Data Centers and Water
Overview of Mission Critical Facilities

July 17, 2026

Tim Startt, PE

Metropolitan Washington
Council of Governments

WRA

Agenda

Why do data centers need water?

How much water do data centers need?

What is the criticality of the water supply to data centers?

Ashburn, VA

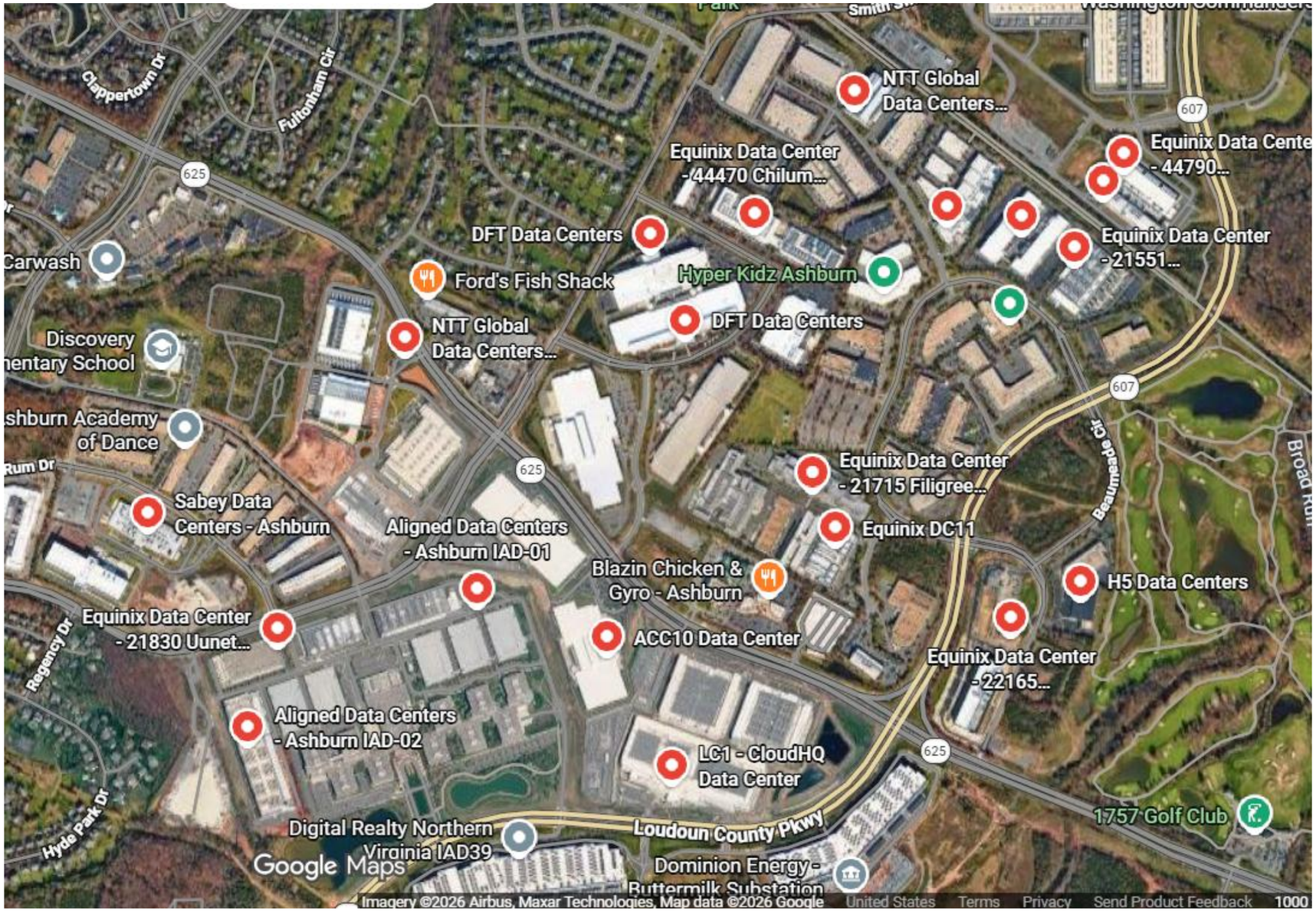
Over 150 data centers

70% of global internet traffic & 30-40% of global internet capacity (estimated)

49 million square feet of data centers

6,000 megawatts capacity (current)

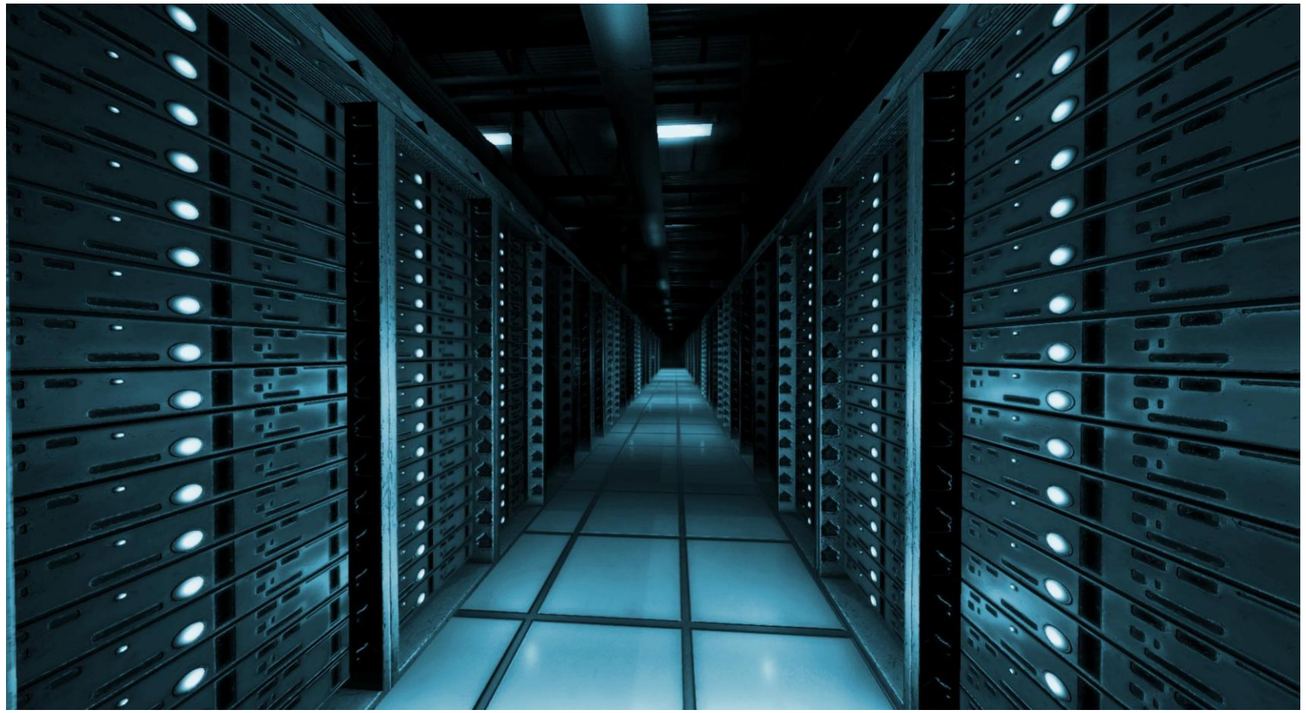
16,600 megawatts by 2038



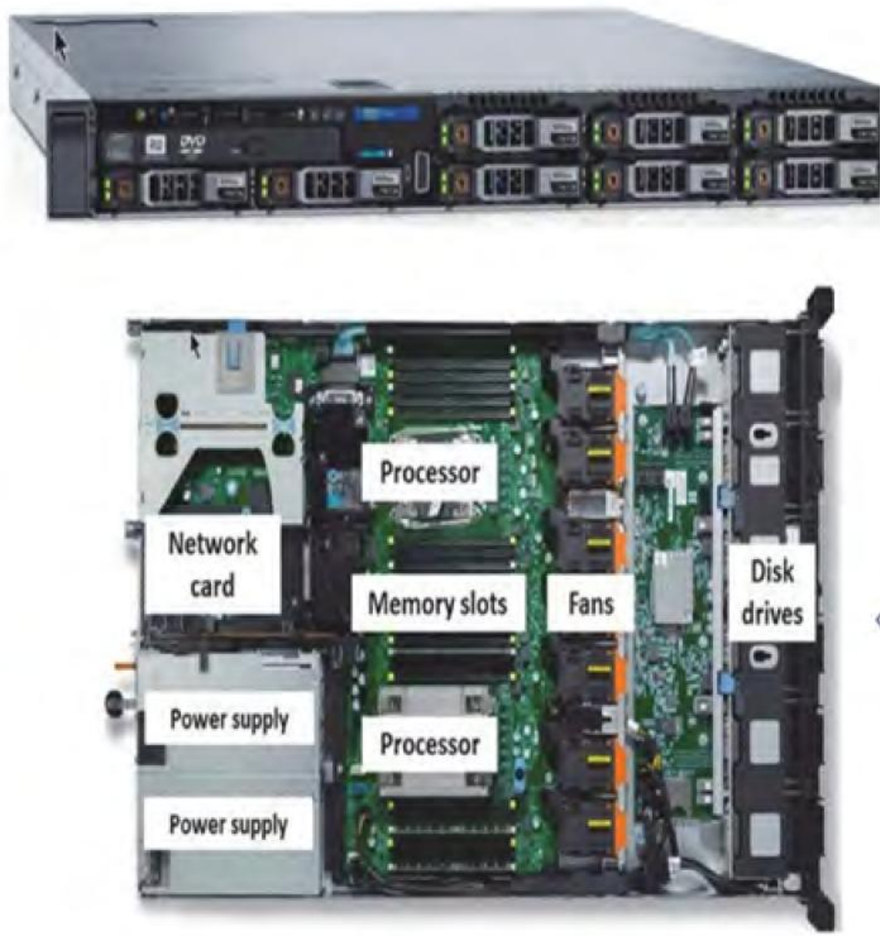
What is a Data Center?

[BG] DATA CENTER. A room or building, or portions thereof, used primarily to house information technology equipment (ITE) and serving a total ITE load greater than 10 kW and 20 W/ft^2 (215 W/m^2) of conditioned floor area.

data center — A building or portion of a building with the primary function to house a computer room and its support areas.

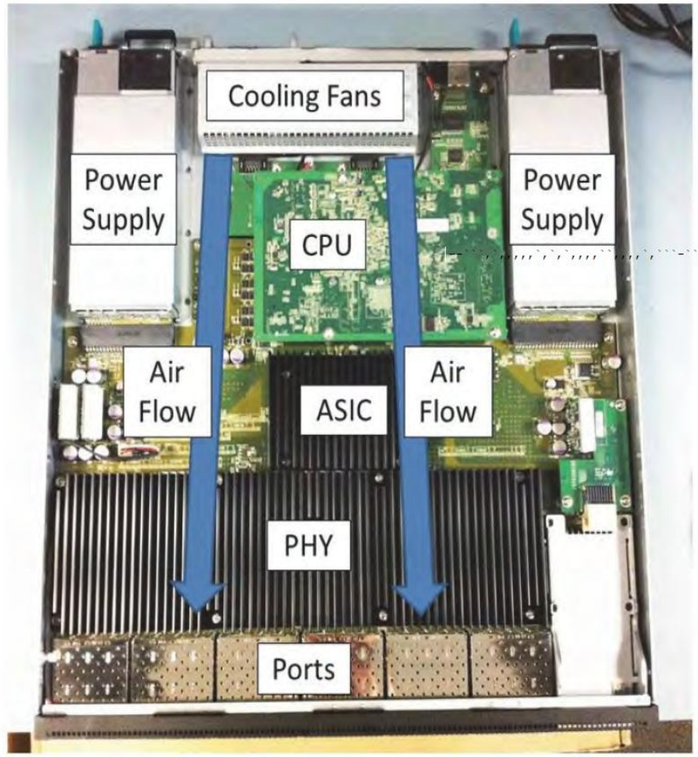


What is inside of a Data Center?



Servers (Compute & Processing)

Storage (Hard drives)

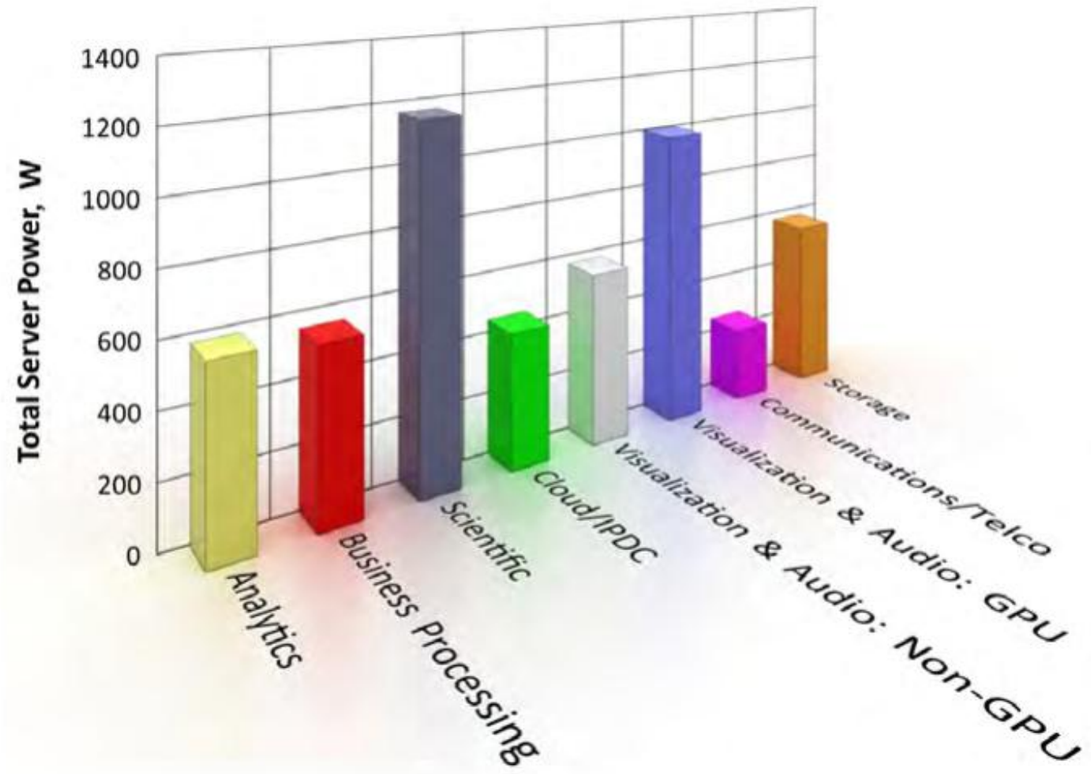


Telecommunications
(Network switches)

What is inside of a Data Center?

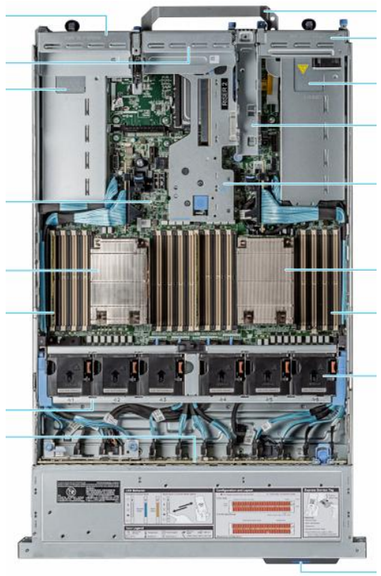
Cloud / IPDC (2U, 2S)
2x 120W CPU
16x 8GB DIMM
8x SATA
4x 1Gb LoM
10Gb Ethernet
16Gb FC HBA
Total Power = 450 W

Scientific (2U, 2S)
2x 145W CPU
16x 16GB DIMM
2x 300W GPU
4x 1Gb LoM
1x 10Gb FDR IB
Total Power = 1150 W



Source: IT Equipment Power Trends, 3rd Edition; ASHRAE Datacom Series

What is inside of a Data Center?



Types of Data Centers

Enterprise

- Privately owned, single owner
- Physical building/facility

Hyperscale

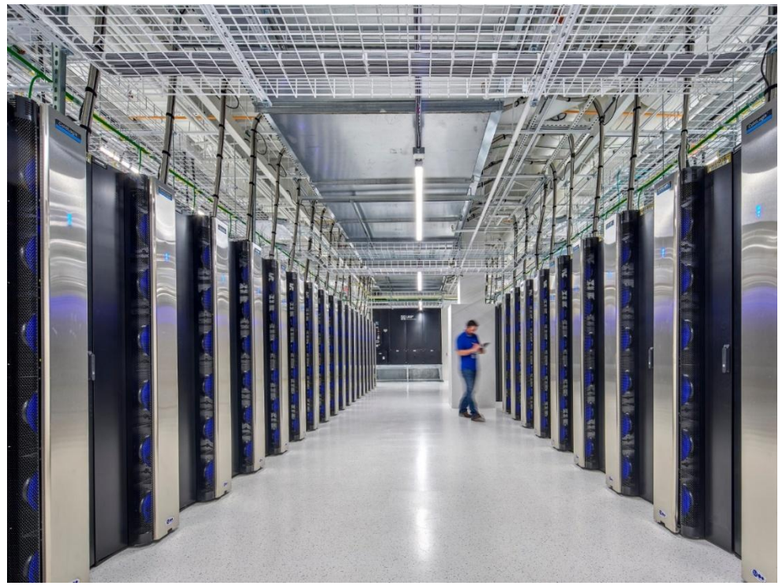
- Large providers (Google, AWS)
- Custom physical building/facility
- Scalable

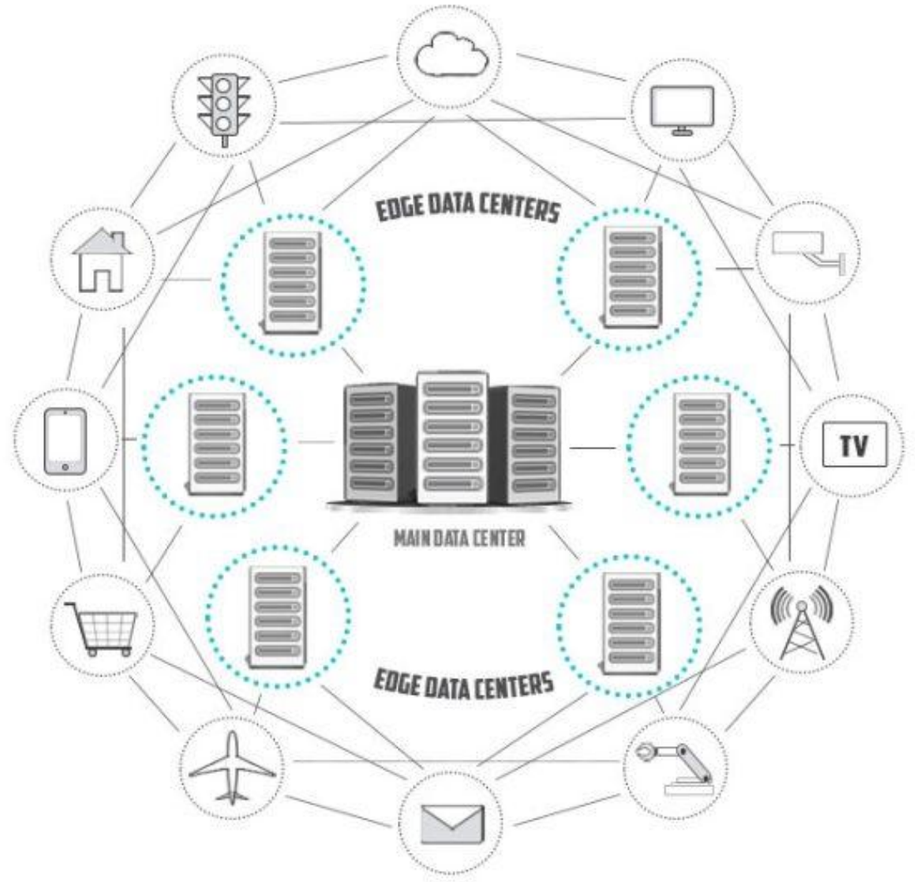
Edge

- Small, de-centralized
- Geographically close to end-users to reduce latency

Colo (Co-location)

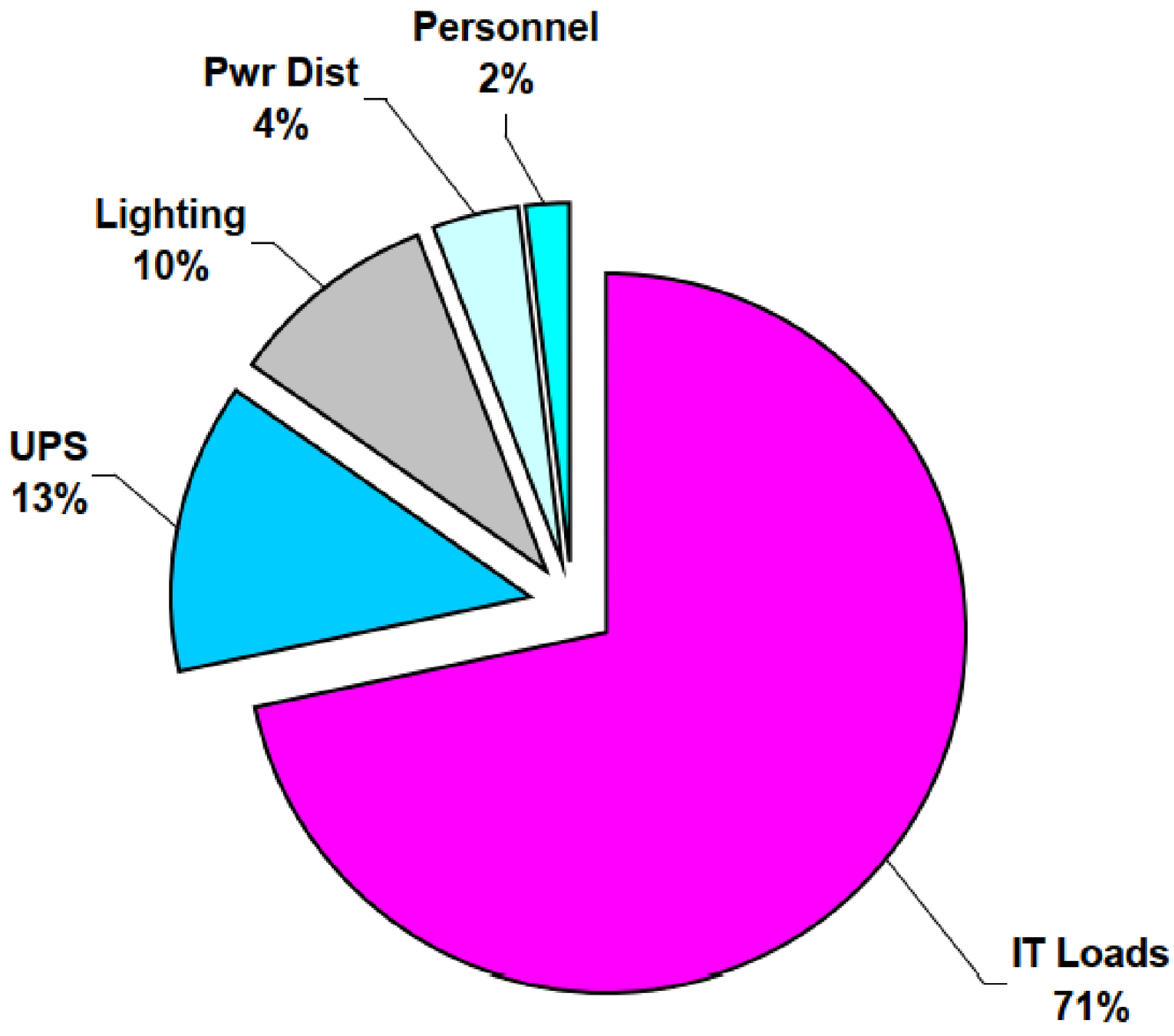
- Rented/leased space in data center facility
- Landlord/Tenant arrangement (Digital Realty, QTS, Cyrus One)





https://mitsubishicritical.com/applications/data-centers/edge-data-centers/

Cooling Loads in Data Centers



Schneider Electric white paper 025 "Calculating Total Cooling Requirements for Data Centers"

IT Cooling Loads

Communications up to 5 kW/cabinet

Data Storage up to 10 kW/cabinet

General Purpose Computing 5-30 kW/cabinet

High Performance Computing 30-**400** kW/cabinet (and increasing)

AI / ML up to **400** kW/cabinet (and increasing)

What is “1 Megawatt”?

1 kW = 3,413 BTU/Hr

1 Ton cooling = 12,000 BTU/Hr

1 Ton cooling = 3.52 kW

1,000 kW = 1 megawatt(MW) = 285 Tons cooling

Average home ≈ 2 to 2.5 Tons cooling

1 megawatt of cooling is equivalent to approximately 150 homes.

50 megawatts of cooling is equivalent to approximately 7,500 homes.

Density of High-Performance Computing (HPC) Cooling Loads

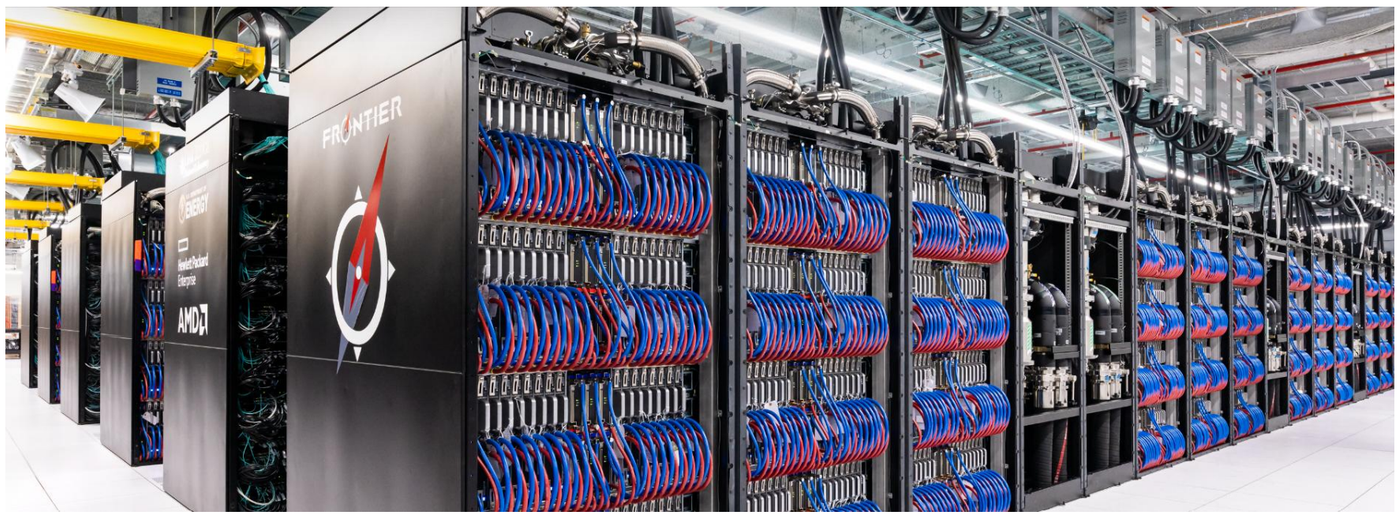
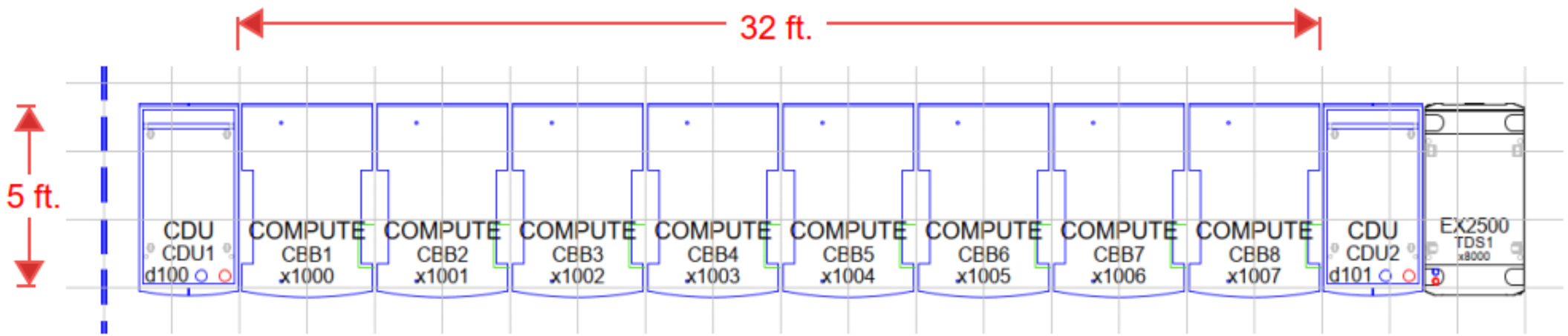


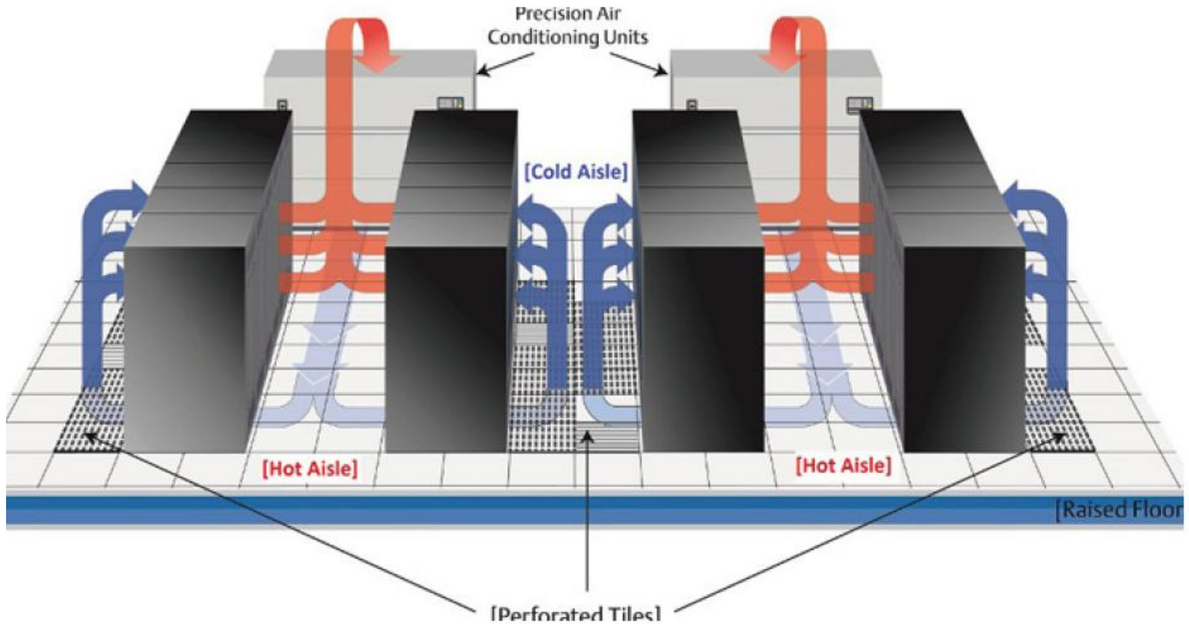
Image of "Frontier", an exascale supercomputer at Department of Energy's Oakridge National Laboratory; https://www.ornl.gov/journeytofrontier

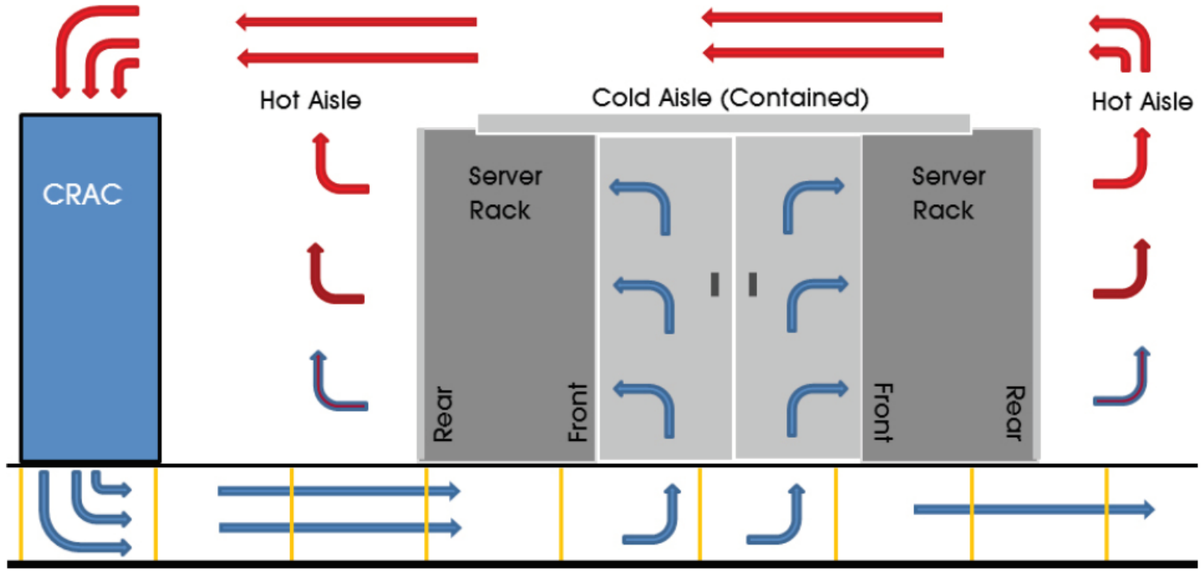


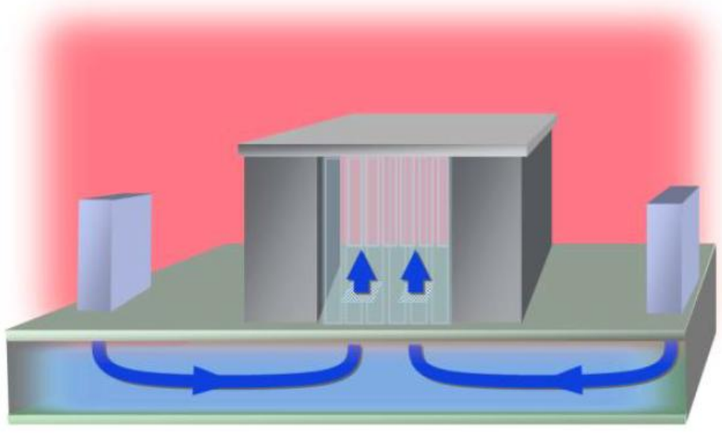
8 cabinets = 920 tons of cooling ≈ 400 homes

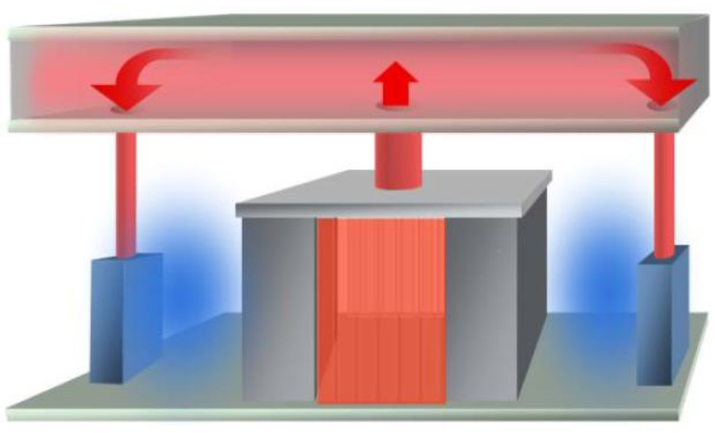
Cooling needed for 400 homes in 160 sq.ft.

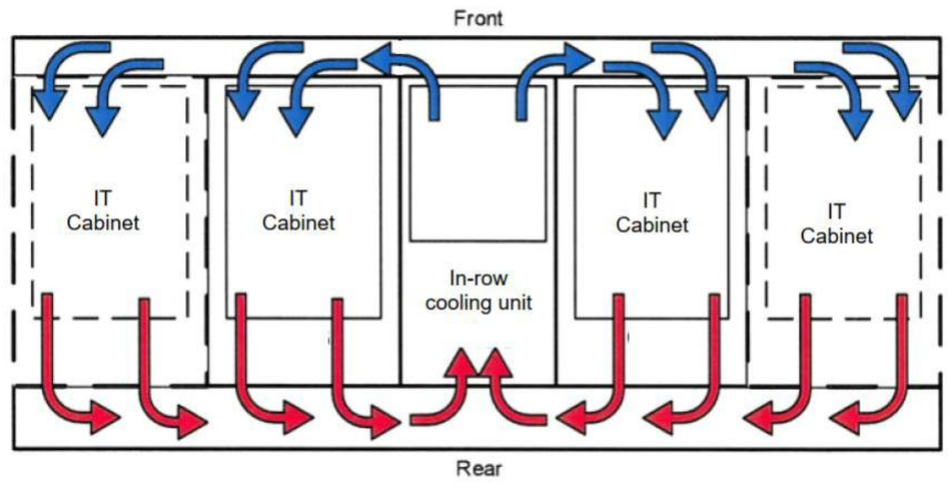
Need to remove heat generated by IT equipment



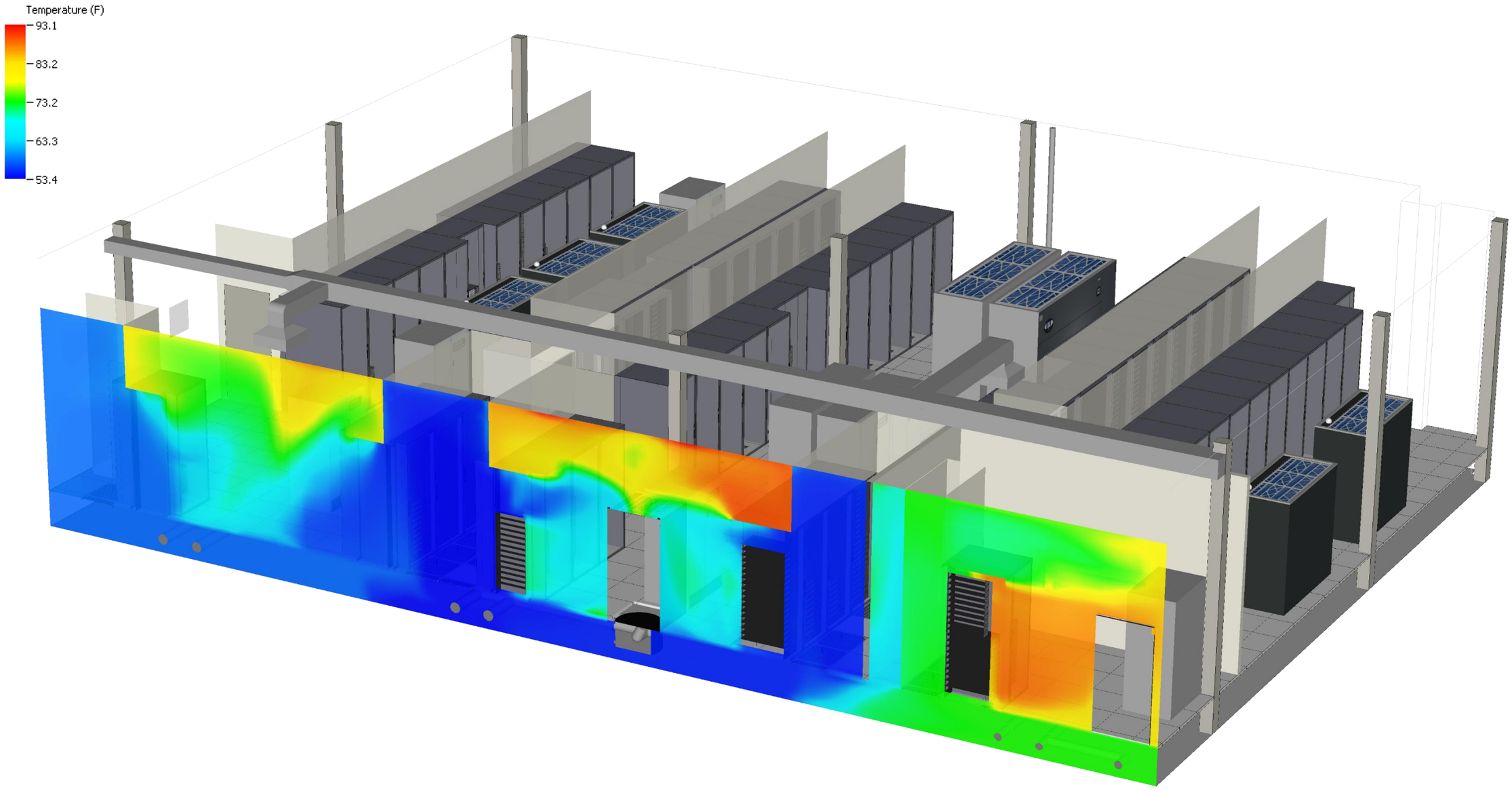






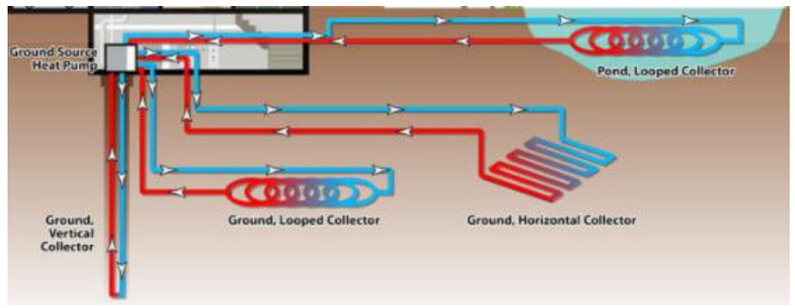


Need to remove heat generated by IT equipment



Heat from IT equipment must be rejected to outside environment

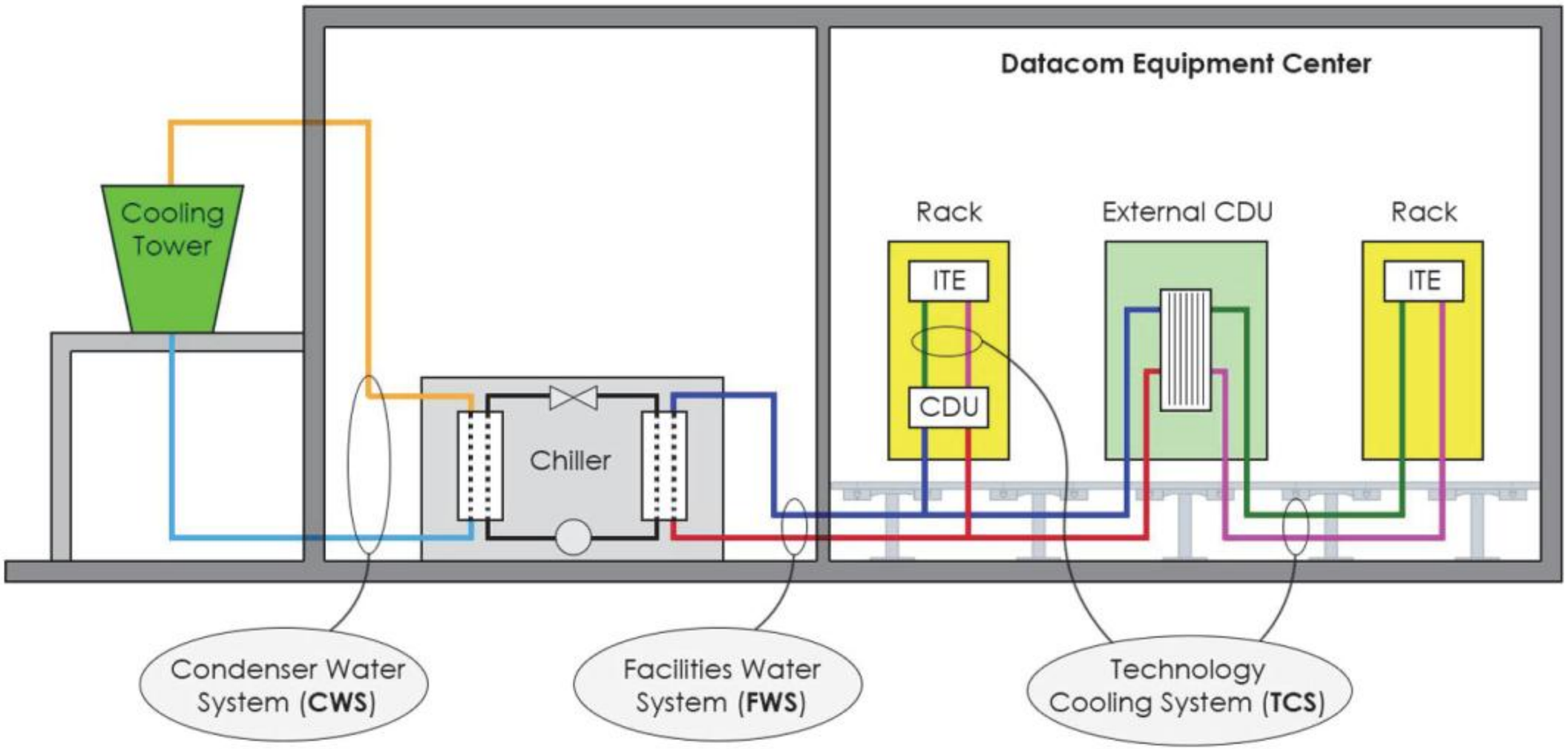
Ground



Air

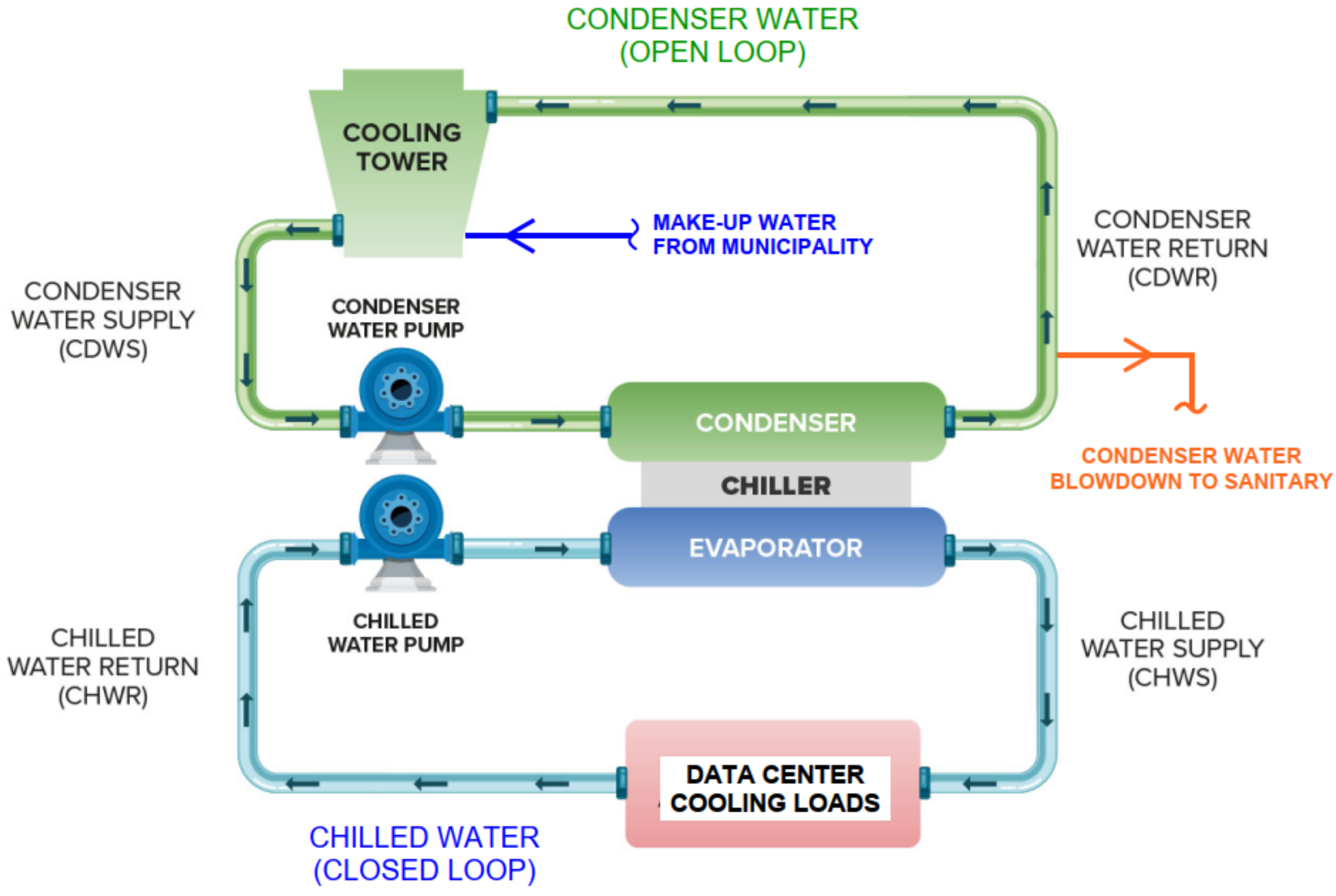
Water

Water has over 20 times the cooling capacity of air



Source: Liquid Cooling Guidelines for Datacom Equipment Centers, 2nd Edition; ASHRAE Datacom Series

Water-Cooled Chiller System Diagram

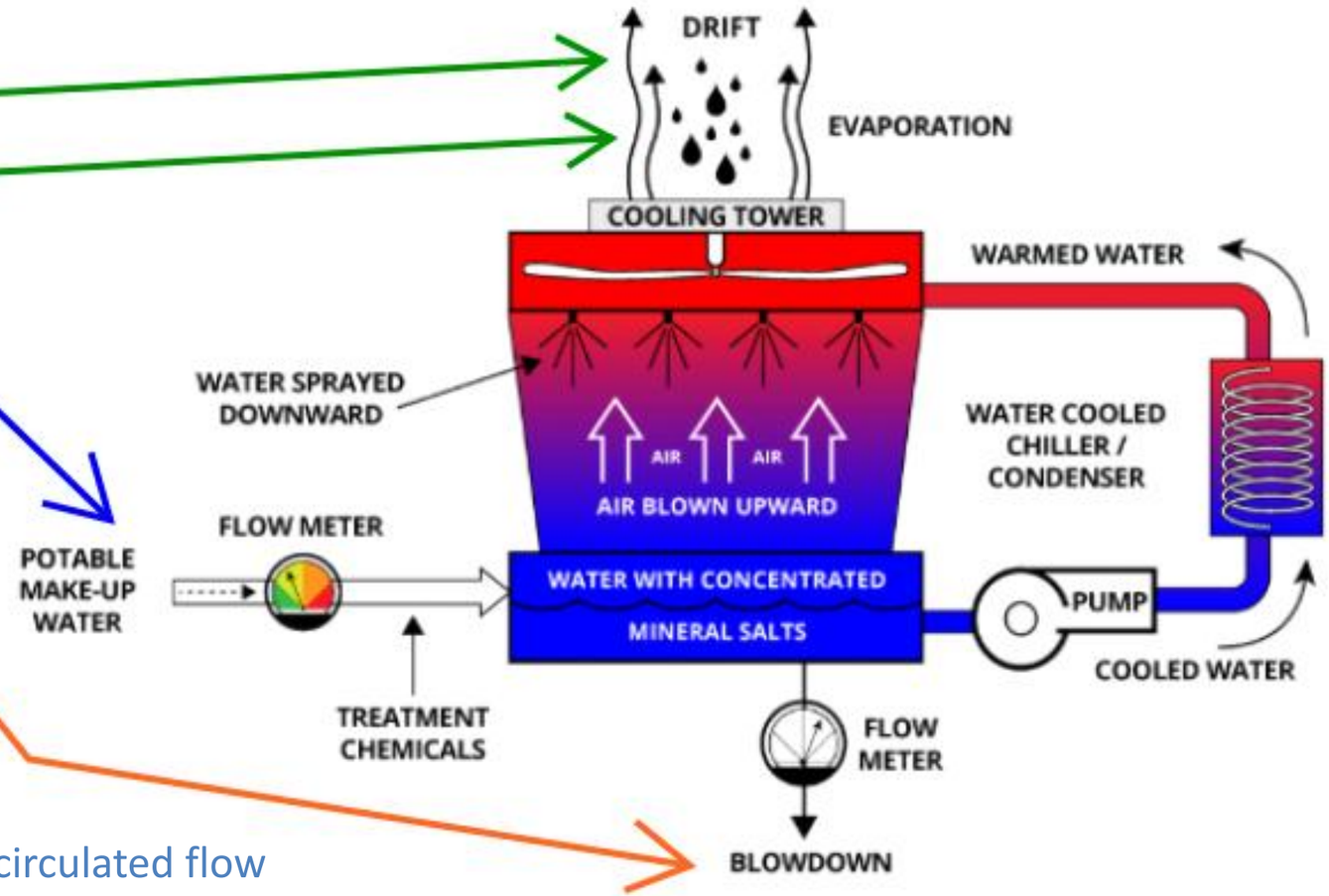


Source: https://www.endocool.com/guide-to-chilled-water-systems-and-improving-efficiency/

Make-up water is needed to offset water lost thru evaporation, drift, and blowdown

MU = E + D + BD

E: Evaporation
D: Drift
MU: Makeup Water
BD: Blowdown



Evaporation: Approximately 1% of recirculated flow
Drift: Approximately 0.05% of recirculated flow
Blowdown: As needed based on conductivity of circulated water

How Much Water Does a Data Center Need?

The table below provides total daily water usage for a system that operates a full load 24 hours per day, based on chiller tonnage and cooling tower cycles of concentration.

DAILY COOLING TOWER WATER USE AT FULL LOAD (GALLONS PER DAY)

	CYCLES OF CONCENTRATION					
Chiller Tonnage (Nameplate)	**3**	**4**	**5**	**6**	**7**	**8**
100	5,480	4,930	4,660	4,380	4,380	4,110
200	10,960	9,860	9,320	8,770	8,490	8,490
400	21,920	19,730	18,360	17,530	17,260	16,710
500	27,400	24,380	23,010	21,920	21,370	21,100
600	33,150	29,320	27,400	26,580	25,750	25,210
800	44,110	39,180	36,710	35,340	34,250	33,700
1000	55,070	49,040	46,030	44,110	42,740	41,920
1500	82,740	73,420	68,770	66,030	64,380	63,010
2000	110,140	97,810	91,780	88,220	85,480	83,840
2500	137,810	122,470	114,790	110,140	107,120	104,930
3000	165,210	146,850	137,810	132,330	128,490	126,030
3500	192,880	171,510	160,550	154,250	149,860	146,850
4000	220,270	195,890	183,560	176,160	171,510	167,950
5000	275,340	245,480	229,590	220,270	214,250	209,860

https://www.energy.gov/femp/estimating-methods-determining-end-use-water-consumption

50 megawatts = 14,200 tons cooling

50 megawatts ≈ 800,000 gal/day*

*at peak load

Mission Critical

mission critical — Any operation, activity, process, equipment, or facility that is essential to continuous operation for reasons of business continuity, personnel safety, security, or emergency management.

Zero downtime

- Redundant power/cooling equipment and distribution paths
- Backup power (Uninterruptable Power System, Generator, Utility)
- On-site storage of water and fuel
- Precision cooling
- Systems control and monitoring
- Operations & maintenance

Tier Requirements Summary

A summary of the preceding requirements defining the four distinct Tier classification levels is in Table 1. In the table, Crtitical Power Distribution is defined as the power from the UPS output to the IT assets.

	Tier I	Tier II	Tier III	Tier IV
Minimum Capacity Components to Support the IT Load	N	N+1	N+1	N After any Failure
Distribution Paths - Electrical Power Backbone	1	1	1 Active and 1 Alternate	2 Simultaneously Active
Critical Power Distribution	1	1	2 Simultaneously Active	2 Simultaneously Active
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerance	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continuous Cooling	No	No	No	Yes

Source: Data Center Site Infrastructure Tier Standard: Topology, 2018, Uptime Institute

Mission Critical

Uptime % (Availability)	Downtime per year	Downtime per quarter	Downtime per month	Downtime per week	Downtime per day (24 hours)
99% — two nines	3.65 days	21.9 hrs	7.31 hrs	1.68 hrs	14.40 min
99.9% — three nines	8.77 hrs	2.19 hrs	43.83 min	10.08 min	1.44 min
99.99% — four nines	52.60 min	13.15 min	4.38 min	1.01 min	8.64 sec
99.999% — five nines	5.26 min	1.31 min	26.30 sec	6.05 sec	864.00 millisec
99.9999% — six nines	31.56 sec	7.89 sec	2.63 sec	604.80 millisec	86.40 millisec

https://www.globalcallforwarding.com/blog/high-availability-infrastructure-guide/

Concurrently Maintainable Source of Water

An objective of the Uptime Institute Tier Standard is the consistent application of infrastructure availability concepts to facility systems that support data center critical environments. Consistent with the concept that the loss of public utility electrical power is a design condition rather than a failure or maintenance mode, the loss of the public utility water supply must also be addressed as a design condition.

Source: Accredited Tier Designer Technical Paper Series: Makeup Water, 2017, Uptime Institute

Mission Critical

Tier Requirements for Makeup Water

Application of Tier concepts requires that the amount of makeup water for evaporative cooling towers stored on site must be sufficient to provide a minimum of 12 hours of on-site makeup water storage that adheres to the requirements of the Tier objective. For a Tier I site, this is a single 12-hour storage solution with a single distribution path. Tier II requires redundant makeup water storage solutions. To provide 12 hours of on-site makeup water when any single storage solution is isolated for planned activities, Tier III requires 12 hours of Concurrently Maintainable and Tier IV requires 12 hours of Concurrently Maintainable and Fault Tolerant makeup water systems.

The preceding example discusses the volume of makeup water for a megawatt-day. The volume must be adjusted to meet the site cooling load and operating duration necessary to meet project requirements. One megawatt-day of makeup water will support a 2-megawatt load for 12 hours; two megawatt-days of makeup water will be required to support a 4-megawatt load for 12 hours.

50 megawatts = 14,200 tons cooling

50 megawatts = 782,000 gal/day

391,000 gallons of storage

Approx. 50 ft diameter by 25 ft height

Source: Accredited Tier Designer Technical Paper Series: Makeup Water, 2017, Uptime Institute

Reclaimed Water – Issues / Concerns

“Outside of data center”

Monitoring and control of chlorine levels

Storm water run-off

- Road salt for winter storms
- Lack of rain

Piping materials

Stagnant water (driven by conditions *“inside of data center”*)

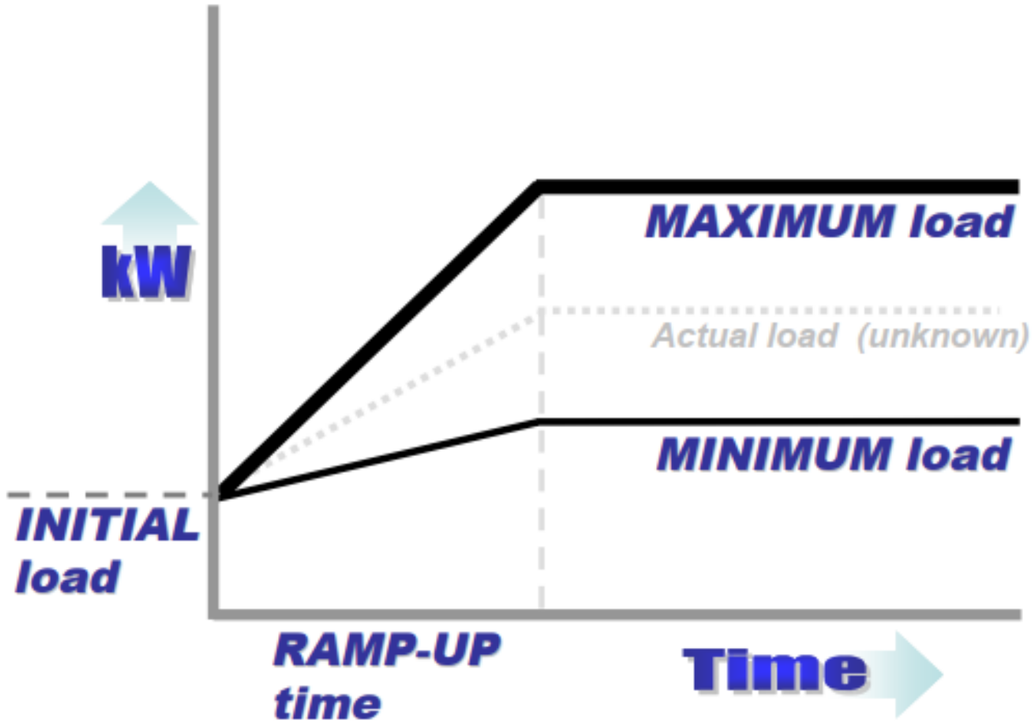
Reliability and resiliency of reclaimed water service*

“Inside of data center”

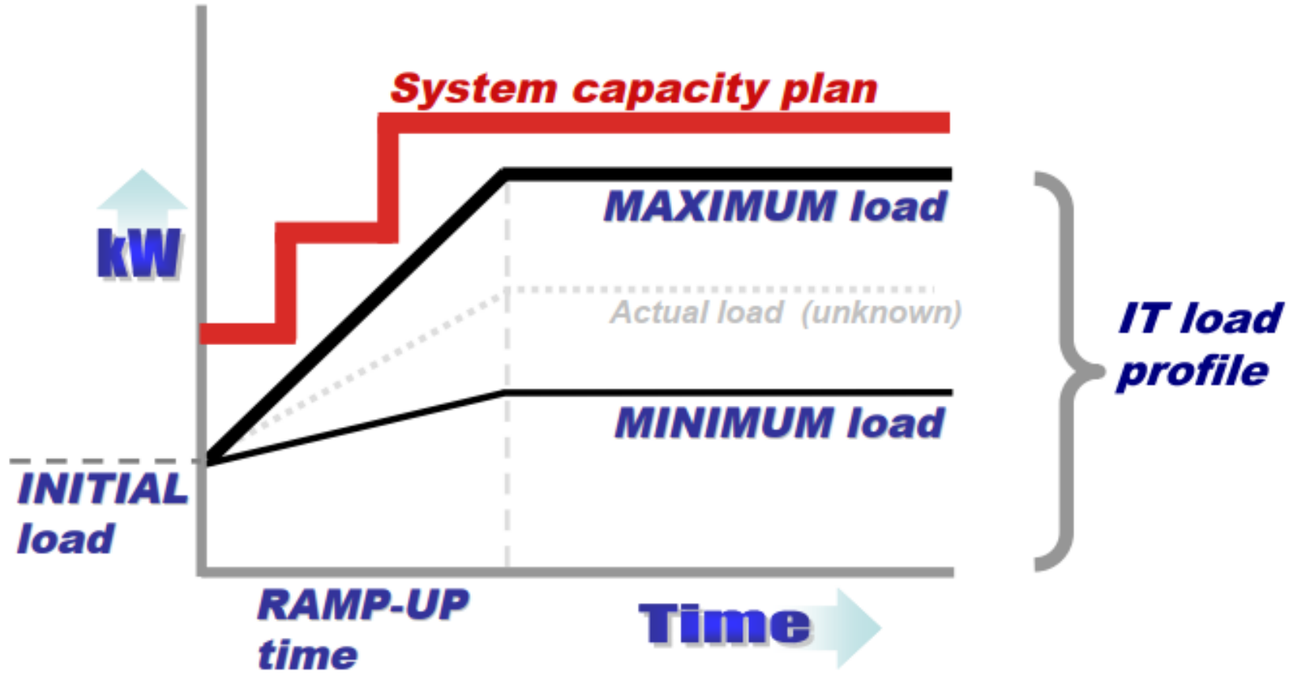
Data center cooling plant chemical treatment designed to *maintain* chlorine levels, not to kill contaminants.

Cooling load profile and redundant cooling equipment

Here's the problem



IT load profile



***System capacity plan** (red line)*

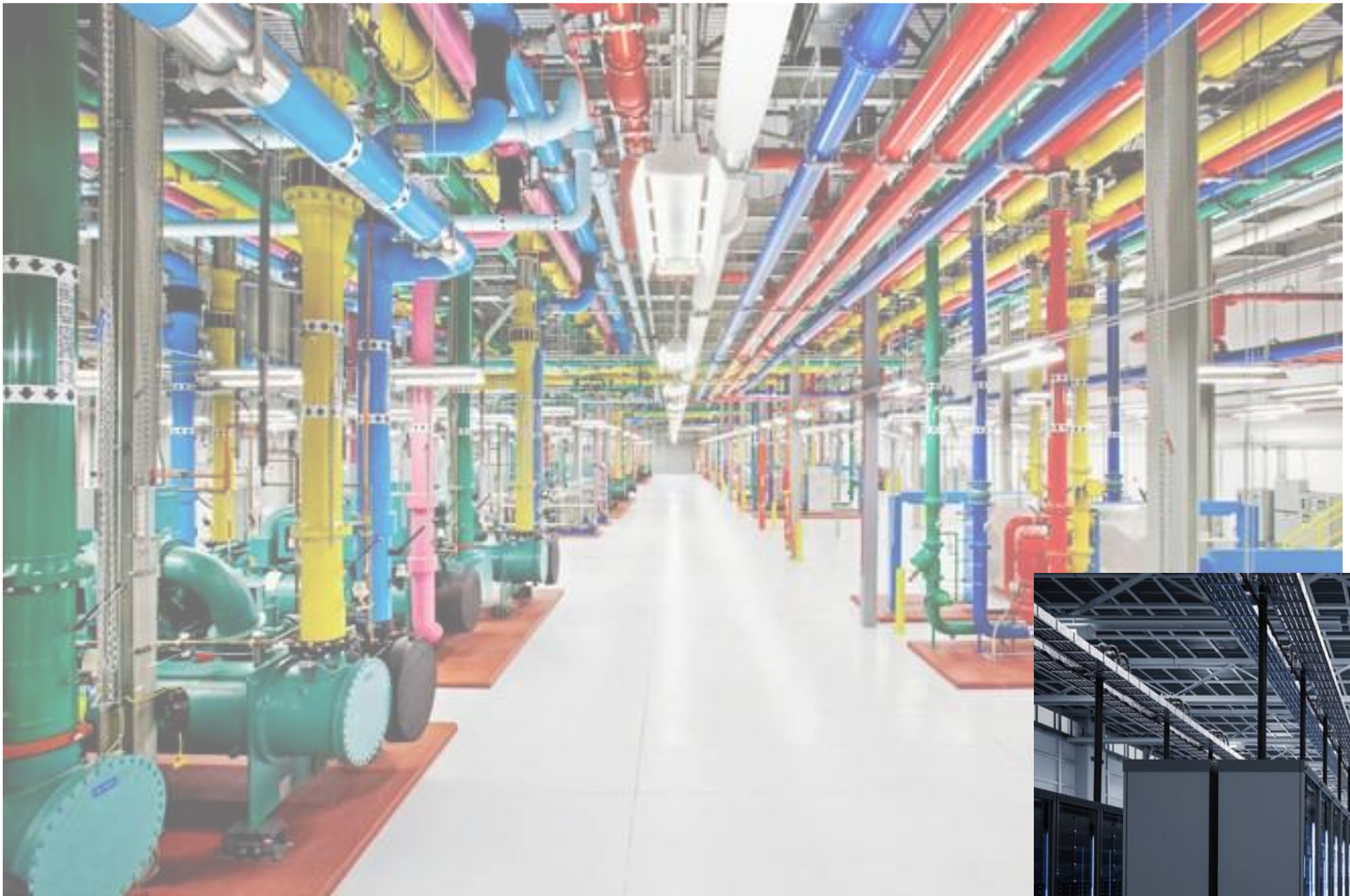
Must be able to support the MAXIMUM final load

Here’s the problem

Between Day 0 and Day 1, with minimal IT load, there is minimal demand for make-up water (either domestic or reclaimed).

Data centers contain redundant capacity components, redundant distribution systems, and potentially redundant utility services.

Data centers have minimal staffing/occupancy resulting in minimal domestic water usage (restrooms, drinking fountains, etc.)



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QUESTIONS?