



**BSR/ASHRAE Addendum *h*  
to ANSI/ASHRAE Standard 90.4-2019**

**Public Review Draft**

# **Proposed Addendum *h* to Standard 90.4-2019, *Energy Standard for Data Centers***

**First Public Review (July, 2022)  
(Draft Shows Proposed Changes to Current Standard)**

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## Foreword

UPSs have become more efficient since the 2016 publication of this standard and their efficiency curves have become flatter over the full load range. The Committee believes it is the responsibility of any Standard to encourage the use of equipment meeting the improved performance standards available from manufacturers today. This has resulted in increased efficiency requirements for the UPS segment of the ELC.

Transformers have also become more efficient as a result of the 2016 publication of Transformer Efficiency Standards by the US Department of Energy (DOE). These standards require compliance only at 35% loading, which is below the design levels of most data center Power Distribution Units (PDUs). PDU manufacturers have recognized this and provide transformers in their equipment that not only meet or exceed the DOE 35% load efficiency minimums, but are also more efficient than standard building transformers at higher load levels. The Committee believes it is our responsibility to encourage the use of equipment that not only meets legal mandates, but also performs well under relevant conditions beyond those that federal authorities prescribe. We have, therefore, adjusted the minimum efficiency (maximum loss) requirements for the ITE Distribution Segment of the ELC to correspond to the loading levels more common to Data Centers (80% for non-redundant, and 40% - 45% for redundant systems). The result is increased ITE Distribution Segment efficiency requirements at load levels above and below the Federally prescribed 35% level as well as adherence to the maximum loss values prescribed in Electrical Codes for Feeders and Branch Circuit Conductors.

The MLC has always required calculation of mechanical loads at 25%, 50%, 75%, and 100% of the ITE Design Load. The ELC required calculations at only 25%, 50%, and 100% which related to Fully Redundant, Non-redundant, or minimally redundant UPS designs. In order to parallel the MLC, the ELC has now been adjusted to require compliance at all four load levels. This also eliminates the need for distinctions among UPS redundancy configurations. The ELC Maximum Loss (Minimum Efficiency) tables have been revised to reflect these changes.

Section 8.2.2 has been removed because of more stringent electrical distribution efficiency requirements in data centers. As a result, the alternative method is no longer available in 90.4.

Lastly, the Incoming Service Segment of the ELC has been eliminated from the ELC calculation. A thorough examination of multiple incoming service designs has revealed that too many combinations of utility transformers (utility or privately owned), voltages, and feeder designs are now being used in data centers for tables to realistically cover all possibilities. Further, the two major elements of the Incoming Service Segment (transformers and feeders) are all covered by Federal transformer regulations and Electrical Code dictums. Therefore, the Standard now simply

requires adherence to those standards and regulations and restricts the ELC calculation to the UPS and Distribution segments where the Standard can realistically require designs meeting efficiency levels that can be reasonably achieved with technologies available today.

*[Note to Reviewers: This addendum makes proposed changes to the standard. These changes are indicated in the text by underlining (for additions) and ~~striketrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.]*

## Addendum h to Standard 90.4-2019

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*Revise Electrical Loss Component (ELC) to reflect current UPS types and efficiencies as well as DOE transformer efficiency standards, and update definitions to match.*

### 3.2 Definitions

**Design electrical loss component (design ELC):** the *design electrical loss component* for the data center or data center addition shall be the combined losses (or the losses calculated from efficiencies) of ~~three~~ two segments of the electrical chain: ~~incoming electrical service segment~~, UPS segment and ITE distribution segment. The design ELC shall be calculated using the ~~worst case~~ highest loss (lowest efficiency) parts of each segment of the power chain in order to demonstrate a minimum level of electrically efficient design. The design ELC does not, and is not intended to, integrate all electrical losses in the facility.

**Incoming electrical service segment:** the *incoming electrical service segment* of the ~~design ELC~~ shall include all elements of the electrical power chain ~~delivering power~~ prior to the UPS segment, beginning with the load side of the *incoming electrical service point* supplying the building, continuing through all other intervening transformers, wiring, and switchgear, and ending at the *manufacturer-provided input terminals* of the UPS or its equivalent location in the circuit. ~~Although the mechanical equipment is normally powered from the same incoming electrical service point, its path and losses are not part of the ELC and, therefore, not part of the incoming electrical service segment calculation.~~

**ITE distribution segment:** the segment of the *design ELC* that includes all elements of the power chain, beginning at the *manufacturer-provided output-load terminals* of the UPS segment, extending through all transformers, wiring, and switchgear; and continuing to and including the receptacles to which ITE or power distribution strips for connection of multipole pieces of ITE to a circuit are intended to be connected. The *ITE distribution segment* shall not include the actual ITE, its power cords, or any accessory part of the ITE. In cases where power is to be hardwired into self-contained, *manufacturer configured cabinets*, the calculation path shall terminate at the power input terminals provided by the manufacture within that equipment. The *ITE distribution segment* used to calculate the *design ELC* shall be the highest loss (lowest efficiency) path. This is normally the longest path that also contains the largest numbers of loss-producing devices such as transformers, ~~switchgear and/or panelboards~~.

**uninterruptible power supply (UPS):** (also referred to as Uninterruptible Power System), a system primarily intended to continue delivering power to the critical load after a utility power interruption. It may also serve to deliver stable power ~~to the critical load~~ when anomalies occur in the incoming power source, which may be the utility or an alternate power source such as a generator. UPS systems are defined by three internationally recognized classifications:

**VFD:** Voltage and Frequency Dependent systems, also known as “Off-Line” or “Standby” UPS systems which are off-line until a power interruption occurs and then rapidly switch into the circuit to maintain power to the critical load.

**VI:** Voltage Independent systems, also known as “Line Interactive” which are similar to VFD systems in that they rapidly switch backup power to the critical load when a power interruption occurs. However, a VI UPS continually passes incoming power to the output while also using the stored energy source to filter incoming power, suppress voltage spikes and provide a degree of voltage regulation.

**VFI:** Voltage and Frequency Independent systems, also known as “Double Conversion,” “Dual Conversion” or “Full Time” UPS which use incoming utility or generator power solely to drive an electronic or mechanical mechanism that re-generates power and delivers it to the critical load without the need to switch anything into or out of the circuit. This results in total isolation of the critical load from incoming power and no break of any duration in the delivered power.

The majority of modern UPS systems are of two fundamental types. Two physical types of UPS systems are in general usage:

(a) “static,” in which incoming alternating current (AC) power is rectified to direct current (DC) and then inverted back to AC, with batteries in the DC portion that assume the load when incoming power fails or anomalies occur, and Battery UPS, in which incoming AC power maintains battery charge and an AC to DC converter, known as an “inverter” delivers power to the critical load on either a continuous or non-continuous basis.

(b) “rotary,” Rotary UPS, in which incoming AC power drives a propulsion unit that turns a generating device, with a heavy flywheel storing kinetic energy that continues to turn the generating portion when incoming power fails or anomalies occur. Batteries are also sometimes used to supplement the kinetic energy storage to extend “ride-through” time. Rotary UPS systems may also include a driven engine for emergency backup (commonly referred to as a Diesel Rotary UPS or “DRUPS”, regardless of fuel type), which is decoupled from the rotary UPS components during normal operation and is not included in efficiency calculations.

Either type of UPS can be made up of one or more modules running in parallel to add capacity, redundancy, or both. DC UPS systems which eliminate the inverter and deliver DC power to the ITE are also used.

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~~**8.2.2 Electrical Distribution systems Alternative for Section 8.4.** Electrical distribution systems shall comply either~~

**8.4.1 Electrical Distribution Systems for Mechanical Loads.** The electrical distribution systems serving mechanical loads shall be designed with pathway transformers complying with DOE (US Department of Energy) 2016 Efficiency Levels or comparative international standards, and conductor losses not exceeding 2% 3%. However, these losses shall not be incorporated into the design ELC calculations set forth in Section 8 of this standard.

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**8.4.1.4 Incoming Electrical Service Segment.** A segment loss value shall be calculated for the incoming electrical service segment of the design ELC. This value shall be based on all equipment efficiencies and resulting losses in this segment at the design load for all downstream equipment served. The Incoming Electrical Service Segment is not part of the ELC calculation. However, all components in the incoming power chain shall meet or exceed published US Department of Energy (DOE) minimum efficiencies for transformers or the equivalent international standards, and US National Electrical Code (NEC) maximum losses for service conductors or the equivalent International Electrical Codes.

**Exception to 8.4.1.4:** Emergency or stand-by power systems are not considered a part of the *incoming electrical service segment*, with the exception of individual elements such as associated transfer switches, transformers, or other devices that are also included between the *design ELC demarcation* and the UPS. DRUPS systems shall be calculated as part of the *UPS Segment* with the engine element decoupled.

**8.4.1.5 UPS Segment Efficiency.** Efficiency and resulting loss through the UPS segment of the ELC shall be calculated at both full and partial loads, ~~depending on configuration,~~ as follows:

- a. ~~For N, N+1, or N+n UPS configurations,~~ losses shall be based on the *manufacturer's stated efficiencies* at 100%, 75%, 50% and 25% of the *UPS operational design load*.
- b. For 2N, 2N+1, 2(N+1) or other dual-fed UPS configurations, ~~the systems are each intended to normally operate at no more than half capacity. Therefore, the UPS losses shall be based on the manufacturer's stated efficiencies at 50% and 25% of the UPS operational design load. Where UPS systems are identical, only one of the systems shall be used in the calculation. Where UPS systems are not identical, both systems shall be calculated, and the system with the lowest efficiency shall be used to compute the UPS segment of the design ELC.~~
- c. Where a UPS has more than one mode of operation (e.g., normal and UPS economy modes), the mode used in these calculations shall be the same as the mode used as the Basis of Design and shall be so designated on the approved *construction documents*.
- d. Where nonrated UPS systems are used, the *efficiencies* and *losses* shall be as published or otherwise provided in writing by the *manufacturer*.

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**8.4.1.7 ~~Combined UPS and Pathway Loss Calculations~~ ELC Calculation.** The *design ELC* shall be calculated as the result of the calculated ~~*incoming electrical service segment loss*~~, the *UPS segment loss*, and the *ITE distribution segment losses* shall be separately reported at each of four (4) load levels: 100%, 75%, 50% and 25% of the ITE Design Load. The electrical system shall meet or exceed the ELC minimum requirements at each of the ITE Design Load levels.

**Informative Note:** If the *ELC* cannot be met at one or more load levels, see Chapter 11 "*Tradeoff Method*" for directions on meeting the Standard requirements by designing a more efficient mechanical system.

**Informative Note:** See Informative Appendix C, Section C1 "*Examples – Design ELC Calculations,*" for method of combining *ELC* segment values.

**8.4.1.8 Alternate Designs.** In the event that a UPS is not used in the design, the incoming and distribution segments shall meet at the point(s) where a UPS would logically be inserted under normal operating conditions. Where another power conditioning device, such as a rectifier, voltage regulator, or harmonic neutralizing *transformer*, is used either in place of a the UPS or in combination with the UPS, or where a Diesel Rotary UPS (DRUPS) *system* is used, the *efficiency* and *loss* for that device shall be included in the UPS segment *efficiency* and *loss* calculation as if it is taking the place of, or is part of, the UPS used in the efficiency calculation in the same manner as that defined for a UPS. In the case of a DRUPS *system*, this calculation shall be performed with the engine decoupled. DRUPS operation under engine-generator power shall be considered a short-term emergency condition and is excluded from the requirements of the Standard in the same manner as are other on-site emergency of standby generators (See Exception under 8.4.1.4). Where no power conditioning device is utilized, the system shall meet the Distribution Component requirements of the ELC.

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**Table 8.5 Maximum Design Electrical Loss Component (Design ELC) and ELC Segments Systems (IT Design Load <100 kW)<sup>a</sup>**

<i>UPS Redundancy Configuration</i>	<b>Single-Feed UPS (N, N+1, etc.) or No UPS<sup>b</sup> Active Dual-Feed UPS (2N, 2N+1, etc.)<sup>e</sup> (See Informative Note “a”)</b>			
<b>Calculation Percentage</b>	100% of IT design load segment ELC	50% <del>75%</del> of IT design load segment ELC	50% of IT design load segment ELC	25% of IT design load segment ELC
<b>Segments of ELC and Overall ELC</b>	<i>Loss / efficiency</i>	<i>Loss / efficiency</i>	<i>Loss / efficiency</i>	<i>Loss / efficiency</i>
<del><i>Incoming Electrical Service Segment</i></del>	15.0% / 85.0%	11.0% / 89.0%	11.0% / 89.0%	10.0% / 90.0%
<i>UPS Segment</i>	8.0% / 92.0%	10.0% / 90.0% 8.5% / 91.5%	10.0% / 90.0% 8.5% / 91.5%	13.5% / 86.5% 9.5% / 90.5%
<i>ITE Distribution Segment</i>	6.0% / 94.0% 6.7% / 93.3%	4.0% / 96.0% 5.0% / 95.0%	4.0% / 96.0% 4.5% / 95.5%	3.0% / 97.0% 2.9% / 97.1%
<b>Electrical Loss / Efficiency Total</b>	26.5% / 73.5% 14.2% / 85.8%	23.1% / 76.9% 13.1% / 86.9%	23.1% / 76.9% 12.6% / 87.4%	24.5% / 75.5% 12.1% / 87.9%
<b>ELC</b>	0.265 0.142	0.231 0.131	0.231 0.126	0.245 0.121

- a. *Informative Note:* Example calculations are shown in Informative Appendix C.
- b. *Informative Note:* These columns apply to electrical configurations resulting in a single output feed from the UPS irrespective of the number of UPS modules that may be paralleled prior to the output feed or the number of branches or subfeeders into which that output feeder may be divided.
- c. *Informative Note:* These columns apply to electrical configurations made up of two distinct and electrically separated UPS systems resulting in two distinct and electrically separate output feeds, either of which is capable of independently supporting the total design load. Systems that meet these criteria may be made up of any number of UPS modules that are paralleled prior to each output feed. Crossties and/or transfer switches downstream of the independent feeds shall not continually tie the two output sections together.
- d.

**Table 8.6 Maximum Design Electrical Loss Component (Design ELC) and ELC Segments Systems (IT Design Load ≥ 100 kW)<sup>a</sup>**

<i>UPS Redundancy Configuration</i>	<b>Single-Feed UPS (N, N+1, etc.) or No UPS<sup>b</sup> Active Dual-Feed UPS (2N, 2N+1, etc.)<sup>e</sup> (See Informative Note “a”)</b>			
<b>Calculation Percentage</b>	100% of IT design load segment ELC	50% <del>75%</del> of IT design load segment ELC	50% of IT design load segment ELC	25% of IT design load segment ELC
<b>Segments of ELC and Overall ELC</b>	<i>Loss / efficiency</i>	<i>Loss / efficiency</i>	<i>Loss / efficiency</i>	<i>Loss / efficiency</i>
<del><i>Incoming Electrical Service Segment</i></del>	15.0% / 85.0%	11.0% / 89.0%	11.0% / 89.0%	10.0% / 90.0%
<i>UPS Segment</i>	6.5% / 93.5% 5.5% / 94.5%	8.0% / 92.0% 5.5% / 94.5%	8.0% / 92.0% 6.0% / 94.0%	11.0% / 89.0% 7.0% / 93.0%
<i>ITE Distribution System</i>	5.0% / 95.0% 5.8% / 94.2%	4.0% / 96.0% 4.6% / 95.4%	4.0% / 96.0% 3.6% / 96.4%	3.0% / 97.0% 2.5% / 97.5%
<b>Electrical Loss / Efficiency Total</b>	24.5% / 75.5% 11.0% / 89.0%	18.9% / 81.1% 9.8% / 90.2%	18.9% / 81.1% 9.4% / 90.6%	22.3% / 77.7% 9.3% / 90.7%
<b>ELC</b>	0.245 0.110	0.189 0.098	0.189 0.094	0.223 0.093

- a. *Informative Note:* Example calculations are shown in Informative Appendix C.
- b. *Informative Note:* These columns apply to electrical configurations resulting in a single output feed from the UPS, irrespective of the number of UPS modules that may be paralleled prior to the output feed, or the number of branches or subfeeders into which that output feeder may be divided.
- c. *Informative Note:* These columns apply to electrical configurations made up of two distinct and electrically separated UPS systems resulting in two distinct and electrically separate output feeds, either of which is capable of independently supporting the total design load. Systems that meet these criteria may be made up of any number of UPS modules that are paralleled prior to each output feed. Crossties and/or transfer switches downstream of the independent feeds shall not continually tie the two output sections together.