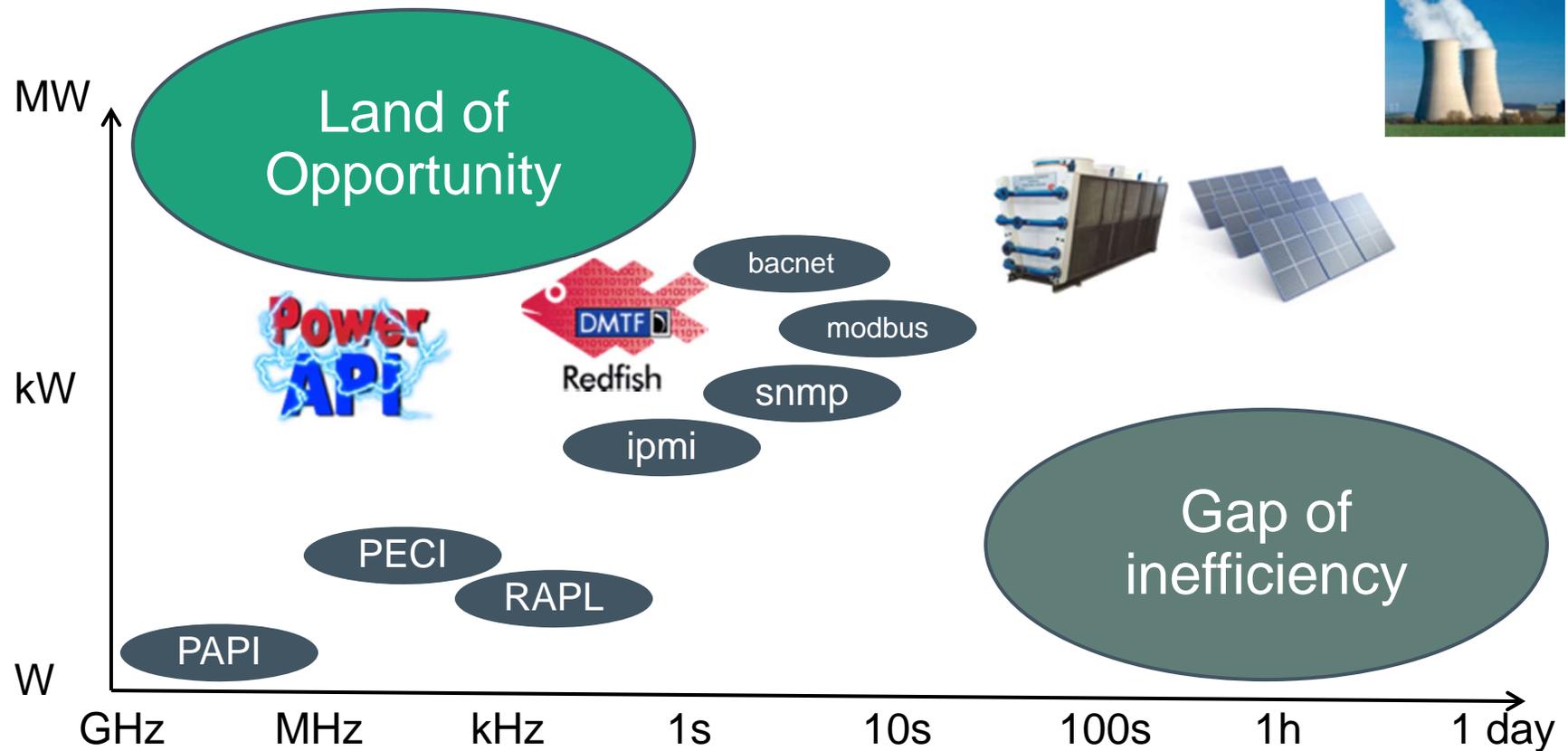


Dynamic Liquid Cooling BoF

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Monitoring and Controls – an overview



Apollo 8000 System Technologies

Intelligent Cooling Distribution Unit

- 320 KW power capacity
- Scaled redundancy with row level control
- Active vacuum system monitors for leaks

Dry-disconnect servers

- 100% water cooled components
- Designed for serviceability

Management infrastructure

- HPE iLO4, IPMI 2.0 and DCMI 1.0
- Rack-level Advanced Power Manager

Warm water

- Closed secondary loop in CDU
- Isolated and open facility loop

Power infrastructure

- Up to 80kW per rack
- Four 30 - 32A 3-phase 380-480VAC

Raised Floor



Open door view of 4 f8000, redundant iCDU racks and underfloor plumbing kit

Goldstone Monitoring

ALERT SUMMARY

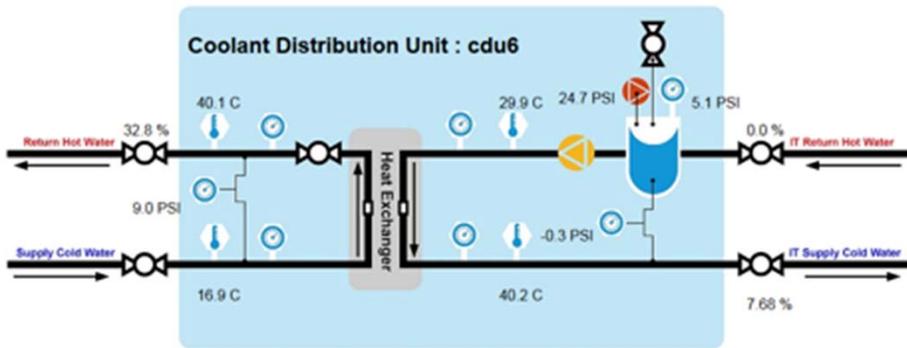
cdu1	CBB7	CBB8	CBB9	cdu2	CBB10	CBB11	cdu3	CBB12	cdu4	CBB13
CBB14	CBB15	cdu5	CBB16	CBB17	cdu6					

HP-Logo

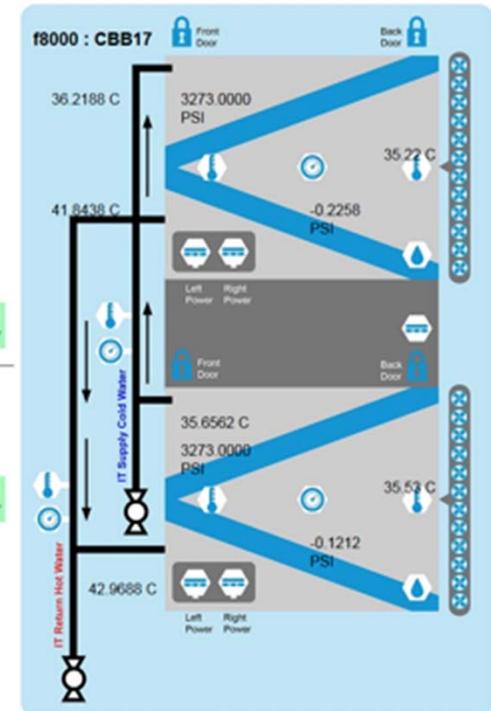
ALERT SUMMARY

cdu1	CBB7	CBB8	CBB9	cdu2	CBB10	CBB11	cdu3	CBB12	cdu4	CBB13
CBB14	CBB15	cdu5	CBB16	CBB17	cdu6					

HP-Logo



BMS is Offline	High H2O Alarm	CDU Leak Alarm	Modbus Offline	Tank Overflow	VFD Alarm	Low H2O Alarm	Low Pump Diff PSI
High Pump Diff PSI	High Fac In PSI	High Fac Out PSI	Iso Valve Won't Open	Rotation Fail Alarm	Iso Valve Won't Close	Mid Vac Tank Level Warn	Vac PSI Leak Alarm
CDU Critical	CDU Warning	Low Vac PSI Alarm	Vac Pump Run Long	Low Fac Diff PSI	Vac Pump Lockout	VFD Lockout	



CBB17HI

Door #0 Sensor	Door #1 Sensor	
Leak #0 Detector	Leak #1 Detector	Leak #2 Detector

CBB17LO

Door #0 Sensor	Door #1 Sensor	
Leak #0 Detector	Leak #1 Detector	Leak #2 Detector

ESIF High Performance Computing Data Center

PUE: lights & plugs 9.96 + cooling 2.67 + pumps 7.10 + HVAC 4.71 + IT Equipment 714.58 = **1.034**

ERE: lights & plugs 9.96 + cooling 2.67 + pumps 7.10 + HVAC 4.71 + IT Equipment 714.58 - re-use 195.60 = **0.760**

fan power: 0.0 0.0 0.0 0.0 KW

water to top: 29 100 100 100 %

tower status: ON ON OFF OFF

A	B	C	D
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Outside Roof
 Thermosyphon
 Air Temperature: 7.1 C
 Relative Humidity: 52.1 %

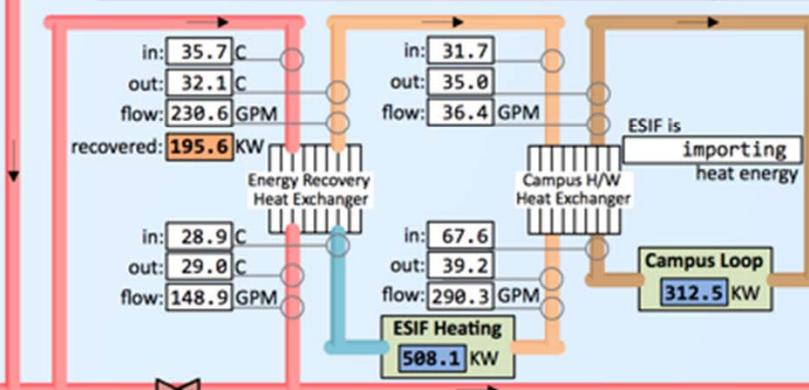
Data Center Cooling Towers 16.7 C

ceiling air: 34.3 F
Hot Air Plenum

HPC Datacenter

Peregrine Cooling Distribution Units										
	10	9	8	7	6	5	4	3	2	1
in:	23.0	23.1	23.3	23.1	24.0	24.0	23.9	22.9	18.2	18.6
out:	33.2	34.8	35.4	34.2	37.7	37.1	35.8	37.7	36.4	36.6

input water:	64.8	65.5
output water:	23.9	23.3
coil flow:	12.9	13.1
coil pump power:	0.4	0.4
air in temp:	30.0	27.8
air out temp:	20.2	20.1
fan power:	2.1	2.1
heat energy captured:	82.5	69.3



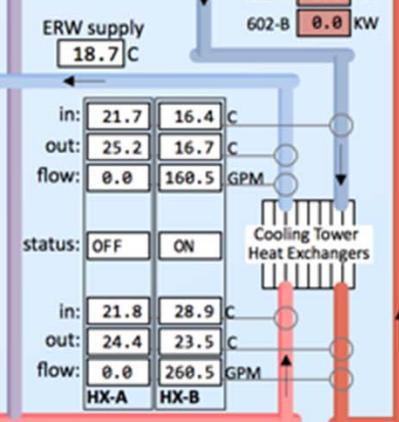
35.4 C ERW pre energy recovery

CLOSED bypass valve

2nd Floor Mechanical

604-A 1.9 KW
604-B 0.0 KW

28.4 C ERW post energy recovery



4th Floor Mechanical
 as of Tue Nov 17 09:34:57 MST 2015

Next generation ultra-efficient HPC system

In production at the DoE National Renewable Energy Laboratory (NREL)



 **Hewlett Packard**
Enterprise

- The first HPC data center dedicated solely to advancing energy systems integration, renewable energy research, and energy efficiency technologies
- **New ultra-energy-efficient, petascale HPC system**
- \$1 million in annual energy savings and cost avoidance through efficiency improvements
- Petascale (one million billion calculations/ second)
- Average PUE of 1.06 or better
- Source of heat for ESIF's 185,000 square feet of office and lab spaces, as well as the walkways
- 1MW of data center power in under 1,000 sq. ft. => very energy-dense configuration
- **Designed to support NREL's mission, address research challenges, reduce risks and accelerate the transformation of our energy system.**

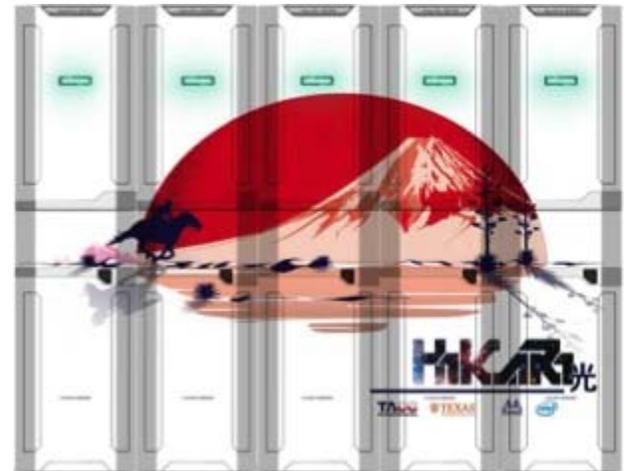
HP Apollo 8000 Hikari Cluster



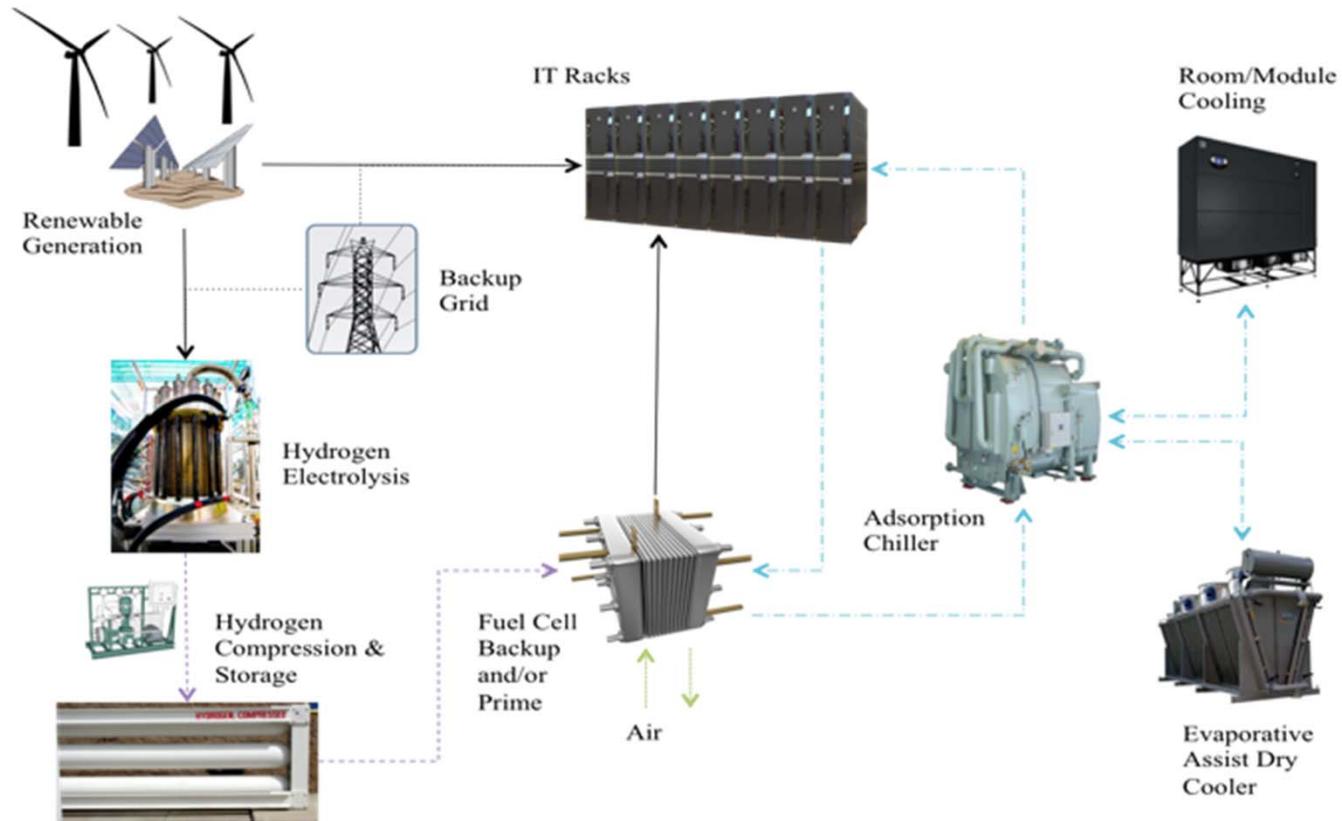
 Hewlett Packard
Enterprise

System Attributes

- 432 HP XL730f Trays (~432 Tflops)
 - HP XL730f E5-2690 Dual Socket
 - 64G HP 8GB 1Rx4 RDIMM
 - 120GB M.2 Storage
 - 1:1 EDR Fabric



Towards Carbon-Free Data Centers



Apollo 8000 - Most Innovative Product of 2014



**US Department of Energy
2014 Sustainability Award**