National Aeronautics and Space Administration

Sustainability: NASA Advanced Supercomputing Facility at Ames Research Center

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Supercomputing Facility @ Ames

3 Separate Data Centers

- Building N258, a traditional legacy data center, built in 1986. Home to Pleiades & Cabeus Computers, Data Storage, and offices for 200 NAS staff. Peak performance: 7.1 PFs; PUE: 1.36.
  - 4MW IT equipment, approximately 300 racks.
  - 1MW Cooling System (3+1 Chillers & Cooling Tower). Raised floor cooling with rear-door heat exchangers on compute racks.
  - 6MW capacity Rotary UPS for entire building load.

- R&D088, Prototype Modular Data Center Facility, built in 2016 & 2017. Home to Electra Computer. Peak performance 8.3 PFs; PUE: 1.04.
  - 1.4 MW - 18 air cooled racks (HPE E-Cells) & 16 HPE Apollo 8600.
  - MDC1 uses filtered outside air & evaporative cooling over 81^{o} F.
  - MDC2 uses water cooled heatsinks on processors – process water cooled by dry air and evaporative cooler to 80^{o} F.

- R&D099, Modular Supercomputing Facility, built in 2019. Home to Aitken Computer. Peak performance: 13.1 PFs; PUE: 1.044.
  - 2.1 MW - 8 Apollo 8600 & 16 HPE Apollo 9000
  - Water cooled heatsinks on processors plus Apollo 9000 has water cooled circuit boards, eliminating fans – process water cooled by dry and evaporative cooler to 90^{o} F.

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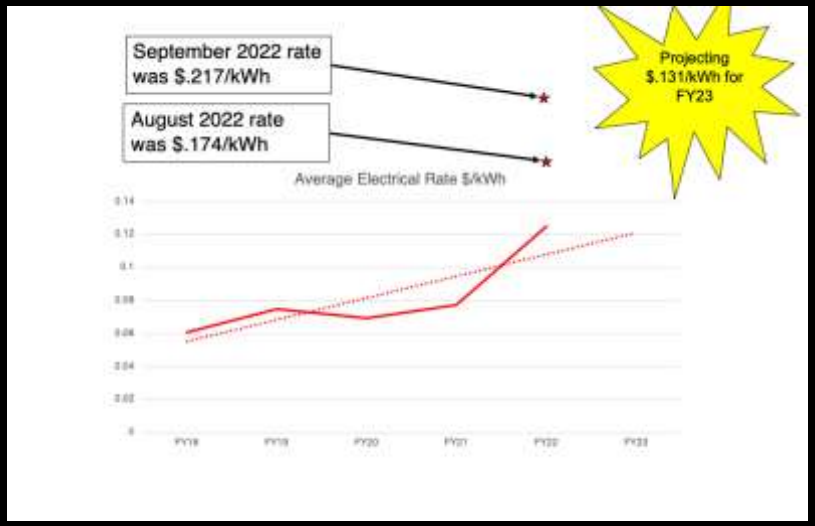
Sustainability at NAS

Sustainability objective at NAS is focused on both energy and water usage and is one of the factors in our design and procurement process.

- When running out of floor space and headroom in cooling, contracted a 3rd part survey in 2015, to determine the “best” approach for expanding the facility.
- In 2017, after successful completion of our prototype modules (R&D088 housing Electra), NAS committed all future expansion to a modular data center facility.
- Built a 1-acre cement platform with a potential draw of 30 MWs – space for 12 compute modules and 1 data module.
- Aitken module in R&D099, with a power draw of 2.1 MW supports 90º F warm-water cooling. When compared to our traditional data center the evaporative coolers annually save:
  - Over 6 million kWh (~$400K), and
  - Over 5.5 million gallons of water (~70K).
- Evaporative coolers are specified for their low water use. The coolers use water when day-time temperatures rise and are dry through the night and morning.
  - 90º F cooling water permits extended dry operation and uses less water, yielding a Water Usage Effectiveness (WUE) for the Module of 0.10L per kWh; US Department of Energy reports the WUE of an average data center is 1.8L per kWh.
    WUE is calculated as the (Annual Water Used) /(IT Energy Used).

Challenge: Utility Costs

- Utility costs are paid directly from program funding.
  As utility costs increase, resources for the user community are reduced. Procurement of new IT equipment and infrastructure is delayed.
- NASA Ames receives hydroelectric power from the Western Area Power Association (WAPA) on Pacific Gas & Electric (PG&E) distribution lines.
  - Availability is very high and Public Safety Power Shutdowns are unlikely to affect our data centers.
- Highly variable energy rates are a challenge Energy pricing varies by month and are dependent on reservoir water storage levels.
  - In October 2022, before California's wettest season in 40 years, energy was $0.305/kWh.
  - In June 2023, with reservoirs nearing 100%, energy was $0.055/kWh.
- Water is also available without restrictions. However, during the drought, our site received a lot of high hardness well water that resulted in more frequent maintenance.



Software Efficiency

- NAS measures energy usage per job including breakdown on a per node basis.
  - Power imbalance in a node used to pinpoint potential performance issues.
  - Team is starting to examine energy-focused code optimization. Note, performance optimization indirectly reduces energy usage for a job.
- Energy usage per job, is used to chart power usage along with computational work by processor type and informs the decision process to retire aging hardware.

Questions?

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