Recommendations for Meeting Energy Efficiency Requirements for New Federal Data Centers

Summary

- New laboratories and data centers must reduce total energy cost by 30% using Appendix G of ASHRAE 90.1-2007 including all approved addenda. Data centers should also use additional baseline requirements specified in this document. Total energy cost includes plug and process loads (i.e. "non-regulated" loads).
- Agencies are encouraged to consider plug and process load efficiency measures to meet the total savings requirement. However, if such measures are used to meet any part of the savings requirement, the project must also demonstrate that the energy cost of "regulated" loads (envelope, HVAC, lighting) is reduced by 30%.

1 Introduction

1.1 Purpose of this document

The purpose of this document is to provide recommendations for meeting the energy efficiency requirements for new federal laboratories and data centers, specifically to comply with Executive Order (E.O.) 13423 and EPACT 2005/10 CFR 433[1]. Federal agencies may consider using these recommendations until the U.S. Department of Energy issues formal guidance on meeting the energy efficiency requirements for laboratories and data centers.

This document does not provide recommendations on technologies and strategies to meet the savings requirements.

[1] The new construction energy efficiency requirements in EPACT 2005 /10 CFR 433 is planned to be revised in 2011 to require 30% less energy cost compared to the base case defined by ASHRAE 90.1, 2007 instead of ASHRAE 90.1, 2004. Since there is no major difference in these editions with respect to related materials covered under Appendix G, this guideline will refer to ASHRAE 90.1, 2007 as the baseline.

1.2 Background

E.O. 13423, sec. 2(f) states that "…new construction and major renovations of agency buildings comply with the Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings set forth in the Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding …"

The High Performance and Sustainable Buildings (HPSB) guidance (available at http://www.wbdg.org/pdfs/hpsb_guidance.pdf) requires that: "For new construction, reduce the energy use by 30 percent compared to the baseline building performance rating per the American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., (ASHRAE)/Illuminating Engineering Society of North America (IESNA) Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential."

2 Recommendations

2.1 Use ASHRAE 90.1-2007 Appendix G and all approved addenda

As required by the HPSB, new laboratories and data centers should be designed to reduce the total energy cost by 30 percent compared to the baseline building performance rating per ASHRAE Standard 90.1-2007. Savings shall be calculated using the Performance Rating Method found in Appendix G of the standard, which specifies that energy savings should be calculated using the formula below:

Percentage improvement = 100 x (baseline building performance – proposed building performance) / baseline building performance

Baseline building performance is the total annual energy cost of the baseline building as specified in the standard.

Proposed building performance is the total annual energy cost of the proposed building as specified in the standard.

As specified in the standard, the total annual energy cost includes all end uses i.e. "regulated loads" (envelope, lighting, HVAC) as well as "non-regulated" loads (plug, process and other loads). Therefore, in the case of data centers total energy cost includes energy use of servers, PDUs, storage, UPS systems, etc.

All addenda to ASHRAE 90.1-2007 that are current and approved at the time of evaluation shall be used. Addenda are available at: http://www.ashrae.org/technology/page/132.

2.2 Additional Requirements for Data Centers

ASHRAE 90.1-2007 and its current approved addenda and their interpretations do not include data center baseline performance requirements in their scope. It is recommended that the following additional specifications be used to calculate the baseline building

performance and proposed building performance for data centers. Some of these specifications are modifications to the requirements in Appendix G (and are indicated as such), while others are new requirements not addressed in Appendix G.

2.2.1 HVAC systems

Baseline HVAC System Type (modifies section G3.1.1)

The baseline HVAC system for a standalone computer rooms with a cooling load greater than or equal to 50ton or a new computer room within a building with a cooling load greater than or equal to 20ton shall be single-zone variable air volume (VAV) with chilled water and no reheat. Otherwise the baseline shall be system 3 or 4 as specified in Table G3.1.1B.

HVAC operation schedule (modifies Table G3.1 part 4)

HVAC fans shall remain on during occupied and unoccupied hours in systems primarily serving computer rooms, for both the baseline design and the proposed design.

Computer room humidification and dehumidification (modifies Table G3.1 part 10)

If the proposed design includes computer room humidification, then the computer room humidification system, schedules, and setpoints in the baseline building design shall be the same as the proposed design.

For systems serving computer rooms, the baseline shall not have reheat for the purpose of dehumidification.

Computer room economizers

The baseline HVAC system for computer rooms with a cooling load greater than or equal to 75,000 Btu/hr shall include an integrated water-side economizer meeting the requirements of Section 6.5.1.2 in the baseline building design. The baseline HVAC system for computer rooms with a cooling load less than 75,000 Btu/hr shall not have an economizer.

Chilled Water Design Supply Temperature (modifies section G3.1.3.8)

Chilled water design supply temperature for the baseline building design shall be modeled at 48°F and return water temperature at 58°F.

Chilled Water Supply Temperature Reset (modifies section G3.1.3.9)

Chilled water supply temperature for the baseline building design shall be reset based on outdoor dry bulb temperature using the following schedule: 48°F at 80°F and above, 56°F at 60°F and below, and ramped linearly between 48°F and 56°F at temperatures between 80°F and 60°F.

Design Supply Air Temperature (SAT)

System design supply air temperature for the baseline building design shall be 60°F.

Design temperature difference between supply and return air

The system design temperature difference between supply and return air at the CRAH/CRAC units for the baseline building design shall be 20°F. The temperature difference for the proposed building design with IT load more than 175kW shall be substantiated through CFD modeling.

Design Relative Humidity (RH)

The system design relative humidity range for the baseline building design shall be based on a maximum of 80% and a minimum of 20%.

Computer room equipment schedules

Computer room equipment schedules shall be modeled as a constant fraction of the peak design load per the following monthly schedule:

Month 1, 5, 9 – 25%

Month 2, 6, 10 – 50%

Month 3, 7, 11 – 75%

Month 4, 8, 12 – 100%

(This randomized schedule is intended to capture part load system performance within a single annual simulation).

2.2.2 IT Electrical Power Chain

Transformer Efficiency

The system requirement for transformer efficiency for the baseline building design shall be based on 98% at 25% load factor, 98.5% at 50% load factor, 99% at 75% load factor and above.

UPS (Uninterruptable Power Distribution) Efficiency

The system requirement for UPS efficiency for the baseline building design shall be based on 85% at 25% load factor, 90% at 50% load factor, 95% at 75% load factor, and 92% at 100% load factor.

PDU (Power Distribution Unit) Efficiency

The system requirement for PDU efficiency for the baseline building design shall be based on 97.6% at 25% load factor, 98.5% at 50% load factor, 99% at 75% load factor and above.

2.3 Plug and process energy efficiency measures

In some laboratories and most data centers, plug and process loads may constitute a majority of the total energy use. Therefore considering efficiency measures in regulated loads (HVAC, lighting, envelope, water heating) alone will result in extremely stringent efficiency requirements i.e. it will require a very high level of efficiency in the regulated loads to meet the 30% reduction in total load. For example, if regulated loads are only 50% of the total energy cost (which is a typical scenario for a data center), a project will need to achieve 60% savings in the regulated loads to meet the minimum 30% savings in total energy cost.

ASHRAE 90.1, 2007 does not specify baseline requirements for plug and process loads. Ordinarily, ASHRAE 90.1, 2007 requires that the plug and process loads be identical in the baseline and the proposed design. However, the standard allows an "exceptional calculation method" to account for savings from energy efficiency measures in non-regulated loads e.g. high efficiency refrigerators and freezers in laboratories or IT virtualization in data centers.

Agencies are strongly encouraged to consider and implement plug and process load efficiency measures to meet the savings requirement. Agencies should clearly document the baseline assumptions for these loads and justify that a) the baseline assumptions for these loads reflect typical practice; b) the efficiency level of these loads in the proposed design are in fact better than standard practice; and c) the measures will provide persistent savings through the building's life cycle. Note that typically the design team does not have responsibility for plug and process load efficiency measures.

While agencies are encouraged to include process load efficiency measures, it is important to ensure that the regulated loads (HVAC, lighting, envelope, water heating) also meet energy efficiency policy objectives. For example, in data centers agencies should not assume that the savings requirement can be achieved solely or even substantially through improvements in IT efficiency (especially because IT efficiency has historically increased at a much higher rate than infrastructure efficiency).

2.4 Regulated load energy savings requirement

If plug and process load efficiency measures are used to meet any part of the savings requirement, the project must also demonstrate that the total energy cost of "regulated" loads (envelope, HVAC, lighting, water heating) is reduced by 30% compared to the baseline regulated loads. The regulated load savings shall be calculated after inclusion of efficiency measures in non-regulated loads as follows:

Regulated load percentage improvement = 100 x (baseline regulated load performance – proposed regulated load performance) / baseline regulated load performance

Baseline regulated load performance is the total annual energy cost of the regulated loads of the baseline building. The baseline regulated load shall be calculated after inclusion of any and all efficiency measures in the non regulated loads.

Proposed regulated load performance is the total annual energy cost of the regulated loads of the proposed building.

Section 2.5 shows an example of savings calculations for a data center design which includes energy efficiency measures in both regulated and non-regulated loads.

2.5 Example 1 of Data Center Savings Calculation

Consider the design of a new data center that includes energy efficiency measures in HVAC and lighting as well as IT. Under ASHRAE 90.1, HVAC and lighting are considered regulated loads while IT is considered a non-regulated load.

Table 1 shows the annual energy costs for the baseline design (A), the baseline design after inclusion of efficiency measures in non-regulated loads (B) and the proposed design (C). For the baseline design, the total annual energy cost is $100,000, divided equally between regulated and non-regulated loads. The inclusion of IT efficiency measures reduces the non-regulated load energy cost to $40,000 and also results in reducing the regulated load energy cost to $40,000 (by virtue of reduced IT load on the infrastructure). Finally, for the proposed design, HVAC and lighting efficiency measures result in $25,000 annual energy cost for regulated loads. In this example, PUE of the center is assumed to be 2.2.

Table 1.Baseline and proposed design energy costs for an example data center.

	A. **Baseline Design** Annual Energy Cost ($)	**B.** **Baseline Design after inclusion of efficiency measures in non-regulated loads** Annual Energy Cost ($)	**C.** **Proposed Design** Annual Energy Cost ($)
Regulated load (HVAC, lighting, envelope, water heating)	$ 50,000	$ 40,000	$ 28,000
Non-regulated load (IT, UPS, other misc.)	$ 50,000	$ 40,000	$ 40,000

Total	**$100,000**	**$80,000**	**$68,000**

Calculation of total energy savings:

- Total baseline energy cost = $100,000
- Total energy cost savings = $100,000 - $68,000 = $32,000
- Total energy cost % savings = $32,000 / $100,000 = 32%

The proposed design meets the 30% minimum for the total energy savings.

Since the proposed design includes savings in non-regulated loads, the proposed design also has to demonstrate a 30% reduction in regulated loads, as required by section 2.4 of this document.

Calculation of regulated loads energy savings:

- Regulated load baseline energy cost = $40,000
- Regulated load energy cost savings = $40,000 - $25,000 = $15,000
- Regulated load energy cost % savings = $12,000 / $40,000 = 30%

The proposed design meets the 30% minimum for the regulated load energy cost savings.

2.6 Example 2 of Data Center Savings Calculation

Table 2 shows the annual energy costs for the baseline design (A), the baseline design after inclusion of efficiency measures in non-regulated loads (B) and the proposed design (C). For the baseline design, the total annual energy cost is $135,000. In this example, PUE of the center is assumed to be 1.5.

Table 2.Baseline and proposed design energy costs for an example data center.

	A. **Baseline Design** Annual Energy Cost ($)	**B.** **Baseline Design after inclusion of efficiency measures in non-regulated loads** Annual Energy Cost ($)	**C.** **Proposed Design** Annual Energy Cost ($)
Regulated load (HVAC, lighting, envelope, water	$ 35,000	$ 28,000	$ 14,000

heating)			
Non-regulated load (IT, UPS, other misc.)	$ 100,000	$ 80,000	$ 80,000
Total	**$135,000**	**$108,000**	**$94,000**

Calculation of total energy savings:

- Total baseline energy cost = $135,000
- Total energy cost savings = $135,000 - $94,000 = $41,000
- Total energy cost % savings = $41,000 / $135,000 = 30%

The proposed design meets the 30% minimum for the total energy savings.

Since the proposed design includes savings in non-regulated loads, the proposed design also has to demonstrate a 30% reduction in regulated loads, as required by section 2.4 of this document.

Calculation of regulated loads energy savings:

- Regulated load baseline energy cost = $28,000
- Regulated load energy cost savings = $28,000 - $14,000 = $14,000
- Regulated load energy cost % savings = $14,000 / $28,000 = 50%

The proposed design meets the 30% minimum for the regulated load energy cost savings.

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