lighting, Exterior Building Lighting Power 10.4 Mandatory Provisions on Other Equipment: Electric Motors	Comply with 5.4 Mandatory Provisions on Building Envelope: Insulation, Fenestration and Doors, and Air Leakage 6.4 Mandatory Provisions on Heating, Ventilating, and AC: Equipment Efficiencies, Verification and Labeling Requirements, Load Calculations, Controls, and HVAC Systems Construction and Insulation 7.4 Mandatory Provisions on Water Heating: Load Calculations, Equipment Efficiencies, Service Hot Water Piping Insulation, Service Water Heating System Controls, and Pools 8.4 Mandatory Provisions on Power: Voltage Drop 9.4 Mandatory Provisions on Lighting: Lighting Controls, Tandem Wiring, Exit Signs, Exterior Building Grounds Lighting, Exterior Building Lighting Power 10.4 Mandatory Provisions on Other Equipment: Electric Motors	Nearly all UFC references to ASHRAE 90.1 refer to 2004 and 2007 versions.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
7.3.2	On-site Renewable Energy Systems	Building projects must provide for the future installation of on-site renewable energy systems by of a rating of 3.7 Kw per 1000 sq ft or 13,000 BTU/hr per 1000 sq ft and design shall show allocated space and pathways for installation and associated infrastructure.	Mandatory	EA Credit 2: On-site Renewable Energy Use on-site renewable energy systems to offset building energy costs. 1-7 points	Meets AF Energy and Water Criteria	HPSB GPII--On-Site Renewable Energy (EISA Sec523): Meet at least 30% of the hot water demand through the installation of solar hot water heaters, when lifecycle cost effective.	EO 13423: Renewable energy generation projects should be implemented on agency property for agency use.	N/A	N/A	N/A	UFC 4-030-01 (A-1): E.O. 13423:: At least 50 percent of the statutorily required renewable energy consumed by the agency must come from new renewable energy sources. UFC 3-400-01 (2-1.4): Both recovered and renewable energy shall be used in each design to the maximum extent that is life cycle cost effective. Solar hot water shall be used in each design to furnish a minimum of 30 percent of the hot water demand if life cycle cost effective.	
7.3.3.1, 7.3.3.2, 7.3.3.3	Energy Consumption Measurement	Requires the collection of data regarding the consumption of electricity, gas and district heat, with remote communications capability, for main systems and select subsystems as articulated in Table 7.3.3.1B. The data communication shall be automatic and provide hourly profiles, and should be stored for a minimum of 3 years.	Mandatory	EA Credit 5: Measurement and Verification Option 1: Develop M&V plan consistent with Option D: *Calibrated Simulation* in International Performance Measurement & Verification Protocol Volume III with a M&V period of 1 year post-construction occupancy, OR Option 2: Develop M&V plan consistent with Option B: *Energy Conservation Measure Isolation* in International Performance Measurement & Verification Protocol Volume III with a M&V period of 1 year post-construction occupancy. 3 points	Meets AF Energy and Water Criteria	HPSB GPII--Measurement and Verification--EPAct 2005, Sec103: Install building level electricity meters in new major construction and renovation projects to track and continuously optimize performance. EISA Sec 434: Include equivalent meters for natural gas and steam, where natural gas and steam are used.	None identified beyond those already considered.	Energy Cost Budget Method 11.2 Simulation General Requirements Simulate energy cost budget	Energy Cost Budget Method 11.2 Simulation General Requirements Simulate energy cost budget	Energy Cost Budget Method 11.2 Simulation General Requirements Simulate energy cost budget	UFC 3-400-01 (2-5): A utility meter shall be furnished at each building, for each utility serving the building (e.g. district steam, district hot and chilled water, electricity, natural gas, fuel oil, etc.) in the normal units of the utility (i.e. kWh, kW, cf, gallons, etc.). All meters shall be connected to a base wide energy and utility monitoring and control system either directly or via the building HVAC control system. UFC 4-030-01 (C-4.3.1) (EPAct 2005): Federal agencies must have advanced metering capability (hourly measurements of electricity consumption and daily data reports, at a minimum) by October 1, 2012. Metering of gas and water consumption should also be considered.	
Section 7.4: Prescriptive Options												
7.4.1	Prescriptive Option	Requires all building projects to comply with ASHRAE Standard 90.1-2010, plus those requirements articulated in other sections of 7.4	Prescriptive	N/A		N/A	None identified beyond those already considered.	Comply with all aspects of 90.1	Comply with all aspects of 901.1	Comply with all aspects of 901.1	Nearly all UFC references to ASHRAE 90.1 refer to 2004 and 2007 versions.	
7.4.1.1	On-site Renewable Energy Systems	Mandates on-site renewable energy systems with production of not less than 6.0 Kbtu/sq ft.	Prescriptive	EA Credit 2: On-site Renewable Energy Use on-site renewable energy systems to offset building energy costs. % RE of total points 1% 1 3% 2 5% 3 7% 4 9% 5 11% 6	Meets AF Energy and Water Criteria	HPSB GPII--On-Site Renewable Energy (EO 13423): Implement renewable energy generation projects on agency property for agency use, when lifecycle cost effective.	EO 13423: Renewable energy generation projects should be implemented on agency property for agency use.	N/A	N/A	N/A	UFC 4-030-01 (A-1): E.O. 13423:: At least 50 percent of the statutorily required renewable energy consumed by the agency must come from new renewable energy sources. UFC 3-400-01 (2-1.4): Both recovered and renewable energy shall be used in each design to the maximum extent that is life cycle cost effective. Solar hot water shall be used in each design to furnish a minimum of 30 percent of the hot water demand if life cycle cost effective.	
7.4.2	Building Envelope	Requires compliance with ASHRAE 90.1 and the requirements articulated in Tables in Normative Appendices A & B, and those articulated in sections 7.4.2.1-10, which include details regarding insulation, fenestration, permanent projections, vestibules, and continuous air barriers.	Prescriptive	IEQ Credit 7.1: Thermal Comfort - Design Design HVAC and building envelope to meet ASHRAE Standard 55-2004 1 point		N/A	None identified beyond those already considered.	Comply with all aspects of section 5 Building Envelope	Comply with all aspects of section 5 Building Envelope	Comply with all aspects of section 5 Building Envelope	UFC 3-400-02 (2-10.1.3): Suggests selection of the proper Building Envelope Requirements table from within ASHRAE/IESNA Standard 90.1 of 2001 for energy conservation design. UFC 4-030-01 (C-4.2) The Army Corps of Engineers requires the designer to achieve a minimum of 30 percent less energy than ASHRAE 90.1-2004. Fundamental to designing an energy-efficient, high-performance building is integrating the building with the site; using renewable and/or distributed energy resources, and optimizing the building envelope.	
7.4.2.8	Bldg Envelope Trade off option	ASHRAE 90.1 Section 5.6 Trade Off option will not apply unless the modifications and additions noted in ASHRAE 189.1 Section 7.4.2 Apply	Prescriptive	N/A		N/A		Comply with section 5.6 Building Envelope Trade-off Option	Comply with section 5.6 Building Envelope Trade-off Option	Comply with section 5.6 Building Envelope Trade-off Option	UFC 3-400-02 (2-10.1.3): Suggests selection of the proper Building Envelope Requirements table from within ASHRAE/IESNA Standard 90.1 of 2001 for energy conservation design.	
7.4.2.5	Permanent Projection	Requires vertical fenestration on W, S and E sides be shaded by permanent projections in some climate zones	Prescriptive	N/A		N/A		N/A	N/A	N/A	N/A	
7.4.2.10	Continuous Air Barrier	Requires continuous air barrier IAW Normative Appendix B	Prescriptive	N/A		N/A		5.4.3.1 Continuous Air Barrier The entire building envelope shall be designed and constructed with a continuous air barrier.	5.4.3.1 Building Envelope Seal The entire building envelope shall be sealed, caulked, gasketed, or weather stripped.	5.4.3.1 Building Envelope Seal The entire building envelope shall be sealed, caulked, gasketed, or weather stripped.	N/A	
7.4.3.1	Minimum Equipment Efficiencies	Requires products used in projects to comply with: Option 1: The National Appliance Energy Conservation Act (NAECA), EPAct, and EISA. OR Option 2: ENERGY STAR requirements Sec 7.4.7.3 and Tables C-1-C15 in Appendix C, and ASHRAE 90.1 with additional requirements for renewable energy and peak load energy use reductions.	Prescriptive	N/A		N/A	National Appliance Energy Conservation Act, EPAct, and EISA	Comply with 6.4.1 Equipment Efficiencies, Verification, and Labeling Requirements.	Comply with 6.4.1 Equipment Efficiencies, Verification, and Labeling Requirements.	Comply with 6.4.1 Equipment Efficiencies, Verification, and Labeling Requirements.	UFC 3-400-01 (2-1.3) (Federal Acquisition Regulation Part 23): All energy consuming products shall be either ENERGY STAR-qualified or FEMP-recommended. These products are in the upper 25 percent of energy efficiency in their class.	
7.4.3.2	Ventilation Controls	Demand Control Ventilation should comply with ASHRAE 62.1 and supersedes ASHRAE 90.1, plus specifications regarding CO2 sensors.	Prescriptive	N/A		N/A		6.4.3.9 Ventilation Controls for High-Occupancy Areas DCV required for spaces over 500 ft2 and with design occupancy for ventilation of greater than 40 people per 1000 ft.	6.4.3.9 Ventilation Controls for High-Occupancy Areas. DCV required for spaces over 500 ft2 and with design occupancy for ventilation of greater than 40 people per 1000 ft.	6.4.3.8 Ventilation Controls for High-Occupancy Areas. Systems with design greater than 3000 cfm and area larger than 100 people per ft2 shall have means to automatically reduce outdoor air intake. Also meet ASHRAE 62.	N/A	

ASHRAE 189.1 Reference	Subject	Summary (requirement met or requirement not met)	Mandatory, Prescriptive, or Performance	LEED 2009 (NC)	LEED meets AF Energy and Water Criteria	HPSB (12/2008)	DoD Policy Directives	ASHRAE 90.1 (2010)	ASHRAE 90.1 (2007)	ASHRAE 90.1 (2004)	Unified Facilities Criteria (as of 3/2011)	International Green Construction Code (v2.0, Nov 2010)
7.4.3.3	Duct and Plenum Leakage	Use Seal Level A for duct sealing.	Prescriptive	N/A		N/A		Comply with 6.4.4.2 Ductwork and Plenum Leakage Duct work and Plenums shall be constructed to seal class A. Ductwork designed to operate at static pressure in excess of 3 in and all ductwork located outdoors shall be leak - tested.	Comply with 6.4.4.2 Ductwork and Plenum Insulation All supply and return ducts and plenum shall be thermally insulated in accordance with Table 6.8.2A and 6.8.2B	Comply with 6.4.4.2 Ductwork and Plenum Leakage Seal according to Table 6.4.4.2A and industry standards. Leak test ductwork designed to operate at static pressures over 3 in.	N/A	
7.4.3.4	Economizers	Requires economizers usage as articulated in ASHRAE 90.1 but with additional requirements as articulated in 7.4.3.4	Prescriptive	N/A		N/A		Comply with 6.5.1 Economizers Cooling Systems shall include either an air or water economizer meeting requirements 6.5.1.1 through 6.5.1.4	Comply with 6.5.1 Economizers Cooling Systems shall include either an air or water economizer meeting requirements 6.5.1.1 through 6.5.1.4	Comply with 6.5.1 Economizers Cooling Systems shall include either an air or water economizer meeting requirements 6.5.1.1 through 6.5.1.4	UFC 3-401-01FA (TI 811-12---6-4): The use of an economizer cycle in air conditioning systems can be a cost effective conservation measure, depending on climatic conditions and the type of mechanical system. The economizer cycle utilizes OA to reduce the building's cooling requirements when the OA dry bulb temperature is less than the required changeover temperature. At optimum conditions, the space temperature is maintained at setpoint without the addition of mechanical cooling.	
7.4.3.5	Zone Control	Uses ASHRAE 90.1 requirements, but reduces exceptions to compliance slightly. The amount of air reheated or recooled supplied to a zone shifts from 30% to 15%.	Prescriptive	N/A		N/A		Comply with 6.5.2.1 Zone Controls Zone controls shall prevent reheating, recooling, mixing of supplying air that was previously heated or cooled by the system or other simultaneous heating and cooling to the same zone.	Comply with 6.5.2.1 Zone Controls Zone controls shall be capable of operating in sequence the supply of heating and cooling energy to the *zone*.	Comply with 6.5.2.1 Zone Controls Zone controls shall be capable of operating in sequence the supply of heating and cooling energy to the *zone*.	N/A	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
7.4.3.7	Controls	Mandates multi stage cooling, multispeed or variable speed drive on small DX and chilled water units, with additional requirements for sizing and performance.	Prescriptive	N/A		N/A		Comply with 6.4.3 Controls	Comply with 6.4.3 Controls	Comply with 6.4.3 Controls	N/A	
7.4.3.8	Exhaust Air Energy Recovery	Requires energy recovery systems with at least 60% energy recovery effectiveness	Prescriptive	N/A		N/A		Comply with 6.5.6.1 Exhaust Air Energy Recovery Shall have an energy recovery system with at least a 50% energy recovery effectiveness.	Comply with 6.5.6.1 Exhaust Air Energy Recovery Individual fan systems to have 2400 L/s or greater and minimum outdoor air supply of 70% or greater with at least 50% recovery efficiency.	Comply with 6.5.6.1 Exhaust Air Energy Recovery Individual fan systems to have 5000 cfm or greater and minimum outdoor air supply of 70% or greater with at least 50% recovery efficiency.	N/A	
7.4.3.10-11	Duct and Pipe Insulation	Requires insulation specifications for duct and pipe insulation as articulated in ASHRAE 90.1.	Prescriptive	N/A		N/A	None identified beyond those already considered.	Comply with 6.4.4.2 Ductwork and Plenum Leakage Duct work and Plenums shall be constructed to seal class A. Ductwork designed to operate at static pressure in excess of 3 in and all ductwork located outdoors shall be leak - tested.	Comply with 6.4.4.2 Ductwork and Plenum Insulation All supply and return ducts and plenum shall be thermally insulated in accordance with Table 6.8.2A and 6.8.2B	Comply with 6.4.4.2 Ductwork and Plenum Leakage Seal according to Table 6.4.4.2A and industry standards. Leak test ductwork designed to operate at static pressures over 3 in.	N/A	
7.4.3.12	Automatic controls of HVAC and Lights	Required for hotels/motels with over 50 rooms (and presumably dormitories). Requires outlets, TV's and HVAC to be controlled when unoccupied.	Prescriptive	N/A		N/A		6.5.3.4 Supply-air temperature reset controls Multiple zone HVAC systems must include controls that automatically rest supply-air temperature to representative building loads or outdoor air temperature.	N/A	N/A	N/A	
7.4.4	Service Water Heating	Requires compliance with ASHRAE 90.1 plus additional requirements regarding system efficiency and insulation.	Prescriptive	N/A		N/A		Comply with Section 7. Service Water Heating	Comply with Section 7. Service Water Heating	Comply with Section 7. Service Water Heating	UFC 3-420-01 (1-9.1): Plumbing system energy usage and equipment efficiencies shall comply with UFC 3-400-01, Energy Conservation, requirements.	
7.4.5.1	Peak Load Reduction	Mandates automatic load reduction of at least 10% for all building projects during peak load times	Prescriptive	N/A		N/A		N/A	N/A	N/A	N/A	
7.4.6	Lighting	Requires compliance with ASHRAE 90.1, plus lighting power limits, occupancy sensors, and automatic controls.	Prescriptive	IEQ Credit 6.1: Controllability of Systems- Lighting Provide individual lighting controls for 90% of the building occupants and system controls for all shared multi-occupant spaces. 1 point		HPSB GPIV--Daylighting: Provide automatic dimming controls or accessible manual lighting controls, and appropriate glare control.		Comply with Section 9 Lighting	Comply with Section 9 Lighting	Comply with Section 9 Lighting	UFC 3-530-01: Design: Interior, Exterior, Lighting and Controls --- Multiple requirements	
7.4.7	Other Equipment	In addition to compliance with ASHRAE 90.1 standards, requires performance standards for electric motors, heat recovery on supermarket refrigeration equipment, and an ENERGY STAR mandate for most appliances and electronics.	Prescriptive	N/A		N/A		Comply with Section 10 Other Equipment	Comply with Section 10 Other Equipment	Comply with Section 10 Other Equipment	UFC 3-400-01 (2-1.3) (Federal Acquisition Regulation Part 23): All energy consuming products shall be either ENERGY STAR-qualified or FEMP-recommended. These products are in the upper 25 percent of energy efficiency in their class.	
Section 7.5: Performance Options												
7.5.2	Energy Costs	Requires that the building project has an annual energy cost less than it could under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	EA Prerequisite 2: Minimum Energy Performance Establish a minimum level of energy efficiency for proposed building to reduce environmental and economic impacts. Follow ASHRAE 90.7, OR ASHRAE Advanced Energy Design, OR Advanced Buildings "Core Performance" Guide.		N/A	None identified beyond those already considered.	Comply with Section 11	Comply with Section 11	Comply with Section 11	N/A	

ASHRAE 189.1 Reference	Subject	Summary (requirement met or requirement not met)	Mandatory, Prescriptive, or Performance	LEED 2009 (NC)	LEED meets AF Energy and Water Criteria	HPSB (12/2008)	DoD Policy Directives	ASHRAE 90.1 (2010)	ASHRAE 90.1 (2007)	ASHRAE 90.1 (2004)	Unified Facilities Criteria (as of 3/2011)	International Green Construction Code (v2.0, Nov 2010)
7.5.3	Annual CO2 equivalent	Requires that the building project has an annual carbon dioxide equivalent emissions less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	N/A		HPSB GPII--- Benchmarking: Compare actual performance data from the first year of operation with the energy design target, preferably by using ENERGY STAR® Portfolio Manager for building and space types covered by ENERGY STAR®. Verify that the building performance meets or exceeds the design target, or that actual energy use is within 10% of the design energy budget for all other building types.	EO 13514	N/A	N/A	N/A	N/A	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
7.5.4	Annual Load Factor/Peak Load Demand	Requires that the building project has an annual peak electricity demand less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	EA Prerequisite 2: Minimum Energy Performance Establish a minimum level of energy efficiency for proposed building to reduce environmental and economic impacts. Follow ASHRAE 90.7, OR ASHRAE Advanced Energy Design, OR Advanced Buildings "Core Performance"		N/A	EO 13514	N/A	N/A	N/A	N/A	
Section 8 ASHRAE 198.1: Indoor Environmental Air Quality												
8.3.1	IAQ Mandatory Provisions	Mandates the use of Ventilation Rate Procedure and other procedures. Increases filtration requirements and other air-cleaning devices. Comply with Sections 4-7 of ANSI/ASHRAE Standard 62.1	Mandatory	IEQ Prerequisite 1: Minimum Indoor Air Quality Performance Meet requirements of Sections 4-7 of ASHRAE Standard 62.1-2007		HPSB GPIV--Ventilation and Thermal Comfort: Meet ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality.	None identified beyond those already considered.	N/A	N/A	N/A	UFC 4-030-01 (C-6): At a minimum, meet the requirements of ASHRAE 62-1999, Ventilation for Acceptable Indoor Air Quality and approved Addenda. UFC 4-030-01 (C-6.1): Where feasible, design mechanical ventilation systems to comply with the recommended design approaches in ASHRAE 2001 Fundamentals Chapter 32, "Space Air Diffusion" and achieve an air change effectiveness (E) greater than or equal to 0.9 as determined by ASHRAE 129-1997.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
8.3.1.2	Outdoor Air Delivery Monitoring	Requires a outdoor airflow measurement device.	Mandatory	IEQ Credit 2: Increases Ventilation Provide additional outdoor air with either mechanically ventilated systems or naturally ventilated systems. 1 point		HPSB GPIV--Ventilation and Thermal Comfort: Meet ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality.		N/A	N/A	N/A	N/A	
8.3.1.3	Filtration and Air Cleaner Requirement	Higher air filtration and cleaning requirements for all facilities	Mandatory	IEQ Credit 5: Indoor Chemical a and Pollutant Source Control Requires entryway system at least 10 ft long, exhaust spaces where hazardous gases are present used, install new air filtration of MERV 13 minimum, and provide containment for hazardous liquid wastes. 1 point		HPSB GPIV--Ventilation and Thermal Comfort: Meet ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality.		N/A	N/A	N/A	UFC 4-030-01 (C-6.2): Filtration media with Minimum Efficiency Reporting Value (MERV) of 8 must be used at each return air grill. Replace all filtration media immediately prior to occupancy—filtration media shall have a MERV of 13 as determined by ASHRAE 52.2-1999	
8.3.1.4	Environmental Tobacco Smoke	Smoking is not allowed inside buildings, and requires designated smoking areas be to be located at least 25ft from building entrances.	Mandatory	IEQ Prerequisite 2: Environmental Tobacco Smoke Control Prohibit on-property smoking within 25 feet of entries, outdoor air intakes and operable windows.		HPSB GPIV--Environmental Tobacco Smoke Control: Implement a policy and post signage indicating that smoking is prohibited within the building and within 25 feet of all building entrances, operable windows, and building ventilation intakes during building occupancy.	EO 13058: Limits smoking in and around federal buildings.	N/A	N/A	N/A	N/A	
8.3.1.5	Building Entrances	Requires entry mat system at all entries	Mandatory	IEQ Credit 5: Indoor Chemical a and Pollutant Source Control Requires entryway system at regularly used exterior entrances 1 point		N/A		N/A	N/A	N/A	N/A	
8.3.3	Acoustical Control	Building projects should meet exterior and interior acoustical controls.	Mandatory	N/A		N/A		N/A	N/A	N/A	N/A	
8.3.4	Day lighting by top lighting	Mandates Minimum Requirements for Daylight Zones and Skylights	Mandatory	IEQ Credit 8.1: Daylight and Views - Daylight Demonstrate at least 75% of building's regularly occupied spaces achieve daylighting standards 1 point		HPSB GPIV-- Daylighting: Achieve a minimum daylight factor of 2 percent (excluding all direct sunlight penetration) in 75 percent of all space occupied for critical visual tasks.	None identified beyond those already considered.	5.5.4.2 Fenestration Area The total vertical fenestration shall be less than 40% of the gross wall area. Minimum skylight area shall not exceed 5% of the gross roof area. Total daylight area under a skylight shall be a minimum of half the floor area.	Section 5.5.4.2 Fenestration Area Total vertical fenestration area shall be less than 40% of the gross wall area. Skylight fenestration area shall be less than 5% of the gross roof area.	Section 5.5.4.2 Fenestration Area Total vertical fenestration area shall be less than 50% of the gross wall area. Skylight fenestration area shall be less than 5% of the gross roof area.	UFC 4-030-01 (C-4.2.1): Take advantage of natural site elements, such as vegetation, landforms, solar access, and wind direction to reduce the energy load of the building. Use passive solar design techniques, including passive solar heating, trombe walls, and natural ventilation. Orient and size windows, and locate landscape with solar geometry, predominate wind direction, and building load requirements in mind. Well-designed sun control and shading devices are particularly important in buildings that employ passive solar heating or daylighting.	
8.3.5	Isolation of Building from Pollutants in Soil	Ground level foundations built on Brownfields or in Zone1 counties will have *Soil Gas Retarding System.*	Mandatory	N/A		N/A		N/A	N/A	N/A	N/A	
Section 8.4: Prescriptive Options												
8.4.1.1	Daylighting: Minimum Effective Aperture	Sets minimum Effective Aperture area for day lighting for office spaces and classroom	Prescriptive	IEQ Credit 8.1: Daylight and Views - Daylight Demonstrate at least 75% of building's regularly occupied spaces achieve daylighting standards 1 point	Meets AF Energy and Water Criteria	HPSB GPIV-- Daylighting: Achieve a minimum daylight factor of 2 percent (excluding all direct sunlight penetration) in 75 percent of all space occupied for critical visual tasks.	None identified beyond those already considered.	5.5.4.2 Fenestration Area The total vertical fenestration shall be less than 40% of the gross wall area. Minimum skylight area shall not exceed 5% of the gross roof area. Total daylight area under a skylight shall be a minimum of half the floor area.	Section 5.5.4.2 Fenestration Area Total vertical fenestration area shall be less than 50% of the gross wall area. Skylight fenestration area shall be less than 5% of the gross roof area.	Section 5.5.4.2 Fenestration Area Total vertical fenestration area shall be less than 50% of the gross wall area. Skylight fenestration area shall be less than 5% of the gross roof area.	N/A	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
		Places testing, documentation and formulation		IEQ Credit 4.2: Low Emitting Materials - Paints and Coatings Paints must not exceed VOC limits in Green Seal Standard GS-11. Anti-corrosive and anti-rust paints must not exceed VOC limit in GS-03. Clear finishes must not exceed VOC content in SCAQMD Rule 1113 1 point		HPSB GPIV--- Low-Emitting Materials: Specify materials and products with low pollutant emissions, including composite wood products, adhesives, sealants, interior paints and finishes, carpet systems, and furnishings.						
				IEQ Credit 4.1: Low-Emitting Materials - Adhesives and Sealants Follow rule SCAQMD Rule 1168 for VOC's and conduct air sample testing. 1 point								

ASHRAE 189.1 Reference	Subject	Summary (requirement met or requirement not met)	Mandatory, Prescriptive, or Performance	LEED 2009 (NC)	LEED meets AF Energy and Water Criteria	HPSB (12/2008)	DoD Policy Directives	ASHRAE 90.1 (2010)	ASHRAE 90.1 (2007)	ASHRAE 90.1 (2004)	Unified Facilities Criteria (as of 3/2011)	International Green Construction Code (v2.0, Nov 2010)
8.4.2	Materials	requirements on reported emissions or VOC contents. Materials include adhesives and sealants; paints and coatings; floor covering material; and composite wood, wood structural panel, and agrifiber products. Requirements may follow CA/DHS/EHLB/R-174, SCAQMD Rule 1168 or 1113, GS-36, GS-11, or third-party verification through CARB.	Prescriptive	IEQ credit 4.3: Low-Emitting Materials- Flooring Systems Option 1: Carpet and carpet cushion required to meet Carpet and Rug Institute Green Label program. AND Carpet adhesive has to meet IEQ credit 4.1. AND Hard surface flooring must comply with FloorScore standard and be verified by a third party or non-carpet areas must be FloorScore certified and be at least 25% of floor area. AND floors with a sealer or stain must meet SCAQMD Rule 1113. AND tile adhesives must meet SCAQMD Rule 1168. Option 2: All flooring materials must meet California Department of Health Services Standard for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale environmental Chambers. 1 point		HPSB GPV--Environmentally Preferable Products: Use products that have a lesser or reduced effect on human health and the environment over their lifecycle when compared with competing products or services that serve the same purpose.		N/A	N/A	N/A	N/A	code shall not apply.
Section 8.5: Performance Options												
8.5.1	Daylighting simulation	Demonstrate through simulations of classrooms and office spaces that there is usable luminance using ray-tracing or radiosity computer model or CIE Overcast Sky Model or the CIE Clear Sky Model. And the direct sunlight does not strike a work surface more than 20% of the time.	Performance	IEQ Credit 8.1: Daylight and Views - Daylight Demonstrate at least 75% of building's regularly occupied spaces achieve daylighting standards		HPSB GPIV-- Daylighting: Achieve a minimum daylight factor of 2 percent (excluding all direct sunlight penetration) in 75 percent of all space occupied for critical visual tasks.	None identified beyond those already considered.	N/A	N/A	N/A	N/A	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
8.5.2	Materials	Model materials for VOC concentrations. The sum should comply with section 4.3 of CA/DHS/EHLB/R-14	Performance	IEQ Credit 4.2: Low Emitting Materials - Paints and Coatings Paints must not exceed VOC limits in Green Seal Standard GS-11. Anti-corrosive and anti-rust paints must not exceed VOC limit in GS-03. Clear finishes must not exceed VOC content in SCAQMD Rule 1113 1 point IEQ Credit 4.1: Low-Emitting Materials - Adhesives and Sealants Follow rule SCAQMD Rule 1168 for VOC's and conduct air sample testing. 1 point IEQ credit 4.3: Low-Emitting Materials- Flooring Systems Option 1: Carpet and carpet cushion required to meet Carpet and Rug Institute Green Label program. AND Carpet adhesive has to meet IEQ credit 4.1. AND Hard surface flooring must comply with FloorScore standard and be verified by a third party or non-carpet areas must be FloorScore certified and be at least 25% of floor area. AND floors with a sealer or stain must meet SCAQMD Rule 1113. AND tile adhesives must meet SCAQMD Rule 1168. Option 2: All flooring materials must meet California Department of Health Services Standard for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale environmental Chambers. 1 point		HPSB GPIV--- Low-Emitting Materials: Specify materials and products with low pollutant emissions, including composite wood products, adhesives, sealants, interior paints and finishes, carpet systems, and furnishings.	None identified beyond those already considered.	N/A	N/A	N/A	N/A	
Section 9 ASHRAE 189.1: The Building's Impact on Atmosphere, Materials, and Resources												
9.3.1.1	Diversion	50% of construction debris must be recycled or reused.	Mandatory	MR Credit 2: Construction Waste Management Recycle or salvage at least 50% of non-hazardous construction and demolition debris. 1-2 points		N/A	AR 420-49, Chapter 3, contains policy for Solid Waste Management. AR 420-49, paragraph 3-6, sub-paragraph d., states that construction and demolition debris should be recycled when possible. Air Force Instruction (AFI) 32-7042, Waste Management, states that installations should pursue cost-effective management approaches that decrease the landfill space required for C&D debris, decrease the amount of HW contaminating C&D debris, and help the Air Force uphold its commitment to pollution prevention.	N/A	N/A	N/A	UFC 1-900-01 (1-4.2): Construction and demolition debris should be recycled when possible. UFC 4-030-01 (C-5.2): Consider deconstructing buildings (the systematic dismantling of buildings) rather than demolishing them. In project specifications, incorporate requirements to divert from landfills a high percentage of both construction waste and demolition debris by salvage, recycling, or recovery. Include the development and implementation of a plan for sorting construction waste for recycling. Use products and assemblies that minimize disposable packaging and storage requirements.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
9.3.1.2	Total waste	Places maximum limits of 12,000lbs per 10,000 sq ft of waste generated for projects where buildings and hardscapes make up less that 5% of the site landcover. Waste generation must be tracked throughout construction.	Mandatory	N/A		N/A	AR 420-49, Chapter 3, contains policy for Solid Waste Management. AR 420-49, paragraph 3-6, sub-paragraph d., states that construction and demolition debris should be recycled when possible. Air Force Instruction (AFI) 32-7042, Waste Management, states that installations should pursue cost-effective management approaches that decrease the landfill space required for C&D debris, decrease the amount of HW contaminating C&D debris, and help the Air Force uphold its commitment to pollution prevention.	N/A	N/A	N/A	UFC 1-900-01 (1-4.2): Construction and demolition debris should be recycled when possible. UFC 4-030-01 (C-5.2): Consider deconstructing buildings (the systematic dismantling of buildings) rather than demolishing them. In project specifications, incorporate requirements to divert from landfills a high percentage of both construction waste and demolition debris by salvage, recycling, or recovery. Include the development and implementation of a plan for sorting construction waste for recycling. Use products and assemblies that minimize disposable packaging and storage requirements.	
9.3.2	Extracting , Harvesting, and/or Manufacturing	Materials and products are to be manufactured according to regulations on the country of origin. Wood products shall not be from endangered species unless it conforms with CITES	Mandatory	N/A		HPSB GPV--Environmentally Preferable Products: Use products that have a lesser or reduced effect on human health and the environment over their lifecycle when compared with competing products or services that serve the same purpose.	USA is signator of CITES, so DOD must comply	N/A	N/A	N/A	N/A	
9.3.3	Refrigerants	CFC-based refrigerants in HVAC systems will not be used. Fire suppression systems shall not contain ozone depleting substances	Mandatory	EA Prerequisite 3: Fundamental Refrigerant Management Zero use of CFC based refrigerants in new HVAC&R systems. For older systems create a CFC phase-out plan.		HPSB GPV--Ozone Depleting Compounds (CAA, 1990): Eliminate the use of ozone depleting compounds during and after construction where alternative environmentally preferable products are available.		N/A	N/A	N/A	UFC 4-030-01 (C-4.1): Only use heating, ventilating, air-conditioning (HVAC), and refrigerating equipment containing with non-CFC-based refrigerants. Use of HVAC, refrigeration, and fire suppression equipment free of HCFCs and Halons is also recommended.	

ASHRAE 189.1 Reference	Subject	Summary (requirement met or requirement not met)	Mandatory, Prescriptive, or Performance	LEED 2009 (NC)	LEED meets AF Energy and Water Criteria	HPSB (12/2008)	DoD Policy Directives	ASHRAE 90.1 (2010)	ASHRAE 90.1 (2007)	ASHRAE 90.1 (2004)	Unified Facilities Criteria (as of 3/2011)	International Green Construction Code (v2.0, Nov 2010)
9.3.4.1	Recyclables	Requires area serving building be dedicated to the collection and storage of materials for recycling	Mandatory	MR Prerequisite 1: Storage and Collection of Recyclables Provide an easily accessible area for collection and storage of materials for recycling		HPSB GPV-- Recycling: Incorporate adequate space, equipment, and transport accommodations for recycling in the building design.	None identified beyond those already considered.	N/A	N/A	N/A	UFC 4-030-01 (C-7.3): Ensure the design provides space and bins for collection and storage of occupants' recyclables.	
9.3.4.2	Reusable goods	Requires buildings projects with residential space to have an area serving the building to be dedicated to the collection and reuse of materials.	Mandatory	N/A		HPSB GPV-- Recycling: Incorporate adequate space, equipment, and transport accommodations for recycling in the building design.		N/A	N/A	N/A	UFC 4-030-01 (C-7.3): Ensure the design provides space and bins for collection and storage of occupants' recyclables.	
9.3.4.3	Fluorescent and HID Lamps	Requires an area serving the building to be dedicated to the collection and storage of fluorescent and HID lamps and ballasts.	Mandatory	N/A		N/A		N/A	N/A	N/A	UFC 4-030-01 (C-7.3): Ensure the design provides space and bins for collection and storage of occupants' recyclables.	
Section 9.4: Prescriptive Options												
9.4.1.1	Recycled Content	Recycled materials must make up at least 10% of the cost of the building materials	Prescriptive	MR Credit 3: Materials Reuse Use salvaged, refurbished or reused materials of at least 5% (I point) or 10% (2 points) based on cost of all building materials on the project. 1-2 points		HPSB GPV-- Recycled Content (Sec 6002 of RCRA): For EPA-designated products, specify products meeting or exceeding EPA's recycled content recommendations. For other products, specify materials with recycled content when practicable. If EPA-designated products meet performance requirements and are available at a reasonable cost, a preference for purchasing them shall be included in all solicitations relevant to construction, operation, maintenance of or use in the building.	The DoD Green Procurement Policy requires the services to have preferential purchasing programs for EPA recycled content products designated in the Comprehensive Procurement Guidelines (CPG), USDA biobased products, EnergyStar products, FEMP Energy Efficient Standby Power Devices, DOE Water Conserving products, California Low VOV products, EPA Asbestos Alternative products; products that reduce EPA priority chemicals (cadmium, lead, PCB, mercury and naphthalene), and any other products that are environmentally preferable according to EPA criteria. Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," directs Federal agencies to use recycled content, biobased products, environmentally preferable products, and reduce the quantity of toxic and hazardous chemicals and materials acquired, used, or disposed of by agencies.	N/A	N/A	N/A	UFC 4-030-01 (C-5.4): Use EPA-designated recycled content products (http://www.epa.gov/cpg/products.htm) to the maximum extent practicable—required under the Resource Conservation and Recovery Act of 1994, Section 6002	
9.4.1.2	Regional Materials	At least 15% of building materials, based upon cost, must be made within 500 miles of the project site.	Prescriptive	MR Credit 5: Regional Materials Use only building materials and products that have been extracted, harvested, or recovered and manufactured with in 500 miles. Using a minimum of 10% (1 point) or 20% (2 points) of the cost of total materials. 1-2 points		N/A	None identified beyond those already considered.	N/A	N/A	N/A	N/A	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
9.4.1.3	Biobased Products	Biobased products must make up at least 5% of the cost of the building materials.	Prescriptive	N/A		HPSB GPV--Biobased Content (Sect 9002, Farm Security and Rural Investment Act (FSRIA)): For USDA designated products, specify products with the highest content level per USDA's biobased content recommendations. For other products, specify biobased products made from rapidly renewable resources and certified sustainable wood products. If these designated products meet performance requirements and are available at a reasonable cost, a preference for purchasing them shall be included in all solicitations relevant to construction, operation, maintenance of or use in the building.	The DoD Green Procurement Policy requires the services to have preferential purchasing programs for EPA recycled content products designated in the Comprehensive Procurement Guidelines (CPG), USDA biobased products, EnergyStar products, FEMP Energy Efficient Standby Power Devices, DOE Water Conserving products, California Low VOV products, EPA Asbestos Alternative products; products that reduce EPA priority chemicals (cadmium, lead, PCB, mercury and naphthalene), and any other products that are environmentally preferable according to EPA criteria. Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," directs Federal agencies to use recycled content, biobased products, environmentally preferable products, and reduce the quantity of toxic and hazardous chemicals and materials acquired, used, or disposed of by agencies.	N/A	N/A	N/A	UFC 4-030-01 (Appendix D)-- Green Procurement section articulates other Federal mandates.	
9.4.1.3.1	Wood Building Components	Certified wood must make up at least 60% of total wood used in the project.	Prescriptive	MR Credit 7: Certified Wood Use minimum of 50% wood-based materials that are certified by the Forest Stewardship Council. 1 point		HPSB GPV--Environmentally Preferable Products: Use products that have a lesser or reduced effect on human health and the environment over their lifecycle when compared with competing products or services that serve the same purpose.	None identified beyond those already considered.	N/A	N/A	N/A	UFC 4-030-01 (C-5.6): Use timber products obtained from sustainably managed forests, certified through third-party agencies such as the Forest Stewardship Council (FSC). Where economically feasible, give preference to rapidly renewable and bio-based materials or products, such as agricultural-fiber sheathing, linoleum, and bamboo flooring, over inert or non-recycled alternatives.	
Section 9.5: Performance Options												
9.5	Performance Option	Life-Cycle Assessment be performed for a minimum of two building alternatives. Requires report and documentation of critical peer review by third party.	Performance	N/A		N/A	None identified beyond those already considered.	N/A	N/A	N/A	N/A	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
Section 10 ASHRAE 189.1: Construction and Plans for Operation												
10	Construction and Plans for Operation	Requirements for construction and plans for operation, including commissioning, acceptance testing, M&V, transportation mgt, erosion and sediment control, and IAQ during construction		IEQ Credit 3.1: Construction Indoor Air Quality Management Plan - During construction Meet or exceed control measures for SMACNA IAQ Guidelines, protect on-site installed absorptive material from moisture damage and if air handlers are used during construction filter with media of at least MERV 8. 1 point		HPSB GPIV-Protect Indoor Quality during Construction: Follow the recommended approach of the Sheet Metal and Air Conditioning Contractor's National Association Indoor Air Quality Guidelines for Occupied Buildings under Construction, 2007.	UFC 4-030-01 (B-4.3.3): Implementing Building Commissioning is required for all Air Force projects involving new construction or major renovation. Project teams should follow the current American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Guideline 0, The Commissioning Process and Guideline 1 (The HVAC Commissioning Process), and, where applicable, use the Unified Facilities Guide Specifications (UFGS) for particular systems.	6.7.2.4 System Commissioning HVAC Control systems shall be tested to ensure that control elements are in proper working order.	6.7.2.4 System Commissioning HVAC Control systems shall be tested to ensure that control elements are in proper working order.	6.7.2.4 System Commissioning HVAC Control systems shall be tested to ensure that control elements are in proper working order.	UFC 4-030-01 (B-4.4.3): The Air Force expects their design and construction agents to integrate commissioning into the project development process. They do not fund, require, or recommend hiring a separate, independent commissioning authority.	
10.3.1.1	Bldg Acceptance Testing	Requires acceptance testing by the authority having jurisdiction (AHJ)	Mandatory	N/A		N/A	None identified beyond those already considered.	N/A	N/A	N/A	UFC 4-030-01 (3-4.2.9): A walk-through during the final acceptance of punch list items should include the facility O&M team to ensure operational questions have been asked of the construction contractor.	

ASHRAE 189.1 Reference	Subject	Summary (requirement met or requirement not met)	Mandatory, Prescriptive, or Performance	LEED 2009 (NC)	LEED meets AF Energy and Water Criteria	HPSB (12/2008)	DoD Policy Directives	ASHRAE 90.1 (2010)	ASHRAE 90.1 (2007)	ASHRAE 90.1 (2004)	Unified Facilities Criteria (as of 3/2011)	International Green Construction Code (v2.0, Nov 2010)
10.3.1.2-4	Building Project Commissioning	Requires building commissioning for all buildings over 5000 sq ft, including commissioning plan. Commissioning must include HVAC&R systems, building envelope, irrigation, plumbing, water pumping and mixing, water heating, renewable energy, and measurement devices.	Mandatory	EA Prerequisite1: Fundamental Commissioning of Building Energy Systems Must at a minimum commission the following systems: HVAC&R, Lighting controls, hot water systems, and renewable energy systems		HPSB GP1--Commissioning: Employ commissioning practices tailored to the size and complexity of the building and its system components in order to verify performance of building components and systems and help ensure that design requirements are met. This should include an experienced commissioning provider, inclusion of commissioning requirements in construction documents, a commissioning plan, verification of the installation and performance of systems to be commissioned, and a commissioning report.	UFC 4-030-01 (B-4.3.3): Implementing Building Commissioning is required for all Air Force projects involving new construction or major renovation. Project teams should follow the current American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Guideline 0, The Commissioning Process and Guideline 1 (The HVAC Commissioning Process), and, where applicable, use the Unified Facilities Guide Specifications (UFGS) for particular systems.	6.7.2.4 System Commissioning HVAC Control systems shall be tested to ensure that control elements are in proper working order.	6.7.2.4 System Commissioning HVAC Control systems shall be tested to ensure that control elements are in proper working order.	6.7.2.4 System Commissioning HVAC Control systems shall be tested to ensure that control elements are in proper working order.	UFC 4-030-01 (B-4.4.3): The Air Force expects their design and construction agents to integrate commissioning into the project development process. They do not fund, require, or recommend hiring a separate, independent commissioning authority.	Section 302 (1) Where ASHRAE 189.1 has been adopted, only administrative provisions of the code shall apply and the remainder of the code shall not apply.
10.3.2.2	Maintenance Plan	Mandates maintenance plan for mechanical, electrical, plumbing, and fire protection systems in accordance with ASHRAE Standard 180	Mandatory	N/A		HPSB GPI-- Integrated Design: Use a collaborative, integrated planning and design process that establishes performance goals for siting, energy, water, materials, and indoor environmental quality along with other comprehensive design goals and ensures incorporation of these goals throughout the design and lifecycle of the building • Considers all stages of the building's lifecycle, including deconstruction.	None identified beyond those already considered.	N/A	N/A	N/A	UFC 4-030-01 (3-4.2.11): Throughout the construction phase the sustainability team should be tailoring the O&M program to support the installation's maintenance philosophy. The construction contractor is required to provide O&M manuals and information from their equipment suppliers. Contractors must provide information electronically, and with enough detail to support interface with the Installation's building automation system/environmental management system (BAS/EMS). Manufacturer warranty information and manuals should be compiled for easy access and interface with the BAS/EMS system.	
10.3.2.3	Service Life Plan	Mandates Service Life Plan for structural, building envelope, and hardscape materials.	Mandatory	N/A		HPSB GPI-- Integrated Design: Use a collaborative, integrated planning and design process that establishes performance goals for siting, energy, water, materials, and indoor environmental quality along with other comprehensive design goals and ensures incorporation of these goals throughout the design and lifecycle of the building • Considers all stages of the building's lifecycle, including deconstruction.		N/A	N/A	N/A	UFC 4-030-01 (3-4.2.13): Establish a baseline of operating parameters for the operations and maintenance program. Consult metrics and lessons learned from previous projects, as well as, industry norms and manufacturer specifications. Use this baseline to assess facility degradation during the life of the facility, and to trigger appropriate maintenance or repair activities in the future.	
10.3.2.4	Transportation Management Plan	Mandates a Transportation Management Plan, with varying mandates based upon ownership/leasing arrangements.	Mandatory	N/A		HPSB GPI-- Integrated Design: Use a collaborative, integrated planning and design process that establishes performance goals for siting, energy, water, materials, and indoor environmental quality along with other comprehensive design goals and ensures incorporation of these goals throughout the design and lifecycle of the building • Considers all stages of the building's lifecycle, including deconstruction.		N/A	N/A	N/A	N/A	
There are no Prescriptive or Performance Options for Section 10												

Within the ASHRAE 189.1 Column,
RED means that this requirement is more stringent than others considered
ORANGE means that the ASHRAE 189 requirement could be more stringent based upon how the

Appendix B
Offutt AFB Crosswalk

This appendix summarizes the ASHRAE 189.1 requirements for high performance sustainable buildings, the degree to which the Offutt AFB Weather Agency Headquarters facility conforms to those requirements, actions that are needed to ensure conformance, and the likely added cost of such actions, if any.

ASHRAE 189.1 Reference	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
Section 5: Site Sustainability						
5.3.1.1 and 5.3.1.2	Site Selection	Building site must be on brownfield, greyfield, or greenfield with restrictions.	Mandatory	**LEED (SS1, SS2, and SS3)** has similar points	Requirement met or exceeded.	LEED application; greenfield site, not located on restricted areas .
5.3.2.1	Mitigation of Heat Island Effect	Requires at least 50% of site hardscape (roads, sidewalks, courtyards and parking lots of the building project) to be shaded.	Mandatory	**LEED (SS 7.1)** has similar points	Requirement not met.	Parking lot is old concrete, therefore SRI is assumed to be <29. Adding trees to provide shading is not feasible.
5.3.2.2	Mitigation of Heat Island Effect	Requires 30% of walls shall be shaded on east and west of building based on shade angle at 10 and 3 on summer solstice.	Mandatory	No similar requirements	Requirement not met; but can be met at minimal cost.	Walls are not presently shaded (see exterior building pictures); East shading not required (per 5.3.2.2 exceptions for zone 5). This requirement does not apply if 75% of opaque wall surface in E and W have SRI of 29. Assuming it would not conflict with base architectural guidelines, this requirement can be met by simply choosing outside wall color/material with SRI ≥ 29. Cost would be minimal.
5.3.2.3	Mitigation of Heat Island Effect	Requires a minimum of 75% of the roof to be SRI of 78 for low-sloped roof or SRI of 29 for steep-sloped roofs, or to be covered by Energy Star Roof Products	Mandatory	**LEED (SS7.2)** has similar points	Requirement met or exceeded.	LEED application.
5.3.3	Reduction of light pollution.	Requires exterior lighting system comply with section 9 of ASHRAE Std 90.1.	Mandatory	Already complying with **ASHRAE 90.1**	Requirement met or exceeded.	Already complying with ASHRAE 90.1
Section 5.4: Prescriptive Options						
5.4.1.1	Site Development	40% of the entire site shall be planted or use permeable pavers	Prescriptive	**LEED (SS 5.2)** requires landscaping the area of the building footprint, but does not address site size (see case 2)	Requirement met or exceeded.	LEED application; 305,694 SF of open space /749,814 SF of property area is >40%.
5.4.1.2	Effective Pervious Area for All Sites	For greenfield sites, 20% of the site should contain native or adapted plants	Prescriptive	**LEED (SS 5.2)** requires landscaping the area of the building footprint, but does not address site size (assume all DoD facilities fall into Case 2)	Requirement met or exceeded.	LEED application; landscaping contains native and adapted plants (WE 1.2).
Section 5.5: Performance Options						
5.5.1	Site Development	Buildings must manage 20% to 50% of rainfall through infiltration, reuse, or evapotransporation.	Performance	**LEED (SS 5.2)** that may meet this based upon region and other variables. **EISA Sec 438** requires the restoration to pre-development hydrology to "the maximum extent technically feasible."	Requirement met or exceeded.	LEED application.
Section 6: Water Use Efficiency						
6.3.1	Water Use Efficiency- Landscape Design	60% of the building site landscaping must be bio-diverse plants, with additional requirements for irrigation systems and controls	Mandatory	**UFC 3-201-02 (B-5.5.1)** Select water-efficient plants. **UFC 4-030-01 (C-3.1):** Design landscape through xeriscaping or use of native plants. No specific requirements for landscaping percentage	Requirement met or exceeded.	LEED application; landscaping contains native adapted plants (WE 1.2); no permanent irrigation (WE 1.1), so irrigation control complies.
6.3.2	Water Use Efficiency- Building water use requirements:	Places water flow requirements on plumbing fixtures	Mandatory	**LEED (WE2)** requires 50% water use reduction in sewage fixtures; **HPSB** and **EO 13432** require 20% reductions.	Requirement not met; but can be met at minimal cost.	Building meets or exceeds all requirements except that it uses 1.6 GPF water closets rather than the 1.28 GPF. However, both 1.6 GPF and 1.28 GPF water closets are readily available in the same $100-$1,000 cost range. Therefore we conclude that 1.28 GPF water closets could have been installed while remaining within the original construction cost ceiling.
6.3.2.2-3	Water Use- Appliances and HVAC Systems	Requires Energy Star appliances, and water metering and recovery/reuse requirements for HVAC systems.	Mandatory	**UFC 4-711-01 (8-1.5)** requires Energy Star building products and appliances.	Requirement met or exceeded.	Offutt already likely meets this requirement. Offutt design specification 15645A, para 2.7.2, page 11, requires installation of a water treatment system for the condensers and chillers. Section 15181, para 2.9.2, page 20, requires that water to be used in the chilled, chilled-hot and condenser water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils.
6.3.3	Water Consumption Measurement	Extensive metering and submetering requirements and remote reading capabilities for both potable and reclaimed water.	Mandatory	Per **A7C Memorandum**, DoD Facilities Metering Installation Initiative (27 April 2006), all new construction should install potable water meters **UFC 4-030-01 (C-3.1):** Employ measurement and verification methods, and use water meters	Requirement not met.	Specification section 11250, para 2.6.1, page 10, requires each water softener to have a displacement or turbine type water meter that conforms to AWWA C700 or C701. Specification section 15181, para 2.9.6.4, page 22, requires water meter with an electric contacting register and remote cumulative counter be installed in each chiller make-up water line to provide input on water usage by the chemical treatment system. Specification section 15400, para 2.12, page 28, requires installation of a domestic water service meter. Meter shall be provided with a pulse generator, remote readout register and all necessary wiring and accessories for connection to building EMCS. Para 3.4, page 41, requires installation of a water meter remote readout register. In order to fully comply water sub-meters are needed for 2 chillers and 3 boilers.
Section 6.4: Prescriptive Options						

ASHRAE 189.1 Reference	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
6.4.1	Site Water Use Reduction	Golf courses and driving ranges have irrigation water restrictions	Prescriptive	No other golf course/driving range specific directives	N/A	
6.4.2	Building Water Use Reduction	Water use reductions for cooling towers, food operations and medical facilities.	Prescriptive	No similar cooling tower, food operations, or medical facility directives	Requirement met or exceeded.	Section 11250 softener design specs, para 2.1.5, page 7, requires that total hardness expressed as calcium carbonate be less than 13.4 mg/l.
6.4.3	Special Water Features	Water requirements for fountains, water features, pools, and spas.	Prescriptive	No other water feature specific directives	N/A	
Section 6.5: Performance Options						
6.5.1	Site Water Use Reduction	Potable water can not make up more than 35% of total water demand for landscaping	Performance	**LEED (WE1)** requires a 50% reduction in potable water use for irrigation (2 points), or no potable water use in irrigation (4 points).	Requirement met or exceeded.	LEED application.
6.5.2	Building Water Use Reduction	Building project water use shall be less than or equal to what would be achieved through compliance with 6.3.2, 6.4.2, and 6.4.3.	Performance	Unclear if ASHRAE is more strenuous	Performance; no action needed.	
Section 7: Energy Efficiency						
7.3	Mandatory Provisions for Energy Efficiency	Requires ASHRAE Standard 90.1-2010 sections 5.4, 6.4 7.4, 8.4, 9.4, and 10.4.	Mandatory	Already complying with this requirement per **UFCs** and their requirement for **ASHRAE 90.1** compliance	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1
7.3.2	On-site Renewable Energy Systems	Building projects must provide for the future installation of on-site renewable energy systems.	Mandatory	Other standards/codes require renewable energy, but this only requires *for the future* installation of renewable energy systems	Requirement met or exceeded.	Assume RE could be installed on roof or elsewhere on site.
7.3.3.1, 7.3.3.2, 7.3.3.3	Energy Consumption Measurement	Requires consumption data recording with remote communication capabilities for electricity, gas and district heat for main systems and some subsystems.	Mandatory	**LEED (EA5), HPSB (GP2),** and **UFC 4-030-01** have metering requirements and conditions, but none require remote communication capabilities and subsystems.	Requirement not met.	Does not meet standard for gas metering. Specification section 15951, para 1.3.4, page 10, requires that the facility incorporate the existing Offutt AFB Base wide Energy Monitoring and Control System (EMCS) / Heating, Ventilating and Air Conditioning (HVAC) Direct Digital Control (DDC) system, which is a Honeywell Excel 5000 System utilizing programmable controllers and associated operating software, manufactured by Honeywell, Inc. Notwithstanding Section 00700 Contract Clauses FAR 52.236-5, Material and Workmanship, all new programmable DDC controllers and associated software, required for this project, shall be manufactured by Honeywell, Inc. Specification section 15951, para 1.3, page 8, requires installation of a Direct Digital Control System to provide control of the HVAC systems and all other building level systems. Specification section 15195N, para 2.5, page 8, requires gas meter that conforms to ANSI B109.2 or B109.3. Meter must connect to EMCS. Specification section 15195N, para 2.5, page 8, requires installation of an ANSI B109.2 or 109.3 compliant gas meter. Gas meter shall be equipped with pulse totalizer for connection to EMCS. EMCS shall indicate gas usage in cubic feet of gas used. Full compliance requires installation of gas sub-meters for each of the 3 boilers.
Section 7.4: Prescriptive Options						
7.4.1	Prescriptive Option	Requires all building projects to comply with ASHRAE Standard 90.1-2010	Prescriptive	Already complying with this **ASHRAE 90.1**	Requirement met or exceeded.	Already complying with this ASHRAE 90.1
7.4.1.1	On-site Renewable Energy Systems	Mandates on-site renewable energy systems with production of not less than 4.0 Kbtu/sq ft (with additional requirements for Energy Star)	Prescriptive	Similar **HPSB (GP2)** and **LEED (EA 2)** points for RE, but none mandate as a ratio of sq ft.	Requirement not met.	Compliance would require installation of rooftop solar panels.
7.4.2	Building Envelope	Requirements compliance with ASHRAE 90.1 regarding insulation, fenestration, permanent projections, vestibules, and continuous air barriers, except where noted otherwise	Prescriptive	**HPSB** and **UFCs** require **ASHRAE 90.1** requirements, but without caveats	Requirement not met.	Roof insulation is 4" Membrane, 4" poly (U=0.03). Windows are triple coated 1/4" 30.29% glazing (U=0.31); SHGC = 0.26. Does not meet vertical fenestration orientation requirement per formula calculation. Compliance would have required building front to face any direction other than west. We assume this could have been done at minimal cost.
7.4.2.8	Bldg Envelope Trade off option	ASHRAE 90.1 Section 5.6 Trade Off option will not apply unless the modifications and additions noted in ASHRAE 189.1 Section 7.4.2 Apply	Prescriptive	Reduces a compliance option from **ASHRAE 90.1**, making compliance more difficult	Requirement likely met; if not can be met at minimal cost.	Building meets all requirements except fenestration orientation as described above.
7.4.2.5	Permanent Projection	Requires vertical fenestration on W, S and E sides be shaded by permanent projections in some climate zones	Prescriptive	Site specific requirements; no similar requirements in other codes	Requirement likely met; if not can be met at minimal cost.	Per LEED submission, windows have sun shades, light shelves, and high efficiency window glazing that reduces energy use by 50%.

ASHRAE 189.1 Reference	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.2.10	Continuous Air Barrier	Requires continuous air barrier	Prescriptive	Similar but less rigorous requirements in **ASHRAE 90.1**	Requirement met or exceeded.	Section 7920 design specs on sealants requires extensive sealing of all interior and exterior joints, voids, wall penetrations, metal reglets, etc. ASHRAE 189.1 requires testing the completed building and demonstrating that the air leakage rate of the building envelope does not exceed 0.4 cfm/ft2 under a pressure differential of 0.3 in. water (1.57 lb/ft2) (2.0 L/s·m2 under a pressure differential of 75 Pa) in accordance with ASTM E779 or an equivalent approved method. Unclear whether building was ever tested, but we assume it would meet this requirement. Specification section 7413, para 2.1.3, page 7, requires that air infiltration of the wall panel system shall be limited to 0.06 CFM/SF at a positive pressure differential of 1.57 psf when tested in accordance with ASTM E 283.
7.4.3.1	Minimum Equipment Efficiencies	Requires products used in projects to comply with: Option 1: The National Appliance Energy Conservation Act (NAECA), EPAct, and EISA. OR Option 2: ENERGY STAR requirements Sec 7.4.7.3 and Tables C-1-C15 in Appendix C, and ASHRAE 90.1 with additional requirements for renewable energy and peak load energy use reductions	Prescriptive	DoD families must already comply with **NAECA, EPAct,** and **EISA**	Requirement met or exceeded.	DoD families must already comply with NAECA, EPAct, and EISA
7.4.3.2	Ventilation Controls	Demand Control Ventilation should comply with ASHRAE 62.1 and supersedes ASHRAE 90.1, plus specifications regarding CO2 sensors.	Prescriptive	**ASHRAE 90.1** requires DCV, but no specific requirements for CO2 sensors.	Requirement met or exceeded.	Specification section 15951, para 1.3, page 8, requires installation of a Direct Digital Control System to provide control of the HVAC systems and all other building level systems.
7.4.3.3	Duct and Plenum Leakage	Use Seal Level A for duct sealing.	Prescriptive	**ASHRAE 90.1 (2010)** requires Sea Level A. Older editions of ASHRAE 90.1 do not.	Requirement met or exceeded.	Specification section 15895, para 2.8.1., page 17, requires Seal Level A on all ductwork.
7.4.3.4	Economizers	Requires economizer usage as articulated in ASHRAE 90.1 but with additional requirements as articulated in 7.4.3.4	Prescriptive	More stringent than **ASHRAE 90.1** requirements	Requirement likely met; if not can be met at minimal cost.	LEED application.
7.4.3.5	Zone Control	Slightly narrow exceptions from ASHRAE 90.1 compliance	Prescriptive	Slightly narrows the **ASHRAE 90.1** exceptions where compliance is not required	Requirement met or exceeded.	Specification section 15951, para 1.3, page 8, requires installation of a Direct Digital Control System to provide control of the HVAC systems and all other building level systems.
7.4.3.7	Controls	Mandates multi stage cooling, multispeed or Variable speed drive on small DX and chilled water units, with additional requirements for sizing and performance.	Prescriptive	More stringent than **ASHRAE 90.1** requirements	Requirement met or exceeded.	Specification section 15951, para 1.3, page 8, requires installation of a Direct Digital Control System to provide control of the HVAC systems and all other building level systems.
7.4.3.8	Exhaust Air Energy Recovery	Requires energy recovery systems with at least 60% energy recovery effectiveness	Prescriptive	Greater efficiency than is required in **ASHRAE 90.1**	Requirement not met.	Offutt has 4 primary exhaust risers. Exhaust outflow for the South riser is 6,070 CFM; North riser is 8,735 CFM; East riser is 4,640 CFM; and Auditorium riser is 855 CFM. To comply with standard need to install one 1,000 CFM ERV and 3 ea 10,000 CFM ERVs
7.4.3.10-11	Duct and Pipe Insulation	Requires insulation specifications for duct and pipe insulation as articulated in ASHRAE 90.1 appendix	Prescriptive	Similar requirements in **ASHRAE 90.1**	Requirement likely met; if not can be met at minimal cost.	Specification section 15080 requires 1.5"-3" thick insulation on piping depending on diameter; and 1"-2" thick insulation on ductwork. 189.1 calls for 1"-3.5" for piping depending on diameter and R8 for ductwork
7.4.3.12	Automatic controls of HVAC and Lights	Required for hotels/motels with over 50 rooms (dormitories?). Requires outlets, TV's and HVAC to be controlled when unoccupied.	Prescriptive	No similar requirements	N/A	
7.4.4	Service Water Heating	Requires compliance with ASHRAE 90.1 plus additional requirements regarding system efficiency and insulation.	Prescriptive	Requires **ASHRAE 90.1** compliance plus additional features	Requirement likely met; if not can be met at minimal cost.	Small Instantaneous Electric Heaters, and several 30 Gal Electric heaters - all point of use. Meets energy efficiency ratings of ASHRAE 90.1 Table 7.2.2.

ASHRAE 189.1 Reference	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.5.1	Peak Load Reduction	Mandates automatic load reduction of at least 10% for all building projects during peak load times	Prescriptive	No similar requirements	Requirement likely met; if not can be met at minimal cost.	The entire under floor air distribution system is either pressure controlled or interlocked with Air Handling units (AHUs) that are temperature controlled. Pressure Sensors are located in duct and under floor plenum. AAHUs are temperature controlled. All auxiliary units are interlocked with the primary unit and automatically switched to operate continuously at constant volume. (Also see 6.3.2.3)Offutt qualified for the EQ 6.1 credit for Controllability of systems: Lighting. Total allowed watts for ASRAE 90.1 1999 for Offutt is 245,609 watts. Actual Design is 186,259 watts. As per the ASRAE 189.1 comparison to the 90.1 2007, Lighting power allowance = 0.9 multiplied by the ASHRAE 90.1 values (Sections 9.5 and 9.6). Therefore, it is assumed that 221,048 watts is the total allowed for 90.1 2007 -- Offutt is 24.16% less than ASRAE 90.1 1999 and 15.74% less than ASRAE 2007. There is an EMCS that manages the building operating schedule as per the Qualitative energy control summary
7.4.6	Lighting	Requires compliance with ASHRAE 90.1, plus lighting power limits and occupancy sensors.	Prescriptive	**LEED (IEQ 6.1)** has a light control point; uncertainty regarding stringency	Requirement likely met; if not can be met at minimal cost.	Offutt qualified for the EQ 6.1 credit for Controllability of systems: Lighting. Total allowed watts for ASRAE 90.1 1999 for Offutt is 245,609 watts. Actual Design is 186,259 watts. As per the ASRAE 189.1 comparison to the 90.1 2007, Lighting power allowance = 0.9 multiplied by the ASHRAE 90.1 values (Sections 9.5 and 9.6). Therefore, it is assumed that 221,048 watts is the total allowed for 90.1 2007 -- Offutt is 24.16% less than ASRAE 90.1 1999 and 15.74% less than ASRAE 2007. There is an EMCS that manages the building operating schedule as per the Qualitative energy control summary.
7.4.7	Other Equipment	In addition to compliance with ASHRAE 90.1 standards, requires performance standards for electric motors, heat recovery on supermarket refrigeration equipment, and an ENERGY STAR mandate for most appliances and electronics.	Prescriptive	Exceeds **ASHRAE 90.1** standards, plus **UFC3-400-01 (2-1.3)** requirements for Energy Star	Requirement likely met; if not can be met at minimal cost.	MENA MG 1 compliance is required throughout design specifications.
Section 7.5: Performance Options						
7.5.2	Energy Costs	Requires that the building project has an annual energy cost less than it could under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	Performance; no action needed.	
7.5.3	Annual CO2 equivalent	Requires that the building project has an annual carbon dioxide equivalent emissions less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	Performance; no action needed.	
7.5.4	Annual Load Factor/Peak Load Demand	Requires that the building project has an annual peak electricity demand less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	Performance; no action needed.	
Section 8: Indoor Environmental Air Quality						
8.3.1	IAQ Mandatory Provisions	Mandates compliance with Sections 4-7 of ANSI/ASHRAE Standard 62.1 , plus increases filtration requirements and other air-cleaning devices	Mandatory	**LEED (IEQ Prereq1), HPSB(GP4),** and **UFC 4-030-01(C-6)** only require ASHRAE 62.1 compliance	Requirement met or exceeded.	LEED application.
8.3.1.2	Outdoor Air Delivery Monitoring	Requires a outdoor airflow measurement device.	Mandatory	No similar requirements	Requirement met or exceeded.	Offutt already meets this requirement. Exception applies under 8.3.1.2.3 for CO2 sensors already installed with accuracy of +/- 75 ppm.
8.3.1.3	Filtration and Air Cleaner Requirement	Higher air filtration and cleaning requirements for all facilities	Mandatory	More strenuous air filtration relative to **LEED (IEQ 5)**	Requirement met or exceeded.	LEED application.
8.3.1.4	Environmental Tobacco Smoke	Smoking is not allowed inside buildings, and requires designated smoking areas be to be located at least 25ft from building entrances.	Mandatory	Similar requirements for **LEED (Prereq 2)** and **HPSB (GP4)**	Requirement met or exceeded.	LEED application; smoking is not allowed with 25 ft of building.
8.3.1.5	Building Entrances	Requires entry mat system at all entries	Mandatory	**LEED (IEQ 5)** requires mats at *regularly used* entrances, not all	Requirement not met, but can be met at minimal cost.	LEED application. Additional entry mats would be minimal cost.
8.3.3	Acoustical Control	Building projects should meet exterior and interior acoustical controls.	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Specification section 7212, para 1.2, page 3 requires STC 48 and 50 wall insulation shown on drawing sheets A-2.12 thru 2.15. Specification section 9510, para 2.2.1 requires acoustical ceiling tiles with minimum ceiling attenuation class (CAC) of 30.
8.3.4	Day lighting by top lighting	Mandates Minimum Requirements for Minimum Daylight Zone by Toplighting and Skylight parameters	Mandatory	Daylight points/recommendations in **LEED (IEQ 8.1)** and **HPSB(GP4),** but 189 seems more prescriptive	Requirement met or exceeded.	Finished ceiling height on 3rd floor is 14.3 feet. This requirement does not apply if ceiling height is less than 15 feet.
8.3.5	Isolation of Building from Pollutants in Soil	Ground level foundations built on Brownfields or in Zone1 counties will have *Soil Gas Retarding System*.	Mandatory	No similar requirements	N/A	
Section 8.4: Prescriptive Options						

ASHRAE 189.1 Reference	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
8.4.1.1	Daylighting: Minimum Effective Aperture	Sets minimum Effective Aperture area for day lighting for office spaces and classroom	Prescriptive	Similar daylight recommendations in **LEED (IEQ 8.1)** and **HPSB (GP4),** but measured differently	Requirement not met, but can be met at minimal cost.	Specification section 8800, para 2.2.2, page 7, requires that insulated glass have 41% visible light transference rating. Windows make up at least 40% of outside wall area on west face, so affective apperture is at least 0.16. However, window area on other walls is less than 40% so affective appertures will be <0.15 required by 189.1 Increasing window area on these walls would not necessarily increase construction cost.
8.4.2	Materials	Places testing, documentation and formulation requirements on reported emissions or VOC contents. Materials include adhesives and sealants; paints and coatings; floor covering material; and composite wood, wood structural panel, and agrifiber products. Requirements may follow CA/DHS/EHLB/R-174, SCAQMD Rule 1168 or 1113, GS-36, GS-11, or third-party verification through CARB.	Prescriptive	Similar requirements in **LEED (IEQ 4.1, 4.2 and 4.3)**	Requirement met or exceeded.	LEED application; received points 4.1, 4.2, and 4.3.
Section 8.5: Performance Options						
8.5.1	Daylighting simulation	Demonstrate through simulations of classrooms and office spaces that there is usable luminance using ray-tracing or radiosity computer model or CIE Overcast Sky Model or the CIE Clear Sky Model. And the direct sunlight does not strike a work surface more than 20% of the time.	Performance	Difficult to calculate impact of performance options	Performance; no action needed.	
8.5.2	Materials	Model materials for VOC concentrations. The sum should comply with section 4.3 of CA/DHS/EHLB/R-14	Performance	Difficult to calculate impact of performance options	Performance; no action needed.	
Section 9: The Building's Impact on Atmosphere, Materials, and Resources						
9.3.1.1	Diversion	50% of construction debris must be recycled or reused.	Mandatory	Similar **LEED (MR 2)** requirement	Requirement met or exceeded.	LEED application; achieved by MR2.1 & MR2.2.
9.3.1.2	Total waste	Places maximum waste limits for projects where buildings and hardscapes make up less that 5% of the site landcover. Waste generation must be tracked throughout construction.	Mandatory	No similar requirements	Requirement met or exceeded.	LEED application; 43K tons waste for building. Building is 188,000 SF so it can't exceed 6 tons per 10,000 SF. 43/18 is < 6 tons (See LEED project summary for details).
9.3.2	Extracting , Harvesting, and/or Manufacturing	Materials and products are to be manufactured according to regulations on the country of origin. Wood products shall not be from endangered species unless it conforms with CITES	Mandatory	DoD must follow US code and CITES.	Requirement met or exceeded.	
9.3.3	Refrigerants	CFC-based refrigerants in HVAC systems will not be used. Fire suppression systems shall not contain ozone depleting substances	Mandatory	Similar requirements for **LEED (EA3)** and **HPSB (GP4)**	Requirement met or exceeded.	LEED application; EA pre3.
9.3.4.1	Recyclables	Requires area serving building be dedicated to the collection and storage of materials for recycling	Mandatory	Similar requirements for **LEED (MR Pre1)** and **HPSB (GP4)**	Requirement met or exceeded.	LEED application; MR pre1.
9.3.4.2	Reusable goods	Requires buildings projects with residential space to have an area serving the building to be dedicated to the collection and reuse of materials.	Mandatory	Similar requirements for **HPSB (GP4)**	N/A	
9.3.4.3	Fluorescent and HID Lamps	Requires an area serving the building to be dedicated to the collection and storage of fluorescent and HID lamps and ballasts.	Mandatory	No similar requirements, although recycling area could collect bulbs	Requirement met or exceeded.	LEED application; MR pre1.
Section 9.4: Prescriptive Options						
9.4.1.1	Recycled Content	Recycled materials must make up at least 10% of the cost of the building materials	Prescriptive	Similar points in **LEED (MR 3)**, assumes 2 points	Requirement met or exceeded.	LEED application.
9.4.1.2	Regional Materials	At least 15% of building materials, based upon cost, must be made within 500 miles of the project site.	Prescriptive	**LEED (MR5)** goals for regional materials, allow 1 point for 10%, or 2 points for 20%	Requirement met or exceeded.	LEED application; achieved by MR5.
9.4.1.3	Biobased Products	Biobased products must make up at least 5% of the cost of the building materials.	Prescriptive	No similar requirement	Requirement not met.	Insufficient data available to complete calculation. Total cost of materials is $12.559M, so biobased products must amount to $627,974
9.4.1.3.1	Wood Building Components	Certified wood must make up at least 60% of total wood used in the project.	Prescriptive	Exceeds **LEED (MR7)** goals for certified wood use	Requirement not met.	Insufficient data available to complete calculation.
Section 9.5: Performance Options						
9.5	Performance Option	Life-Cycle Assessment be performed for a minimum of two building alternatives. Requires report and documentation of critical peer review by third party.	Performance	No similar requirements	Performance; no action needed.	Cost information for this should be available, and this not require those requirements in the prescriptive option.
Section 10: Construction and Plans for Operation						
10	Construction and Plans for Operation	Requirements for construction and plans for operation, including commissioning, acceptance testing, M&V, transportation mgt, erosion and sediment control, and IAQ during construction	Mandatory	More extensive planning requirements relative to **LEED (IEQ3)**	Requirement met or exceeded.	LEED application.
10.3.1.1	Bldg Acceptance Testing	Requires acceptance testing by the authority having jurisdiction (AHJ)	Mandatory	No similar requirements, but required by other jurisdictional requirements	Requirement met or exceeded.	LEED application.
10.3.1.2-4	Building Project Commissioning	Requires building commissioning for all buildings over 5000 sq ft, including commissioning plan. Commissioning must include HVAC&R systems, building envelope, irrigation, plumbing, water pumping and mixing, water heating, renewable energy, and measurement devices.	Mandatory	More extensive commissioning requirements relative to **LEED (EA Prereq 1)**	Requirement met or exceeded.	LEED application.
10.3.2.2	Maintenance Plan	Mandates maintenance plan for mechanical, electrical, plumbing, and fire protection systems in accordance with ASHRAE Standard 180	Mandatory	No similar requirements	Requirement met or exceeded.	O&M maintenance plans included in commissioning report
10.3.2.3	Service Life Plan	Mandates Service Life Plan for structural, building envelope, and hardscape materials.	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Plan does not exist, but cost to prepare plan in-house would be minimal.
10.3.2.4	Transportation Management Plan	Mandates a Transportation Management Plan, with varying mandates based upon ownership/leasing arrangements.	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Plan does not exist, but cost to prepare plan in-house would be minimal.
There are no Prescriptive or Performance Options for Section 10						

Appendix C
Tyndall AFB Crosswalk

This appendix summarizes the ASHRAE 189.1 requirements for high performance sustainable buildings, the degree to which the Tyndall AFB fitness center conforms to those requirements, actions that are needed to ensure conformance, and the likely added cost of such actions, if any.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
Section 5: Site Sustainability						
5.3.1.1 and 5.3.1.2	Site Selection	Building site must be on brownfield, greyfield, or greenfield with restrictions.	Mandatory	LEED (SS1, SS2, and SS3) has similar points	Requirement met or exceeded.	Per LEED documentation; Tyndall achieved point SS1, SS2, and SS3. Tyndall was built on a brownfield site.
5.3.2.1	Mitigation of Heat Island Effect	Requires at least 50% of site hardscape (roads, sidewalks, courtyards and parking lots of the building project) to be shaded or have higher SRI	Mandatory	LEED (SS 7.1) has similar points	Requirement not met.	Asphalt parking lots do not meet minimum SRI ≥ 29.
5.3.2.2	Mitigation of Heat Island Effect	Requires 30% of walls shall be shaded on east and west of building based on shade angle at 10 and 3 on summer solstice.	Mandatory	No similar requirements	Requirement not met; but can be met at minimal cost.	Windows have awnings to provide shade but not for 30% of wall area. Assuming it would not violate existing architectural regulations, balance of this requirement can be met by simply choosing outside wall color/material with SRI ≥ 29. Cost would be minimal.
5.3.2.3	Mitigation of Heat Island Effect	Requires a minimum of 75% of the roof to be SRI of 78 for low-sloped roof or SRI of 29 for steep-sloped roofs, or to be covered by Energy Star Roof Products	Mandatory	LEED (SS7.2) has similar points	Requirement met or exceeded.	Per LEED documentation.
5.3.3	Reduction of light pollution.	Requires exterior lighting system comply with section 9 of ASHRAE Std 90.1.	Mandatory	Already complying with ASHRAE 90.1	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1
Section 5.4: Prescriptive Options						
5.4.1.1	Site Development	40% of the entire site shall be planted or use permeable pavers	Prescriptive	LEED (SS 5.2) requires landscaping the area of the building footprint, but does not address site size (see case 2)	Requirement met or exceeded.	Per LEED documentation; point achieved, 60,350 SF building area to 218,465 SF of vegetated open space.
5.4.1.2	Effective Pervious Area for All Sites	For greenfield sites, 20% of the site should contain native or adapted plants	Prescriptive	LEED (SS 5.2) requires landscaping the area of the building footprint, but does not address site size (assume all DoD facilities fall into Case 2)	N/A	Does not apply, since Tyndall is a brownfield
Section 5.5: Performance Options						
5.5.1	Site Development	Buildings must manage 20% to 50% of rainfall through infiltration, reuse, or evapotransporation.	Performance	LEED (SS 5.2) that may meet this based upon region and other variables. EISA Sec 438 requires the restoration to pre-development hydrology to "the maximum extent technically feasible."	N/A	
Section 6: Water Use Efficiency						
6.3.1	Water Use Efficiency- Landscape Design	60% of the building site landscaping must be bio-diverse plants, with additional requirements for irrigation systems and controls	Mandatory	UFC 3-201-02 (B-5.5.1) Select water-efficient plants. UFC 4-030-01 (C-3.1): Design landscape through xeriscaping or use of native plants. No specific requirements for landscaping percentage.	Requirement met or exceeded.	Per LEED documentation; plants are native (per WE1.1-2).
6.3.2	Water Use Efficiency- Building water use requirements:	Places water flow requirements on plumbing fixtures	Mandatory	LEED (WE2) requires 50% water use reduction in sewage fixtures; HPSB and EO 13432 require 20% reductions.	Requirement met or exceeded.	Per design specifications, water closets are 1.28 GPF; urinals are 0.125 GPF; kitchen faucet is 1.5 GPM; other sinks are 2.2 GPM; and shower heads are 1.5 GPM.
6.3.2.2-3	Water Use- Appliances and HVAC Systems	Requires Energy Star appliances, and water metering and recovery/reuse requirements for HVAC systems.	Mandatory	UFC 4-711-01 (8-1.5) requires Energy Star building products and appliances.	Requirement met or exceeded.	Tyndall already likely meets this requirement. Tyndall design specification 23.25.00 requires installation of a water treatment system for the boilers, condensers and chillers. Section 23.64.26 requires that water to be used in the chilled, chilled-hot and condenser water systems shall be treated to maintain the conditions recommended by this specification. This implies that it is reclaimed and reused.
6.3.3	Water Consumption Measurement	Extensive metering and submetering requirements and remote reading capabilities for both potable and reclaimed water.	Mandatory	Per A7C Memorandum, DoD Facilities Metering Installation Initiative (27 April 2006), all new construction should install potable water meters UFC 4-030-01 (C-3.1): Employ measurement and verification methods, and use water meters	Requirement met or exceeded.	Specification section 22.00.00 requires installation of a domestic water service meter. Cold water meters 2 inches and smaller shall be positive displacement type. Cold water meters 2-1/2 inches and larger shall be turbine type. Meter register may be round or straight reading type, as provided by the local utility. Meter shall be provided with a pulse generator, remote readout register and all necessary wiring and accessories. Design drawing M-900 (page 219 of combined set) requires DDC water control metering to monitor and trend water consumption (GPM) for domestic cold water, domestic hot water, heating hot water, and chilled water systems. Output for chilled and hot water shall include MBH and tons respectively. Flow meters are to be installed in the supply lines of respective flow consumptions.
Section 6.4: Prescriptive Options						
6.4.1	Site Water Use Reduction	Golf courses and driving ranges have irrigation water restrictions	Prescriptive	No other golf course/driving range specific directives	N/A	

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
6.4.2	Building Water Use Reduction	Water use reductions for cooling towers, food operations and medical facilities.	Prescriptive	No similar cooling tower, food operations, or medical facility directives	N/A	Standard applies to commercial food service operations. Should not apply to a food demonstration kitchen.
6.4.3	Special Water Features	Water requirements for fountains, water features, pools, and spas.	Prescriptive	No other water feature specific directives	N/A	No pool or other water features present. Saunas are present but do not fall in the water feature category.
Section 6.5: Performance Options						
6.5.1	Site Water Use Reduction	Potable water cannot make up more than 35% of total water demand for landscaping	Performance	LEED (WE1) requires a 50% reduction in potable water use for irrigation (2 points), or no potable water use in irrigation (4 points).	Requirement met or exceeded.	Per LEED documentation; an irrigation system will not be used. The plans and specifications will require the contractor to provide a one year establishment and maintenance plan in a Florida #1 quality for one year after installation.
6.5.2	Building Water Use Reduction	Building project water use shall be less than or equal to what would be achieved through compliance with 6.3.2, 6.4.2, and 6.4.3.	Performance	Unclear if ASHRAE is more strenuous	Requirement met or exceeded.	
Section 7: Energy Efficiency						
7.3	Mandatory Provisions for Energy Efficiency	Requires ASHRAE Standard 90.1-2010 sections 5.4, 6.4 7.4, 8.4, 9.4, and 10.4.	Mandatory	Already complying with this requirement per UFCs and their requirement for ASHRAE 90.1 compliance	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1
7.3.2	On-site Renewable Energy Systems	Building projects must provide for the future installation of on-site renewable energy systems.	Mandatory	Other standards/codes require renewable energy, but this only requires *for the future* installation of renewable energy systems	Requirement met or exceeded.	Per LEED documentation; LEED EA 2 achieved - Passive Solar hot water heating photovoltaics installed.
7.3.3.1, 7.3.3.2, 7.3.3.3	Energy Consumption Measurement	Requires consumption data recording with remote communication capabilities for electricity, gas and district heat for main systems and some subsystems.	Mandatory	LEED (EA5), HPSB (GP2), and UFC 4-030-01 have metering requirements and conditions, but none require remote communication capabilities and subsystems.	Requirement met or exceeded.	Design drawing M-900 (page 219 of combined set) requires that the DDC controller monitor and trend total building AMPS (on all phases), KW, KVA, KWH, and power factor. This must be integrated with existing installation NEXUS system. In addition the DDC must monitor and trend gas consumption at the gas meter.
Section 7.4: Prescriptive Options						
7.4.1	Prescriptive Option	Requires all building projects to comply with ASHRAE Standard 90.1-2010	Prescriptive	Already complying with this ASHRAE 90.1	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1
7.4.1.1	On-site Renewable Energy Systems	Mandates on-site renewable energy systems with production of not less than 4.0 Kbtu/sq ft (with additional requirements for Energy Star)	Prescriptive	Similar HPSB (GP2) and LEED (EA 2) points for RE, but none mandate as a ratio of sq ft.	Requirement not met.	
7.4.2	Building Envelope	Requirements compliance with ASHRAE 90.1 regarding insulation, fenestration, permanent projections, vestibules, and continuous air barriers, except where noted otherwise	Prescriptive	HPSB and UFCs require ASHRAE 90.1 requirements, but without caveats	Requirement met or exceeded.	Per LEED documentation, roof insulation exceeds requirements; building has 10% ratio of window to wall area; visual light transmission factor of 0.28; need for permanent projections can be addressed by low-E insulated glass, interior blinds, and light boxes; SHGC of vertical fenestration = 0.249 exeeds requirements; trade off option does not apply; and fenestration orientation exceeds requirements.
7.4.2.8	Bldg Envelope Trade off option	ASHRAE 90.1 Section 5.6 Trade Off option will not apply unless the modifications and additions noted in ASHRAE 189.1 Section 7.4.2 Apply	Prescriptive	Reduces a compliance option from ASHRAE 90.1, making compliance more difficult	N/A	
7.4.2.5	Permanent Projection	Requires vertical fenestration on W, S and E sides be shaded by permanent projections in some climate zones	Prescriptive	Site specific requirements; no similar requirements in other codes	Requirement met or exceeded.	Fenestration orientation exceeds requirements per formula calculation. The formula for zones 1-4: (AN*SHGCN+AS*SHGCS)≥1.1(AE*SHGCE+AW*SHGCW). (2,029 SF *0.249 +2341 SF*0.249) = 1088.1 1.1*(0 + 1345*0.249) = 368.4

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.2.10	Continuous Air Barrier	Requires continuous air barrier	Prescriptive	Similar but less rigorous requirements in ASHRAE 90.1	Requirement met or exceeded.	Section 07.92.00 design specs on sealants requires extensive sealing of all interior and exterior joints, voids, wall penetrations, metal reglets, etc. ASHRAE 189.1 requires testing the completed building and demonstrating that the air leakage rate of the building envelope does not exceed 0.4 cfm/ft2 under a pressure differential of 0.3 in. water (1.57 lb/ft2) (2.0 L/s·m2 under a pressure differential of 75 Pa) in accordance with ASTM E779 or an equivalent approved method. Unclear whether building was ever tested, but we assume it would meet this requirement since design specification section 08.11.16 requires that when tested in accordance with ASTM E 283, air infiltration shall not exceed 0.06 cubic feet per minute per square foot of fixed area at a test pressure of 6.24 pounds per square foot (50 mile per hour wind).
7.4.3.1	Minimum Equipment Efficiencies	Requires products used in projects to comply with: Option 1: The National Appliance Energy Conservation Act (NAECA), EPAct, and EISA. OR Option 2: ENERGY STAR requirements Sec 7.4.7.3 and Tables C-1-C15 in Appendix C, and ASHRAE 90.1 with additional requirements for renewable energy and peak load energy use reductions.	Prescriptive	DoD families must already comply with NAECA, EPAct, and EISA	Requirement met or exceeded.	Assumed to comply based on DoD requirement.
7.4.3.2	Ventilation Controls	Demand Control Ventilation should comply with ASHRAE 62.1 and supersedes ASHRAE 90.1, plus specifications regarding CO2 sensors.	Prescriptive	ASHRAE 90.1 requires DCV, but no specific requirements for CO2 sensors.	Requirement met or exceeded.	Per LEED documentation building has DDC and CO2 sensors. This is also required by design specification section 23.09.23.
7.4.3.3	Duct and Plenum Leakage	Use Seal Level A for duct sealing.	Prescriptive	ASHRAE 90.1 (2010) requires Sea Level A. Older editions of ASHRAE 90.1 do not.	Requirement met or exceeded.	Design specification section 23.00.00 requires use of Sealant Type A on all HVAC ductwork.
7.4.3.4	Economizers	Requires economizer usage as articulated in ASHRAE 90.1 but with additional requirements as articulated in 7.4.3.4	Prescriptive	More stringent than ASHRAE 90.1 requirements	N/A	Per 189.1 economizers are not required for Zone 2.
7.4.3.5	Zone Control	Slightly narrow exceptions from ASHRAE 90.1 compliance	Prescriptive	Slightly narrows the ASHRAE 90.1 exceptions where compliance is not required	Requirement met or exceeded.	Specification section 23.09.23 requires installation of a Direct Digital Control System to provide control of the HVAC systems and all other building level systems.
7.4.3.7	Controls	Mandates multi stage cooling, multispeed or Variable speed drive on small DX and chilled water units, with additional requirements for sizing and performance.	Prescriptive	More stringent than ASHRAE 90.1 requirements	Requirement met or exceeded.	Specification section 23.09.23 requires installation of a Direct Digital Control System to provide control of the HVAC systems and all other building level systems. It also specifies variable air volume (VAV) system, which requires variable speed fans.
7.4.3.8	Exhaust Air Energy Recovery	Requires energy recovery systems with at least 60% energy recovery effectiveness	Prescriptive	Greater efficiency than is required in ASHRAE 90.1	N/A	Facility does not have energy recovery ventilators. Two exhaust fans have flow rates of 4,200 CFM and 750 CFM respectively. Assuming less than 50% outside air at full design flow, ERVs are not required per 189.1.
7.4.3.10-11	Duct and Pipe Insulation	Requires insulation specifications for duct and pipe insulation as articulated in ASHRAE 90.1 appendix	Prescriptive	Similar requirements in ASHRAE 90.1	Requirement met or exceeded.	Tyndall already likely mets this requirement. 189.1 calls for 1"-3.5" insulation for piping depending on diameter and R-8 for ductwork. Design specifications section 23.07.00 requires minimum of 2" thick insulation on all ductwork, and 1"-3" insulation on piping depending on diameter.
7.4.3.1.2	Automatic controls of HVAC and Lights	Required for hotels/motels with over 50 rooms (dormitories?). Requires outlets, TV's and HVAC to be controlled when unoccupied.	Prescriptive	No similar requirements	N/A	Tyndall RFP stated: "Provide a Siemens Apogee DDC control system including associated equipment and accessories. All new devices are accessible without the use of gateways, unless gateways are shown on the design drawings and specifically requested by the Government."
7.4.4	Service Water Heating	Requires compliance with ASHRAE 90.1 plus additional requirements regarding system efficiency and insulation.	Prescriptive	Requires ASHRAE 90.1 compliance plus additional features	Requirement met or exceeded.	189.1 requires 80% efficiency for gas water heaters. Per LEED documentation water heater is 80% efficient. As per the Measurement and verification plan prepared by TLC ENG for Archetecture states: "The primary source of domestic water heating for is reclaimed heat from the heat recovery chiller. The secondary source of hot water are the roof-mounted solar thermal collection panels. Instantaneous gas water heaters are installed only as a backup source for water heating."
7.4.5.1	Peak Load Reduction	Mandates automatic load reduction of at least 10% for all building projects during peak load times	Prescriptive	No similar requirements	Requirement met or exceeded.	Assume existing DDC integrated with NEXUS can provide needed 10% peak load reduction.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.6	Lighting	Requires compliance with ASHRAE 90.1, plus lighting power limits and occupancy sensors.	Prescriptive	LEED (IEQ 6.1) has a light control point; uncertainty regarding stringency	Requirement met or exceeded.	Per LEED documentation, there are automatic controls based on occupancy throughout. Includes occupancy motions sensors and automatic zone dimming using daylight sensors.
7.4.7	Other Equipment	In addition to compliance with ASHRAE 90.1 standards, requires performance standards for electric motors, heat recovery on supermarket refrigeration equipment, and an ENERGY STAR mandate for most appliances and electronics.	Prescriptive	Exceeds ASHRAE 90.1 standards, plus UFC3-400-01 (2-1.3) requirements for Energy Star	Requirement met or exceeded.	Design specification require conformance to NEMA MG 1 throughout.
Section 7.5: Performance Options						
7.5.2	Energy Costs	Requires that the building project has an annual energy cost less than it could under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	
7.5.3	Annual CO2 equivalent	Requires that the building project has an annual carbon dioxide equivalent emissions less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	
7.5.4	Annual Load Factor/Peak Load Demand	Requires that the building project has an annual peak electricity demand less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	
Section 8: Indoor Environmental Air Quality						
8.3.1	IAQ Mandatory Provisions	Mandates compliance with Sections 4-7 of ANSI/ASHRAE Standard 62.1 , plus increases filtration requirements and other air-cleaning devices	Mandatory	LEED (IEQ Prereq1), HPSB(GP4), and UFC 4-030-01(C-6) only require ASHRAE 62.1 compliance	Requirement met or exceeded.	Meets 62.1
8.3.1.2	Outdoor Air Delivery Monitoring	Requires a outdoor airflow measurement device.	Mandatory	No similar requirements	Requirement met or exceeded.	Design drawing M-900 indicates it does have outdoor airflow monitor. It is connected to the DDC system and provides continuous information about air flow rate, temperature, damper actuation, and hi-lo values.
8.3.1.3	Filtration and Air Cleaner Requirement	Higher air filtration and cleaning requirements for all facilities	Mandatory	More strenuous air filtration relative to LEED (IEQ 5)	Requirement met or exceeded.	Per LEED documentation points EQ3.1 and EQ5 should meet requirment. Also design specification section 23.00.00 requires high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method shall be as listed under the Label Service and shall meet the requirements of UL 586. All HVAC filters are MERV 13 or higher.
8.3.1.4	Environmental Tobacco Smoke	Smoking is not allowed inside buildings, and requires designated smoking areas be to be located at least 25ft from building entrances.	Mandatory	Similar requirements for LEED (Prereq 2) and HPSB (GP4)	Requirement met or exceeded.	Smoking is not allowed with 25 ft of building
8.3.1.5	Building Entrances	Requires entry mat system at all entries	Mandatory	LEED (IEQ 5) requires mats at *regularly used* entrances, not all	Requirement met or exceeded.	Negligable difference from EQ5
8.3.3	Acoustical Control	Building projects should meet exterior and interior acoustical controls.	Mandatory	No similar requirements	Requirement not met; but can be met at minimal cost.	Standard requires STC rating ≥ 50 for wall and floor-ceiling assemblies. Design specification section 09.51.00 requires a ceiling system with an attenuation class (CAC) of 40 when determined in accordance with ASTM E 1414. It includes fixture attenuators over light fixtures and other ceiling penetrations, and acoustical blanket insulation adjacent to partitions, as required to achieve the specified CAC. Section 10.22.26 requires acoustical panels with minimum STC = 40, and partitions with minimum STC = 42. Tyndall's windows meet the exterior envelope acoustical standard and we assume the rest of the structure's exterior also meets it. The interior standard requires an STC rating ≥ 50 for wall and floor-ceiling assemblies. Tyndall design specification includes attenuators over light fixtures and other ceiling penetrations, and acoustical blanket insulation adjacent to partitions and acoustical panels with minimum STC = 40, and partitions with minimum STC = 42. The insulation, joint sealing, roof, masonry, and other specifications suggest the STC requirement for the building envelope probably is met. If not, more expensive building tiles or wallboard would have been required, but given the small number of interior offices at Tyndall, the total cost would have been minimal.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
8.3.4	Day lighting by top lighting	Mandates Minimum Requirements for Minimum Daylight Zone by Toplighting and Skylight parameters	Mandatory	Daylight points/recommendations in LEED (IEQ 8.1) and HPSB(GP4), but 189 seems more prescriptive	Requirement is not met.	Building has average lighting power allowance of 0.55 W/SF. Per 189.1 this requires minimum skylight-roof ratio of 3.0%. Per LEED documentation, roof top sky lighting provides indirect solar lighting through the roof structure in the gymnasium, group training rooms, and main lobby areas. Skylight-roof ratio is 2.8%, so requirement is not met. Per RS Means 2011 Interior Cost Data, page 154,category 08_62_13 (Domed Unit Skylight), line item 2300 (Insulated Safety Glass with Aluminum Frame), cost is $98.60/SF installed. Effetive roof area is 40,210 SF. 3% equals 1,206 SF required for skylights. Existing skylights have area of 1,134 SF, for a difference of 72 SF. At $98.60/SF, cost to upgrade skylights is $7,100.
8.3.5	Isolation of Building from Pollutants in Soil	Ground level foundations built on Brownfields or in Zone1 counties will have *Soil Gas Retarding System*.	Mandatory	No similar requirements	Requirement met or exceeded.	Design specification section 03.30.53 for cast in place concrete requires polyethylene vapor barrier sheeting with a minimum thickness of 6 mils or other equivalent material having a vapor permeance rating not exceeding 0.5 perms as determined in accordance with ASTM E 96/E 96M.
Section 8.4: Prescriptive Options						
8.4.1.1	Daylighting: Minimum Effective Aperture	Sets minimum Effective Aperture area for day lighting for office spaces and classroom	Prescriptive	Similar daylight recommendations in LEED (IEQ 8.1) and HPSB (GP4), but measured differently	N/A	This requirement applies only to classrooms and offices. This facility has no classrooms. Offices are located on the west side of the building. This requirement only applies to the north, south, and east-facing facades. Accordingly this requirement does not apply.
8.4.2	Materials	Places testing, documentation and formulation requirements on reported emissions or VOC contents. Materials include adhesives and sealants; paints and coatings; floor covering material; and composite wood, wood structural panel, and agrifiber products. Requirements may follow CA/DHS/EHLB/R-174, SCAQMD Rule 1168 or 1113, GS-36, GS-11, or third-party verification through CARB.	Prescriptive	Similar requirements in LEED (IEQ 4.1, 4.2 and 4.3)	Requirement met or exceeded.	Per LEED documentationrReceived points 4.1, 4.2, and 4.3.
Section 8.5: Performance Options						
8.5.1	Daylighting simulation	Demonstrate through simulations of classrooms and office spaces that there is usable luminance using ray-tracing or radiosity computer model or CIE Overcast Sky Model or the CIE Clear Sky Model. And the direct sunlight does not strike a work surface more than 20% of the time.	Performance	Difficult to calculate impact of performance options	N/A	
8.5.2	Materials	Model materials for VOC concentrations. The sum should comply with section 4.3 of CA/DHS/EHLB/R-14	Performance	Difficult to calculate impact of performance options	N/A	
Section 9: The Building's Impact on Atmosphere, Materials, and Resources						
9.3.1.1	Diversion	50% of construction debris must be recycled or reused.	Mandatory	Similar LEED (MR 2) requirement	Requirement met or exceeded.	Achieved by MR 2 (recycle/salvage 75% or more)
9.3.1.2	Total waste	Places maximum waste limits for projects where buildings and hardscapes make up less that 5% of the site landcover. Waste generation must be tracked throughout construction.	Mandatory	No similar requirements	Requirement met or exceeded.	Assume this is met, given that so much was recycled/reused.
9.3.2	Extracting , Harvesting, and/or Manufacturing	Materials and products are to be manufactured according to regulations on the country of origin. Wood products shall not be from endangered species unless it conforms with CITES	Mandatory	DoD must follow US code and CITES.	Requirement met or exceeded.	Government follows these regs.
9.3.3	Refrigerants	CFC-based refrigerants in HVAC systems will not be used. Fire suppression systems shall not contain ozone depleting substances	Mandatory	Similar requirements for LEED (EA3) and HPSB (GP4)	Requirement met or exceeded.	Per LEED documentation; EA pre3
9.3.4.1	Recyclables	Requires area serving building be dedicated to the collection and storage of materials for recycling	Mandatory	Similar requirements for LEED (MR Pre1) and HPSB (GP4)	Requirement met or exceeded.	Per LEED documentation; MR pre1
9.3.4.2	Reusable goods	Requires buildings projects with residential space to have an area serving the building to be dedicated to the collection and reuse of materials.	Mandatory	Similar requirements for HPSB (GP4)	N/A	
9.3.4.3	Fluorescent and HID Lamps	Requires an area serving the building to be dedicated to the collection and storage of fluorescent and HID lamps and ballasts.	Mandatory	No similar requirements, although recycling area could collect bulbs	Requirement met or exceeded.	Per LEED documentation; MR pre1
Section 9.4: Prescriptive Options						
9.4.1.1	Recycled Content	Recycled materials must make up at least 10% of the cost of the building materials	Prescriptive	Similar points in LEED (MR 3), assumes 2 points	Requirement met or exceeded.	Per LEED documentation MR 4.1 and 4.2 achieved; 20% recycled - submittal indicates 39.7% combined recycled content value as a percentage of total materials cost.
9.4.1.2	Regional Materials	At least 15% of building materials, based upon cost, must be made within 500 miles of the project site.	Prescriptive	LEED (MR5) goals for regional materials, allow 1 point for 10%, or 2 points for 20%	Requirement met or exceeded.	Achieved by MR5 - LEED submittal states 35.495% of total building material value is within 500 miles of the project site.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
9.4.1.3	Biobased Products	Biobased products must make up at least 5% of the cost of the building materials.	Prescriptive	No similar requirement	Requirement met or exceeded.	Given the project is almost at the 60% threshold for the FSC requirement (59+%), and the biobased standard is a minimum of 5% of building materials (by cost), I would think we can reason that, in the absence of any biobased information in the project specifications, that the 60% requirement for 9.4.1.3.1 probably fulfills the 5% requirement for 9.4.1.3., especially since this is a gym and the gym floors are high quality wood.
9.4.1.3.1	Wood Building Components	Certified wood must make up at least 60% of total wood used in the project.	Prescriptive	Exceeds LEED (MR7) goals for certified wood use	Requirement not met; but can be met at minimal cost.	Per LEED documentation 59.093% of FSC Certifed Wood by cost. Minimal increase of FSC wood products (measured in terms of content) can meet the 60% requirement of 189.1 (section 9.4.1.3.1)
Section 9.5: Performance Options						
9.5	Performance Option	Life-Cycle Assessment be performed for a minimum of two building alternatives. Requires report and documentation of critical peer review by third party.	Performance	No similar requirements	N/A	
Section 10: Construction and Plans for Operation						
10	Construction and Plans for Operation	Requirements for construction and plans for operation, including commissioning, acceptance testing, M&V, transportation mgt, erosion and sediment control, and IAQ during construction	Mandatory	More extensive planning requirements relative to LEED (IEQ3)	Requirement met or exceeded.	All areas required by design specifications.
10.3.1.1	Bldg Acceptance Testing	Requires acceptance testing by the authority having jurisdiction (AHJ)	Mandatory	No similar requirements, but required by other jurisdictional requirements	Requirement met or exceeded.	Per design specifications building commissioning and acceptance was completed.
10.3.1.2-4	Building Project Commissioning	Requires building commissioning for all buildings over 5000 sq ft, including commissioning plan. Commissioning must include HVAC&R systems, building envelope, irrigation, plumbing, water pumping and mixing, water heating, renewable energy, and measurement devices.	Mandatory	More extensive commissioning requirements relative to LEED (EA Prereq 1)	Requirement met or exceeded.	Per design specifications building commissioning and acceptance was completed.
10.3.2.2	Maintenance Plan	Mandates maintenance plan for mechanical, electrical, plumbing, and fire protection systems in accordance with ASHRAE Standard 180	Mandatory	No similar requirements	Requirement met or exceeded.	Design specification section 01.78.23 requires submission of Operation and Maintenance (O&M) Data specifically applicable to this contract and a complete and concise depiction of the provided equipment, product, or system. Organize and present information in sufficient detail to clearly explain O&M requirements at the system, equipment, component, and subassembly level. Include an index preceding each submittal. Submit in accordance with this section and Section 01 33 00 SUBMITTAL PROCEDURES.
10.3.2.3	Service Life Plan	Mandates Service Life Plan for structural, building envelope, and hardscape materials.	Mandatory	No similar requirements	Requirement not met; but can be met at minimal cost.	Plan does not exist but can easily be prepared in-house at minimal cost.
10.3.2.4	Transportation Management Plan	Mandates a Transportation Management Plan, with varying mandates based upon ownership/leasing arrangements.	Mandatory	No similar requirements	Requirement not met; but can be met at minimal cost.	Plan does not exist but can easily be prepared in-house at minimal cost.
There are no Prescriptive or Performance Options for Section 10						

Appendix D
Travis AFB Crosswalk

This appendix summarizes the ASHRAE 189.1 requirements for high performance sustainable buildings, the degree to which the Travis AFB C-17 hangar conforms to those requirements, actions that are needed to ensure conformance, and the likely added cost of such actions, if any.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
Section 5: Site Sustainability						
5.3.1.1 and 5.3.1.2	Site Selection	Building site must be on brownfield, greyfield, or greenfield with restrictions.	Mandatory	**LEED (SS1, SS2, and SS3)** has similar points	Requirement met or exceeded.	Per LEED documentation. Travis achieved SS Credit 3 The LEED Submittal Template has been provided stating that the site has been documented as contaminated by a Phase II Environmental Site Assessment.
5.3.2.1	Mitigation of Heat Island Effect	Requires at least 50% of site hardscape (roads, sidewalks, courtyards and parking lots of the building project) to be shaded or have higher SRI	Mandatory	**LEED (SS 7.1)** has similar points	Requirement met or exceeded.	Per LEED documentation. The LEED Submittal Template has been provided stating that 61.58% of the non-roof impervious surfaces on-site have been paved with highly reflective materials. Calculations provided in the submittal claim that of the 123.145.3 sq.ft. of total non-roof impervious surfaces, 75,833.4 sq.ft. (61.58%) have been paved with non-colored concrete.
5.3.2.2	Mitigation of Heat Island Effect	Requires 30% of walls shall be shaded on east and west of building based on shade angle at 10 and 3 on summer solstice.	Mandatory	No similar requirements	Requirement not met; but can be met at minimal cost.	Windows do not have awnings and there are no trees to provide shade for 30% of wall area. However, light exterior wall color likely has SRI ≥ 29. If not, and assuming it would not violate existing architectural compatibility regulations, this requirement can be met by simply choosing outside wall color/material with SRI ≥ 29. Cost would be minimal.
5.3.2.3	Mitigation of Heat Island Effect	Requires a minimum of 75% of the roof to be SRI of 78 for low-sloped roof or SRI of 29 for steep-sloped roofs, or to be covered by Energy Star Roof Products	Mandatory	**LEED (SS7.2)** has similar points	Requirement not met; but can be met at minimal cost.	Per design specfications, hangar has low sloped roof which requires SRI ≥ 78. Existing roof color is too dark to meet this requirement. However, roof products may have been Energy Star or, assuming it would not violate existing architectural compatibility regulations, this requirement could have been met by simply choosing a roof color/material with SRI ≥ 29. Cost would be minimal.
5.3.3	Reduction of light pollution.	Requires exterior lighting system comply with section 9 of ASHRAE Std 90.1.	Mandatory	Already complying with **ASHRAE 90.1**	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1
Section 5.4: Prescriptive Options						
5.4.1.1	Site Development	40% of the entire site shall be planted or use permeable pavers	Prescriptive	**LEED (SS 5.2)** requires landscaping the area of the building footprint, but does not address site size (see case 2)	N/A	Does not apply since Travis is a brownfield.
5.4.1.2	Effective Pervious Area for All Sites	For greenfield sites, 20% of the site should contain native or adapted plants	Prescriptive	**LEED (SS 5.2)** requires landscaping the area of the building footprint, but does not address site size (assume all DoD facilities fall into Case 2)	N/A	Does not apply since Travis is a brownfield
Section 5.5: Performance Options						
5.5.1	Site Development	Buildings must manage 20% to 50% of rainfall through infiltration, reuse, or evapotransporation.	Performance	**LEED (SS 5.2)** that may meet this based upon region and other variables. **EISA Sec 438** requires the restoration to pre-development hydrology to "the maximum extent technically feasible."	Requirement met or exceeded.	Design specifications call for landscaping with a combination of ginger rock and indigenous low ground cover. Ginger rock provides a pervious surface equivalent to what would be provided by pervious pavers. This should meet requirement via infiltration.
Section 6: Water Use Efficiency						

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
6.3.1	Water Use Efficiency- Landscape Design	60% of the building site landscaping must be bio-diverse plants, with additional requirements for irrigation systems and controls	Mandatory	**UFC 3-201-02 (B-5.5.1)** Select water-efficient plants. **UFC 4-030-01 (C-3.1):** Design landscape through xeriscaping or use of native plants. No specific requirements for landscaping percentage.	Requirement not met.	Xeriscape planting and irrigation to reduce water use will be provided. Replacement of turf with xeriscape planting will be provided. The landscape treatment of the immediate area around the hangar consists of two basic elements, ginger rock and low ground covers that are climate adapted to the Travis area. The irrigation system is for plant establishment only, and should be turned off after a maximum of three years.189.1 does not provide an exception for xeriscape landscaping, but it does achieve the same end result in water use reduction. Hangar xeriscaping should qualify as meeting this requirement.
6.3.2	Water Use Efficiency- Building water use requirements:	Places water flow requirements on plumbing fixtures	Mandatory	**LEED (WE2)** requires 50% water use reduction in sewage fixtures; **HPSB** and **EO 13432** require 20% reductions.	Requirement met or exceeded.	Per page 11 of basis for design specifications, hangar incorporates 1.28 GPF water closets; 0.5 GPF urinals; 0.5 GPM lavatory faucets; 1.5 GPM sink faucets; and 1.5 GPM shower heads.
6.3.2.2-3	Water Use- Appliances and HVAC Systems	Requires Energy Star appliances, and water metering and recovery/reuse requirements for HVAC systems.	Mandatory	**UFC 4-711-01 (8-1.5)** requires Energy Star building products and appliances.	Requirement met or exceeded.	Per design specifications, page 197, HVAC systems in cooling mode are rated at <60,000 Btu, thus condensate recovery and reuse is not required per 189.1. Per basis of design specifications, page 11, HVAC system incorporates separate remote pulse initiator gas, water, and electric meters. Use of Energy Star products and appliances is assumed throughout.
6.3.3	Water Consumption Measurement	Extensive metering and submetering requirements and remote reading capabilities for both potable and reclaimed water.	Mandatory	Per **A7C Memorandum**, DoD Facilities Metering Installation Initiative (27 April 2006), all new construction should install potable water meters **UFC 4-030-01 (C-3.1):** Employ measurement and verification methods, and use water meters	Requirement met or exceeded.	Per basis of design specifications, page 11, HVAC system incorporates a remote pulse initiator water meter. Incoming cold water meter is installed in the main water line outside the building. Per 189.1, sub-meters are not required since the hangar uses instantaneous gas-fired point of use hot water heaters and does not have cooling towers, evaporative coolers, or irrigated landscape.
Section 6.4: Prescriptive Options						
6.4.1	Site Water Use Reduction	Golf courses and driving ranges have irrigation water restrictions	Prescriptive	No other golf course/driving range specific directives	N/A	
6.4.2	Building Water Use Reduction	Water use reductions for cooling towers, food operations and medical facilities.	Prescriptive	No similar cooling tower, food operations, or medical facility directives	N/A	
6.4.3	Special Water Features	Water requirements for fountains, water features, pools, and spas.	Prescriptive	No other water feature specific directives	N/A	
Section 6.5: Performance Options						
6.5.1	Site Water Use Reduction	Potable water cannot make up more than 35% of total water demand for landscaping	Performance	**LEED (WE1)** requires a 50% reduction in potable water use for irrigation (2 points), or no potable water use in irrigation (4 points).	Requirement met or exceeded.	Per LEED documentation. Per WE Credit 1: Landscaping installed does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment will be removed within one year of installation.
6.5.2	Building Water Use Reduction	Building project water use shall be less than or equal to what would be achieved through compliance with 6.3.2, 6.4.2, and 6.4.3.	Performance	Unclear if ASHRAE is more strenuous	Performance; no action needed.	
Section 7: Energy Efficiency						
7.3	Mandatory Provisions for Energy Efficiency	Requires ASHRAE Standard 90.1-2010 sections 5.4, 6.4 7.4, 8.4, 9.4, and 10.4.	Mandatory	Already complying with this requirement per **UFCs** and their requirement for **ASHRAE 90.1** compliance	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.3.2	On-site Renewable Energy Systems	Building projects must provide for the future installation of on-site renewable energy systems.	Mandatory	Other standards/codes require renewable energy, but this only requires *for the future* installation of renewable energy systems	Requirement met or exceeded.	Assume RE could be installed on roof or elsewhere on site.
7.3.3.1, 7.3.3.2, 7.3.3.3	Energy Consumption Measurement	Requires consumption data recording with remote communication capabilities for electricity, gas and district heat for main systems and some subsystems.	Mandatory	**LEED (EA5), HPSB (GP2),** and **UFC 4-030-01** have metering requirements and conditions, but none require remote communication capabilities and subsystems.	Requirement not met.	Per basis of design specifications, page 11, HVAC system incorporates separate remote pulse initiator gas, water, and electric meters. Per page 16, five digit electronic programmable watt-hour meters with solid-state demand registers will be provided. Included in the meter will be the necessary KYZ initiation hardware for Energy Monitoring and Control System (EMCS) coordinated with the mechanical Direct Digital Control System (DDC).Watt-hour meter shall be directly mounted on pad mounted transformers. Incoming cold water meter is installed in the main water line outside the building. Gas meter is installed in main line prior to entering the hangar. Per 189.1, sub-meters are required for natural gas HVAC systems > 500,000 Bth/hour. Thus sub-meters will be required for both of the 1,900,000 Btu/hour gas-fired hangar bay heaters. Primary hangar gas meter per design drawing PO.01 is American Meter Company model RPM 3.5MG65, 4,300 CFH/122 CFM, installed on a 2" gas line. Comparable gas meter is the 5,500 CFH RPM 5.5M American gas meter, which costs $2,500. Assuming an additional $500 for installation, each meter installed would be $3,000 for a total estimated cost of $6,000.
Section 7.4: Prescriptive Options						
7.4.1	Prescriptive Option	Requires all building projects to comply with ASHRAE Standard 90.1-2010	Prescriptive	Already complying with this **ASHRAE 90.1**	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1
7.4.1.1	On-site Renewable Energy Systems	Mandates on-site renewable energy systems with production of not less than 4.0 Kbtu/sq ft (with additional requirements for Energy Star)	Prescriptive	Similar **HPSB (GP2)** and **LEED (EA 2)** points for RE, but none mandate as a ratio of sq ft.	Requirement not met.	
7.4.2	Building Envelope	Requirements compliance with ASHRAE 90.1 regarding insulation, fenestration, permanent projections, vestibules, and continuous air barriers, except where noted otherwise	Prescriptive	**HPSB** and **UFCs** require **ASHRAE 90.1** requirements, but without caveats	Requirement met or exceeded.	
7.4.2.8	Bldg Envelope Trade off option	ASHRAE 90.1 Section 5.6 Trade Off option will not apply unless the modifications and additions noted in ASHRAE 189.1 Section 7.4.2 Apply	Prescriptive	Reduces a compliance option from **ASHRAE 90.1**, making compliance more difficult	N/A	Travis complies with 7.4.2.
7.4.2.5	Permanent Projection	Requires vertical fenestration on W, S and E sides be shaded by permanent projections in some climate zones	Prescriptive	Site specific requirements; no similar requirements in other codes	Requirement not met; but can be met at minimal cost.	No permanent projections (i.e., awnings) are provided on the west, south, or east faces. Per 189.1 vertical fenestration shall be shaded by permanent projections that have an area weighted average projection factor of not less than 0.50. Should be able to also meet this requirement by using low-E insulated glass, window blinds, light boxes, etc., which would probably be cheaper than installing permanent projections.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.2.10	Continuous Air Barrier	Requires continuous air barrier	Prescriptive	Similar but less rigorous requirements in **ASHRAE 90.1**	Requirement met or exceeded.	Section 07.92.00 design specs on sealants requires extensive sealing of all interior and exterior joints, voids, wall penetrations, metal reglets, etc. ASHRAE 189.1 requires testing the completed building and demonstrating that the air leakage rate of the building envelope does not exceed 0.4 cfm/ft2 under a pressure differential of 0.3 in. water (1.57 lb/ft2) (2.0 L/s·m2 under a pressure differential of 75 Pa) in accordance with ASTM E779 or an equivalent approved method. Unclear whether building was ever tested, but we assume it would meet this requirement since design specification section 08.11.16, para 1.2.2 requires that when tested in accordance with ASTM E 283, air infiltration shall not exceed 0.06 cubic feet per minute per square foot of fixed area at a test pressure of 6.24 pounds per square foot (50 mile per hour wind). In addition, 189.1 provides an exception to this requirement for climate zones 1, 2, and 3 as long as the building complies with section 5.4.3.1 of 90.1.
7.4.3.1	Minimum Equipment Efficiencies	Requires products used in projects to comply with: Option 1: The National Appliance Energy Conservation Act (NAECA), EPAct, and EISA. OR Option 2: ENERGY STAR requirements Sec 7.4.7.3 and Tables C-1-C15 in Appendix C, and ASHRAE 90.1 with additional requirements for renewable energy and peak load energy use reductions.	Prescriptive	DoD families must already comply with **NAECA, EPAct,** and **EISA**	Requirement met or exceeded.	DoD families must already comply with **NAECA, EPAct,** and **EISA**
7.4.3.2	Ventilation Controls	Demand Control Ventilation should comply with ASHRAE 62.1 and supersedes ASHRAE 90.1, plus specifications regarding CO2 sensors.	Prescriptive	**ASHRAE 90.1** requires DCV, but no specific requirements for CO2 sensors.	Requirement met or exceeded.	This only applies to densely occupied spaces (i.e.,≥25 people/1,000 SF). However, CO2 sensors are provided in all occupied spaces,and the facility incorporates a DCV system.
7.4.3.3	Duct and Plenum Leakage	Use Seal Level A for duct sealing.	Prescriptive	**ASHRAE 90.1 (2010)** requires Seal Level A. Older editions of ASHRAE 90.1 do not.	Requirement met or exceeded.	Design specification section 23.30.13, para 2.2, page 4, requires that all supply, return, and exhaust ductwork be constructed to pressure classification of 3 inch water gauge, and all ductwork will be airtight. Para 3.1.1.5, page 8, requires that all ductwork penetrations be packed with mineral fiber. This implies that all transverse and longitudinal joints and wall penetrations are sealed, thereby meeting seal class A.
7.4.3.4	Economizers	Requires economizer usage as articulated in ASHRAE 90.1 but with additional requirements as articulated in 7.4.3.4	Prescriptive	More stringent than **ASHRAE 90.1** requirements	Requirement met or exceeded.	Per basis of design specification, page 9, both split system air conditioners incorporate economizers.
7.4.3.5	Zone Control	Slightly narrow exceptions from ASHRAE 90.1 compliance	Prescriptive	Slightly narrows the **ASHRAE 90.1** exceptions where compliance is not required	Requirement met or exceeded.	Separate AHUs are provided for offices and open bays. AHUs are tied into existing base DDC system.
7.4.3.7	Controls	Mandates multi stage cooling, multispeed or Variable speed drive on small DX and chilled water units, with additional requirements for sizing and performance.	Prescriptive	More stringent than **ASHRAE 90.1** requirements	Requirement met or exceeded.	Hangar employs split system air conditioning units with rated cooling capacity <60,000 Btu. The units employ variable speed fans (VAV) per design specification page 10.
7.4.3.8	Exhaust Air Energy Recovery	Requires energy recovery systems with at least 60% energy recovery effectiveness	Prescriptive	Greater efficiency than is required in **ASHRAE 90.1**	Requirement not met.	Facility does not have energy recovery ventilators. Split air conditioning system exhaust fans have flow rates of 2,000 CFM drawing 45% outside air. Accordingly, ERVs are not required per 189.1. However, the two gas-fired HVAC system exhaust fans have flow rates of 6,500 CFM drawing 100% outside air. Accordingly, ERVs are required. Cost estimate for 8,000 CFM ERV per RE Means is $13,400, for a total estimated cost of $26,800.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.3.10-11	Duct and Pipe Insulation	Requires insulation specifications for duct and pipe insulation as articulated in ASHRAE 90.1 appendix	Prescriptive	Similar requirements in **ASHRAE 90.1**	Requirement met or exceeded.	Per design specification, page 197, air conditioning ductwork insulation is R-4.2 (90.1 table 6.8.2A/B requires none for zone 2) and heating ductwork insulation is R-8 (90.1 table 6.8.2A/B requires R3.5-R6 for zone 2). Per design specification section 23.07.00, para 3.3.1, page 19, return ductwork will have a minimum 2" thick insulation (90.1 Table 6.8.2A/B requires R3.5: 2" = R6-7-R8.3). Per design specification section 23.07.00, para 2.1, page 5, all pipe insulation must meet or exceed the requirements of ASHRAE 90.1 - IP.
7.4.3.12	Automatic controls of HVAC and Lights	Required for hotels/motels with over 50 rooms (dormitories?). Requires outlets, TV's and HVAC to be controlled when unoccupied.	Prescriptive	No similar requirements	N/A	
7.4.4	Service Water Heating	Requires compliance with ASHRAE 90.1 plus additional requirements regarding system efficiency and insulation.	Prescriptive	Requires **ASHRAE 90.1** compliance plus additional features	Requirement met or exceeded.	Per design drawing P0.01, hangar uses two instantaneous tankless gas fired hot water flash heaters, Takagi model TM-1, 235 MBH, minimum input 25 MBH, which is 81% efficient.
7.4.5.1	Peak Load Reduction	Mandates automatic load reduction of at least 10% for all building projects during peak load times	Prescriptive	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Per basis of design specification page 10, all controls for the HVAC system will be Direct Digital Controls (DDC). The HVAC systems and control points are Outside Air Temperature; Split System Air Conditioners-Supply fan status/start/stop, SA temperature, RA temperature, MA temperature, SA smoke detector, economizer dampers position, gas heating valve position, RA carbon dioxide, SA high limit switch, filter pressure switch and room temperature; VAV Box-SA flow, SA damper position, SA temperature and zone temperature; Ductless Split System Air Conditioner-Split system start/stop and zone temperature; Air Handler-Supply fan status/start/stop, SA temperature, SA smoke detector, SA high limit switch, gas heating valve position, OA temperature and filter pressure switch; Infrared Heater-Start/stop and zone temperature; Exhaust Fan-Start/stop, fan status and room temperature (where required); Domestic Hot Water-Pump status/start/stop, DHW temperature, DHWS temperature, TWS temperature and TWR temperature; and Pulse Initiators-Gas meter, water meter and electric meter. We assume the DDC system has the capability to selectively reduce peak demand load throughout the facility when required.
7.4.6	Lighting	Requires compliance with ASHRAE 90.1, plus lighting power limits and occupancy sensors.	Prescriptive	**LEED (IEQ 6.1)** has a light control point; uncertainty regarding stringency	Requirement likely met; if not can be met at minimal cost.	Per basis of design specification page 19, fluorescent and high intensity discharge (HID) fixtures with occupancy sensors, automatic lighting shutoff systems, and dimming systems are provided. In addition, skylights have automatic photocontrols.
7.4.7	Other Equipment	In addition to compliance with ASHRAE 90.1 standards, requires performance standards for electric motors, heat recovery on supermarket refrigeration equipment, and an ENERGY STAR mandate for most appliances and electronics.	Prescriptive	Exceeds **ASHRAE 90.1** standards, plus **UFC3-400-01 (2-1.3)** requirements for Energy Star	Requirement likely met; if not can be met at minimal cost.	189.1 Table C-13 specifies minimum nominal efficiency based on motor size (kW), open or closed configuration, and number of poles (2, 4, or 6). This data was not readily available in design specifications. However, National Electrical Manufacturers Association (NEMA) MG 1 (2006) standard for motors and generators applies throughout design specifications. NEMA MG-1 and 189.1 Table C-13 are identical.
Section 7.5: Performance Options						
7.5.2	Energy Costs	Requires that the building project has an annual energy cost less than it could under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	Performance option.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.5.3	Annual CO2 equivalent	Requires that the building project has an annual carbon dioxide equivalent emissions less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	Performance option.
7.5.4	Annual Load Factor/Peak Load Demand	Requires that the building project has an annual peak electricity demand less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	Performance option.
Section 8: Indoor Environmental Air Quality						
8.3.1	IAQ Mandatory Provisions	Mandates compliance with Sections 4-7 of ANSI/ASHRAE Standard 62.1 , plus increases filtration requirements and other air-cleaning devices	Mandatory	**LEED (IEQ Prereq1), HPSB(GP4),** and **UFC 4-030-01(C-6)** only require ASHRAE 62.1 compliance	Requirement met or exceeded.	Meets 62.1
8.3.1.2	Outdoor Air Delivery Monitoring	Requires a outdoor airflow measurement device.	Mandatory	No similar requirements	Requirement met or exceeded.	Design specifications, page 206, requires an outside air measurement system equipped with a calibrated local or remote device capable of measuring the quantity of outside air on a continuous basis and displaying that quantity on a readily accessible display device.
8.3.1.3	Filtration and Air Cleaner Requirement	Higher air filtration and cleaning requirements for all facilities	Mandatory	More strenuous air filtration relative to **LEED (IEQ 5)**	Requirement met or exceeded.	Per LEED documentation.
8.3.1.4	Environmental Tobacco Smoke	Smoking is not allowed inside buildings, and requires designated smoking areas be to be located at least 25ft from building entrances.	Mandatory	Similar requirements for **LEED (Prereq 2)** and **HPSB (GP4)**	Requirement met or exceeded.	Per LEED documentation.
8.3.1.5	Building Entrances	Requires entry mat system at all entries	Mandatory	**LEED (IEQ 5)** requires mats at *regularly used* entrances, not all	Requirement met or exceeded.	Per LEED documentation.
8.3.3	Acoustical Control	Building projects should meet exterior and interior acoustical controls.	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Per 189.1, sound transmission class (STC) ≥ 50 is required. Design specification section 09.51.00, para 1.3.1, page 3, requires that the contractor provide a ceiling system with an attenuation class (CAC) of 35 when determined in accordance with ASTM E 1414. Provide fixture attenuators over light fixtures and other ceiling penetrations, and provide acoustical blanket insulation adjacent to partitions, as required to achieve the specified CAC. Provide test ceiling continuous at the partition and assembled in the suspension system in the same manner that the ceiling will be installed on the project. Design specification section 08.11.13, para 2.2, page 3, requires the contractor to provide sound insulated door and frame assemblies into rooms requiring wall assemblies to be sound insulated with an STC rating as required. The STC rating for the door and frame assembly shall be not less than the wall assembly STC rating.
8.3.4	Day lighting by top lighting	Mandates Minimum Requirements for Minimum Daylight Zone by Toplighting and Skylight parameters	Mandatory	Daylight points/recommendations in **LEED (IEQ 8.1)** and **HPSB(GP4),** but 189 seems more prescriptive	Requirement not met.	Documentation implies there are skylights in each bay, but cannot find any other references with more detailed information. Design drawings do not show any skylights. Requirement only applies to buildings ≤ 3 stories high. Technically the hangar is one story, but is clearly more than 3 stories high. Per formula calculation, each bay will need 625 SF of skylights at a total estimated cost of $120,000.
8.3.5	Isolation of Building from Pollutants in Soil	Ground level foundations built on Brownfields or in Zone1 counties will have *Soil Gas Retarding System.*	Mandatory	No similar requirements	Requirement met or exceeded.	Per design specification section 03.30.00, para 3.4.1, page 14, contractor shall provide a vapor barrier beneath the on-grade concrete floor slab. Requirement is to use the greatest widths and lengths practicable to eliminate joints wherever possible; lap joints a minimum of 12 inches and tape or cement joints; remove torn, punctured, or damaged vapor barrier material and provide with new vapor barrier prior to placing concrete; and ensure concrete placement does not damage vapor barrier material.
Section 8.4: Prescriptive Options						

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
8.4.1.1	Daylighting: Minimum Effective Aperture	Sets minimum Effective Aperture area for day lighting for office spaces and classroom	Prescriptive	Similar daylight recommendations in **LEED (IEQ 8.1)** and **HPSB (GP4),** but measured differently	Requirement not met.	189.1 standard requires north, south, and east window apertures to have an Eavf of .1 (climate zone 3) for administrative/class space. Drawing A1.09 and Window schedule (drawing A6.01) provide a window aperture to vertical wall space ration of .05. The window aperture on the north, south, and east sides of tha administrative space would need to double to meet the minimum standard of .1. Estimated cost: $3K for three additional 3'4"x8' aluminum insulated windows that meet ATFP requirements (MEANS Fac. Constr. Cost data, 2011, p. 286: Window size approximately quivalent to 4'x8' alum. Sliding glass door. Additional added to meet ATFP requirement noted in drawings, for a total of approx. $1K/window.
8.4.2	Materials	Places testing, documentation and formulation requirements on reported emissions or VOC contents. Materials include adhesives and sealants; paints and coatings; floor covering material; and composite wood, wood structural panel, and agrifiber products. Requirements may follow CA/DHS/EHLB/R-174, SCAQMD Rule 1168 or 1113, GS-36, GS-11, or third-party verification through CARB.	Prescriptive	Similar requirements in **LEED (IEQ 4.1, 4.2 and 4.3)**	Requirement likely met; if not can be met at minimal cost.	Per LEED documentation. Received IEQ points 4.1 and 4.2. but did not earn credit 4.3 for carpet systems.
Section 8.5: Performance Options						
8.5.1	Daylighting simulation	Demonstrate through simulations of classrooms and office spaces that there is usable luminance using ray-tracing or radiosity computer model or CIE Overcast Sky Model or the CIE Clear Sky Model. And the direct sunlight does not strike a work surface more than 20% of the time.	Performance	Difficult to calculate impact of performance options	N/A	
8.5.2	Materials	Model materials for VOC concentrations. The sum should comply with section 4.3 of CA/DHS/EHLB/R-14	Performance	Difficult to calculate impact of performance options	N/A	
Section 9: The Building's Impact on Atmosphere, Materials, and Resources						
9.3.1.1	Diversion	50% of construction debris must be recycled or reused.	Mandatory	Similar **LEED (MR 2) r**equirement	Requirement met or exceeded.	Per LEED documentation.
9.3.1.2	Total waste	Places maximum waste limits for projects where buildings and hardscapes make up less that 5% of the site landcover. Waste generation must be tracked throughout construction.	Mandatory	No similar requirements	Requirement met or exceeded.	Per LEED documentation.
9.3.2	Extracting , Harvesting, and/or Manufacturing	Materials and products are to be manufactured according to regulations on the country of origin. Wood products shall not be from endangered species unless it conforms with CITES	Mandatory	DoD must follow US code and CITES.	Requirement met or exceeded.	DoD must follow US code and CITES.
9.3.3	Refrigerants	CFC-based refrigerants in HVAC systems will not be used. Fire suppression systems shall not contain ozone depleting substances	Mandatory	Similar requirements for **LEED (EA3)** and **HPSB (GP4)**	Requirement met or exceeded.	Per LEED documentation.
9.3.4.1	Recyclables	Requires area serving building be dedicated to the collection and storage of materials for recycling	Mandatory	Similar requirements for **LEED (MR Pre1)** and **HPSB (GP4)**	Requirement met or exceeded.	Per LEED documentation.
9.3.4.2	Reusable goods	Requires buildings projects with residential space to have an area serving the building to be dedicated to the collection and reuse of materials.	Mandatory	Similar requirements for **HPSB (GP4)**	N/A	
9.3.4.3	Fluorescent and HID Lamps	Requires an area serving the building to be dedicated to the collection and storage of fluorescent and HID lamps and ballasts.	Mandatory	No similar requirements, although recycling area could collect bulbs	Requirement met or exceeded.	Per LEED documentation.
Section 9.4: Prescriptive Options						
9.4.1.1	Recycled Content	Recycled materials must make up at least 10% of the cost of the building materials	Prescriptive	Similar points in **LEED (MR 3)**, assumes 2 points	Requirement met or exceeded.	Per LEED documentation. MR 4.1 and 4.2 achieved - Submittal indicates 34.879% combined recycled content value as a percentage of total materials cost.
9.4.1.2	Regional Materials	At least 15% of building materials, based upon cost, must be made within 500 miles of the project site.	Prescriptive	**LEED (MR5)** goals for regional materials, allow 1 point for 10%, or 2 points for 20%	Requirement met or exceeded.	Design specification section 03.30.00, para 1.3, page 5, requires contractor to submit documentation indicating distance between manufacturing facility and the project site. Indicate distance of raw material origin from the project site. Indicate relative dollar value of local/regional materials to total dollar value of products included in project. However, available documentation provides no details upon which to base a calculation.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
9.4.1.3	Biobased Products	Biobased products must make up at least 5% of the cost of the building materials.	Prescriptive	No similar requirement	Requirement may be met; insufficient data to verify.	Design specification section 03.30.00, para 1.3, page 5, requires contractor to submit documentation indicating types of biobased materials in products and biobased content, along with the relative dollar value of biobased content products to total dollar value of products included in project: available documentation provides no details upon which to base a calculation. However, since 9.4.1.3.1 is essentially met, and given the larger than normal amount of wood used in this facility (due to gym floors and similar gym characteristics), the 5% biobased materials by cost standard may be met.
9.4.1.3.1	Wood Building Components	Certified wood must make up at least 60% of total wood used in the project.	Prescriptive	Exceeds **LEED (MR7)** goals for certified wood use	Requirement met or exceeded.	Per LEED documentation.
Section 9.5: Performance Options						
9.5	Performance Option	Life-Cycle Assessment be performed for a minimum of two building alternatives. Requires report and documentation of critical peer review by third party.	Performance	No similar requirements		
Section 10: Construction and Plans for Operation						
10	Construction and Plans for Operation	Requirements for construction and plans for operation, including commissioning, acceptance testing, M&V, transportation mgt, erosion and sediment control, and IAQ during construction	Mandatory	More extensive planning requirements relative to **LEED (IEQ3)**	Requirement likely met; if not can be met at minimal cost.	Per LEED documentation.
10.3.1.1	Bldg Acceptance Testing	Requires acceptance testing by the authority having jurisdiction (AHJ)	Mandatory	No similar requirements, but required by other jurisdictional requirements	Requirement met or exceeded.	Assume acceptance in conjunction with building commissioning.
10.3.1.2-4	Building Project Commissioning	Requires building commissioning for all buildings over 5000 sq ft, including commissioning plan. Commissioning must include HVAC&R systems, building envelope, irrigation, plumbing, water pumping and mixing, water heating, renewable energy, and measurement devices.	Mandatory	More extensive commissioning requirements relative to **LEED (EA Prereq 1)**	Requirement met or exceeded.	Per design specification section 23.08.00, contractor had to prepare Commissioning Plan in accordance with Commissioning Standard, no later than 28 days after the approval of the Commissioning Specialist. Commissioning plan included air handlers, DX condensing units, ductless fan coils, exhaust fans, domestic hot water system, and compressed air system. Included both pre-testing and final functional testing of systems installation, electronics, controls, piping, balance, etc.
10.3.2.2	Maintenance Plan	Mandates maintenance plan for mechanical, electrical, plumbing, and fire protection systems in accordance with ASHRAE Standard 180	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Design specification section 08.11.13, para 1.2, requires that the contractor submit operation and maintenance data. We assume this would constitute an O&M plan.
10.3.2.3	Service Life Plan	Mandates Service Life Plan for structural, building envelope, and hardscape materials.	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Cost to prepare plan in-house would be minimal.
10.3.2.4	Transportation Management Plan	Mandates a Transportation Management Plan, with varying mandates based upon ownership/leasing arrangements.	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Cost to prepare plan in-house would be minimal.
There are no Prescriptive or Performance Options for Section 10						

Appendix E
Minot AFB Crosswalk

This appendix summarizes the ASHRAE 189.1 requirements for high performance sustainable buildings, the degree to which the Minot AFB dormitory conforms to those requirements, actions that are needed to ensure conformance, and the likely added cost of such actions, if any.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
Section 5: Site Sustainability						
5.3.1.1 and 5.3.1.2	Site Selection	Building site must be on brownfield, greyfield, or greenfield with restrictions.	Mandatory	**LEED (SS1, SS2, and SS3)** has similar points	Requirement not met; but can be met at minimal cost.	Site is a greenfield that does not qualify for any listed exclusion. Compliance would require building on a brownfield, greyfield, or a different greenfield site, which may or may not be possible based on available sites and base master plan.
5.3.2.1	Mitigation of Heat Island Effect	Requires at least 50% of site hardscape (roads, sidewalks, courtyards and parking lots of the building project) to be shaded or have higher SRI	Mandatory	**LEED (SS 7.1)** has similar points	N/A	Climate zone 7 is excluded from this requirement.
5.3.2.2	Mitigation of Heat Island Effect	Requires 30% of walls shall be shaded on east and west of building based on shade angle at 10 and 3 on summer solstice.	Mandatory	No similar requirements	N/A	Climate zone 7 is excluded from this requirement.
5.3.2.3	Mitigation of Heat Island Effect	Requires a minimum of 75% of the roof to be SRI of 78 for low-sloped roof or SRI of 29 for steep-sloped roofs, or to be covered by Energy Star Roof Products	Mandatory	**LEED (SS7.2)** has similar points	Meets or exceeds requirement.	Final design submittal document page 55/530 requires using asphalt shingle roofing material with SRI ≥ 29. Roof has steep slope.
5.3.3	Reduction of light pollution.	Requires exterior lighting system comply with section 9 of ASHRAE Std 90.1.	Mandatory	Already complying with **ASHRAE 90.1**	Meets or exceeds requirement.	Assumed to comply with ASHRAE 90.1
Section 5.4: Prescriptive Options						
5.4.1.1	Site Development	40% of the entire site shall be planted or use permeable pavers	Prescriptive	**LEED (SS 5.2)** requires landscaping the area of the building footprint, but does not address site size (see case 2)	Meets or exceeds requirement.	In the proposed site design, vegetated and pedestrian-oriented open space adjacent to the building equals at least twice the area of the building footprint.
5.4.1.2	Effective Pervious Area for All Sites	For greenfield sites, 20% of the site should contain native or adapted plants	Prescriptive	**LEED (SS 5.2)** requires landscaping the area of the building footprint, but does not address site size (assume all DoD facilities fall into Case 2)	Requirement not met.	The majority of the area proposed to be developed with this project is grassed with some trees, with the exception of the tennis court. With the proposed improvements, including the parking area expansion there is a significant reduction in green area. Therefore, based on our observations and the current layout, this credit does not appear to be achievable. Cost estimate to meet requirement (in lieu of most grass planting in specs) (all native/adaptive plants) Access road trees: 12 trees x $425 = $5,100 (used in 5.3.2.1) Access road shrubs (example): 600 linear feet, assume 1 shrub every 5' = 100 shrubs 50 snowberry shrubs x $38/shrub (matl & labor, Means p.1095) 50 gray dogwood shrubs x $95 shrub (M&L, Means p. 1095) (50x$38)+(50x$95) = $6,650 Trees and shrubs around dorm (example)(Means p.1095 and 1096) 10 red dogwood x $199(M&L) = $1,990 10 birch x $253(M&L) = $2,350 10 green ash x $410 = $4,100 250 gray dogwood x $95 =$23,750 250 snowberry x $38 = $9,500 Total cost of meeting standard: $53,440
Section 5.5: Performance Options						

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
5.5.1	Site Development	Buildings must manage 20% to 50% of rainfall through infiltration, reuse, or evapotransporation.	Performance	**LEED (SS 5.2)** that may meet this based upon region and other variables. **EISA Sec 438** requires the restoration to pre-development hydrology to "the maximum extent technically feasible."	Meets or exceeds requirement.	The design-build proposal includes a Stormwater Management Plan that reduces impervious cover, promotes on-site infiltration, and captures and treats the runoff from 90% of the average annual rainfall using best management practices (BMPs) Detention/settlement ponds are sized for the 100 yr storm, which will exceed credit requirements.
Section 6: Water Use Efficiency						
6.3.1	Water Use Efficiency-Landscape Design	60% of the building site landscaping must be bio-diverse plants, with additional requirements for irrigation systems and controls	Mandatory	**UFC 3-201-02 (B-5.5.1)** Select water-efficient plants. **UFC 4-030-01 (C-3.1):** Design landscape through xeriscaping or use of native plants. No specific requirements for landscaping percentage.	Requirement not met.	Landscaping is to comply with LEED v.2.2 for native type and low maintenance principles. There is not and will not be an automatic irrigation system on the project site. The contractor will be responsible to perform watering, as needed and in such a manner that promotes the healthy growth, color and appearance for a period of 365 days (Establishment Period). Cost increase already included in 5.4.1.2 above.
6.3.2	Water Use Efficiency-Building water use requirements:	Places water flow requirements on plumbing fixtures	Mandatory	**LEED (WE2)** requires 50% water use reduction in sewage fixtures; **HPSB** and **EO 13432** require 20% reductions.	Requirement met or exceeded.	Final design submittal document page 38/30 states that showers are fiberglass with pressure balanced valves and 2 gpm heads. Lavatories in public areas are vitreous china with electronic infrared sensor operated, low flow 1.5 gpm, faucets. Lavatories in living spaces are molded into the countertop and feature single handle faucet with 1.5 gpm aerator. Kitchen sinks are stainless steel with single handle faucet with swing spout and 1.5 gpm flow restrictor. Lavatories and kitchen sinks will be provided with check valve on hot water supply after stop. Water closets in resident rooms are floor set vitreous china with low flow dual flush capability. Water closets in public areas feature floor set vitreous china with 1.3 gpf electronic infrared sensor operated flush valves.
6.3.2.2-3	Water Use-Appliances and HVAC Systems	Requires Energy Star appliances, and water metering and recovery/reuse requirements for HVAC systems.	Mandatory	**UFC 4-711-01 (8-1.5)** requires Energy Star building products and appliances.	Requirement not met.	Assume AF facilities use Energy Star appliances throughout. HVAC unit capacity is ≥ 65,000 BTU/hr for each system, so water recovery and reuse is required. Per corrected design specification section 01.86.10, para 1.11.10, page 15, HVAC systems simply drain condensate to the sanitary waste system rather than recover/reuse it. This can be addressed by installing a pipe to collect and route the condensate to a collection barrel at ground level, and then use the water for irrigation purposes instead of routing it down a drain. Estimated cost (labor and material): ≤ $2K.
6.3.3	Water Consumption Measurement	Extensive metering and submetering requirements and remote reading capabilities for both potable and reclaimed water.	Mandatory	Per **A7C Memorandum**, DoD Facilities Metering Installation Initiative (27 April 2006), all new construction should install potable water meters **UFC 4-030-01 (C-3.1):** Employ measurement and verification methods, and use water meters	Requirement met or exceeded.	Final design submittal document page 38/530 states that water service is brought into the building where it is metered via 3" turbine water meter with pulse output capability and remote readout feature. Water meter flow data will be integrated into the base EMCS.
Section 6.4: Prescriptive Options						
6.4.1	Site Water Use Reduction	Golf courses and driving ranges have irrigation water restrictions	Prescriptive	No other golf course/driving range specific directives	N/A	
6.4.2	Building Water Use Reduction	Water use reductions for cooling towers, food operations and medical facilities.	Prescriptive	No similar cooling tower, food operations, or medical facility directives	N/A	
6.4.3	Special Water Features	Water requirements for fountains, water features, pools, and spas.	Prescriptive	No other water feature specific directives	N/A	
Section 6.5: Performance Options						

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
6.5.1	Site Water Use Reduction	Potable water cannot make up more than 35% of total water demand for landscaping	Performance	**LEED (WE1)** requires a 50% reduction in potable water use for irrigation (2 points), or no potable water use in irrigation (4 points).	Requirement met or exceeded.	Final design submittal document page 8/530 states that there is not and will not be an automatic irrigation system on the project site. The contractor will be responsible to perform watering, as needed and in such a manner that promotes the healthy growth, color and appearance for a period of 365 days (Establishment Period).
6.5.2	Building Water Use Reduction	Building project water use shall be less than or equal to what would be achieved through compliance with 6.3.2, 6.4.2, and 6.4.3.	Performance	Unclear if ASHRAE is more strenuous	N/A	Building does not have cooling towers, food operations, or medical facilities so this does not apply.
Section 7: Energy Efficiency						
7.3	Mandatory Provisions for Energy Efficiency	Requires ASHRAE Standard 90.1-2010 sections 5.4, 6.4 7.4, 8.4, 9.4, and 10.4.	Mandatory	Already complying with this requirement per **UFCs** and their requirement for **ASHRAE 90.1** compliance	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1
7.3.2	On-site Renewable Energy Systems	Building projects must provide for the future installation of on-site renewable energy systems.	Mandatory	Other standards/codes require renewable energy, but this only requires *for the future* installation of renewable energy systems	Requirement met or exceeded.	Assume RE could be installed on roof or elsewhere on site.
7.3.3.1, 7.3.3.2, 7.3.3.3	Energy Consumption Measurement	Requires consumption data recording with remote communication capabilities for electricity, gas and district heat for main systems and some subsystems.	Mandatory	**LEED (EA5), HPSB (GP2),** and **UFC 4-030-01** have metering requirements and conditions, but none require remote communication capabilities and subsystems.	Requirement met or exceeded.	Final design submittal document page 38/530 states that the temperature control system will be JCI Metasys and will be fully integrated into the base EMCS. The system will be100% DDC and will monitor and control the HVAC system including each WTA and WTW heat pump unit, all pumps, heat recovery ventilation units, mechanical and electrical room ventilation, domestic water, natural gas and electric consumption, geothermal heat pump load and source side pipe pressure and heat pump total building flow and temperature differential. Gas and electric meters with pulse output and remote reading capability are included.
Section 7.4: Prescriptive Options						
7.4.1	Prescriptive Option	Requires all building projects to comply with ASHRAE Standard 90.1-2010	Prescriptive	Already complying with this **ASHRAE 90.1**	Requirement met or exceeded.	Assumed to comply with ASHRAE 90.1
7.4.1.1	On-site Renewable Energy Systems	Mandates on-site renewable energy systems with production of not less than 4.0 Kbtu/sq ft (with additional requirements for Energy Star)	Prescriptive	Similar **HPSB (GP2)** and **LEED (EA 2)** points for RE, but none mandate as a ratio of sq ft.	Requirement not met.	Geothermal heat pump system does not qualify unless it is used to generate electricity.
7.4.2	Building Envelope	Requirements compliance with ASHRAE 90.1 regarding insulation, fenestration, permanent projections, vestibules, and continuous air barriers, except where noted otherwise	Prescriptive	**HPSB** and **UFCs** require **ASHRAE 90.1** requirements, but without caveats	Requirement likely met; but if not can be met at minimal cost.	Per final design submittal document page 305/530 roof insulation is R-30 (R-20 minimum); vertical fenestration is <40% of wall area; permanent projection requirement can be met with low emissivity insulated glass, blinds, and window boxes; SGHC of bedroom windows is 0.72, core area is 0.42, and entry foyer is 0.55; fenestration orientation does not apply since building is adjacent to existing building on at least one side.
7.4.2.8	Bldg Envelope Trade off option	ASHRAE 90.1 Section 5.6 Trade Off option will not apply unless the modifications and additions noted in ASHRAE 189.1 Section 7.4.2 Apply	Prescriptive	Reduces a compliance option from **ASHRAE 90.1**, making compliance more difficult	N/A	Trade off option does not apply.
7.4.2.5	Permanent Projection	Requires vertical fenestration on W, S and E sides be shaded by permanent projections in some climate zones	Prescriptive	Site specific requirements; no similar requirements in other codes	Requirement not met; but can be met at minimal cost.	No permanent projections exist. However, use of low emissivity insulated glass coupled with interior blinds and light boxes would likely meet this requirement at minimal cost.
7.4.2.10	Continuous Air Barrier	Requires continuous air barrier	Prescriptive	Similar but less rigorous requirements in **ASHRAE 90.1**	Requirement met or exceeded.	Per corrected design specifications section 08.11.16, para 1.2.2, when tested in accordance with ASTM E 283, air infiltration shall not exceed 0.06 cubic feet per minute per square footof fixed area at a test pressure of 6.24 pounds per square foot (50 mile per hour wind).

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.3.1	Minimum Equipment Efficiencies	Requires products used in projects to comply with: Option 1: The National Appliance Energy Conservation Act (NAECA), EPAct, and EISA. OR Option 2: ENERGY STAR requirements Sec 7.4.7.3 and Tables C-1-C15 in Appendix C, and ASHRAE 90.1 with additional requirements for renewable energy and peak load energy use reductions.	Prescriptive	DoD families must already comply with **NAECA, EPAct,** and **EISA**	Requirement met or exceeded.	DoD families must already comply with NAECA, EPAct, and EISA.
7.4.3.2	Ventilation Controls	Demand Control Ventilation should comply with ASHRAE 62.1 and supersedes ASHRAE 90.1, plus specifications regarding CO2 sensors.	Prescriptive	**ASHRAE 90.1** requires DCV, but no specific requirements for CO2 sensors.	N/A	Requirement only applies to densely occupied spaces (i.e., spaces with ≥ 25 people/1,000 SF.
7.4.3.3	Duct and Plenum Leakage	Use Seal Level A for duct sealing.	Prescriptive	**ASHRAE 90.1 (2010)** requires Seal Level A. Older editions of ASHRAE 90.1 do not.	Requirement met or exceeded.	Per corrected design specifications section 23.00.00, para 2.9.1 subsection b, page 13, contractor will provide ductwork that meets the requirements of Seal Class A.
7.4.3.4	Economizers	Requires economizer usage as articulated in ASHRAE 90.1 but with additional requirements as articulated in 7.4.3.4	Prescriptive	More stringent than **ASHRAE 90.1** requirements	Requirement not met.	MAU 1 and MAU 2 both operate at 160,000 Btu/hr in cooling mode, which exceeds the 33,000 Btu/hr threshold; hence economizers are required for each unit. Fans incorporate variable speed motors. MAU 1: 4,200-4,800 CFM. MAU 2; 4,260-5,000 CFM. Thus economizers must handle roughly 5,000 CFM. Per RSMeans, Mechanical Cost Data, page 383, line 4040, ERVs for 6,000 CFM maximum cost $12,100 each installed, for a total estimated cost of $24,200.
7.4.3.5	Zone Control	Slightly narrow exceptions from ASHRAE 90.1 compliance	Prescriptive	Slightly narrows the **ASHRAE 90.1** exceptions where compliance is not required	Requirement met or exceeded.	Per corrected design specifications section 23.00.00, para 2.11.2, page 19, contractor is to provide single-zone draw-through type HVAC units. All HVAC units are controlled through the base EMCS.
7.4.3.7	Controls	Mandates multi stage cooling, multispeed or Variable speed drive on small DX and chilled water units, with additional requirements for sizing and performance.	Prescriptive	More stringent than **ASHRAE 90.1** requirements	Requirement met or exceeded.	Per corrected design specifications section 01.86.10, para 1.3, page 5, facility includes separate DX ground source loop water to air heat pump system for all rooms. Section 23.81.47, para 2.2, page 20, requires use of solid-state variable-speed controllers for motors rated 7.45 kW (10 hp) or less and adjustable frequency drives for larger motors. units. Per final design submittal document page 35/530 there are two ventilation systems located in the attic mechanical equipment space. Each system serves approximately ½ of the building. Each ventilation system consists of a supply air fan section, exhaust air fan section, enthalpy heat wheel, supply and exhaust air f ow measurement stations integral to each fan section, filter sections for airstreams, variable speed motors and drives for supply and exhaust fans and chilled water coil that is used as a hot water coil during the heating season. A reheat coil using warm condenser water discharge from the WTW heat pump(s) would be provided for summer humidity (dew point) control. Normal operation would provide for nearly balanced airflow to the building 24 hours per day.
7.4.3.8	Exhaust Air Energy Recovery	Requires energy recovery systems with at least 60% energy recovery effectiveness	Prescriptive	Greater efficiency than is required in **ASHRAE 90.1**	Requirement met or exceeded.	Per corrected design specifications section 23.00.00, para 2.13.1, page 22-23, contractor will provide Rotary Wheel ERV units that are a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream, with device performance according to ASHRAE 84 and that delivers an energy transfer effectiveness of not less than 70 percent with cross-contamination not in excess of 0.1 percent of exhaust airflow rate at system design differential pressure, including purging sector if provided with wheel.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.3.10-11	Duct and Pipe Insulation	Requires insulation specifications for duct and pipe insulation as articulated in ASHRAE 90.1 appendix	Prescriptive	Similar requirements in **ASHRAE 90.1**	Requirement met or exceeded.	189.1 requires R-6 insulation on HVAC supply ducts and no insulation on return ducts. For pipes insulation thickness required ranges from 1"- 3.5" depending on diameter. Per corrected design specification section 23.07.00, para 2.4.1.1, page 14, all HVAC ducts will have 2" 2.0 inches thick or Type II up to 250 degrees F. Also ASTM C 1290 Type III may be used. Alternately, minimum thickness may be calculated in accordance with ASHRAE 90.1 - IP. This meets the 189.1 requirement. Per corrected design specification section 23.07.00, para 3.2.1.6, page 20-21, minimum pipe insulation ranges from 1" - 3.5" depending on pipe size. This meets the 189.1 requirement.
7.4.3.12	Automatic controls of HVAC and Lights	Required for hotels/motels with over 50 rooms. Requires outlets, TV's and HVAC to be controlled when unoccupied.	Prescriptive	No similar requirements	N/A	Only applies to hotels and motels. Does not include dormitories.
7.4.4	Service Water Heating	Requires compliance with ASHRAE 90.1 plus additional requirements regarding system efficiency and insulation.	Prescriptive	Requires **ASHRAE 90.1** compliance plus additional features	Requirement met or exceeded.	Per final design submittal document page 304/530 facility incorporates gas fired high efficiency domestic water heaters supplemented by geothermal water-to-water heat pumps.
7.4.5.1	Peak Load Reduction	Mandates automatic load reduction of at least 10% for all building projects during peak load times	Prescriptive	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Final design submittal document page 38/530 states that the temperature control system will be JCI Metasys and will be fully integrated into the base EMCS. The system will be100% DDC and will monitor and control the HVAC system including each WTA and WTW heat pump unit, all pumps, heat recovery ventilation units, mechanical and electrical room ventilation, domestic water, natural gas and electric consumption, geothermal heat pump load and source side pipe pressure and heat pump total building flow and temperature differential. Gas and electric meters with pulse output and remote reading capability are included. We assume the DDC system has the capability to selectively reduce peak demand load throughout the facility when required.
7.4.6	Lighting	Requires compliance with ASHRAE 90.1, plus lighting power limits and occupancy sensors.	Prescriptive	**LEED (IEQ 6.1)** has a light control point; uncertainty regarding stringency	Requirement met or exceeded.	Per corrected design specifcation section 26.51.00, para 1.4.1, page 5, contractor will provide lighting control system as indicated. Lighting control equipment shall include: power packs and occupancy sensors. Para 2.10, page 10-11, clarifies that sensors shall have an LED occupant detection indicator. Sensors shall have adjustable sensitivity and adjustable delayed-off time range of 5 minutes to 15 minutes. Wall mounted sensors shall be ivory, ceiling mounted sensors shall be white. Ceiling mounted sensors shall have 360 degree coverage unless otherwise indicated. Ultrasonic/Infrared Combination Sensors are required. Occupancy detection to turn lights on requires both ultrasonic and infrared sensor detection. Lights shall remain on if either the ultrasonic or infrared sensor detects movement. Infrared sensor shall have lens selected for indicated usage and daylight filter to prevent short wavelength infrared interference. Ultrasonic sensor frequency shall be crystal controlled.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
7.4.7	Other Equipment	In addition to compliance with ASHRAE 90.1 standards, requires performance standards for electric motors, heat recovery on supermarket refrigeration equipment, and an ENERGY STAR mandate for most appliances and electronics.	Prescriptive	Exceeds **ASHRAE 90.1** standards, plus **UFC3-400-01 (2-1.3)** requirements for Energy Star	Requirement likely met; if not can be met at minimal cost.	189.1 Table C-13 specifies minimum nominal efficiency based on motor size (kW), open or closed configuration, and number of poles (2, 4, or 6). This data was not readily available in design specifications. However, National Electrical Manufacturers Association (NEMA) MG 1 (2006) standard for motors and generators applies throughout design specifications.
Section 7.5: Performance Options						
7.5.2	Energy Costs	Requires that the building project has an annual energy cost less than it could under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	Performance option.
7.5.3	Annual CO2 equivalent	Requires that the building project has an annual carbon dioxide equivalent emissions less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	Performance option.
7.5.4	Annual Load Factor/Peak Load Demand	Requires that the building project has an annual peak electricity demand less than it would under compliance with under the prescriptive options in other sections of ASHRAE 189.1	Performance	Difficult to calculate impact of performance options	N/A	Performance option.
Section 8: Indoor Environmental Air Quality						
8.3.1	IAQ Mandatory Provisions	Mandates compliance with Sections 4-7 of ANSI/ASHRAE Standard 62.1 , plus increases filtration requirements and other air-cleaning devices	Mandatory	**LEED (IEQ Prereq1), HPSB(GP4),** and **UFC 4-030-01(C-6)** only require ASHRAE 62.1 compliance	Requirement met or exceeded.	Per corrected design specifications section 23.00.00, para 2.11.3, contractor is to provide 2 inch depth, sectional, disposable type filters of the size indicated with a MERV of 8 when tested according to ASHRAE 52.2.
8.3.1.2	Outdoor Air Delivery Monitoring	Requires a outdoor airflow measurement device.	Mandatory	No similar requirements	Requirement met or exceeded.	Final design standard submisson page 57/530 states that each mechanical system will provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor airflow rate, as defined by ASHRAE 62.1-2004. The measuring device will be integral to the equipment specified.
8.3.1.3	Filtration and Air Cleaner Requirement	Higher air filtration and cleaning requirements for all facilities	Mandatory	More strenuous air filtration relative to **LEED (IEQ 5)**	Requirement met or exceeded.	Per corrected design specification section 23.00.00, para 2.10.3, page 18, contractor is to provide 2 inch depth, sectional, disposable type filters of the size indicated with a MERV of 8 when tested according to ASHRAE 52.2. Provide initial resistance at 500 fpm that does not exceed 0.36 inches water gauge. Provide UL Class 2 filters, and nonwoven cotton and synthetic fiber mat media.
8.3.1.4	Environmental Tobacco Smoke	Smoking is not allowed inside buildings, and requires designated smoking areas be to be located at least 25ft from building entrances.	Mandatory	Similar requirements for **LEED (Prereq 2)** and **HPSB (GP4)**	Requirement met or exceeded.	Smoking is not allowed with 25 ft of building.
8.3.1.5	Building Entrances	Requires entry mat system at all entries	Mandatory	**LEED (IEQ 5)** requires mats at *regularly used* entrances, not all	Requirement likely met; if not can be met at minimal cost.	Per corrected design specification section 01.84.00, para 1.3.9, page 4, contractor will provide roll-up floor mats consisting of extruded-aluminum tread rails with anodized finish sitting on continuous vinyl cushions with 2" wide tread rail modules. Provide aluminum hinges and ribbed-design-surface with carpet inserts. Recess concrete slab to match the depth of the floor mat so that top of floor mat is level with adjacent finished floor. Provide flexible vinyl edge-frame members, not less than 1.5" wide, attached to mat at all four edges, with welded mitered corners. Install mat frames to comply with manufacturer's written instructions. To provide clearance between door and mat, coordinate top of mat surface with bottom of doors that swing across mats. Does not specify that mats will be placed at all entry doors, but if not this can be done at minimal cost.
8.3.3	Acoustical Control	Building projects should meet exterior and interior acoustical controls.	Mandatory	No similar requirements	Requirement met or exceeded.	Final design standard submission pages 100-101/530 states that acoustic separation on all vertical interior and exterior walls will be STC ≥ 50. Same is true for acoustical ceiling tiles.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
8.3.4	Day lighting by top lighting	Mandates Minimum Requirements for Minimum Daylight Zone by Toplighting and Skylight parameters	Mandatory	Daylight points/recommendations in **LEED (IEQ 8.1)** and **HPSB(GP4),** but 189 seems more prescriptive	N/A	Does not apply to climate zone 7.
8.3.5	Isolation of Building from Pollutants in Soil	Ground level foundations built on Brownfields or in Zone1 counties will have *Soil Gas Retarding System.*	Mandatory	No similar requirements	N/A	Facility is not on a brownfield site.
Section 8.4: Prescriptive Options						
8.4.1.1	Daylighting: Minimum Effective Aperture	Sets minimum Effective Aperture area for day lighting for office spaces and classroom	Prescriptive	Similar daylight recommendations in **LEED (IEQ 8.1)** and **HPSB (GP4),** but measured differently	Requirement met or exceeded.	This requirement only applies to offices and classrooms. Building has only find one small office, and it exceeds the window aperture requirement. Remainder of building is all residential (not designed or intended to be office or classroom space).
8.4.2	Materials	Places testing, documentation and formulation requirements on reported emissions or VOC contents. Materials include adhesives and sealants; paints and coatings; floor covering material; and composite wood, wood structural panel, and agrifiber products. Requirements may follow CA/DHS/EHLB/R-174, SCAQMD Rule 1168 or 1113, GS-36, GS-11, or third-party verification through CARB.	Prescriptive	Similar requirements in **LEED (IEQ 4.1, 4.2 and 4.3)**	Requirement met or exceeded.	Per LEED documentation, attempting IEQ points 4.1(Low-Emitting Materials, Adhesives & Sealants) 4.2 (Low-Emitting Materials, Paints & Coatings) and 4.3 (Low-Emitting Materials, Carpet Systems).
Section 8.5: Performance Options						
8.5.1	Daylighting simulation	Demonstrate through simulations of classrooms and office spaces that there is usable luminance using ray-tracing or radiosity computer model or CIE Overcast Sky Model or the CIE Clear Sky Model. And the direct sunlight does not strike a work surface more than 20% of the time.	Performance	Difficult to calculate impact of performance options	N/A	Performance option.
8.5.2	Materials	Model materials for VOC concentrations. The sum should comply with section 4.3 of CA/DHS/EHLB/R-14	Performance	Difficult to calculate impact of performance options	N/A	Performance option.
Section 9: The Building's Impact on Atmosphere, Materials, and Resources						
9.3.1.1	Diversion	50% of construction debris must be recycled or reused.	Mandatory	Similar **LEED (MR 2) r**equirement	Requirement met or exceeded.	Goal of project is to divert at least 50% of construction waste from the landfill.
9.3.1.2	Total waste	Places maximum waste limits for projects where buildings and hardscapes make up less that 5% of the site landcover. Waste generation must be tracked throughout construction.	Mandatory	No similar requirements	Requirement met or exceeded.	Buildings and hardscapes are more than 5% of total site landcover. Also per corrected design specification section 01.74.19, para 1.3, page 2, contractor must develop Waste Management Plan. A waste management plan shall be submitted within 15 days after notice to proceed and prior to initiating any site preparation work. The plan shall include the following: a. Name of individuals on the Contractor's staff responsible for waste prevention and management. b. Actions that will be taken to reduce solid waste generation. c. Description of the specific approaches to be used in recycling/reuse of the various materials generated, including the areas and equipment to be used for processing, sorting, and temporary storage of wastes. d. Characterization, including estimated types and quantities, of the waste to be generated. e. Name of landfill and/or incinerator to be used and the estimated costs for use, assuming that there would be no salvage or recycling on the project. f. Identification of local and regional reuse programs, including non-profit organizations such as schools, local housing agencies, and organizations that accept used materials such as materials exchange networks and Habitat for Humanity. g. List of specific waste materials that will be salvaged for resale, salvaged and reused, or recycled. Recycling facilities that will be used shall be identified. h. Identification of materials that cannot be recycled/reused with an explanation or justification. i. Anticipated net cost savings determined by subtracting Contractor program management costs and the cost of disposal from the revenue generated by sale of the materials and the incineration and/or
9.3.2	Extracting , Harvesting, and/or Manufacturing	Materials and products are to be manufactured according to regulations on the country of origin. Wood products shall not be from endangered species unless it conforms with CITES	Mandatory	DoD must follow US code and CITES.	Requirement met or exceeded.	Gov't follows these regs.

Appendix F
Calculations

This appendix provides further details regarding various calculations provided throughout the report.

Appendix F
Calculations Summary

OFFUTT AFB

5.3.2.1—Mitigation of Heat Island Effect

(Based on RSMeans 2011 Facility Construction Data)

Cost Estimate for Parking Lot (no plants/shading):

Note: Parking lot in site plan uses existing 24" thick concrete runway. Assumed costs restricted to striping, signage, and minor alteration work (no cost estimate done for these costs). Cost of planting shade trees (removing 24" concrete) would probably be prohibitive.

Parking lot-new:

FACTS/ASSUMPTIONS:

- Primary sources of information: site layout plan & RSMeans Facilities Construction Cost Data, 2011)
- 842 spaces
- Approx. 34,725 SY per site plan (around 40 SY/space, including lanes and etc.) (compares well to RSMeans est. 43.33 SY/space in assembly estimate: p.1251)

COST ESTIMATES: NEW CONSTRUCTION PARKING

1. Parking garage:

   $18,300/car (median SF cost, RSMeans p. 1435)

   $18,300x842 spaces=$15.40M (for parking garage)

2. Parking lot:

   a. Asphalt: (per assembly specs for 6"base, 3" paving, RSMeans p.1251) $1,250/space

   $1,250x842=$1.05M (for all parking, incl. striping, parking blocks)

b. Concrete: (per assembly specs RSMeans p.1251, replacing 3” asphalt with 6” concrete (ref RSM p.1073), all else in assembly remains the same)

$1,491/space

$1,491x842=$1.25M (for all parking, incl. striping, parking blocks)

c. Pavers (per assembly specs RSMeans p.1251, replacing 3” asphalt with stone pavers (ref RSMeans p.1076), all else in assembly remains the same)

(note: estimate $15/SF as estimated cost per RSMeans p.1076 for stone pavers)

$6,306/space

$6,306x842=$5.3M (for all parking, incl. striping, parking blocks)

6.3.3—Water Consumption Measurement

Calculations for this requirement are based on published water meter set fees from the Board of Water Works of Pueblo, CO, which we assume would be comparable to rates in Nebraska. These rates, which were effective May 1, 2011, are as follows for domestic, commercial, and industrial water meters:

Meter Size	$ Material	$ Labor	$ Equipment	$ Outside Services	$ Total
3/4” without bypass	381	84	40	0	505
1” without bypass	436	84	40	0	560
1½” without bypass	931	158	72	0	1,161
2” without bypass	1,106	158	72	0	1,336
1½” with 1¼” bypass	1,157	232	120	0	1,509
2” with 1¼” bypass	1,337	232	120	0	1,689
3” comp on 4” with 4” bypass	5,318	1,873	576	2,838	10,605
4” comp with 4” bypass	6,370	1,873	576	2,838	11,657
4” comp on 6” with 4” bypass	6,831	1,873	576	2,838	12,118
6” comp with 6” bypass	8,991	1,873	576	2,838	14,278
6” comp on 8” with 6” bypass	9,768	1,873	576	2,838	15,055
6” turbine with 6” bypass	8,081	1,873	576	2,838	13,368
6” turbine on 8” with 6” bypass	8,684	1,873	576	2,838	13,971
8” turbine with 8” bypass	12,337	1,873	576	2,838	17,624

The cost differential going from a 6” turbine with 6” bypass to an 8” turbine with 8” bypass is approximately 31.8 percent. We assume a similar increase going from the 8” turbine to a 10” turbine, which equates to $17,624 X 1.318 = $23,235. Cost estimate for 5 meters would be $116,175. This does not include cost to connect remote meters to monitoring station.

TYNDALL AFB

5.3.2.1—Mitigation of Heat Island Effect

(Per RSMeans 2011 Facilities Construction Cost Data)

Cost estimate for parking lot alternatives (new parking lots)

FACTS AND ASSUMPTIONS

- Primary sources of information: site layout plan (C100-A) and RSM Facility Construction Cost Data/2011, assuming new construction
- 165 car parking spaces + 21 motorcycle parking spaces (LEED documentation, p.309/1466)
- Approximately 5,450 SY of parking: around 38 SY/space (this is about 90% of RSM estimate of 43.33SY/space in assembly estimate, p. 1251)
- Does not include new construction roads outside of parking lots
- SRI: Gravel does not appear to be an acceptable strategy for non-roof SRI
- SRI of ordinary Portland cement typically ranges from .35 to .45 out of 1
- SRI of asphalt is near zero new and between .1 and .15 for older (>5 years) asphalt surfaces
- Special coatings can raise SRI of surfaces as high as .7 or .8 (not considered in this estimate)

COST ESTIMATES: NEW CONSTRUCTION PARKING

1. Parking garage:

   $18,300/space (per RSMeans p. 1435, median SF cost, no adjustments)

   Total: $18,300/space x 172 spaces = $3,147,600

2. Parking lot and road asphalt:

   Per assembly specs (RSMeans p. 1251) with adjustments:

   1.5” asphalt (drawing spec) vs. 3” asphalt (assembly spec)

   Total adjusted cost is 90% of RSMeans adjusted cost (due to smaller SY/space: 38 SY vs 43 SY)

a. $938/space

   $938/space x172 spaces = $161,336

   (165 spaces + 7 car-equiv. spaces for 21 motorcycles = 172 spaces)

b. roadway (2" asphalt and 8" base): 1,780 SY (equiv. to 47 parking spaces at 38 SY/space)

   Per assembly specs (RSMeans p.1251) with adjustments:

   2" asphalt (drawing specs) vs 3" asphalt (assembly spec)

   $955 x 47 = $44,922

c. A bonded 2" concrete overlay can be placed over the asphalt to increase SRI to above .29 and economically prolong the life of the paved surface. Use $15.66/SY (per Offutt cost estimate) as estimated cost of the unbounded concrete overlay:

   (5,535 SY parking spaces + 1,780 SY road) x $15.66/SY = $114,553

   Total: $161,336 (from'a') +$44,922 (from 'b') + $114,553 (from 'c') =$320,800

3. <u>Parking lot and road, concrete</u>:

   a. parking: per assembly specs RSMeans p. 1251, with adjustments:

      -Replacing 3" asphalt with 3" concrete (vs 6" concrete: assume ½ thickness based on asphalt spec thickness) (ref RSM p. 1073, assume $20/SY). Assume parking and road are all 3" thick
      Total adjusted cost is 90% of RSM adjusted cost (due to smaller SY/space: 38 SY vs 43 SY)

      Total parking spaces = 219 (172 parking spaces and 47 parking space equiv. for road)

      -no overlay needed to increase SRI of concrete so use $1,148/space

      Total: $1,148/space x 219 spaces = $251,400

4. <u>Parking lot, Pavers</u>:

   Per assembly specs RSM p.1251, with adjustments:

   Replacing 3" asphalt with stone pavers (ref RSMeans p. 1076)

Total adjusted cost is 90% of RSM adjusted cost (due to smaller AY/space: 34 SY vs 43 SY) $5674/space

Total: $5674/space x 219 spaces = $1,242,600

Conclusion: For new construction, the new concrete parking lot (vs. new asphalt with concrete overlay) appears to be the best alternative to achieve the .29 SRI threshold.

COST ESTIMATE: EXISTING PARKING

1. Adding 2" overlay to existing parking lot:

    a. Whichever alternative is used for new parking, overlay of existing parking will be the same. A bonded 2" concrete overlay can be placed over the asphalt to increase SRI to above .29. Use $15.66/SY as estimated cost of the bounded concrete overlay per USACE unit cost factors.

    There are 101 existing parking spaces (LEED documentation, p. 309 and 1466). Assume existing parking spaces same size as new parking spaces (38 SY/space), for a total of 3,838 SY.

    Total: 3,838 SY x $15.66/SY = $59,875

    Tree shade for parking lots:

    American Sycamore, Laurel Oak and Live Oak are native Florida trees that can provide shade over hard surfaces. The Sycamore grows fastest, and do could be large enough within five years of planting to provide significant shade. It does, however, thrives best near water. The Oaks grow more slowly, and so will take longer to provide the same amount of shade as the Sycamore.

    New parking: Approximately 40 trees could be planted in and around the parking lots to provide shade to the hard surfaces and reducing heat island effects. The cost of planting 8'-10' trees (including all materials and labor) is around $700/tree (RSMeans p. 1096).

    Total: cost of planting 40 10' tall trees is approximately $28,000.

    Existing parking: Assuming existing parking is configured similarly to the new parking, the 49 spaces north of the building and the 52 spaces east of the building can each be shaded with about 12 trees each, for a total of 24 trees, to provide shade to the hard surfaces and reduce heat island effects. The cost of planting 8'-10'

trees (including all materials and labor) is around $700/tree (RSMeans p. 1096).

Total: cost of planting 24 10' tall trees is approximately $16,800.

TRAVIS AFB

8.3.4—Daylighting by Toplighting

For this calculation we assume a separate skylight is required above each of the two bays. For ease of calculation, we assume skylight dimensions of X ft per side. We then increase those dimensions by 0.7 times the hangar height of 80 ft in each direction. This results in a square X ft on a side within a larger square (X+112) ft on a side.

Since the lighting power density of the hangar is 1.295 W/sq ft, the skylight area must equal at least 3.3 percent of the expanded projected area described above. In other words,

$X^2/(X+112)^2 = 0.033$.

Solving the equation results in X = 24.92 ft. That means each skylight will need to be roughly 621 sq ft in area. Per 2011 RSMeans Interior Cost Data, page 154, line 2300, the installed cost of skylighting is $98.60 per sq ft, for a cost per skylight of $61,231, and the two together would have cost $122,462.

MINOT AFB

(Per RSMeans 2011 Facilities Construction Cost Data)

5.3.2.1 - Mitigation of Heat Island Effect: Parking and Access Road Cost Estimate

ACCESS ROAD

Access Road-Asphalt

1800SY (40 parking space equivalents @ 43.33 SY/space per Means p. 1251)

Assume 6" paving and 10" base: $1,900/space (Means p. 1251)

$1,900 x 40 = $76,000 for asphalt access road.

Access Road Concrete

Assume 6" concrete @ $26/SY (Means p. 1073), or $1,207 for mat'l and labor in place of asphalt

$1,900–(asphalt matl & labor) + (concrete matl & labor) = $2,107/space

$2,107 x 40 = $84,280 for concrete access road.

Access Road Overlay

1800SY x $15.66 = $28,200 for overlaying asphalt access road

PARKING LOT

Parking Lot Asphalt

Assume 4" asphalt, 8" base: $1,470/space (Means p. 1251)

$1,470 x 160 spaces = $235,200 for asphalt parking lot

Parking Lot Concrete

Assume 6" concrete @ $26/SY (Means p.1073) (similar to concrete access road above)

$2,107 x 160 spaces = $337,120 for concrete parking lot

Parking Lot Overlay

Parking lot SY = 300' x 180' (per site drawing) = 54,000 SF = 6,000 SY

6000 x $15.66 = $93,960 for overlaying asphalt parking lot

TREES FOR SHADE

Honey Locust tree is native to the Dakotas and grow well in urban/paved areas

$425/tree (matl & labor) (tree size planted: 10'-12', 1.5" caliper)

(tree size at maturity: 40'-60' tall and 40'-50' wide)

Plant at 60' intervals along access road (alternate sides)

12 trees x $425 = $5,100

Plant 15 trees around parking (assume can plant in islands)

15 trees x $425 = $6,375

Total tree cost: $11,475 for shading access road and parking lot

5.4.1.2 - Greenfield Sites: 20 Percent of Site to Contain Native or Adaptive Plants

Assumption: trees in 5.3.2.1 (shade for hardscape) can be included in 20%

From site drawings:

Access road site area: (40'x300')+(55'x400') = 34,000 sf

Parking lot site area: (315x190)+(40x130) = 65,050 sf

Building site area: (530x240) = 127,200 sf

Total Area 226,250 sf

Requirement = .2x226,250 = 45,250 sf to contain native/adaptive plants

Areas possible for plants:

-NW side of access road: (10'x300') = 3,000 sf

(15'x300') = 4,500 sf

-SE side of access road: (10'x450') = 4,500 sf

-NE (front) side of dorm: (250'x50')+(150'x50') = 20,000 sf

-SW (rear) side of dorm: (450'x50') = 22,500 sf

Total available area for plants: 54,500 sf

54,500 sf > 45,250 sf, therefore **20% requirement can be met**.

Cost estimate to meet requirement (in lieu of most grass planting in specs)

(all native/adaptive plants)

Access road trees: 12 trees x $425 = $5,100 (used in 5.3.2.1)

Access road shrubs (example):

600 lf, assume 1 shrub every 5', = 100 shrubs

50 snowberry shrubs x $38/shrub (matl & labor, Means p.1095)

50 gray dogwood shrubs x $95 shrub (M&L, Means p. 1095)

(50x$38)+(50x$95) = $6,650

Trees and shrubs around dorm (example)(Means p.1095 and 1096)

10 red dogwood x $199(M&L) = $1,990

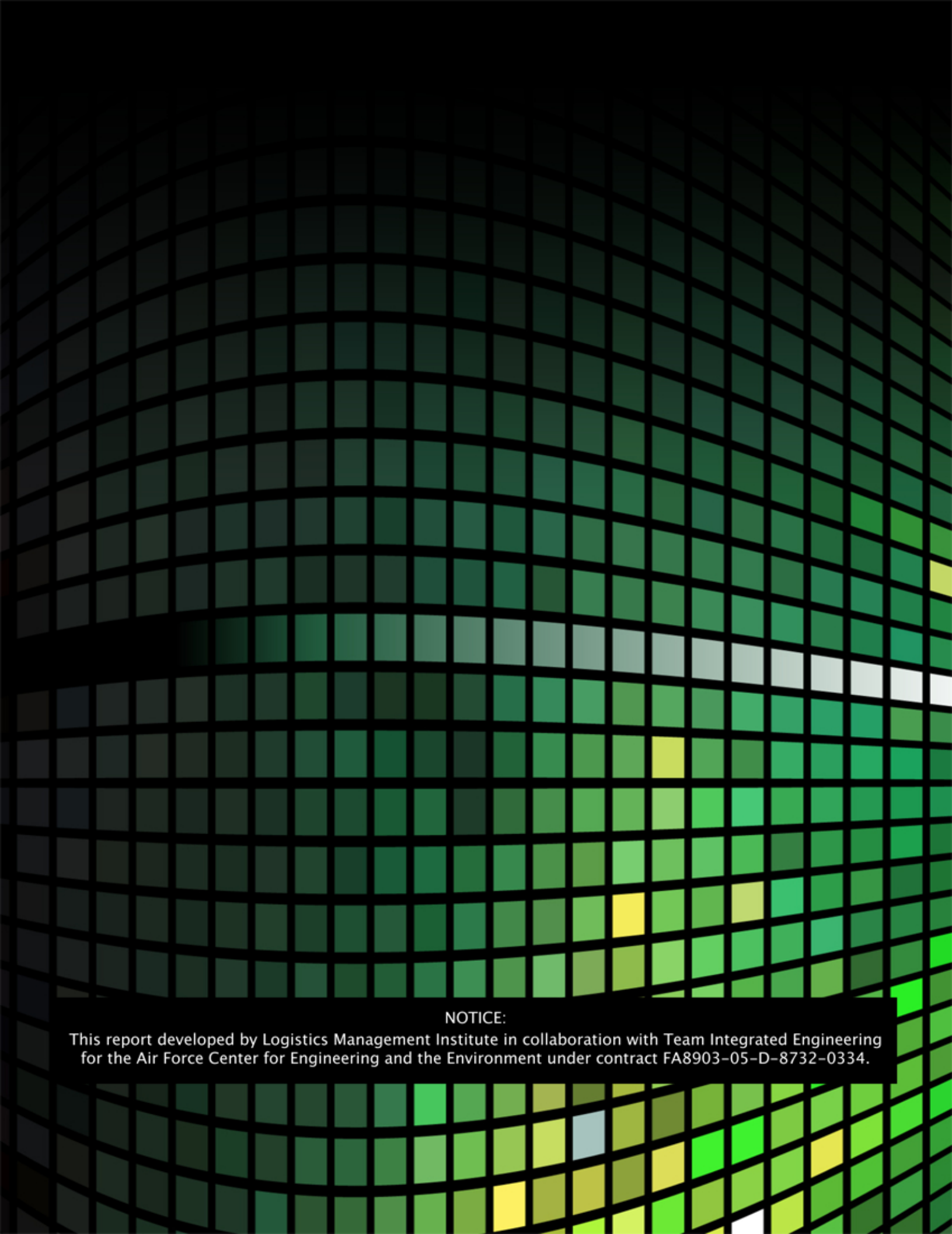
10 birch x $253(M&L) = $2,350

10 green ash x $410 = $4,100

250 gray dogwood x $95 =$23,750

250 snowberry x $38 = $9,500

Total cost of meeting standard: **$53,440**



NOTICE:
This report developed by Logistics Management Institute in collaboration with Team Integrated Engineering for the Air Force Center for Engineering and the Environment under contract FA8903-05-D-8732-0334.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
9.3.3	Refrigerants	CFC-based refrigerants in HVAC systems will not be used. Fire suppression systems shall not contain ozone depleting substances	Mandatory	Similar requirements for **LEED (EA3)** and **HPSB (GP4)**	Requirement met or exceeded.	Per LEED requirements in design specifications.
9.3.4.1	Recyclables	Requires area serving building be dedicated to the collection and storage of materials for recycling	Mandatory	Similar requirements for **LEED (MR Pre1)** and **HPSB (GP4)**	Requirement met or exceeded.	Per LEED requirements in design specifications.
9.3.4.2	Reusable goods	Requires buildings projects with residential space to have an area serving the building to be dedicated to the collection and reuse of materials.	Mandatory	Similar requirements for **HPSB (GP4)**	Requirement likely met; if not can be met at minimal cost.	Designation of this space can be done at little or no cost.
9.3.4.3	Fluorescent and HID Lamps	Requires an area serving the building to be dedicated to the collection and storage of fluorescent and HID lamps and ballasts.	Mandatory	No similar requirements, although recycling area could collect bulbs	Requirement met or exceeded.	Per LEED requirements in design specifications.
Section 9.4: Prescriptive Options						
9.4.1.1	Recycled Content	Recycled materials must make up at least 10% of the cost of the building materials	Prescriptive	Similar points in **LEED (MR 3)**, assumes 2 points	Requirement met or exceeded.	Project will not use salvaged items, but will use materials with recycled content fir at least 10% of all material cost.
9.4.1.2	Regional Materials	At least 15% of building materials, based upon cost, must be made within 500 miles of the project site.	Prescriptive	**LEED (MR5)** goals for regional materials, allow 1 point for 10%, or 2 points for 20%	Requirement met or exceeded.	Planning to attempt this credit for items like asphalt and concrete (want to do thi for no less than 10% of the cost of all project material cost)
9.4.1.3	Biobased Products	Biobased products must make up at least 5% of the cost of the building materials.	Prescriptive	No similar requirement	Requirement likely met; if not can be met at minimal cost.	Per corrected design specification section 09.68.00, para 1.2, page 3, contractor must providedDocumentation indicating type of biobased material in product and biobased content. Indicate relative dollar value of biobased content products to total dollar value of products included in project. Documentation indicating relative dollar value of rapidly renewable materials to total dollar value of products included in project.
9.4.1.3.1	Wood Building Components	Certified wood must make up at least 60% of total wood used in the project.	Prescriptive	Exceeds **LEED (MR7)** goals for certified wood use	Requirement likely met; if not can be met at minimal cost.	Plan to use a minimum of 50% of all wood-based materials from FSC certified sources. Cost for increasing to 60% would be minimal.
Section 9.5: Performance Options						
9.5	Performance Option	Life-Cycle Assessment be performed for a minimum of two building alternatives. Requires report and documentation of critical peer review by third party.	Performance	No similar requirements	N/A	Performance option.
Section 10: Construction and Plans for Operation						
10	Construction and Plans for Operation	Requirements for construction and plans for operation, including commissioning, acceptance testing, M&V, transportation mgt, erosion and sediment control, and IAQ during construction	Mandatory	More extensive planning requirements relative to **LEED (IEQ3)**	Requirement likely met; if not can be met at minimal cost.	Per LEED requirements in design specifications.
10.3.1.1	Bldg Acceptance Testing	Requires acceptance testing by the authority having jurisdiction (AHJ)	Mandatory	No similar requirements, but required by other jurisdictional requirements	Requirement met or exceeded.	Assume acceptance in conjunction with building commissioning.

ASHRAE 189.1	Subject	Summary		Other Regulatory Considerations	Assessment	Comments
10.3.1.2-4	Building Project Commissioning	Requires building commissioning for all buildings over 5000 sq ft, including commissioning plan. Commissioning must include HVAC&R systems, building envelope, irrigation, plumbing, water pumping and mixing, water heating, renewable energy, and measurement devices.	Mandatory	More extensive commissioning requirements relative to **LEED (EA Prereq 1)**	Requirement met or exceeded.	Per corrected design specification section 23.08.00, contractor had to prepare Commissioning Plan . include procedures and methods for documenting and verifying the performance of the HVAC systems so that systems operate in conformity with the design intent. The specification covers all phases of the design-build process and requires a commissioning process that includes the Pre-Design Phase, Design Phase, Construction Phase, Acceptance Phase, and Post-Acceptance Phase. The entire HVAC System shall be commissioned. Documentation required by the specification such as design documentation, the commissioning plan, functional performance test procedures and checklists for equipment and systems, the membership and roles of the commissioning team, the commissioning schedule, and acceptance documentation shall be submitted to the Government.
10.3.2.2	Maintenance Plan	Mandates maintenance plan for mechanical, electrical, plumbing, and fire protection systems in accordance with ASHRAE Standard 180	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Corrected design specification section 01.33.00, para 1.7.5, requires that the contractor submit operation and maintenance instructions and manuals. We assume this would constitute an O&M plan.
10.3.2.3	Service Life Plan	Mandates Service Life Plan for structural, building envelope, and hardscape materials.	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Cost to prepare plan in-house would be minimal.
10.3.2.4	Transportation Management Plan	Mandates a Transportation Management Plan, with varying mandates based upon ownership/leasing arrangements.	Mandatory	No similar requirements	Requirement likely met; if not can be met at minimal cost.	Cost to prepare plan in-house would be minimal.
There are no Prescriptive or Performance Options for Section 10						