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Electronics Take a Bath

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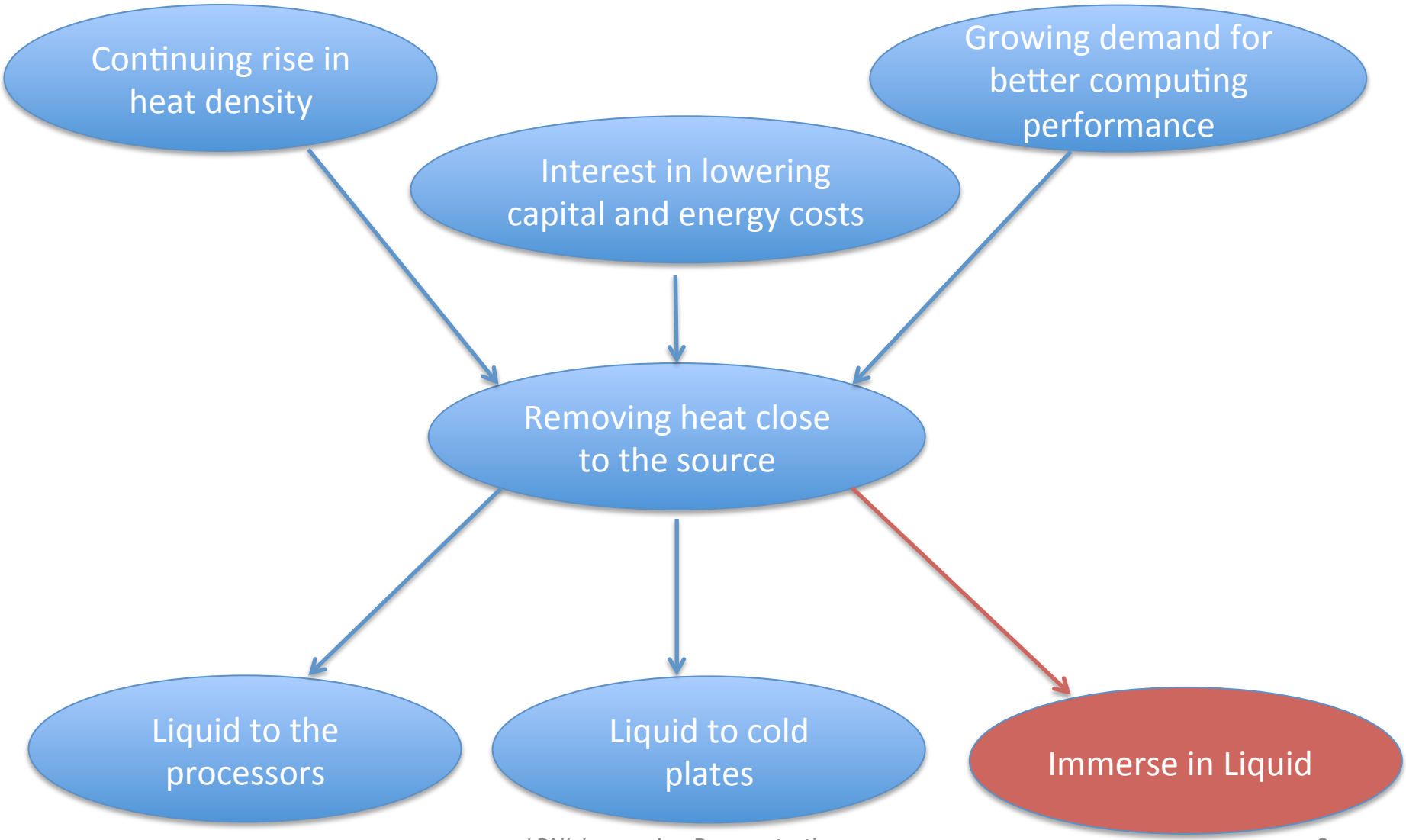
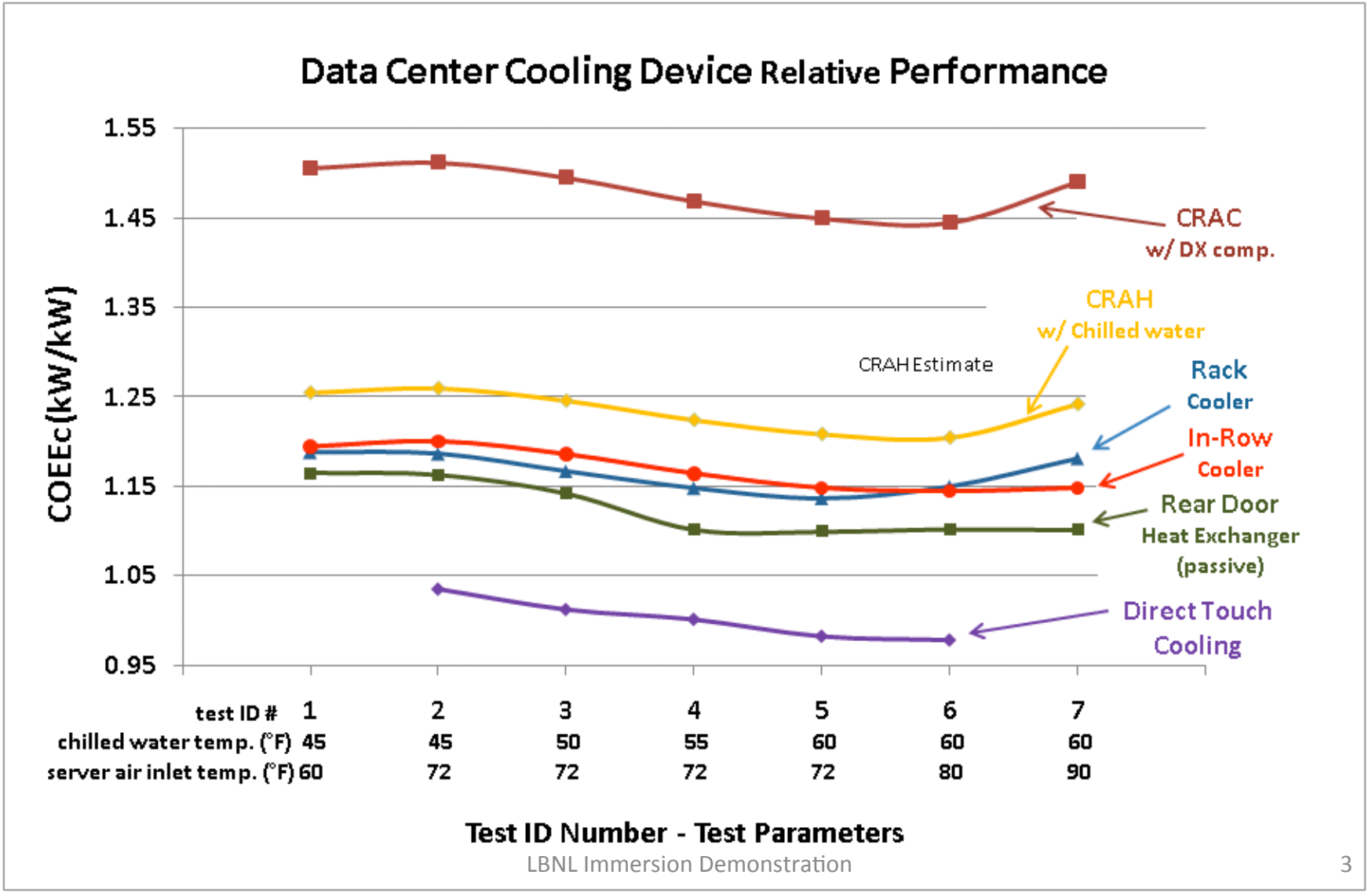
SVLG Data Center Summit

Going beyond the "Chill-Offs"



“Chill-Offs” 1&2 confirmed liquid cooling solutions are more efficient than air cooling



Liquid Immersion (Submersion) Cooling

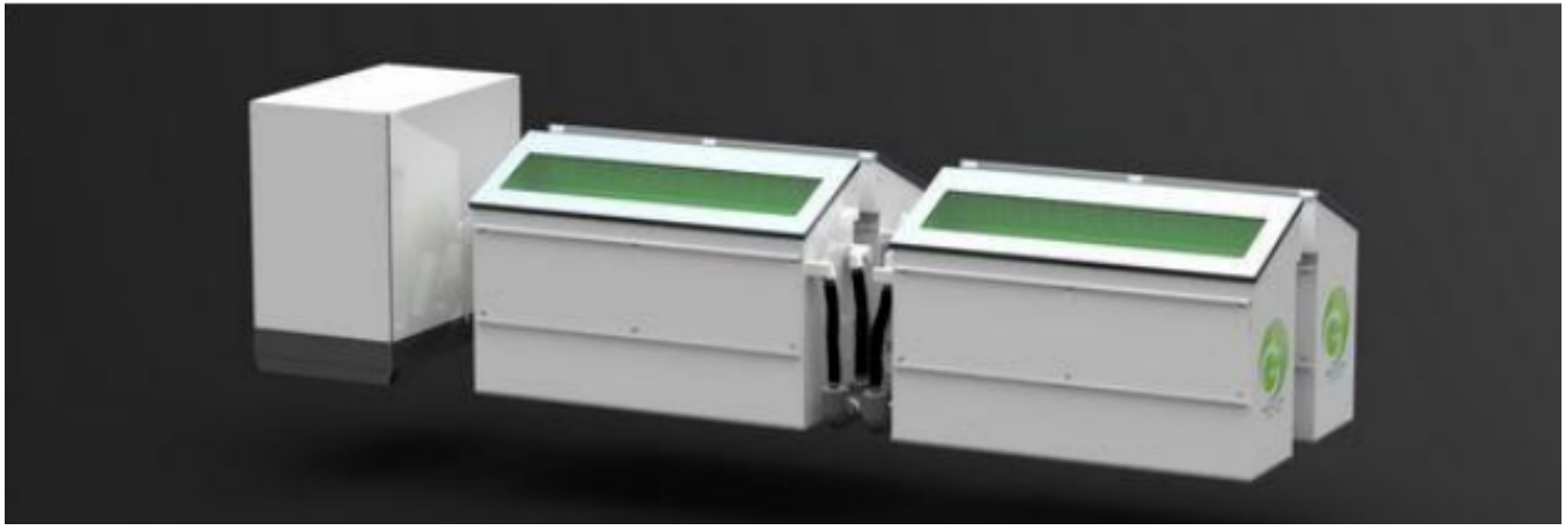
- Immerse electronics in liquid dielectric (non-conductive fluid)
- Used in early CRAY computers
- Also used in:
  - Transformers
  - Capacitors
  - Switch gear

Liquid Immersion Fluids

- Mineral Oil
- Novec 649, other boiling points available

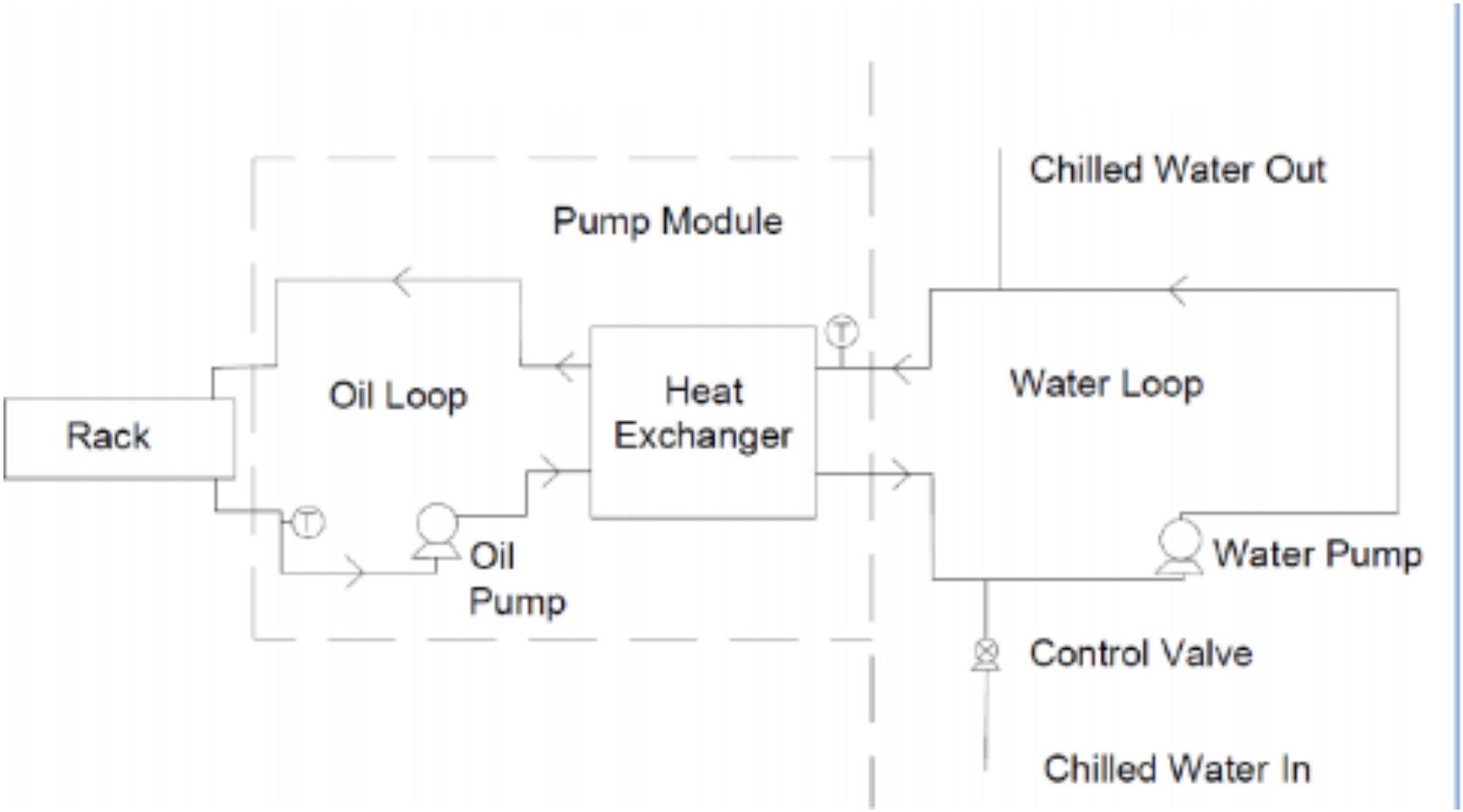
PG&E Submersion Cooling Evaluation

PG&E evaluation of Green Revolution system under the Emerging Technologies Program



Courtesy of PG&E Emerging Technologies Program

Submersion Cooling Schematic



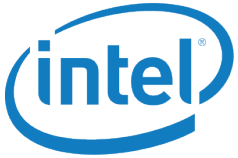
Courtesy of PG&E Emerging Technologies Program

Demand Savings	9.25	(kW)
Energy Savings	81,030	(kWh/yr)
Energy Cost Savings	$ 11,344	($/yr)

Courtesy of PG&E Emerging Technologies Program

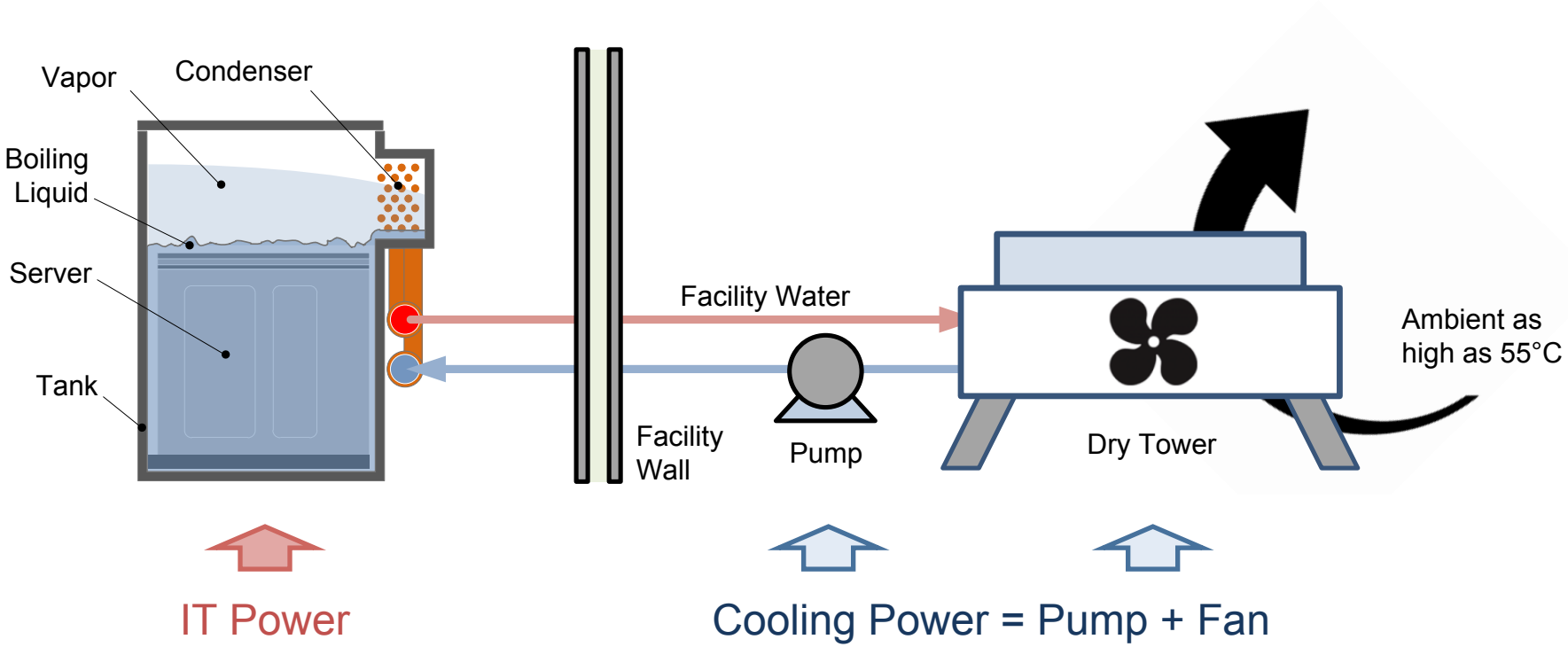
LBNL Led Liquid Immersion Demonstration using Novec 649

- Project team



- Demonstration partner
  - Navy Research Lab – Washington, DC

Open bath liquid immersion cooling using Novec 649

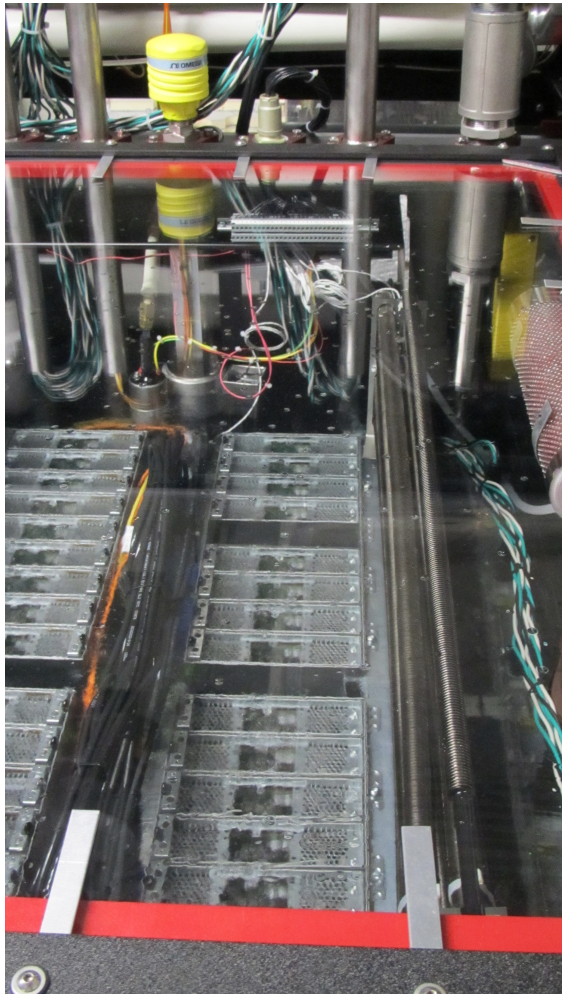


What is missing:

- chillers
- cooling towers
- water use
- raised floors
- computer room air conditioners
- earplugs!
- Server fans

Cooling temperatures

- Immersion systems can cool at relatively high temperatures (30-40°C)
- Heat exchangers can cool this with high inlet temperatures
- Dry coolers (like car radiators) can produce this in most climates

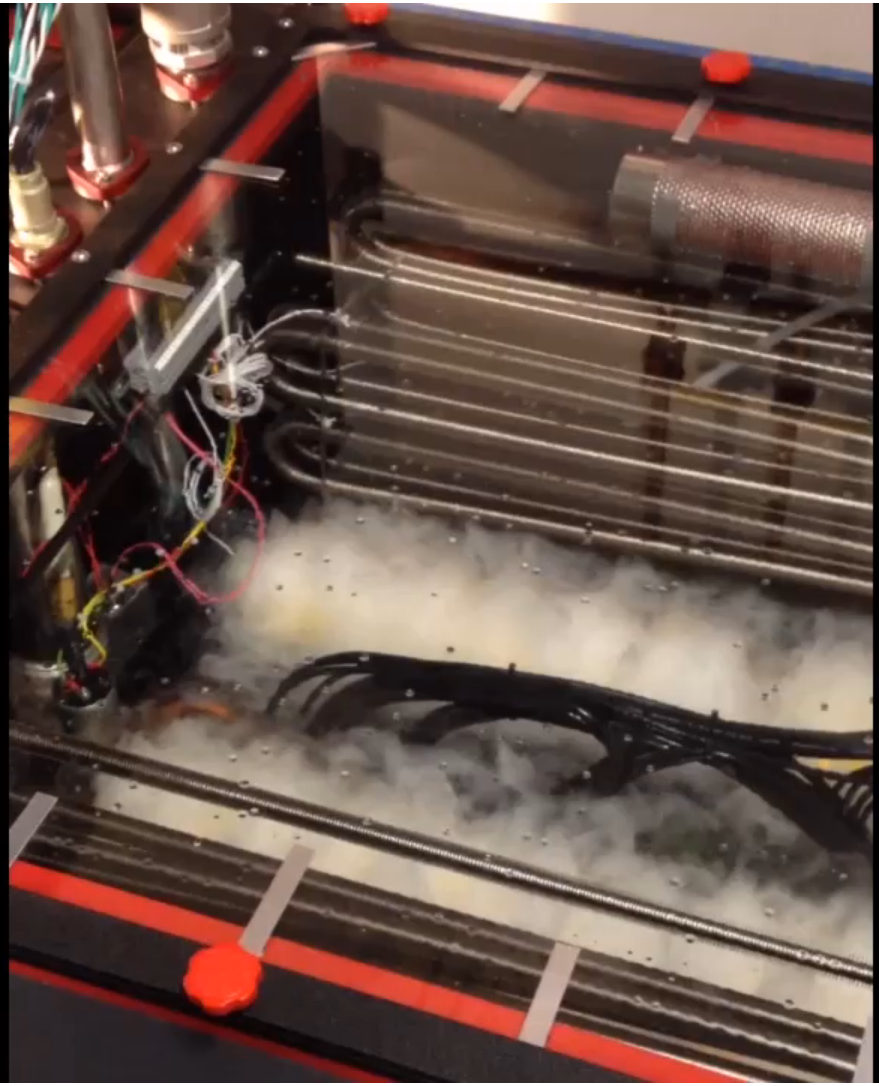


OFF

IDLE

LINPACK RUN

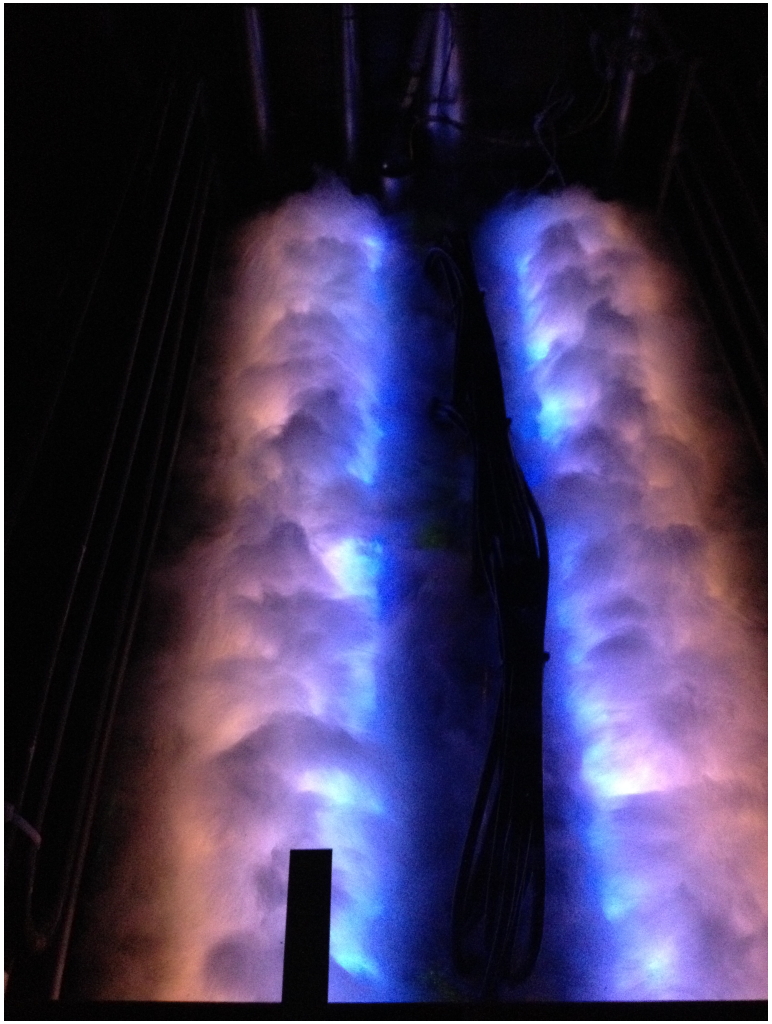
2-Phase Immersion Cooling



Value proposition

Possible next generation computing improvement

- Capital cost savings
- Energy cost savings (& CO^2)
- Water cost savings
- Reliability improvement
- Improved computational ability



Immersion cooling eliminates compressor based systems

Eliminate chillers and CRAC units

Eliminate cooling towers and evaporative water loss

Reduce number of pumps

Eliminate server fans

Many hours of "Free cooling"

Simplified controls

Reduced maintenance cost

Cooling systems can be much simpler

Expected Benefits

- Capital cost savings
- Improved reliability
  - Elimination of potential points of failure
  - Temperature stability improving reliability
- Energy savings (IT and infrastructure)
- Enables high density computing and close interconnection of processors
- In the future, electronics can be optimized for immersion for even better performance
- More potential for heat reuse
- Additional applications – e.g. aviation, military

Downside

- Mineral Oil
  - Inconvenient to handle and perform maintenance
  - Lower heat removal capability
- Novec 649
  - Should be monitored to ensure no decomposition occurs
  - In open bath system is always at 49°C with phase change at the processor, missing additional free cooling hours at lower temperatures.
  - Fluid is expensive

Energy Implications

- PG&E study –
  - ~68 kW IT load; ~2kW cooling pumps
- Bitcoin
  - PUE ~ 1.02
- Current Immersion demonstration
  - In process

Energy Performance

Immersion demonstration partial PUE (cooling):

$$\frac{\text{IT (in bath)+Tank controls + Dry cooler fan + Loop pump}}{\text{IT (in bath)}}$$

Initial results – with fixed pump and fan speeds

$$\text{Partial PUE (cooling)} = \frac{21.399 + .144 + .0719 + .254}{21.399}$$

$$= 1.02$$

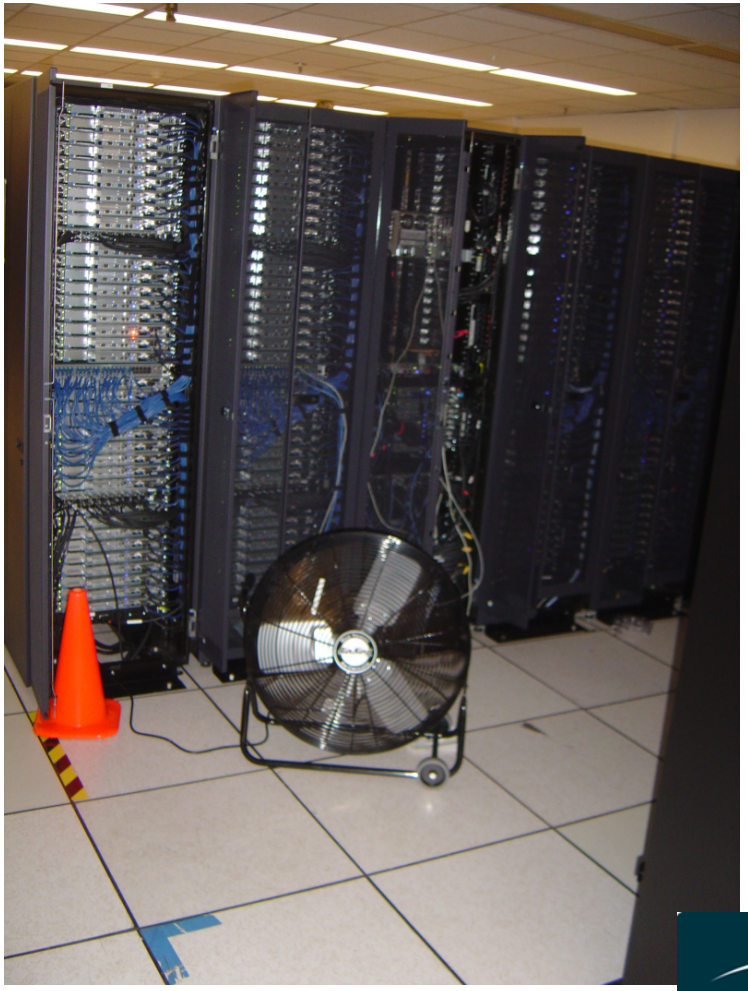
Barriers to Adoption

- Disc drives must be sealed or use solid state
- Off the shelf offerings not available
  - Fans must be removed
  - Boiling enhancement coating must be added (Novec 649)
  - Air cooled equipment not optimal
- IT manufacturers honoring warrantees
- Mineral Oil inconvenience
- Novec 649 – expensive
- Lacking business model (e.g. who provides tank and related systems?)

In summary, liquid immersion cooling offers a very low cost cooling solution but there are some barriers to overcome.

There is growing interest in this technology

High Performance Computing will likely be early adopters



Questions?

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