

Re-examining HPC Energy Efficiency Dashboard Elements

Jim Laros on behalf of the authors,
12th IEEE Workshop on High-
Performance Power-Aware Computing,
27 May 2016

Re-examining HPC Energy Efficiency Dashboard Elements

Bates, N., Hsu. C.H., Imam N., Wilde T., Sartor D

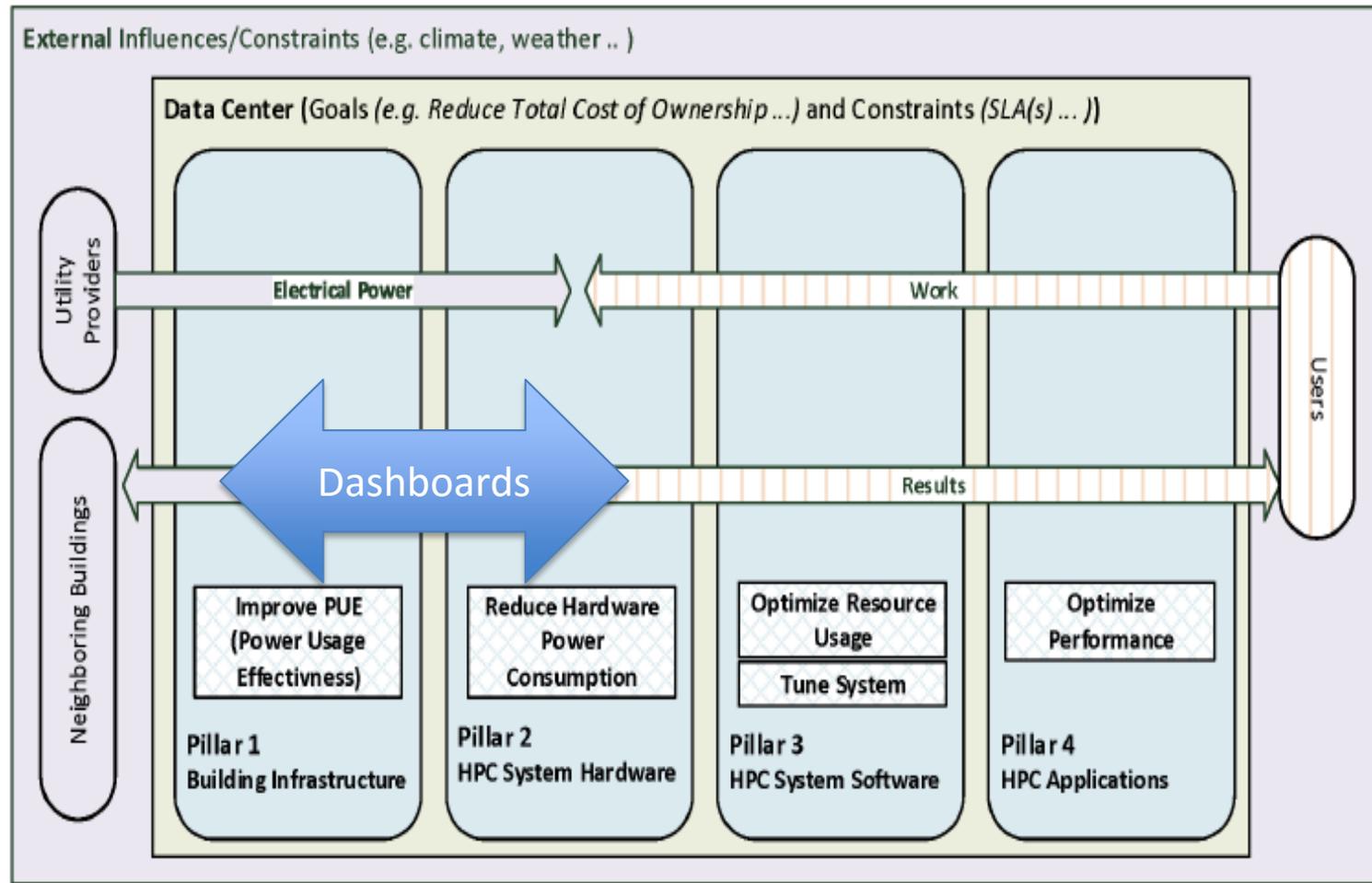
12th IEEE Workshop on High-Performance Power-Aware Computing (HPPAC), 27 May 2016

Held in conjunction w/IEEE International Parallel and Distributed Processing Symposium

Energy Efficient HPC Working Group

- Dashboard: an “easy to read” display used to convey actionable information
- Stakeholder specific
 - Director
 - Facilities Manager
 - System Manager

Data Center High Level Inputs and Outputs



Open Access 4 Pillar Framework Paper: <http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s00450-013-0244-6>

Director: High Priority Metrics

Total energy (kWh) of the HPC Center
Energy cost (\$) of the HPC Center
Total power (kW) of the HPC Center
Total cost of ownership (\$)
HPC system(s) utilization (%)
Total energy (kWh) of the HPC systems
Power usage effectiveness (index)
HPC system efficiency (workload* output/Watt)
*workload is site defined



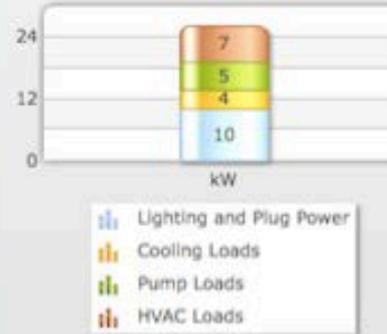
ESIF - Data Center PUE Display (Daily)

Power Usage Effectiveness (PUE) is the ratio of total amount of power used by a computer data center facility to the power delivered to computing equipment.

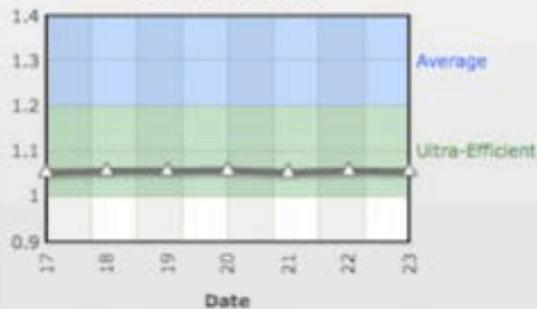
Instantaneous PUE 1.05

Average PUE (Annual) 1.06

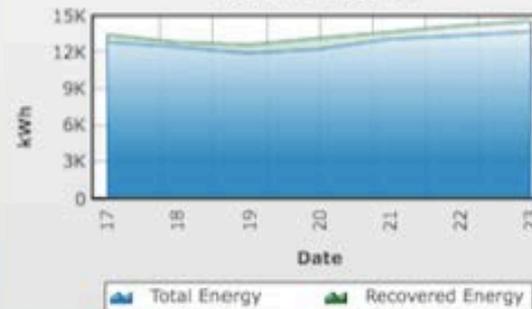
Power Breakout



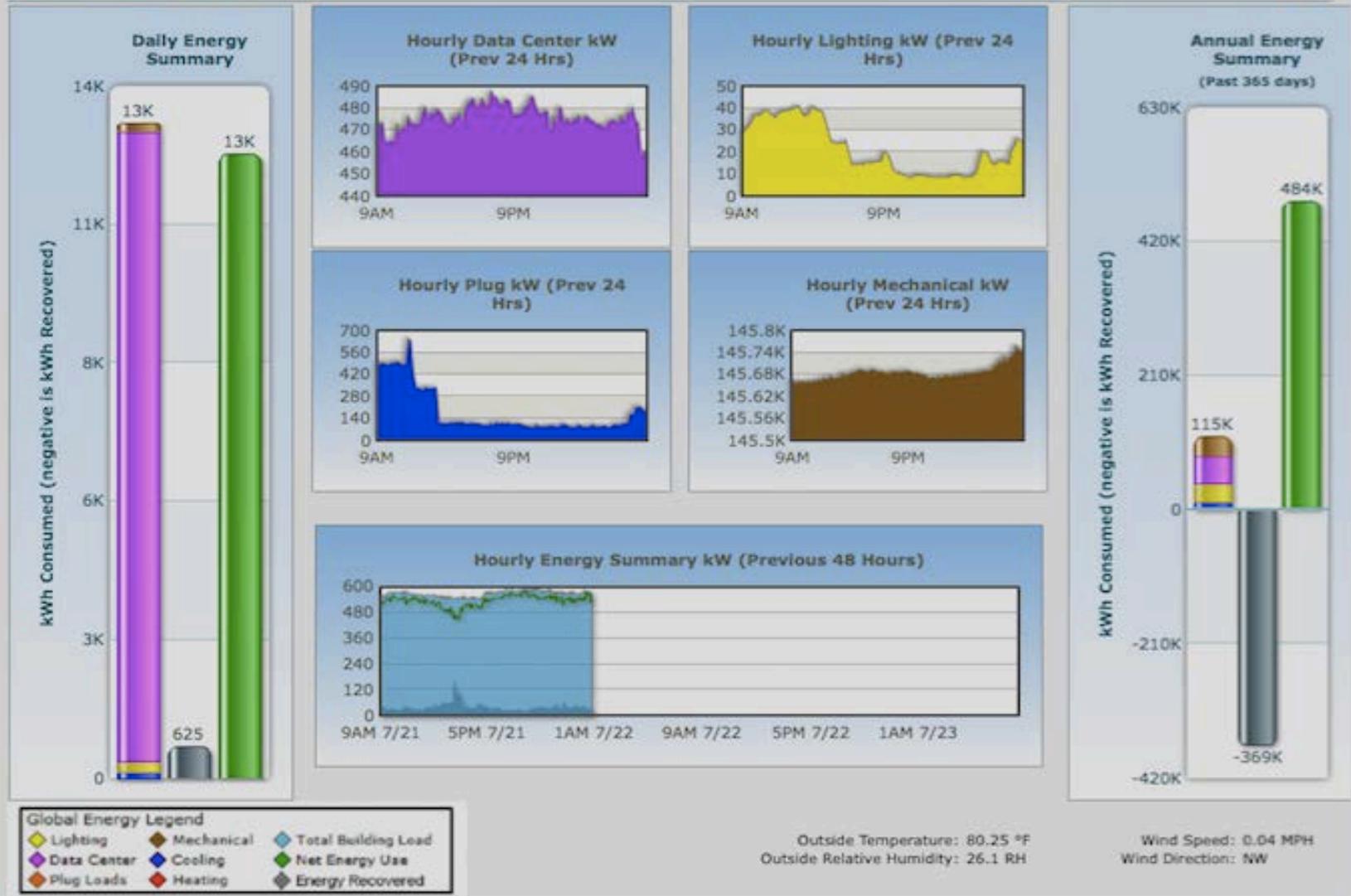
Daily PUE (Previous 7 Days)



Total and Recovered Energy (Previous 7 Days)



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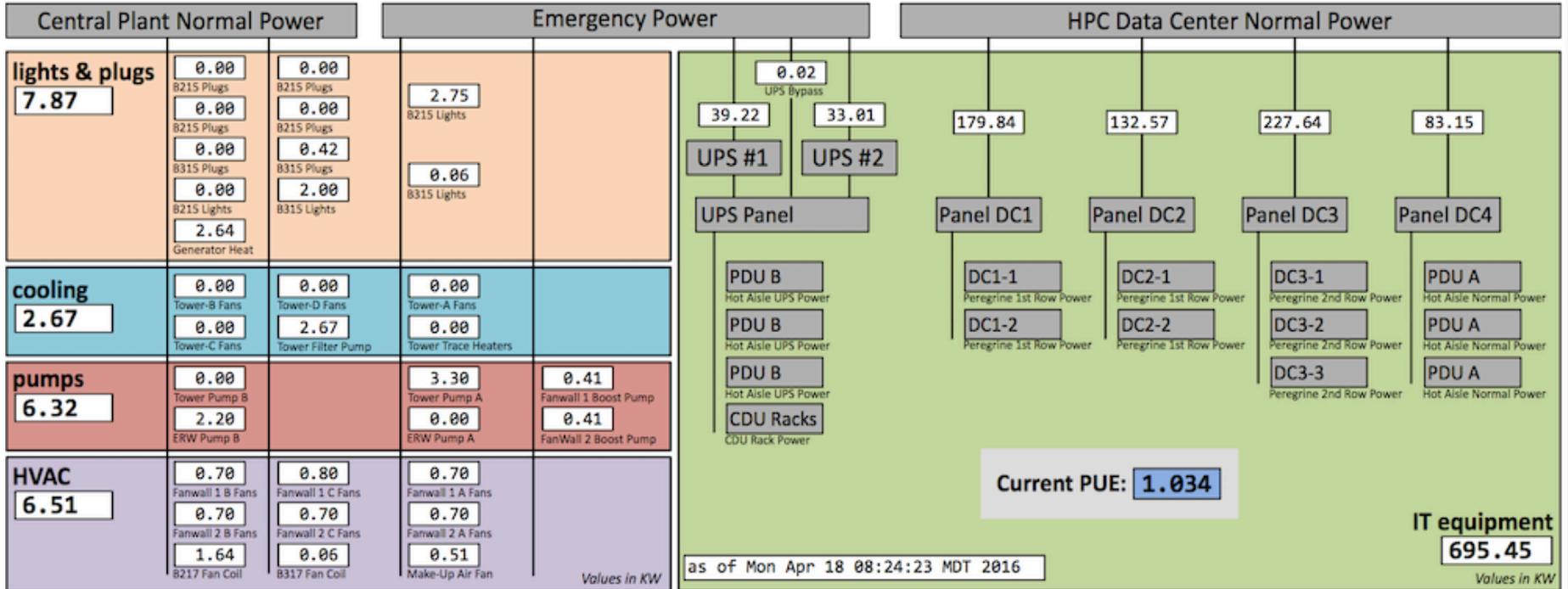


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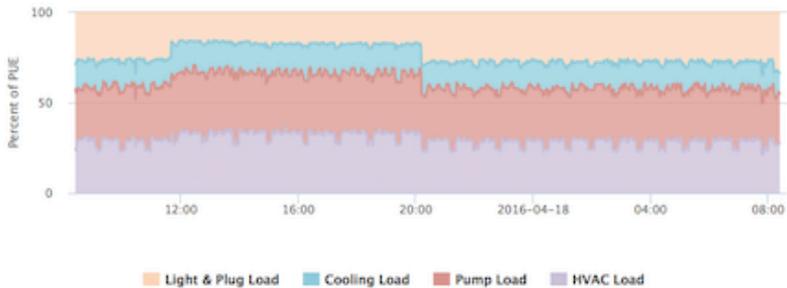
Facility Manager: High Priority Metrics

Maximum power (kW) of the HPC center
Cooling energy (kWh)
Total energy (kWh) of the HPC center
Cooling efficiency (kW/ton)
Maximum IT power (kW)
Water usage effectiveness (L/kWh)
Water cooling plant efficiency (kW/ton)
Water cooling plant load (btuh or ton)
Chiller power (kW) and energy (kWh)
Total IT energy (kWh)
Water cooling supply water temperature (degrees F or C)
Power usage effectiveness (index)
UPS input / output maximum power (kW)
Transformer input/output power (kW) and energy (kWh)

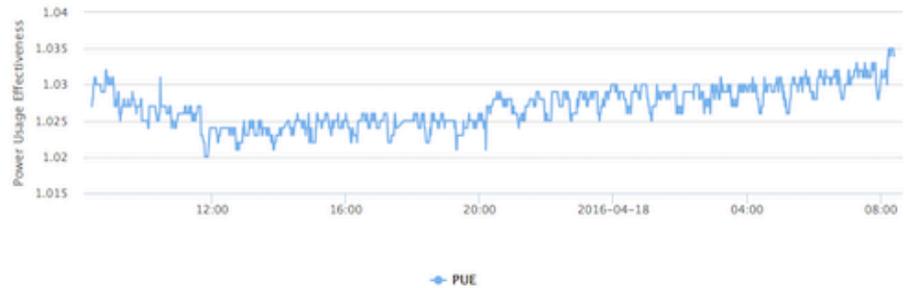
ESIF High Performance Computing Data Center Power Usage Effectiveness



ESIF HPC Data Center PUE Contributors



PUE Recent History



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ESIF High Performance Computing Data Center Celsius

PUE: lights & plugs (5.82) + cooling (3.57) + pumps (6.62) + HVAC (5.09) + IT Equipment (818.21) = **1.026**

ERE: lights & plugs (5.82) + cooling (3.57) + pumps (6.62) + HVAC (5.09) + IT Equipment (818.21) - re-use (228.0) = **0.747**

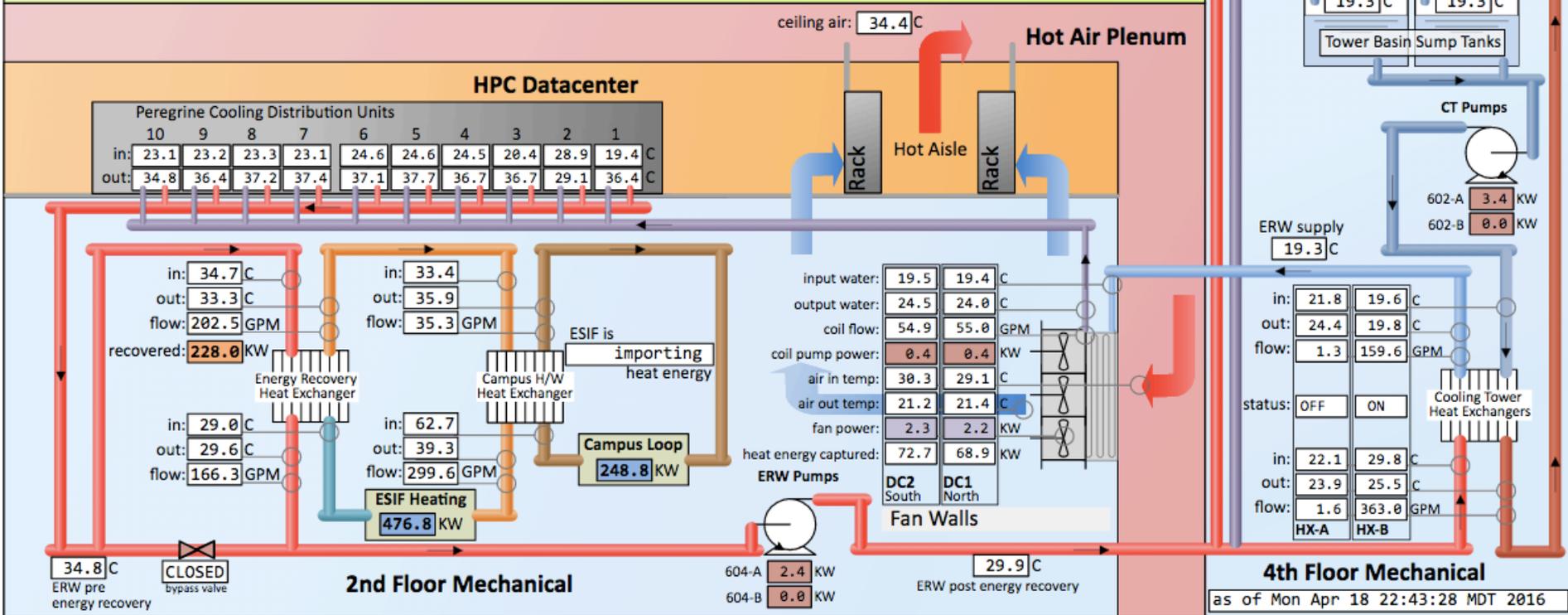
Values in KW

fan power: 0.0 0.0 0.4 0.5 KW
 water to top: 100 100 100 100 %
 tower status: OFF OFF ON ON

A	B	C	D
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Outside Roof
 Air Temperature: 2.7 C
 Relative Humidity: 65.4 %

Data Center Cooling Towers



System Manager: High Priority Metrics

HPC compute system utilization (%)
IT systems (e.g., compute, storage, network) power (kW) and energy (kWh)
Maximum IT power (kW)
Total IT energy (kWh)
Server virtualization (percent)
IT efficiency where workload is site defined (workload output/W)
Energy cost per workload unit of measure (kWh per unit, e.g., kWh/Flop)

Looking forward...

- ERE and iTUE/TUE
- iTUE/TUE



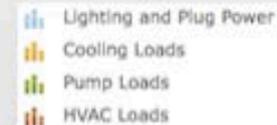
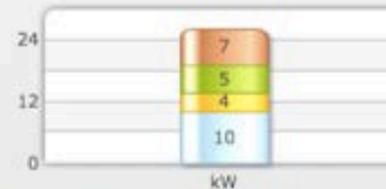
ESIF - Data Center ERE Display (Daily)

Energy Reuse Effectiveness (ERE) is the ratio of total amount of power used by a computer data center facility (minus recovered energy) to the power delivered to computing equipment.

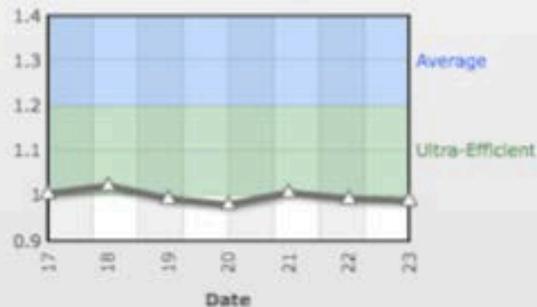
Instantaneous ERE 1.01

Average ERE (Annual) 1.03

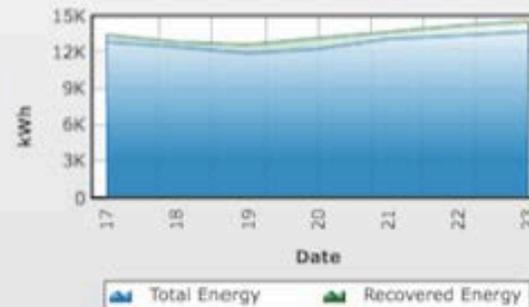
Power Breakout



Daily ERE (Previous 7 Days)



Total and Recovered Energy (Previous 7 Days)



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Future Metrics: TUE and iTUE

DRAFT Technical Requirements Document APEX 2020

LBNL, LANL, SNL

http://www.lanl.gov/projects/apex/_assets/docs/APEX2020_draft_tech_specs_v2.0.pdf

- Description of parasitic power losses within Offeror's equipment, such as fans, power supply conversion losses, power-factor effects, etc. For the computational and storage subsystems separately, give an estimate of the total power and parasitic power losses (whose difference should be power used by computational or storage components) at the minimum and maximum **iTUE**, which is defined as the ratio of total equipment power over power used by computational or storage components. Describe the conditions (e.g. "idle") at which the extrema occur.

Energy Efficient HPC Working Group

Insights:

- Dashboard elements are different for each stakeholder and their importance might change over time.
- Some elements (like Energy cost per workload unit of measure) are more difficult to measure.
- Some elements (like Total Cost of Ownership) are more difficult to measure in 'real-time.'
- Some elements (like IT utilization) might be individual to each system

Further discussion...

HPM 2016

**HPC Power Management:
Knowledge Discovery**

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The Second Workshop on HPC Power Management: Knowledge Discovery

**Thursday, August 25, 2016 9am – 5:30pm
Baltimore, Maryland**

<http://hpm.ornl.gov/>

Thank you!

<http://eehpcwg.llnl.gov>

natalie.jean.bates@gmail.com

Back-up

Energy Efficient HPC Working Group

Director: High Priority Metrics and Frequency of Use

	1x/yr or less	1x/yr<x <1x/mo	1x/mo or more	Never, rarely
Total energy (kWh) of the HPC Center	0%	0%	88%	13%
HPC system(s) utilization (%)	0%	13%	88%	0%
Total energy (kWh) of the HPC systems	0%	0%	88%	13%
Total power (kW) of the HPC Center	13%	13%	75%	0%
Energy cost (\$) of the HPC Center	0%	29%	57%	14%
Power usage effectiveness (index)	0%	38%	50%	13%
HPC system efficiency (workload* output/Watt)	13%	13%	50%	25%
Total cost of ownership (\$)	50%	25%	13%	13%
*workload is site defined				

Facility Manager: High Priority Metrics and Frequency of Use

	1x/yr or less	1x/yr<x<1x/mo	1x/mo or more	Never, rarely
Water cooling supply water temperature	0%	14%	86%	0%
Total energy (kWh) of the HPC center	0%	17%	67%	17%
Maximum IT power (kW)	17%	17%	67%	0%
Chiller power (kW) and energy (kWh)	0%	0%	67%	33%
Total IT energy (kWh)	0%	17%	67%	17%
Power usage effectiveness (index)	0%	17%	67%	17%
Maximum power (kW) of the HPC center	20%	20%	60%	0%
Cooling energy (kWh)	33%	17%	50%	0%
UPS input / output maximum power (kW)	0%	33%	50%	17%
Water cooling plant efficiency (kW/ton)	14%	0%	43%	43%
Transformer input/output power (kW) and	14%	29%	43%	14%
Cooling efficiency (kW/ton)	0%	33%	33%	33%
Water usage effectiveness (L/kWh)	0%	17%	33%	50%
Water cooling plant load (btuh or ton)	0%	17%	33%	50%

System Manager: High Priority Metrics and Frequency of Use

	1x/yr or less	1x/yr<x <1x/mo	1x/mo or more	Never, rarely
HPC compute system utilization (%)	13%	0%	88%	0%
IT systems (e.g., compute, storage, network) power (kW) and energy (kWh)	13%	13%	63%	13%
Maximum IT power (kW)	25%	0%	63%	13%
Total IT energy (kWh)	0%	0%	63%	38%
Server virtualization (percent)	25%	0%	50%	25%
IT efficiency where workload is site defined (workload output/W)	14%	14%	43%	29%
Energy cost per workload unit of measure (kWh per unit, e.g., kWh/Flop)	0%	13%	25%	63%

Energy Efficient HPC Working Group

Sartor D, Mahdavi R, Radhakrishnan B, Bates N, et. al., "General Recommendations for High Performance Computing Data Center Energy Management Dashboard Display". 9th Workshop on High-Performance Power-Aware Computing Conference, held in conjunction with the International Parallel and Distributed Processing Computing Symposium. Boston, MA 2013.

<https://eehpcwg.llnl.gov/pages/pubs.htm>