BSR/ASHRAE Addendum d
to ANSI/ASHRAE Standard 90.4-2022

Public Review Draft

Proposed Addendum d to Standard 90.4-2022, *Energy Standard for Data Centers*

First Public Review (February 2025)
(Draft Shows Proposed Changes to Current Standard)

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Foreword

The current ASHRAE 90.4 MLCs, primarily developed in 2018, are based on air-cooled racks served by CHW CRAH units, served by an air-cooled chiller system. The CRAH units do not include air-economizers and the chiller plant is not water-cooled and does not include a waterside economizer. It is not a particularly efficient data center today, or when it was adopted, but it was a significant improvement over the previous MLCs and it was not particularly controversial, as most new data centers have little trouble meeting these MLCs.

Much has happened since the 90.4 MLCs were last updated in 2018, most notably the explosion of AI data centers with high density liquid-cooled racks. These liquid-cooled racks can be cooled at higher fluid temperatures than typical air-cooled racks, which presents the opportunity to improve the 90.4 MLCs. Meanwhile strides have also been made to improve the efficiency of mechanical systems serving air-cooled racks.

One option is to have separate MLCs for liquid-cooled vs. air-cooled racks, but this is problematic for a couple of reasons. Most data centers have a combination of air-cooled and liquid-cooled racks. In fact, most liquid-cooled racks have a combination of air-cooled and liquid-cooled server components. Data centers are also designed to have the flexibility to serve different fractions of air-cooled vs. liquid-cooled IT.

This addendum was developed by modeling several typical data center systems including these baselines:

a. An entirely air-cooled rack data center – based on the 2018 model with standard air-cooled chillers, PG25, and air economizers
b. An entirely liquid-cooled rack data center – including water-cooled chillers, cooling towers, water economizers, CDUs, PG25, constant TCS flow, and 95°F (35°C) TCS supply temperature.

The proposed MLCs in each climate zone are at about 100% higher (worse) than the higher of the two baselines. This shows that any combination of air-cooling and liquid-cooling should be able to achieve the proposed MLC. We have detailed analyses showing that the following system designs also meet these MLCs:

c. Baseline a with air-cooled chillers and dry coolers instead of air economizers.
d. Baseline b with the TCS supply temperature set to 75°F (24°C) and the water+sewer costs doubled compared to national average utility costs.
e. Baseline b with dry coolers instead of towers (zero water consumption) and 85°F (29°C) TCS supply temperature.
f. Baseline b with dry coolers instead of towers and variable TCS flow and 20% oversized dry coolers and 75°F (24°C) TCS supply temperature.
g. Baseline b with dry coolers instead of towers and variable TCS flow and a lower CDU heat exchanger approach (5°F (2.7°C) instead of 9°F (5°C)) and 75°F (24°C) TCS supply temperature.
h. Baseline b with air-cooled chillers and dry coolers and 75°F (24°C) TCS supply temperature.

Other systems that are expected to meet the proposed MLCs include:

- Air-cooled racks with direct evaporative cooling
- Liquid-cooled racks with immersion cooling
- Several proprietary systems including ones using liquid cooling refrigerant and phase change

Lastly, this section makes changes to both the previous standard and published Addendum g to Standard 90.4-2022.

[Note to Reviewers: This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and strikethrough (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current 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 d to 90.4-2022

Modify the definitions in Section 3 as follows:

3.2 Definitions

Liquid-cooled ITE: *ITE* that is cooled by a fluid other than air and that does not use server fans to flow air through the server. Common liquid cooling fluids include water, glycol, and refrigerant. Individual servers can be partially liquid-cooled and partially air-cooled, with server fans serving the air-cooled devices.

Air-cooled ITE: *ITE* that is cooled by the flow of air through the *ITE* equipment. Onboard server fans are typically used to move air through servers.

Modify the definitions in Section 3 as follows:

6.5 **Maximum Annualized Mechanical Load Component (Annualized MLC).** Annualized MLC shall be calculated using Equation 6.5. The resulting value shall be less than or equal to the value in Table 6.5, "Maximum *Annualized Mechanical Load Component (*Maximum *Annualized MLC)*".

$$\underline{\text{Annualized MLC}} = \frac{\sum \underline{\text{MechE for 25\%, 50\%, 75\%, 100\% ITE Design}} + \text{MechW}_N - \text{HeatRec}_N}{\underline{2.5 \text{ x } 8760 \text{ hours x ITE design power}}} + \sum N = 25{,}50{,}75{,}100(\text{ServerFanAdjustment}_N)$$

Where

MechE =	(*process cooling segment* + *process ventilation segment* + *process heating segment*); all in kWh, determined annually and according to the design, at that percentage of *ITE design.* To show effect of heat recovery on these systems, see 6.5.2(d). To show the effect of on-site renewables on MLC, see 11.2.
MechW_N (kWh) =	total annual makeup water cost and sewer cost of all mechanical *equipment* (e.g. cooling towers, evaporative coolers, humidifiers, water filtration or treatment *equipment*) at a constant *ITE* load of *N*% of the design *ITE* load. Sewer costs include blowdown from cooling towers, water filtration equipment, etc. This includes mechanical *equipment* serving *data center* electrical *equipment* (e.g., *UPS systems* and *transformers*). Water and sewer costs of

shared *systems* that serve both *data center spaces* and non-*data-center spaces* shall be prorated on an hourly capacity-weighted basis. Water and sewer costs shall be converted from utility billing units to kWh using the actual water, sewer and electricity utility rates for the site or using the following typical utility rates:

Makeup water: $3.86 / 1000 gallons ($1.02 / 1000 liters)

Sewer: $6.95 / 1000 gallons ($1.84 / 1000 liters)

Electricity: $0.11 / kWh

$\text{ServerFanAdjustment}_N$ = - 0.02 for that portion of the ITE load that is *liquid-cooled.* For the portion of ITE load that is *air-cooled* the adjustment = 0.00 if the supply air drybulb temperature (SAT) entering the ITE <= 77F. If SAT > 77F then the *air-cooled* ServerFanAdjustment = + 0.0014 * (SAT – 77F).

Informative Note: For example, if 80% of the ITE load is liquid-cooled and 20% is air-cooled and the SAT in a given load/weather bin is 90F, then the ServerFanAdjustment for that bin = - 0.8 * 0.02 + 0.2 * 0.0014 * (90-77) = -0.0124. [Offer same calculation in Celsius]

Table 6.5 Maximum Annualized Mechanical Load Component (Annualized MLC)

	New *data centers* and *additions* with Design ITE power > 1000~~300~~ kW				*Data centers* with Design ITE power <= 1000~~300~~ kW and *alterations* to *data centers* constructed before 1/1/2026			
Climate zones as listed in ASHRAE Std. 169	*Process heating segment*	*Process ventilation segment*	*Process cooling segment*	Maximum *annualized MLC*	*Process heating segment*	*Process ventilation segment*	*Process cooling segment*	Maximum *annualized MLC*
0A	0	0.01	~~0.28~~0.147	~~0.29~~0.157	0.01	0.01	~~0.35~~0.28	~~0.37~~0.30
0B	0	0.01	~~0.31~~0.150	~~0.32~~0.160	0.01	0.01	~~0.39~~0.31	~~0.41~~0.33
1A	0	0.01	~~0.29~~0.147	~~0.30~~0.157	0.01	0.01	~~0.35~~0.29	~~0.37~~0.31
1B	0	0.01	~~0.30~~0.150	~~0.31~~0.160	0.01	0.01	~~0.37~~0.30	~~0.39~~0.32
2A	0.01	0.01	~~0.26~~0.136	~~0.27~~0.146	0.01	0.01	~~0.33~~0.26	~~0.35~~0.28
3A	0.01	0	~~0.23~~0.117	~~0.24~~0.127	0.01	0.01	~~0.31~~0.23	~~0.33~~0.25
4A	0.01	0	~~0.20~~0.112	~~0.21~~0.122	0.02	0.01	~~0.30~~0.20	~~0.33~~0.23
5A	0.01	0	~~0.18~~0.107	~~0.19~~0.117	0.02	0.02	~~0.29~~0.18	~~0.34~~0.22
6A	0.01	0	~~0.18~~0.111	~~0.19~~0.121	0.02	0.02	~~0.27~~0.18	~~0.31~~0.22
2B	0.01	0	~~0.19~~0.170	~~0.20~~0.180	0.01	0.01	~~0.31~~0.19	~~0.33~~0.21
3B	0.01	0	~~0.19~~0.163	~~0.20~~0.173	0.01	0	~~0.30~~0.19	~~0.33~~0.20
4B	0.01	0	~~0.16~~0.122	~~0.17~~0.132	0.01	0.01	~~0.27~~0.16	~~0.29~~0.18
5B	0.01	0	~~0.16~~0.122	~~0.17~~0.132	0.02	0.02	~~0.26~~0.16	~~0.30~~0.20
6B	0.01	0	~~0.16~~0.103	~~0.17~~0.113	0.02	0.02	~~0.27~~0.16	~~0.31~~0.20
3C	0.01	0	~~0.16~~0.100	~~0.17~~0.110	0.01	0	~~0.26~~0.16	~~0.27~~0.17
4C	0.01	0	~~0.16~~0.100	~~0.17~~0.110	0.01	0	~~0.26~~0.16	~~0.27~~0.17
5C	0.01	0	~~0.16~~0.100	~~0.17~~0.110	0.01	0	~~0.26~~0.16	~~0.29~~0.17
7	0.01	0	~~0.16~~0.111	~~0.17~~0.110	0.03	0.03	~~0.26~~0.16	~~0.31~~0.22
8	0.01	0.01	~~0.14~~0.130	~~0.15~~0.150	0.03	0.04	~~0.25~~0.14	~~0.32~~0.21

6.5.1 **Annualized MLC for Partial Renovations**. For a facility being renovated where only one or two of the *annualized MLC* segments is being modified, compliance requirements in Table 6.5 apply only to the segments being modified. Trade-offs are allowed among *process cooling*, *process heating*, and *process ventilation segment* values to meet the aggregate requirement of only those *annualized MLC* segments involved in the project's scope.

6.5.2 Annualized MLC Calculation Compliance Requirements:

a. Weather data shall be taken exclusively from the NSRB Typical Meteorological Year Version (TMY3) file for a site with location and altitude nearest the data center site.

Informative Note*:* Some *bins* will contain more annual hours than other *bins*, and so are proportionally factored into the model's annual results.

b. Weather data shall be divided into calculation *bins* with a maximum 2°F (1°C) increment. *Systems* using an evaporation process will use wet-bulb with a mean coincident dry-bulb temperature for creating the *bins*. *Systems* with a non-evaporative process shall use dry-bulb temperature with mean coincident ~~wet-bulb~~ moisture ratio for creating the *bins*. Full hourly calculations (using 8760 *bins*, each of one hour) are also acceptable to use.

c. The *systems' energy* calculation may consider operation of *economizer* capacity in the design and available *redundant equipment* at the 100% *ITE* load condition and separately at the *ITE* part-load condition if calculated using partially loaded *equipment efficiencies*.

d. For *data center* designs where heat recovery measures are being provided, Equation 6.5 shall be calculated for compliance with each of the design's heat recovery measures either "active" or "inactive" (at the discretion of the *design professional*.)

Informative Note: This Standard leaves all energy or emission savings credits available for the benefit of the data center's host or neighboring projects, without the possibility of "double counting" such energy or emission credits. Data centers can be reliable and economical all-electric heat sources for nearby buildings and industrial processes. Ideally, potential neighbors and landlords will discover that data centers are an economical way to switch from fossil fuels to a grid electric source for their needed heat. Because the success of heat recovery requires proximity between data center and neighboring buildings, any lower efficiency ITE cooling modes associated with heat export may be considered "inactive" in the *data center's annualized MLC* compliance calculation. Any on-site heat recovery measures may be shown as "active" to lower the *annualized MLC* used for compliance.

e. ~~If the *data center* uses *mechanical cooling*, the calculated *rack* inlet temperature and *dew point* shall be within *Thermal Guidelines for Data Processing Environments* recommended thermal envelope for more than 8460 of the hours per year. If the *data center* does not use *mechanical cooling*, this requirement does not apply.~~ <u>The default cycles of concentration (CoC) for calculating evaporation blowdown shall be 3.5. A custom CoC shall be used if an analysis of the site water chemistry and treatment system is performed.</u>

f. Any *UPS* and *transformer* cooling *system's* input *energy*–shall also be included in this term, evaluated at their corresponding part-load *efficiencies.*

g. The specific electrical losses used to calculate a project's *annualized MLC* shall be greater than or equal to the same electrical *losses* used to calculate the project's *design ELC* used for compliance.

h. Reviewable *annualized MLC* calculations shall separately report results for 100%, 75%, 50%, and 25% *ITE* capacity in the calculations.