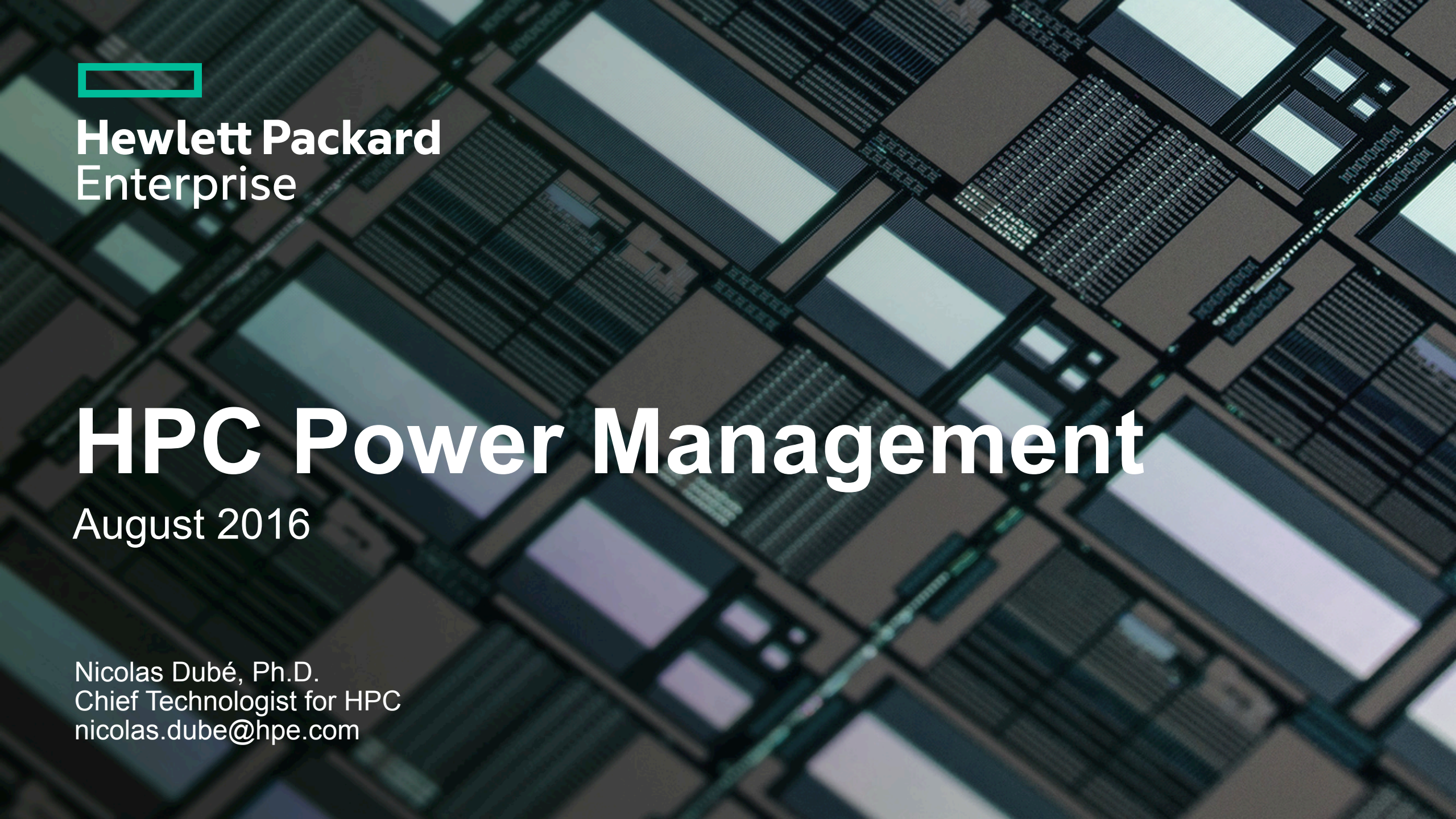

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HPC Power Management

August 2016

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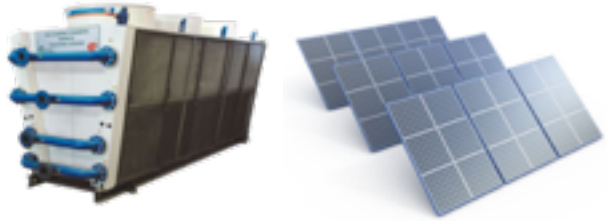
Monitoring and Controls – an overview



MW

kW

W

Land of Opportunity

PowerDAM

Power API

DMTF Redfish

bacnet

modbus

snmp

ipmi

PECI

RAPL

PAPI

Gap of inefficiency

GHz MHz kHz 1s 10s 100s 1h 1 day

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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

Warm water

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

Management infrastructure

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

Power infrastructure

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

Raised Floor

Open door view of 4 Apollo 8000, redundant iCDU racks and underfloor plumbing kit

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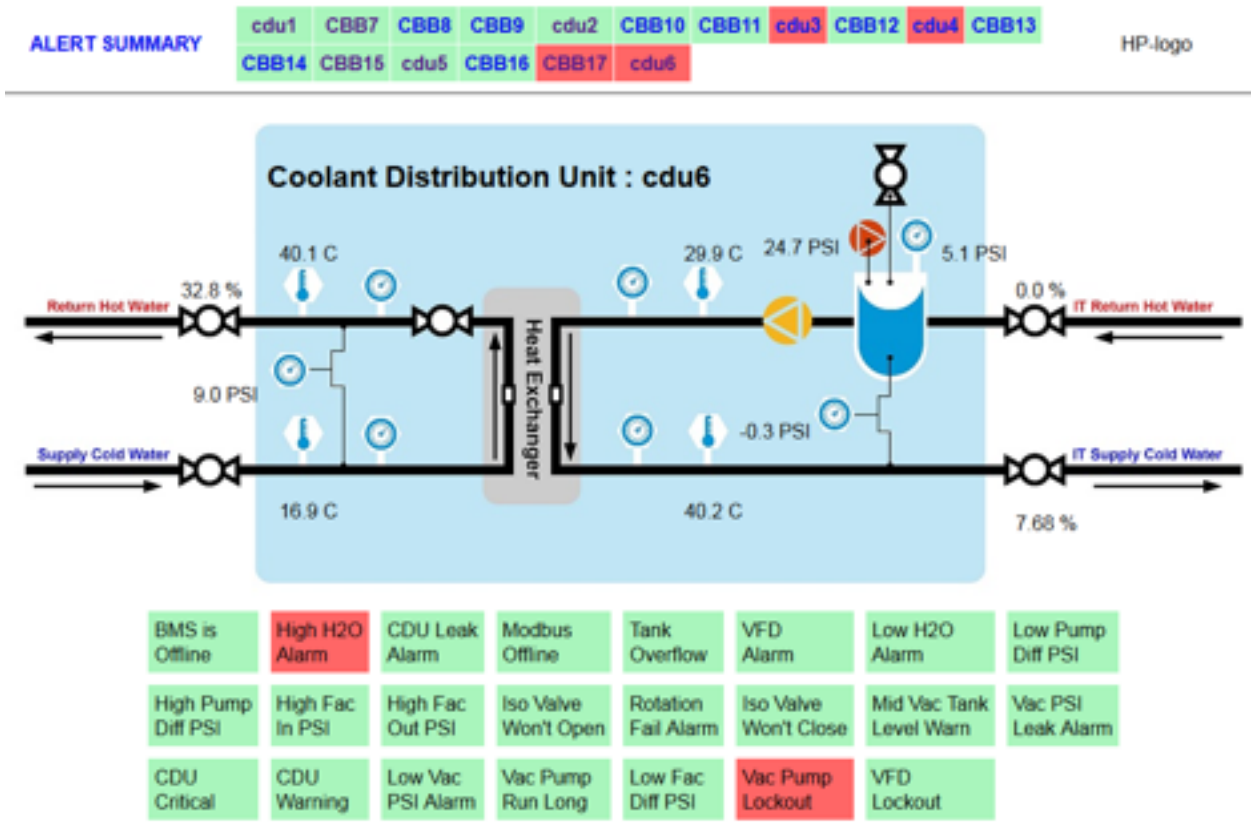
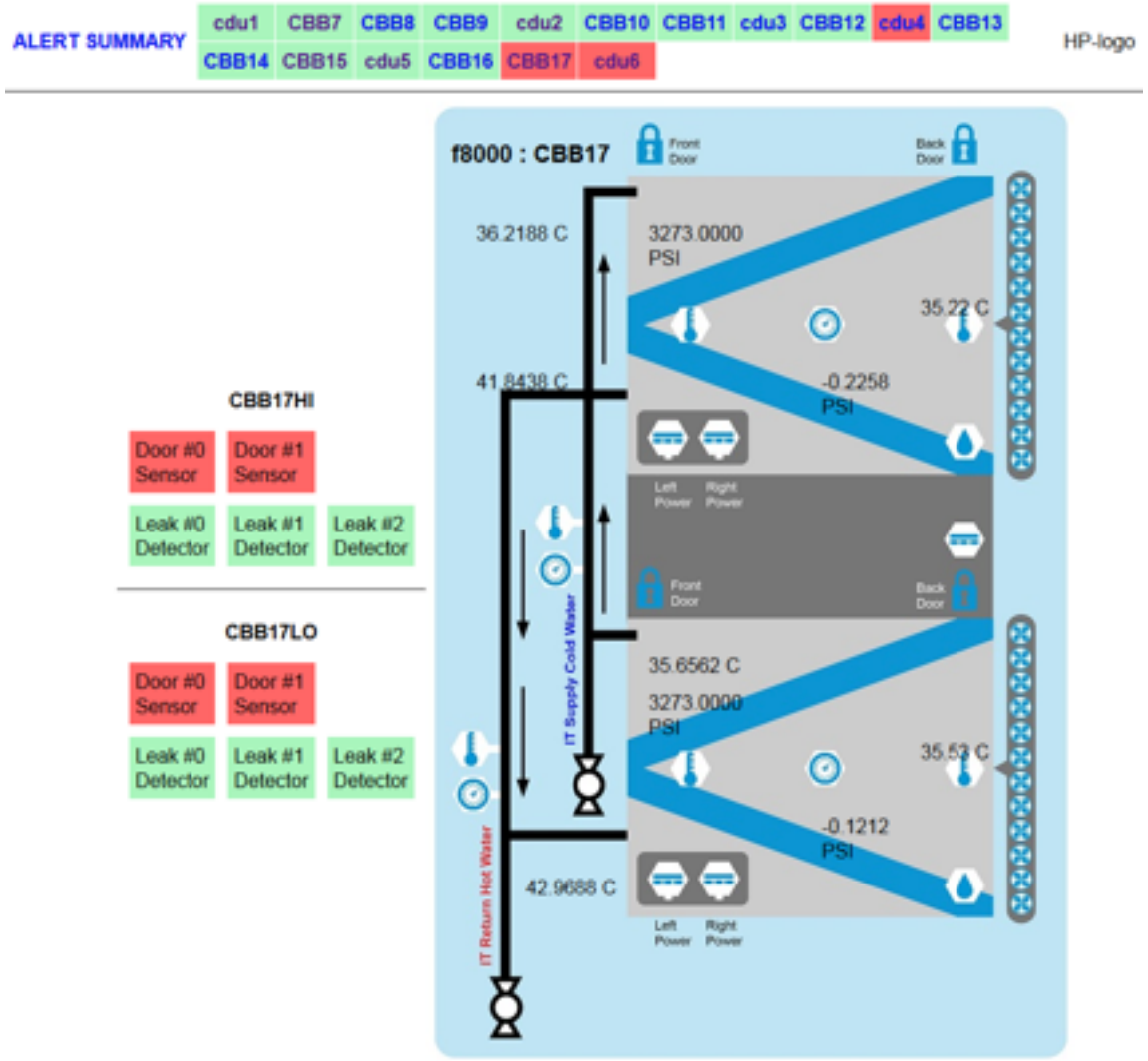
Apollo 8000 System Monitoring





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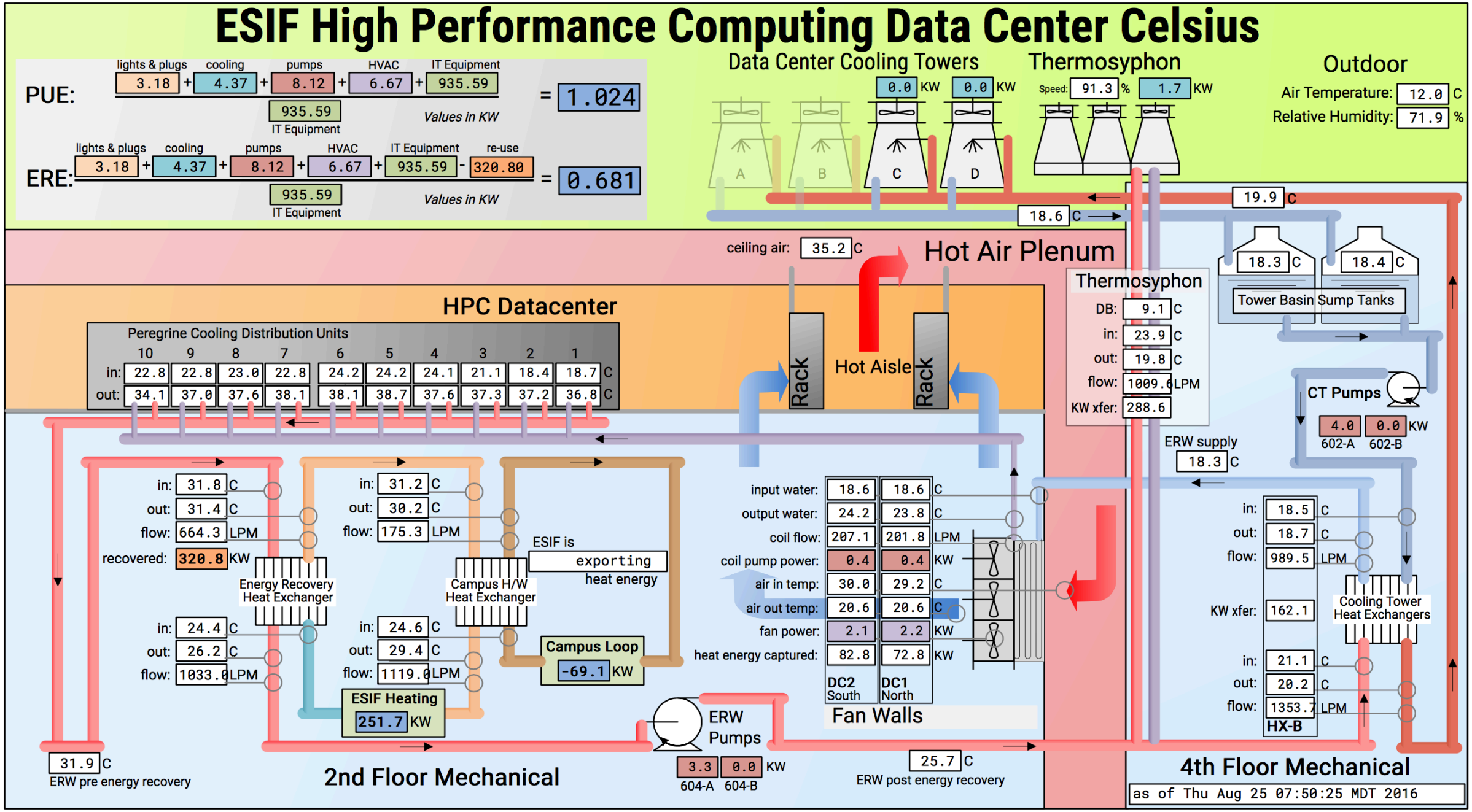
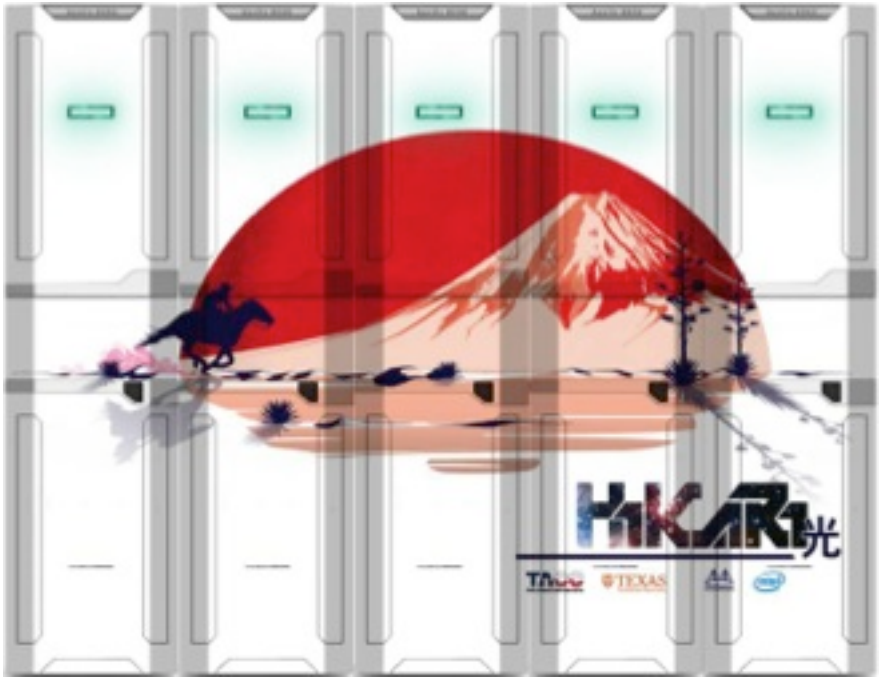
Live monitoring dashboard: http://hpc.nrel.gov/COOL/index2.html



HP Apollo 8000 Hikari Cluster @ TACC – Solar Powered

HVDC 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



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TEXAS NEDO Demonstration Project

The University of Texas at Austin

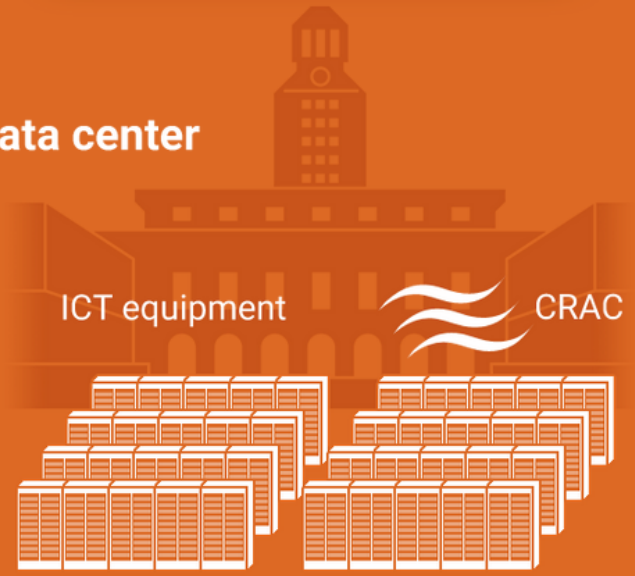
New Energy and Industrial Technology Development Organization

171 kW supplied

13 kW received

380VDC

Data center



Utility

Solar panel

Power conditioner

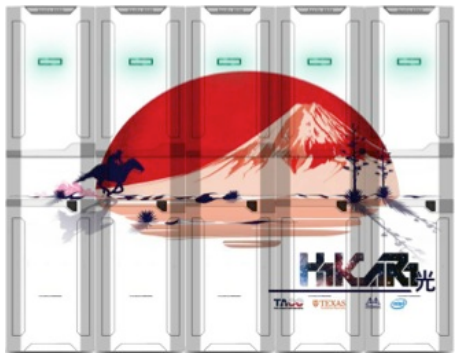
Lithium ion battery

AC

DC

151 kW generated

HPC Systems and Datacenter integration: key take aways



- Various sub-systems use different protocols
  - CPUs, GPUs: PAPI, PECI, RAPL
  - Servers, Racks: ipmi, ilo, snmp, redfish
  - CDUs, Pumps, Facility: bacnet, modbus, proprietary
- Build monitoring and controls interfaces as “products”
  - Standardize and support the common case
- Enable leading sites with open interfaces
  - Feed back into product as it evolves

- Energy efficiency wish list:
  - Build hierarchical monitoring/management/control system
  - Drop little ARM cores (think rPi) everywhere
  - 100% fanless liquid cooled infrastructure
  - HVDC power distribution
  - NVM device with capacity/bandwidth/latency comparable to DRAM
  - Commoditized silicon photonics

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Thanks

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Apollo 8000 HPC system

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

- **The first HPC data center dedicated solely to advancing energy systems integration, renewable energy research, and energy efficiency technologies**

- **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**.

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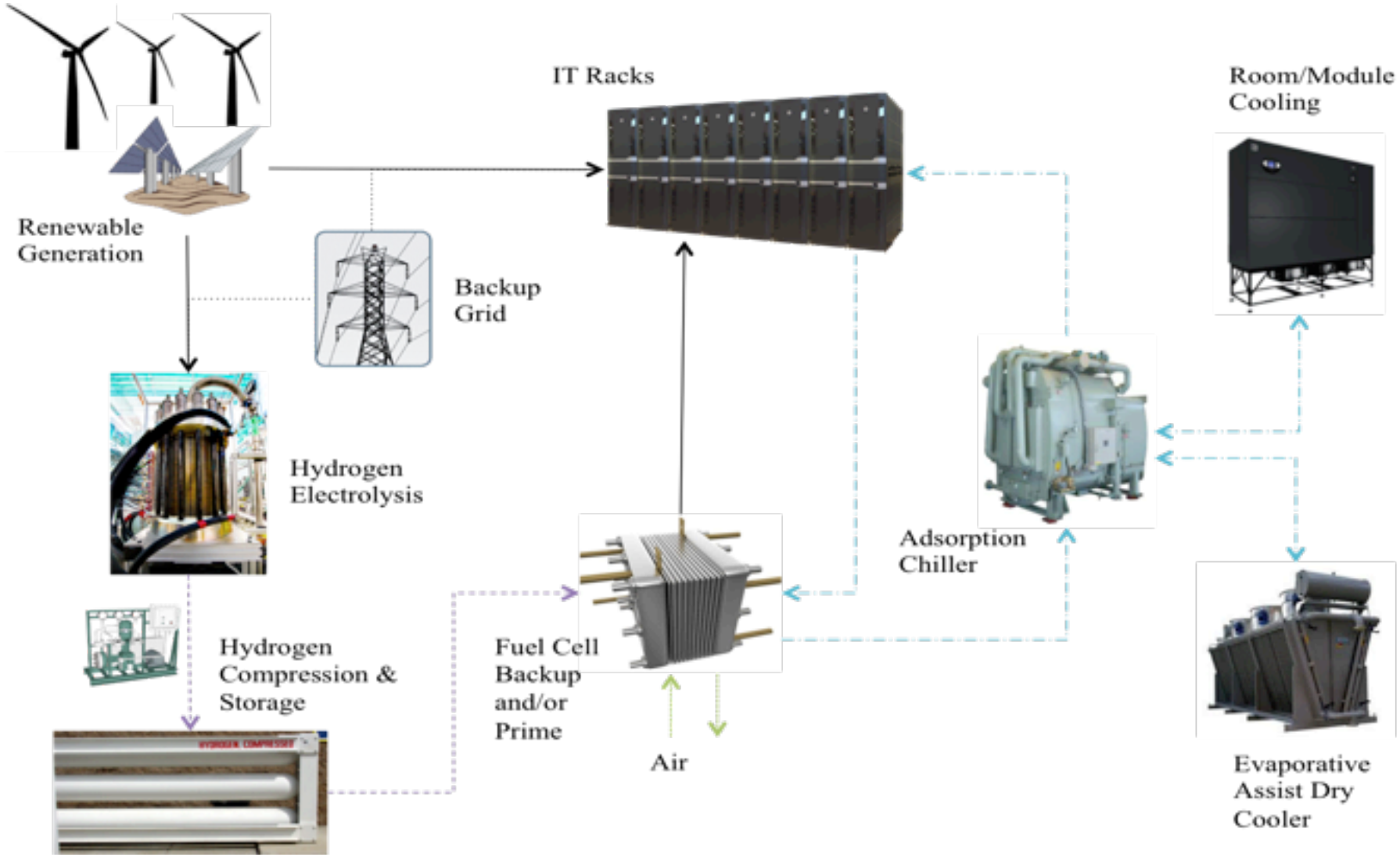
Towards Carbon-Free Data Centers



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Apollo 8000 - Most Innovative Product of 2014

US Department of Energy 2014 Sustainability Award

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