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Subject: Calculating Exterior Lighting Energy Reductions using the Performance Rating Method

Applicability: Directive and Guidance

References:

a. American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 90.1-2004 (2007)(2010)
b. ASHRAE Standard 90.1 User's Manual
c. Illuminating Engineering Society of North America (IESNA), The Lighting Handbook, 9th edition

1. The purpose of this ECB is to establish a clear and consistent method to be used for calculating energy savings for exterior lighting applications in accordance with the intent of the Building Performance Rating Method in Appendix G of ASHRAE Standard 90.1 (Standard 90.1). The method used for determining the exterior lighting baseline is different than the method that is explicitly stated for calculating the interior lighting baseline.

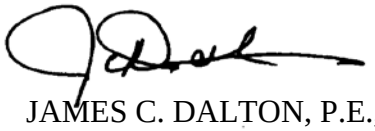
2. Background: Section G3 of Standard 90.1 User's Manual, Calculating Proposed and Baseline Performance, Lighting addresses the Baseline Building Lighting Systems for both the interior and exterior lighting of buildings. This section states that interior lighting power density (LPD) for the baseline building shall be determined using one of two methods: the building area or the space-by-space method. The User's Manual does not indicate that the exterior LPD for the baseline building should be determined by using Table 9.4.5 Lighting Power Densities for Building Exteriors (2004 and 2007 versions), or Table 9.4.3B Individual Lighting Power Allowances for Building Exteriors (2010 version). Instead, the User's Manual indicates that exterior lighting energy credit may be taken for improvements in exterior lighting efficacy or wattage. This implies that both the baseline and proposed exterior lighting should provide the same performance level.

3. In order to establish the baseline exterior energy use, a baseline design must be provided, and that baseline should not be derived from the LPD's of Standard 90.1 Table 9.4.5 or 9.4.3B. The values in these tables are for purposes of determining compliance with the mandatory provisions of Standard 90.1 for exterior lighting calculations, and shall not be used to establish a baseline for exterior lighting calculations, as this may lead to false energy reduction calculations. The baseline exterior lighting power shall be developed from a design that meets the appropriate performance requirements of IESNA's Lighting Handbook (or as otherwise specified in contract documents), with luminaires that conform to the minimum efficiency requirements of Standard 90.1. The proposed design shall meet the same performance requirements for illuminance, and

credit may only be taken for energy reduction achieved through the use of higher efficiency equipment, and/or control measures not otherwise required by Standard 90.1.

4. Further discussion and rationale for the calculation procedure is outlined in Appendix A, and it is derived both from numeric analysis and from the lack of clear direction established by ASHRAE Standard 90.1 informative Appendix G. Appendix B of this ECB details an example case study for exterior lighting calculations.

5. The point of contact for this ECB is Daniel Carpio, CECW-CE, 202-761-4227, Daniel.Carpio@usace.army.mil.



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Appendix A – Analysis and Further Explanation

1. Determination of exterior building lighting power compliance is a two-step process. The first step is to calculate the exterior lighting power allowance (ELPA) by multiplying each area or linear dimension by the appropriate exterior lighting unit power allowance as indicated in Table 9.4.5 (2004 and 2007 editions), or Table 9.4.3B (2007). The second step involves calculation of the exterior connected lighting power (CLP). The building is in compliance if the CLP is less than or equal to the ELPA.
   Note: The ceiling limit, set by the ELPA can be increased by 5% in the 2004 and 2007 versions for the purpose of supplementing the power budget for any of the exterior allowances.

2. While Table 9.4.5 has five distinct tradable, and six non-tradable surface types (or features), there is no sub-division in areas where actual designs would naturally have a high degree of variability such as uncovered parking areas and canopies. Uncovered parking areas are allowed 0.15 w/ft^2 in Table 9.4.5 of 90.1, while IESNA's Lighting Handbook, 9th edition, varies from a minimum horizontal illuminance of 0.2 fc for basic to 0.5 fc for enhanced security (reference Figure 22-21, Recommended Maintained Illumuinance Values for Parking Lots). Canopies have a much higher allowance of 1.25 w/ft^2 in Table 9.4.5, with a relatively high range of recommended illuminance values running from 1 fc to 10 fc (reference Figure 17-20 Service Station or Gas Pump Area Average Illuminance Levels). If a single maximum "ceiling" value is to be given for either uncovered parking or canopies, the value must be high enough such that the highest illuminance indicated by IESNA can be met. In the case where the variability of the specified performance is high, the available savings that can be taken for any design that can be done with a lower value becomes significant because these are not real savings, only reduced performance values that should not translate into energy savings. Combine this condition with the fact that parking areas and canopies (i.e. hardstands) often represent large areas, and thus phantom energy savings become significant as well as erroneous.

3. Some designers have used the exterior lighting power densities in Table 9.4.5 to calculate the baseline energy use, yielding unrealistically high baseline values, and consequently, exaggerated energy savings are claimed. Using table 9.4.5 as a baseline is essentially "gaming"$_1$ the system for most applications in U.S. Army Corps of Engineers projects.

4. The 2010 version of ASHRAE 90.1 subdivides exterior lighting into 5 zones, and provides significantly reduced values for parking lot power allowances. While these values are closer to a realistic baseline, baseline values should still be determined from a compliant design. Additionally, the ASHRAE 90.1-2010 version is not currently referenced as a baseline from which a specific energy reduction value is to be obtained.

5. With all of this in mind, there is still room for debate as to whether or not all exterior lighting applications were really intended to be modeled per Appendix G, as conflicting language is implied or indicated in various chapters and appendices of Standard 90.1. Section G3 of the 2004 Edition of 90.1 User's Manual, Calculation of the Proposed and Baseline Building Performance, Lighting, indicates that lighting power for parking garages and building facades shall be modeled for the

proposed building, but there is no specific mention with regards to other exterior applications. The instruction for the baseline indicates that the lighting power shall be set to the maximum allowed for the corresponding method and category in Section 9.2; however, the only methods mentioned are the building area or space-by-space method, which are associated with interior power.

[1)] Gamesmanship is discussed in chapter 11 Energy Cost Budget Method of the User's Manual.

Appendix B – Case Study Example: BNHQ in Climate Zone 4C

A 60 person office building of 12,000 ft^2 is to be designed for climate zone 4C, and the project includes a 240 x 60 ft (14,400 ft^2) parking lot which is lit by four 175 watt clear BT-28 Metal Halide fixtures. The maintenance factor is 0.80, the average illuminance is 0.66 fc, the minimum illuminance is 0.21 fc and the total parking lot power requirement is 852 watts. Assuming an average of 10 hours operation per day, the annual energy use for the parking lot is 3,103.4 KWhr.

Using the ASHRAE 90.1 baseline target energy budget figures from the Energy and Conservation Design Requirements for SRM Projects (available at https://www.wbdg.org) of 32 kBTU/ ft^2/yr for a BNHQ building results in an equivalent annual energy use for the building of 112,445.1 kWhr (12,000 ft^2 X 32KBtu/ ft^2/yr X 1kWHr/3.415kBtu). Adding in the parking lot lighting energy of 3,103.4 KWhr, the total annual energy use becomes 115,548.5 kWhr. In this case, the exterior lighting application represents just 2.6% of the total.

If the exterior lighting power densities in Table 9.4.5 for Uncovered Parking Areas (0.15 W/ ft^2) were used instead of the actual baseline determined from a design that meets the requirements with fixtures that also meet the minimum efficiencies, then the equivalent total annual energy use of the baseline facility would be 120,312.9 kWhr. This is 4.1% higher than the actual baseline calculated in the previous paragraph. If calculations are done in this manner, the design appears to show a 3.96% reduction in annual energy use without including any energy reduction measures, and this would be nearly 10% of the 40% reduction required in ECB's 2010-14 and 2011-1.

If the project includes a (basic) lit parking lot conforming to IESNA's Lighting Handbook levels, then the baseline exterior lighting energy use should be based upon a design that provides a minimum horizontal illuminance of 0.2 fc, with a uniformity ratio, maximum to minimum of 20:1 and a minimum vertical illuminance of 0.1 fc using luminaires that have a minimum efficacy of 60 lumens per watt. The baseline lighting power density for a compliant design would use as little as 0.06 watt/ ft^2, which is just 40% of the limit set in Table 9.4.5 of ASHRAE 90.1. In this case, any proposed design must meet the same performance requirement, but credit may only be taken for a more efficient design which would likely be based on a combination of higher efficacy fixtures and a lower uniformity ratio.

Alternatively, if the project included an (enhanced security) lit parking lot conforming to IESNA's Lighting Handbook levels, then the baseline exterior lighting energy use should be based upon a design that provides a minimum horizontal illuminance of 0.5 fc, with a uniformity ratio, a maximum to minimum of 15:1 and a minimum vertical illuminance of 0.25 fc using luminaires that have a minimum efficacy of 60 lumens per watt. The baseline lighting power density for a compliant design at this enhanced level would typically use 0.096 watts/ ft^2, which is 63.3% of the limit set in Table 9.4.5 of ASHRAE 90.1.

Assuming the same parking lot in this case is lit by three 400 watt clear ED-28 Metal Halide fixtures, the maintenance factor is 0.80, the average illuminance is 1.45 fc, the minimum illuminance is 0.66

fc and the total parking lot power requirement is 1,386 watts. Using the same average of 10 hours of operation per day, the annual energy use for the parking lot is 5,048.5 kWhr, and the total combined annual energy use would be 117,439.6 kWhr. In this case, the exterior lighting application represents 4.2% of the total, and the minimally compliant design appears to show a 2.3% reduction in energy use without including any real energy reduction measures

The bottom line is that baseline energy use for exterior lighting must be determined from a complete design. The baseline values shall not be taken from ASHRAE Standard 90.1 Table 9.4.5 (2004 and 2007). Using the values of Table 9.4.5 as a baseline would demonstrate false savings by inflating the energy use of the baseline exterior lighting application.