# UFAD Data Center Analysis

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# Project Description:

Throughout the semester, our class has spent time learning and researching datacenters in order to understand cooling and how it may have issues with larger and increasingly common AI datacenters. For this specific project, we were given resources from an underfloor air distribution data center (UFAD) and tasked with using what we have learned in order to classify the data center, as well as show our functions and reasoning for classifying the data center, and proposing ways to enhance the cooling.

## Project steps:

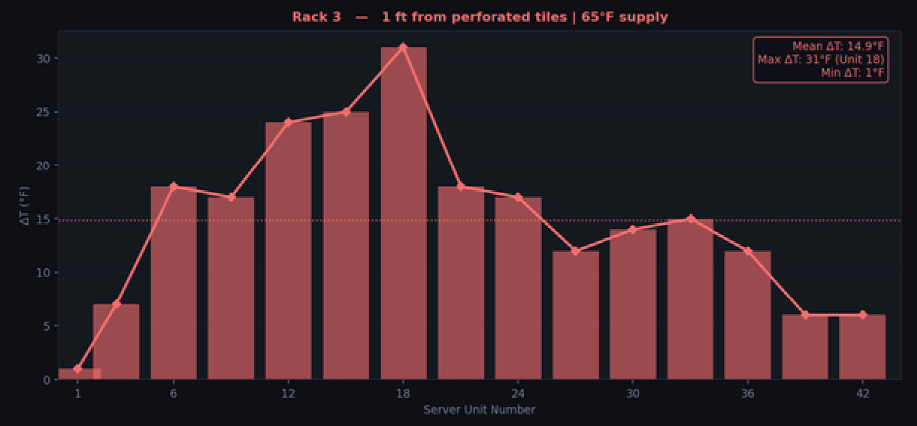
- **Analyze the temperature drop across each server and rack, and plot the temperature drop as a function of server location for each rack.**
- **Show temperature as a function throughout the racks.**
- **Calculate the heat load based on rack 6's case study data.**
- **And finally classify the data center based on ASHRAE Standards.**

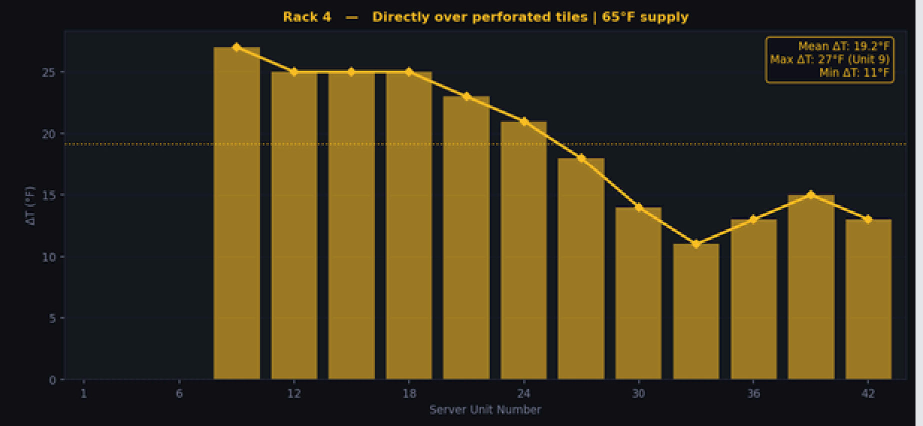
# Functions/Plots for: ΔT / temperature differences among the racks

**Analyze the temperature drop across each server and rack; and plot the temperature drop as a function of server location for each rack.**

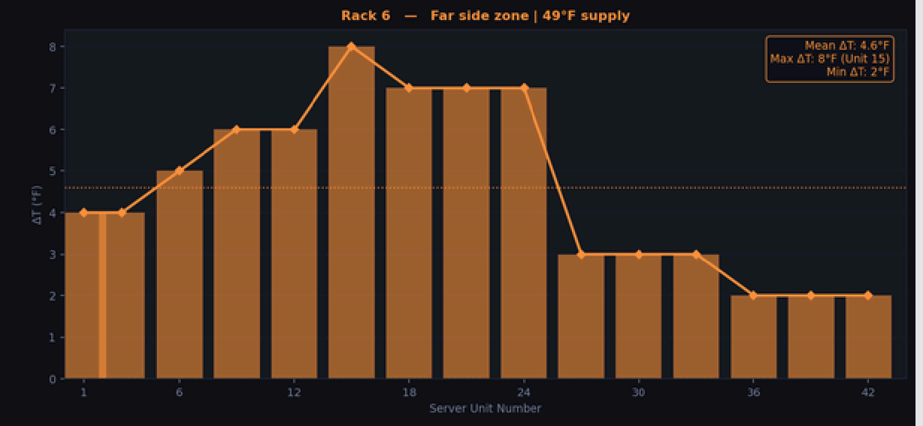


Rack 4 uniform decrease

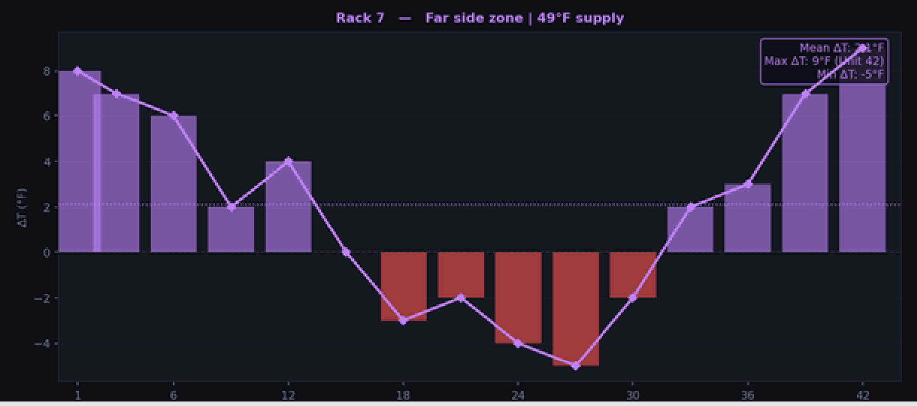


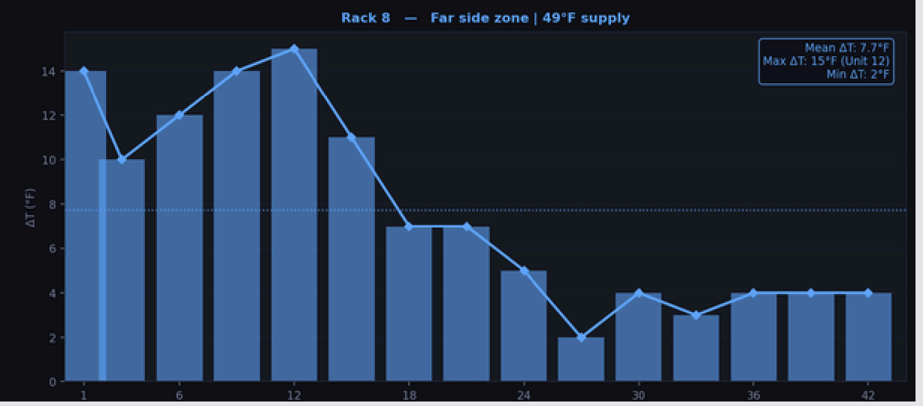








Rack 7 going negative




| Rack 7 |
|---|
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| Rack 7 |
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## Breakdown (All temperature Farenheit)

**Group 1**: rack 1-4 supply air at 65 degrees

**Rack 1**: Temperature difference peaks in the middle of the rack, with a max of 19 and an average of 10.4

**Rack 2**: Much more consistent with low variance, a max temperature difference of 14, and an average of 11.4

**Rack 3**: Had the highest spread, which might imply thermal issues, with a max temperature difference of 31 (unit 18) and an average of 14.9

**Rack 4**: Was the hottest rack overall, with a large average temperature difference of 19.2 and a highest difference of 27

**2nd group** 5-8, 49-degree supply air:

**Rack 5**: Similar spread to rack 1, with a max temperature difference of 22 and an average of 10.7

**Rack 6**: One of the most efficient and uniform racks, with a max difference of only 8 degrees and an average of 4.6

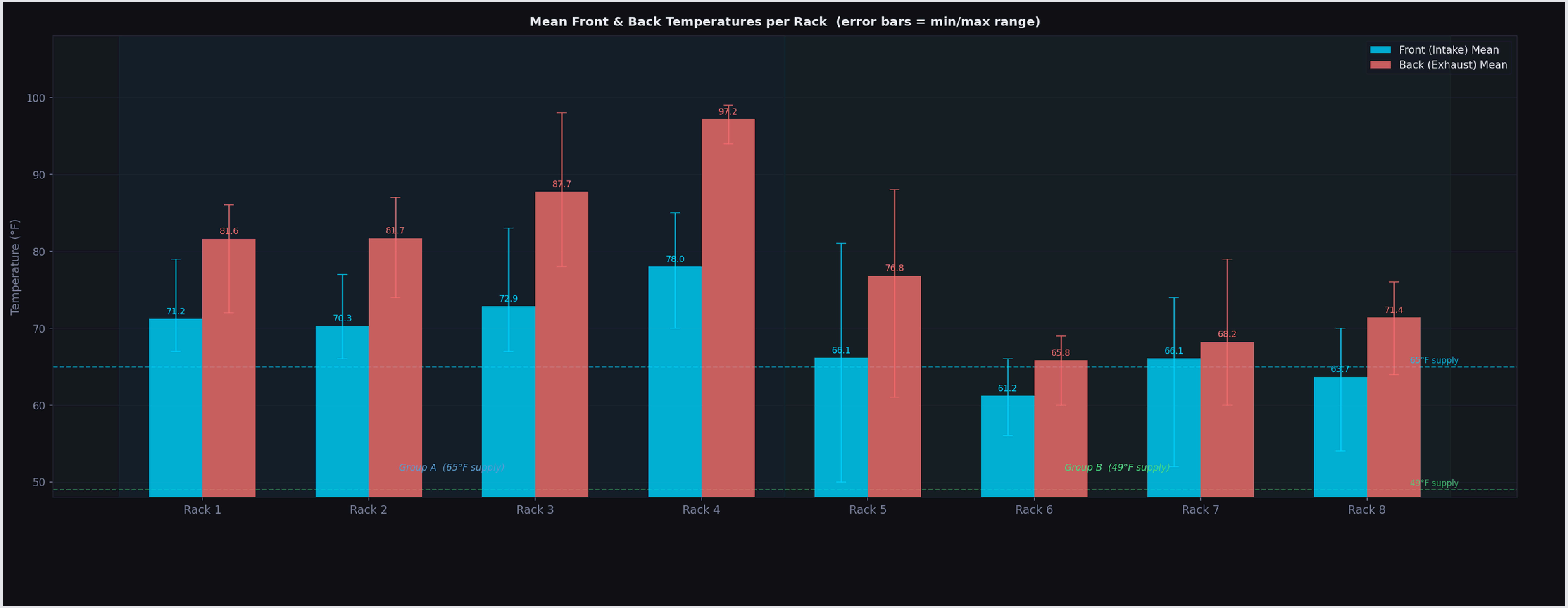
**Rack 7:** Drops to -5 in the lower units where air is coming in, which causes a very low average difference of 2.1 and a maximum difference of 9

**Rack 8**: Another peak in temperature difference in the middle of the rack, with a maximum of 15 degrees and an average of 7.7

## Observations

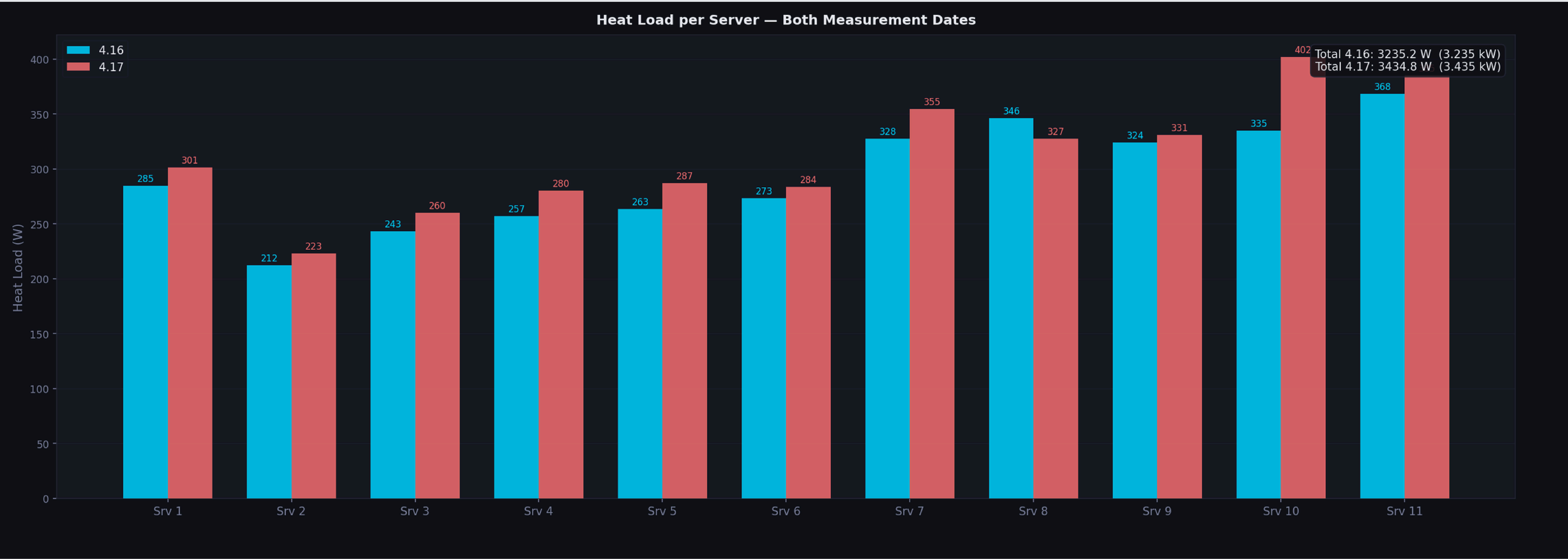
Most racks show the largest temperature difference between the middle and the top of the rack, as shown by the units, so the air gets warmer as it rises through the rack. Rack 4 has the highest heat load, even though it's right above the perforated tiles, so it likely has the hottest/heaviest equipment. Rack 7 has a negative $\Delta T$, which could indicate an airflow issue.

# Temperature function throughout the racks:



# Calculated Heat load:

$$Q(W)=\dot{m}*Cp*\Delta T$$



## Rack 6 — Heat Load Summary Comparison

| Server # | Heat Load (W) 4.16 | Heat Load (kW) 4.16 | Heat Load (W) 4.17 | Heat Load (kW) 4.17 | ΔQ (W) 4.17 − 4.16 | ΔQ (%) |
|---|---|---|---|---|---|---|
| 1 | 284.65 | 0.2846 | 301.39 | 0.3014 | 16.74 | 5.9% |
| 2 | 212.32 | 0.2123 | 222.83 | 0.2228 | 10.51 | 5.0% |
| 3 | 243.09 | 0.2431 | 259.97 | 0.2600 | 16.88 | 6.9% |
| 4 | 257.11 | 0.2571 | 280.22 | 0.2802 | 23.11 | 9.0% |
| 5 | 263.34 | 0.2633 | 286.98 | 0.2870 | 23.63 | 9.0% |
| 6 | 273.47 | 0.2735 | 283.60 | 0.2836 | 10.13 | 3.7% |
| 7 | 327.51 | 0.3275 | 354.50 | 0.3545 | 26.99 | 8.2% |
| 8 | 346.40 | 0.3464 | 327.49 | 0.3275 | -18.91 | -5.5% |
| 9 | 324.12 | 0.3241 | 330.87 | 0.3309 | 6.75 | 2.1% |
| 10 | 334.88 | 0.3349 | 401.85 | 0.4019 | 66.98 | 20.0% |
| 11 | 368.36 | 0.3684 | 385.11 | 0.3851 | 16.74 | 4.5% |
| **TOTAL** | **3235.25** | **3.2352** | **3434.81** | **3.4349** | **199.55** | **6.17** |

# Observations:

**The heat load of this data center increased between the 2 measurement dates with an average increase % of 2-10%, but two servers acted differently.**

**First server 8 was the only server with a decrease, which could simply indicate a change in use or airflow.**

**Server 10, on the other hand, increased by 20% inbetween the dates and already had the highest heat load.**

**Servers 7-11 on the upper half of the rack show to disperse more heat than the lower servers.**

**The racks totaled a 6.2%/200W increase between the 2 dates.**

# Classification according to ASHRAE standards.

## Tc-9.9 (2021)

| Class | Recommended inlet | Allowable inlet | Typical use | RH / dew point |
|---|---|---|---|---|
| A1 | 18–27°C (64–81°F) | 15–32°C (59–90°F) | Enterprise servers, storage | ≤60% RH · DP ≤15°C |
| A2 | 18–27°C (64–81°F) | 10–35°C (50–95°F) | High-end commercial | ≤60% RH · DP ≤21°C |
| A3 | 18–27°C (64–81°F) | 5–40°C (41–104°F) | Volume deployment | DP −12 to 24°C |
| A4 | 18–27°C (64–81°F) | 5–45°C (41–113°F) | Custom/industrial | DP −12 to 24°C |
| H1 | 18–22°C (64–72°F) | 15–25°C (59–77°F) | High-density / AI | Tighter control required |

**Racks 1, 2, and 6 are class A1. Racks 3 and 4 are A2. Racks 5, 7, and 8 are all class A3 due to low inlet temperature.**

**The inlet temp range is from 10-29 degrees celcius (50-85 Fahrenheit). The maximum exhaust temperature recorded was 37.2 degrees Celsius (99 F). The supply air temperature ranges from 18.3-9.4 °C (65-49 F). The determined heat load of rack 6 is an average of 3.33kW between the 2 dates.**

# ASHRAE A2 classified center

# Alternate Cooling Methods

## Water Cooling at the chip

Water cooling at the chip, such as models made for gaming, could be much more efficient at keeping the datacenters cool by addressing the heat at the source.

## Submerging chips in tanks

Towers, electronics, and liquids that can all be used together exist and could be used to keep cool liquid flowing around the processors at all times, which could save energy as it's negating the whole HVAC system and just cooling water with refrigerant.

## Rear-Door Heat Exchangers:

This is a form of liquid cooling that was interesting to me as it's cooling the exhaust air with water and also creating a seal to contain all the hot air before it's put out in the room. Some forms use no fans, and others use fans for higher-density racks. They claim it's able to reduce HVAC costs by up to 90% via rear-door heat exchangers.