Hewlett Packard Enterprise

# FACETS OF GREEN HPC: CARBON-NEUTRAL SITE OPERATIONS, ENERGY EFFICIENCY AND OVERALL SUSTAINABILITY

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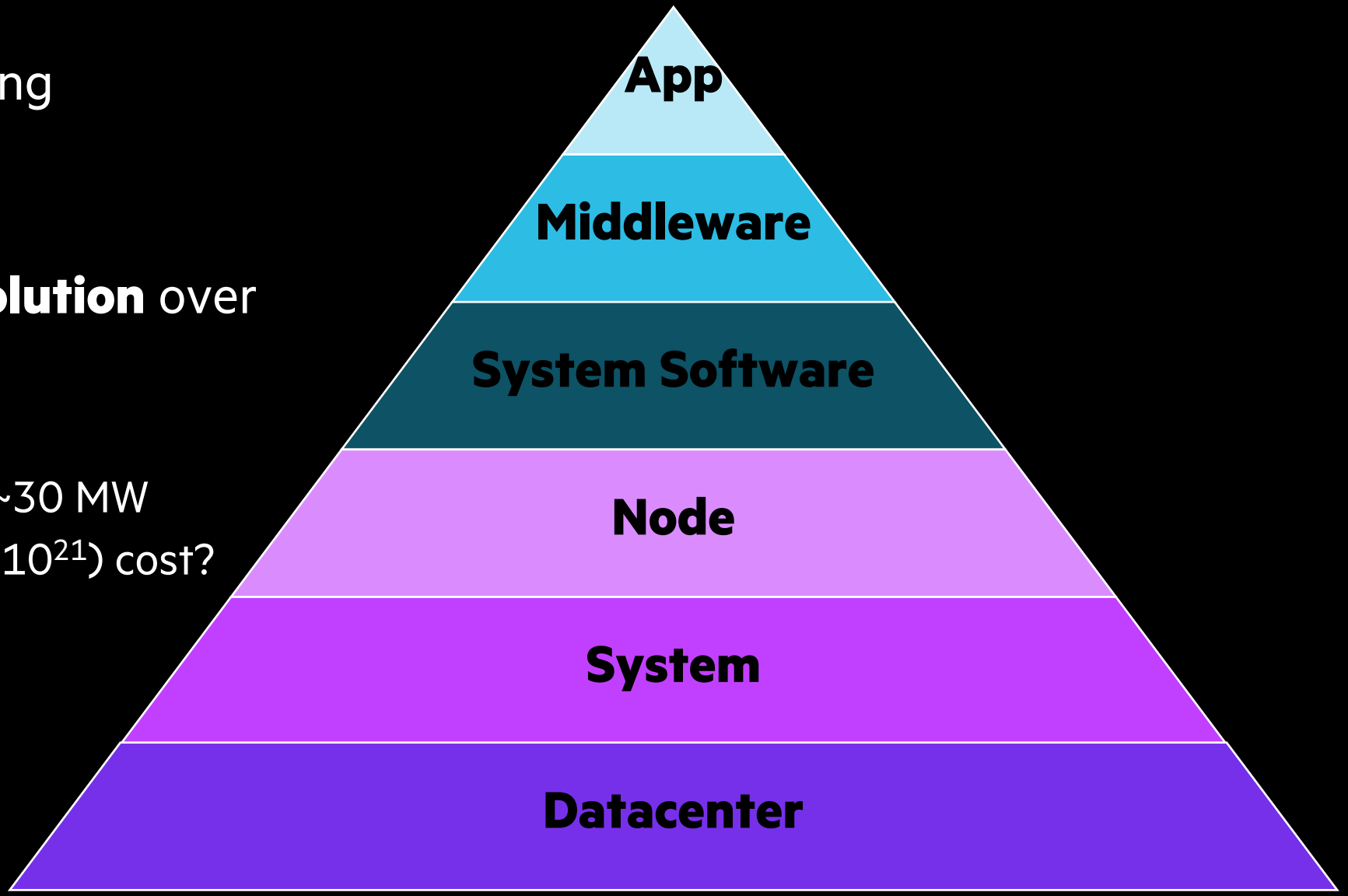
# ENERGY EFFICIENCY

- Energy efficient computing
- green data centers
- carbon neutrality
- prioritizing **energy-to-solution** over time-to-solution

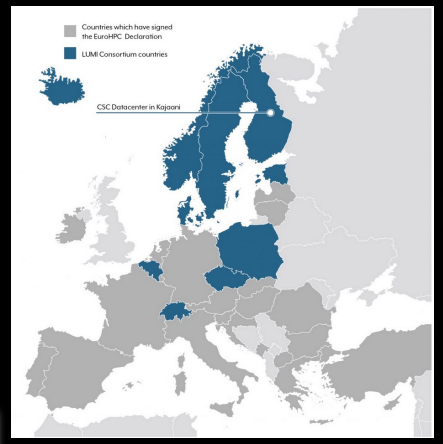
- If ~1.5 Exaflops ($10^{18}$) costs ~30 MW
- How much does a Zettaflop ($10^{21}$) cost?



# LUMI DATACENTER IN KAJAANI

**High end:**

- **Biggest European HPC system**
- **10 partner countries**
- **#3 on June22**
  - **Top500 HPL**
  - **Top500 HPCG**
  - **Green500**

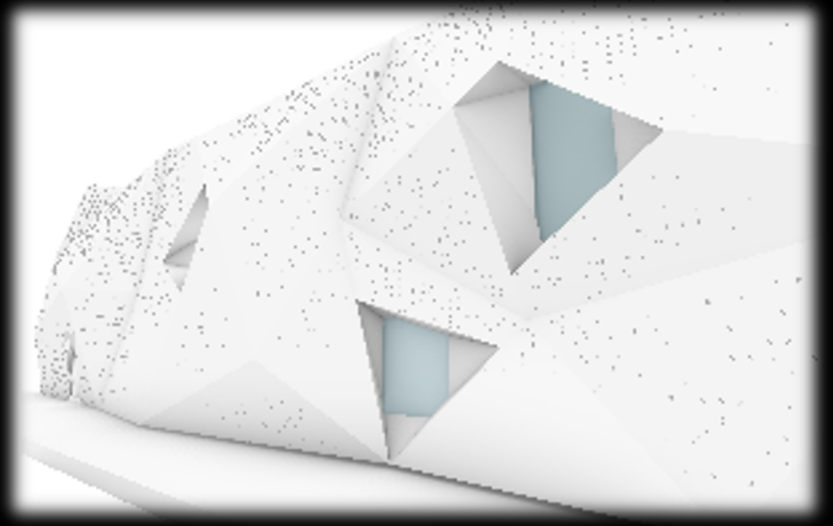



100% hydroelectric energy up to 200 MW

Very reliable power grid: Only one 2 min outage in 38 years

100% free cooling available, PUE 1.03

Waste heat reuse: effective energy price 35 €/MWh, negative $CO_2$ footprint: 13500 tons reduced every year



https://www.lumi-supercomputer.eu/

# FEDERATED COMPUTING ENABLES GREENER IT

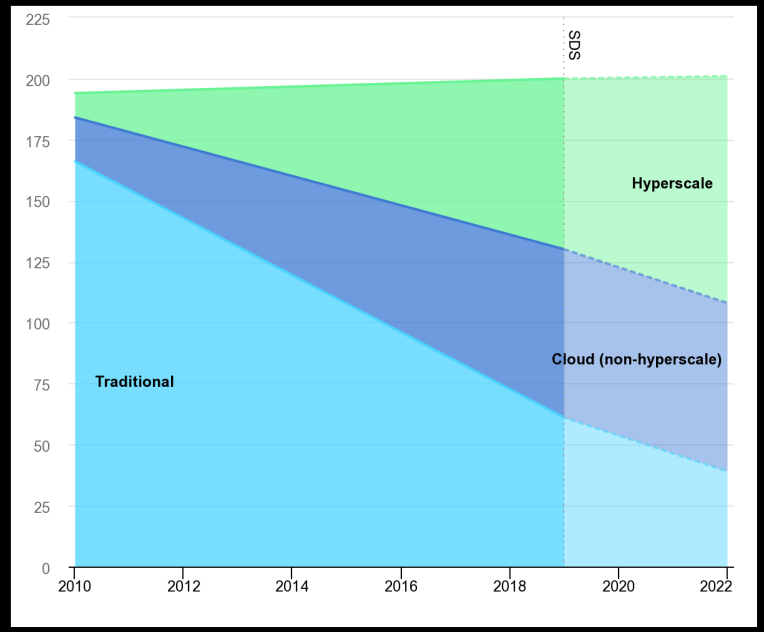
Really?

## Gaia-X and Dataspaces

- Current USPs:
  - Compute near data
  - Vendor agnostic cloud-like computing
  - Trusted computing
  - Composable services
- Green aspects
  - Choose compute resources by ecological criteria
  - Decentralize compute by geographic opportunities
  - Attest Green IT aspects

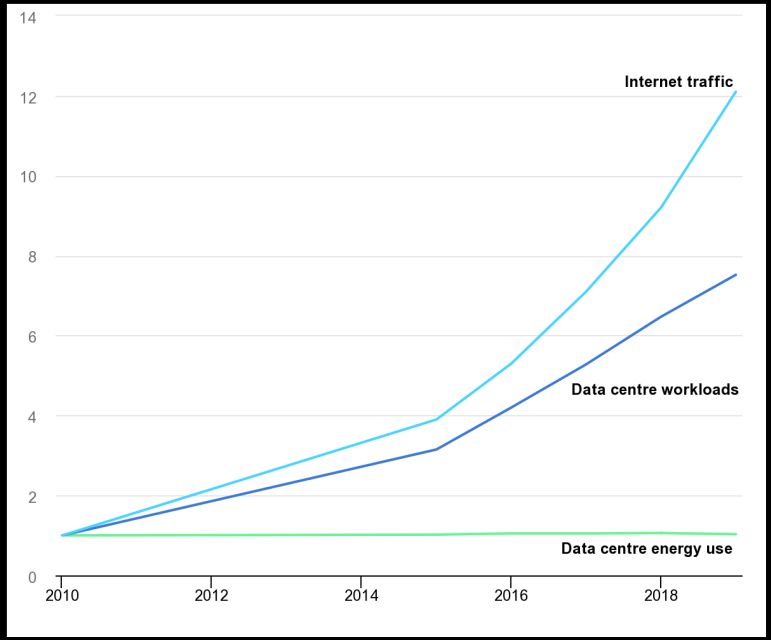
## Worldwide Datacenter Power

- 200 TW (= 4x Switzerland)




## Usage growth by category

- normalized to DC energy use




”How much $CO_2$ do we spend to compute a solution to stop global warming?”

IEA study, 2019/20, last update 2022-03-25 http://iea.org/

# GREENHPC IS NOT JUST ABOUT TCO

- Refuse, Reduce, Reuse, Repurpose, Recycle
- Design for sustainability
- Minimize transport … incl. for recycling
- Grid-interactivity
- Energy consumption

# SUSTAINABILITY BEYOND ENERGY USAGE

## Reduce, Reuse, Recycle

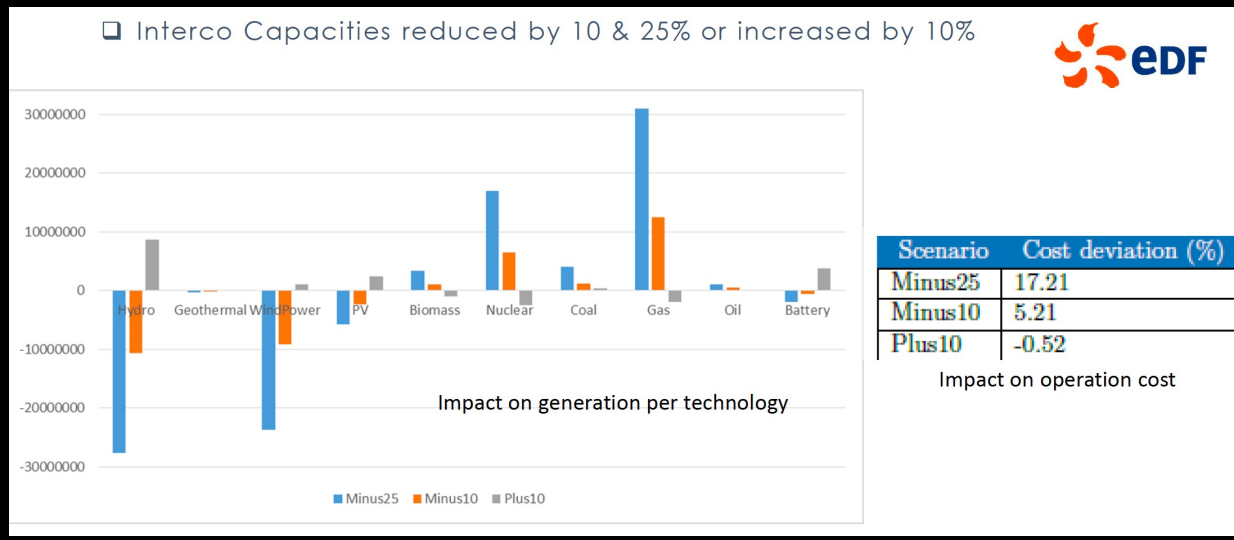
- Sustainability is becoming part of TCO calculation
  - Can become serious part of design space
- Extend hardware lifetime
  - By refurbishing
  - By smarter middleware that can handle degrading components
  - Heterogeneous compute architectures (may) help extend lifetimes of installations
- Use spare cycles
  - This is the original rationale of AWS
  - Edge-to-Cloud paradigm, HPE Greenlake

Key figures:

- 80% of environmental impact influened during design
- 30% of large DC servers are unused
- 73k tons of IT equipment recycled by HPE 2018-2020

## Optimized Energy Network Operations

- Optimization models for short-term (operational), mid-term (planning), long-term (investment) models of multi-energy systems
- Evaluation of how to achieve stability when integration of renewables and power-to-gas happens : Value of Flexibilities



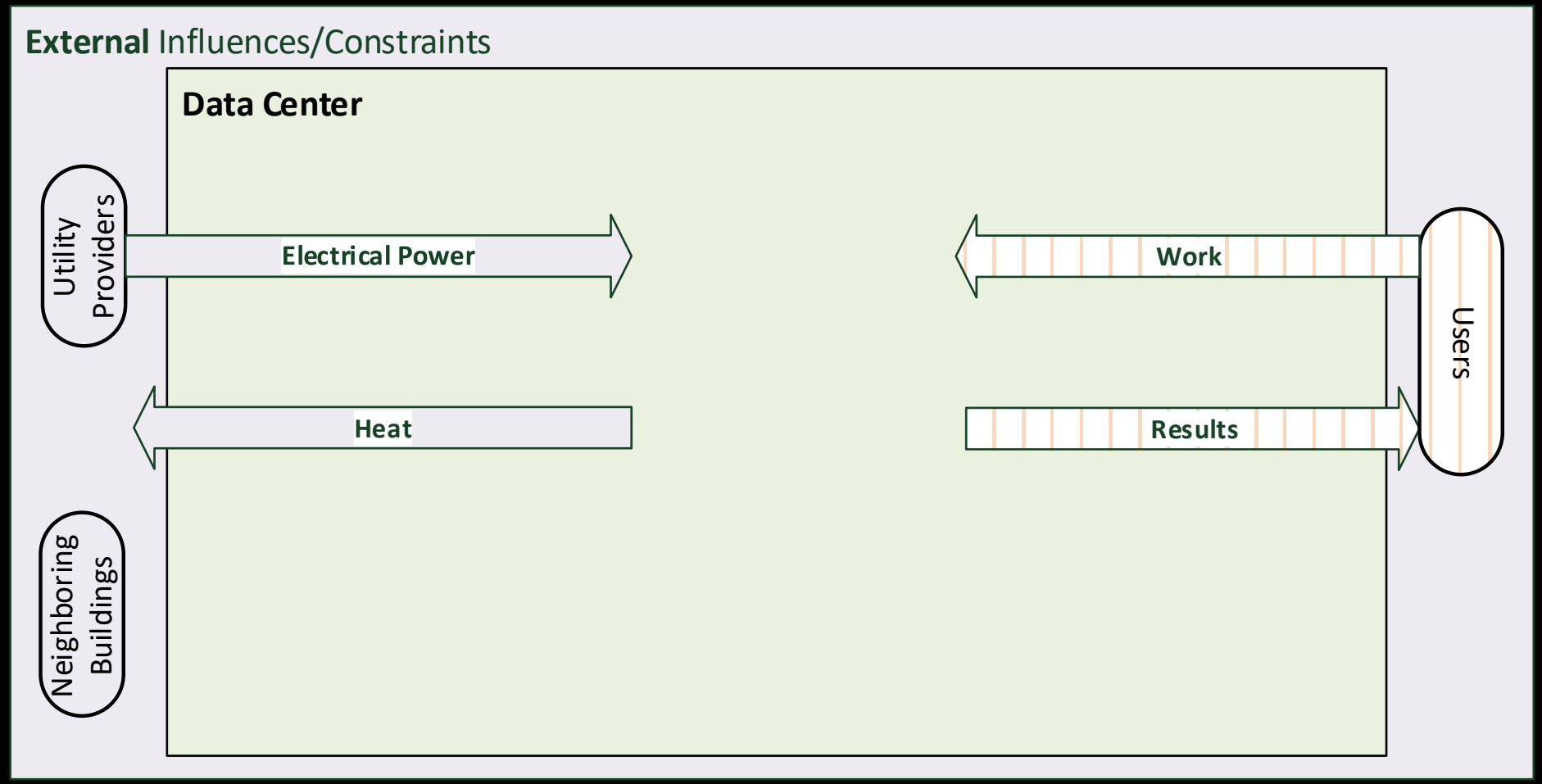

| Scenario | Cost deviation (%) |
|---|---|
| Minus25 | 17.21 |
| Minus10 | 5.21 |
| Plus10 | -0.52 |

Impact on operation cost

https://www.plan4res.eu/

plan4res

# HOLISTIC DATACENTER & OPERATIONAL EFFICIENCY - 4 PILLAR FRAMEWORK




Torsten Wilde: Assessing the Energy Efficiency of High Performance Computing (HPC) Data Centers, Dissertation, Technical University Munich (TUM), 2018, http://nbn-resolving.de/urn/resolver.pl?urn:nbn:de:bvb:91-diss-20180326-1399734-1-7

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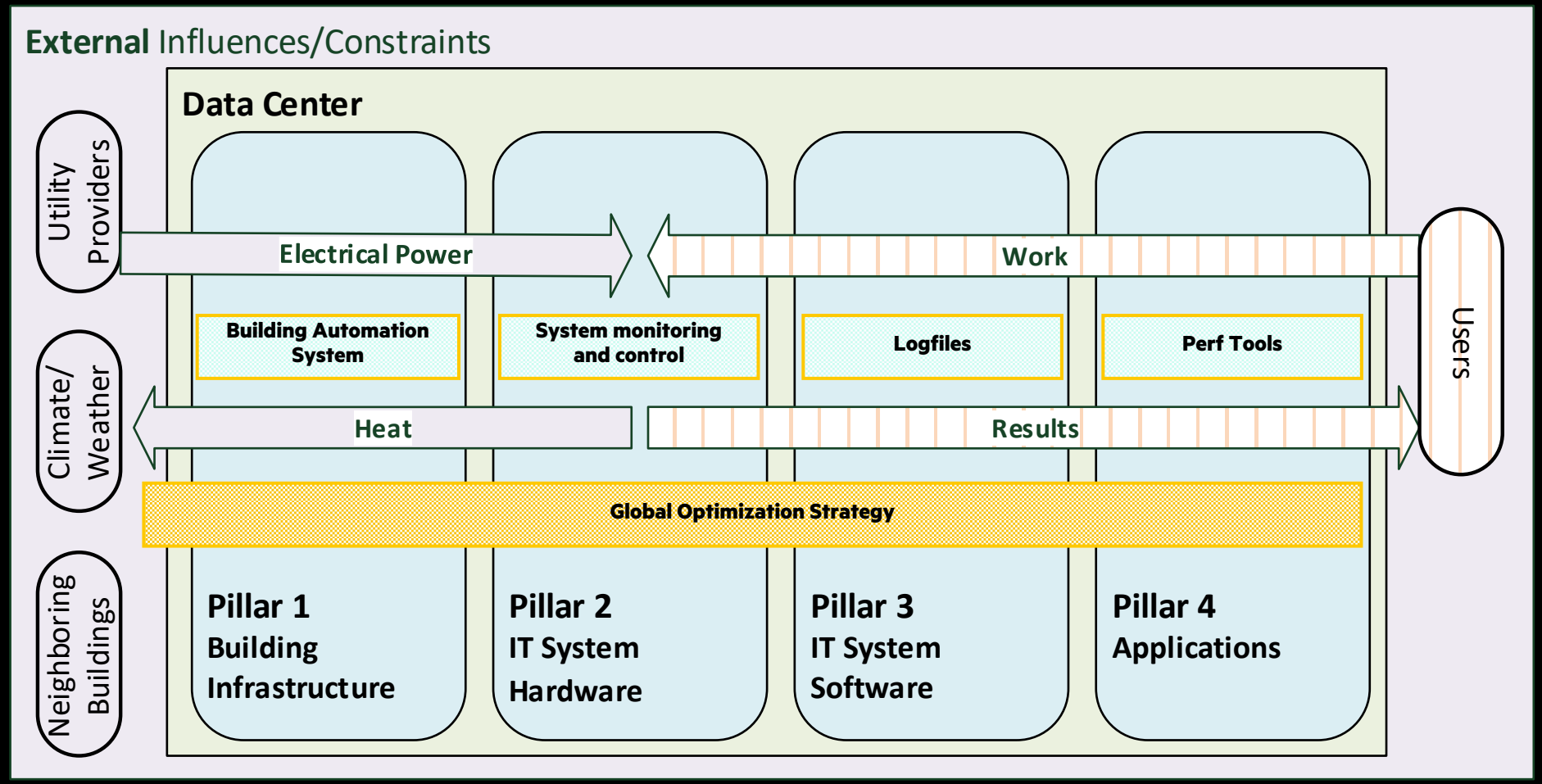

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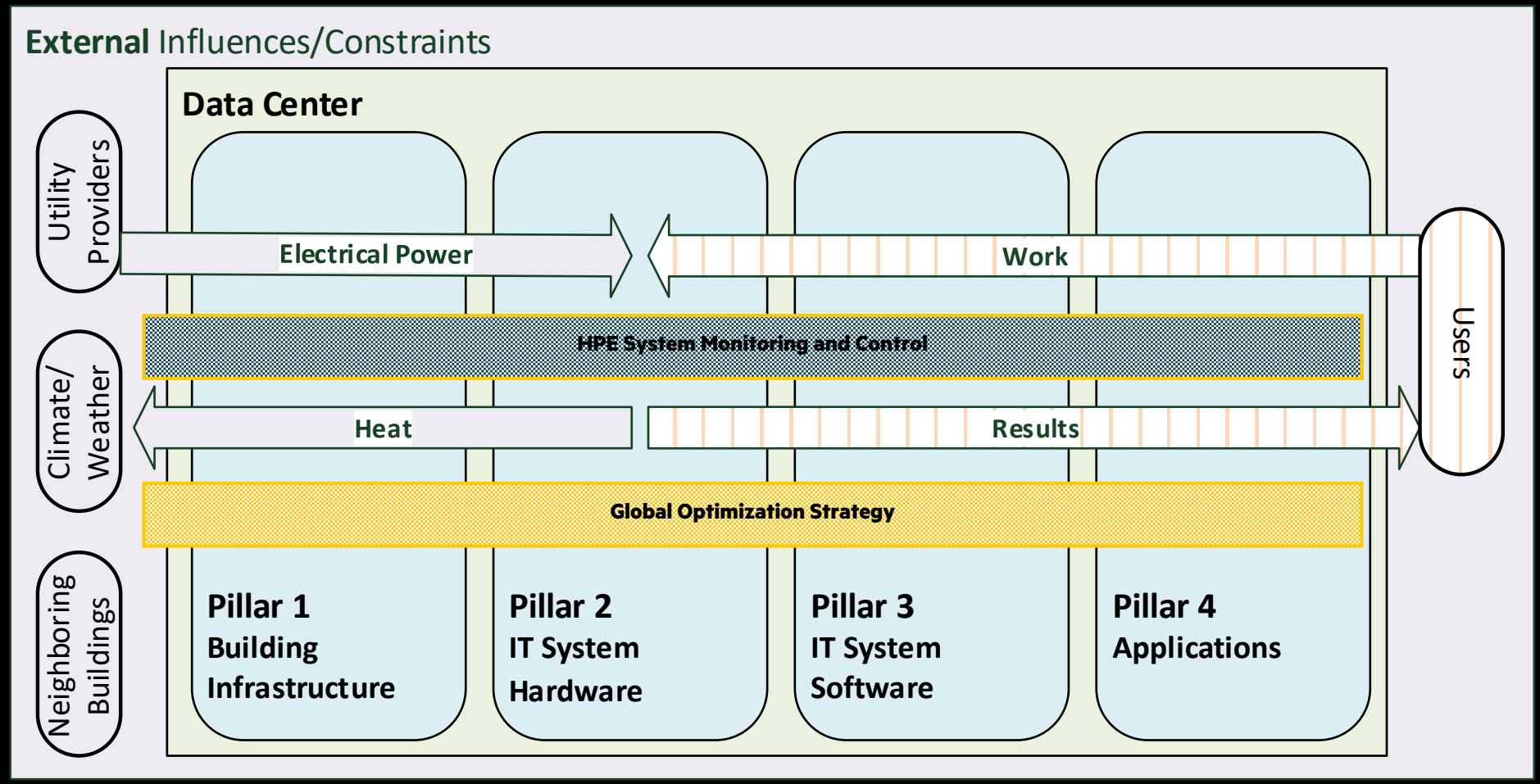
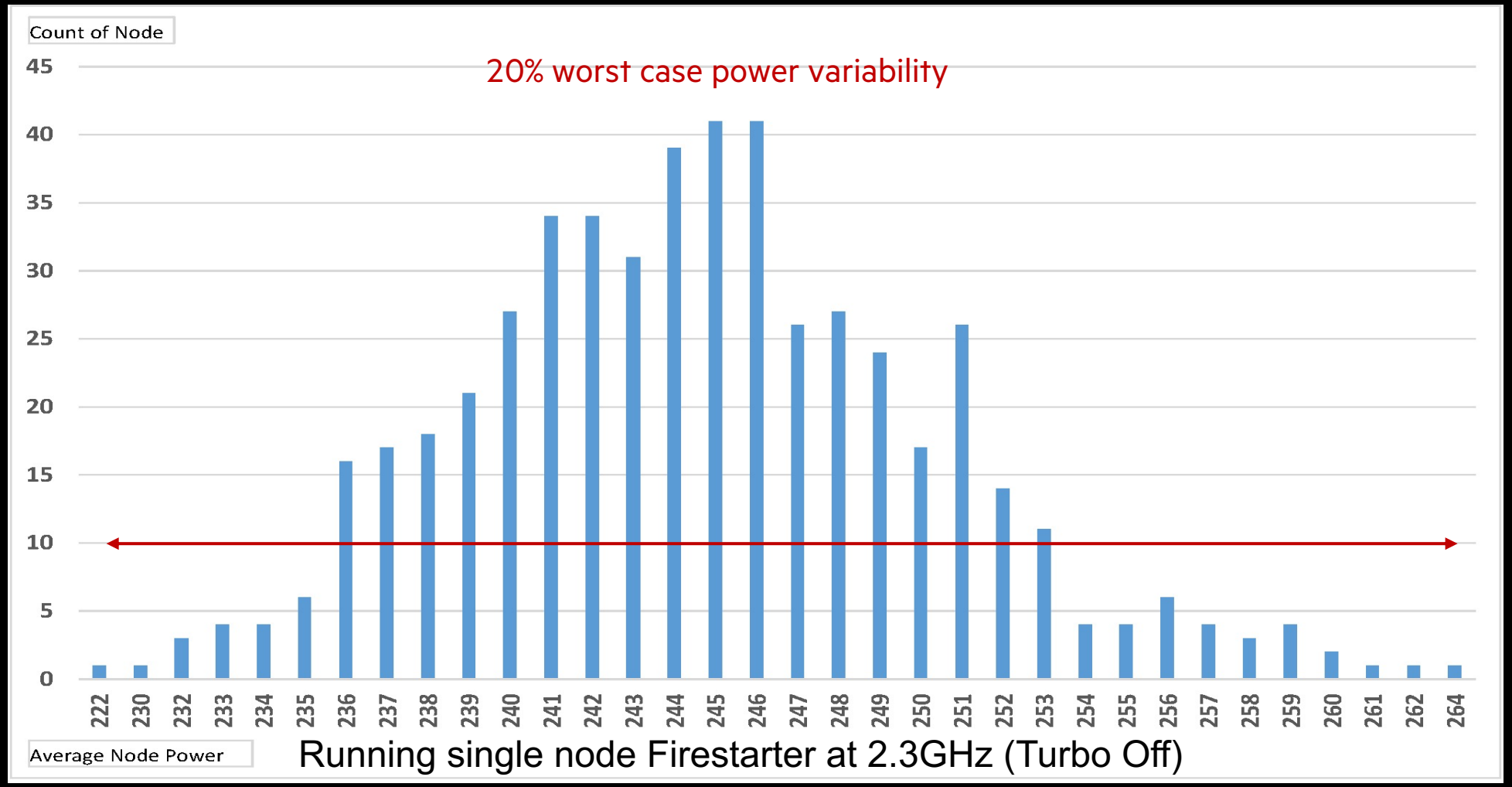
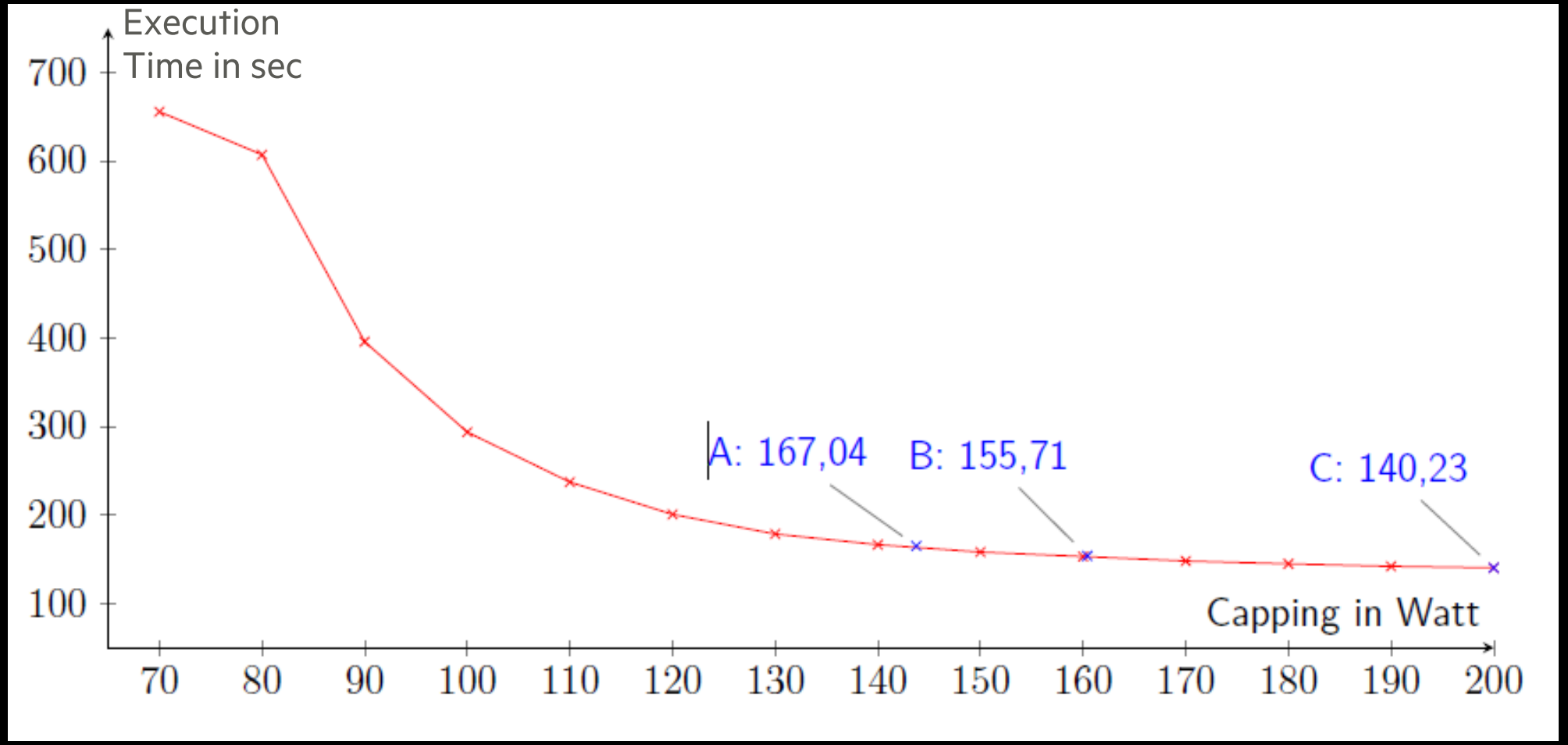


# NODE HISTOGRAM POWER VARIABILITY SUPERMUC PHASE1 (INTEL SANDY BRIDGE-EP XEON E5-2680 8C) – ONE ISLAND (514 NODES)

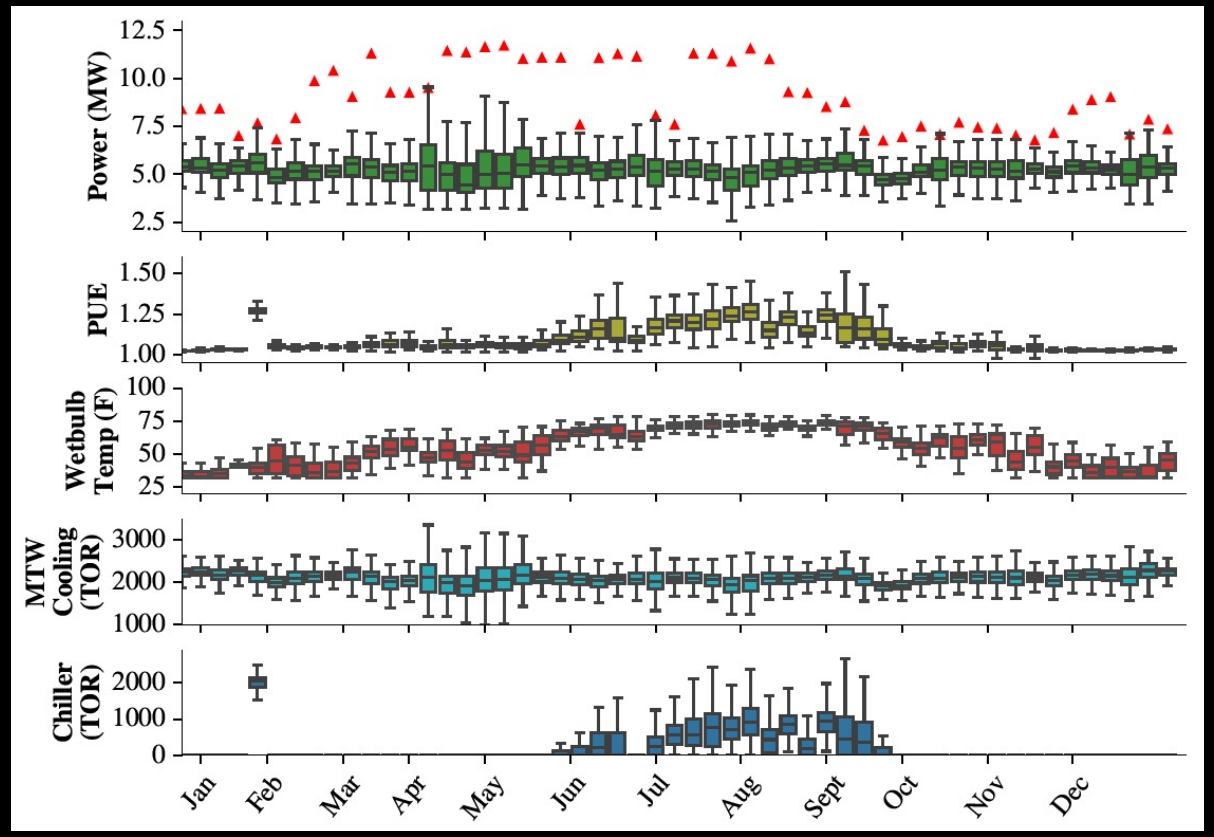


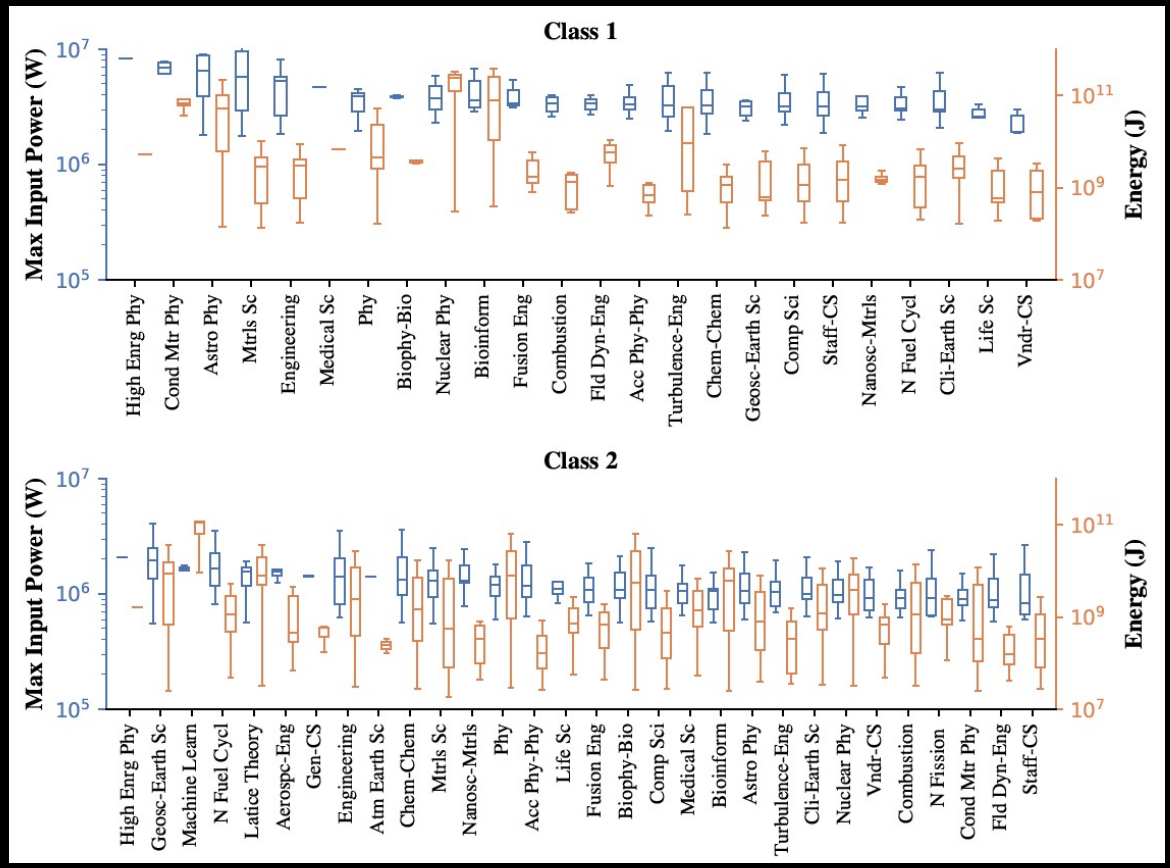

Wilde T., Auweter A., Shoukourian H., Bode A. (2015) Taking Advantage of Node Power Variation in Homogenous HPC Systems to Save Energy. In: High Performance Computing. ISC High Performance 2015. Lecture Notes in Computer Science, vol 9137. Springer, Cham

# RUNNING NAS PARALLEL BENCHMARKS WITH DIFFERENT POWER CAPS ON AMD EPYC 7702



# ORNL SUMMIT AVERAGE POWER BEHAVIOR*



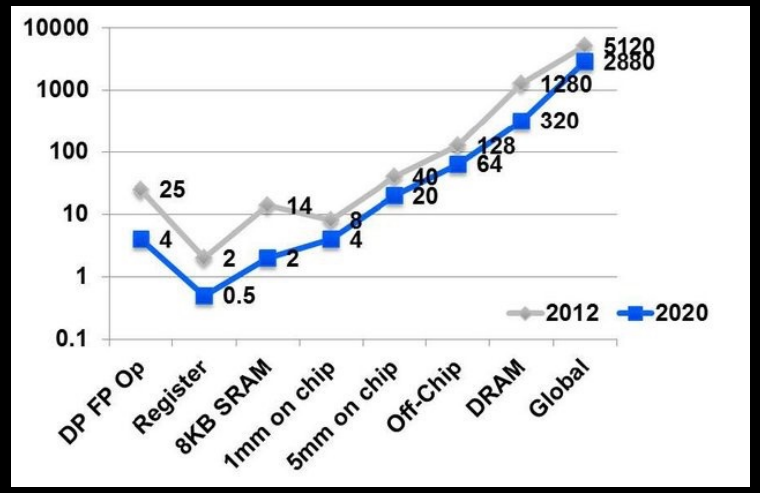




Average power consumption was between 5MW and 6MW with a constant small percentage of extremes that touches both the system idle (2.5MW) and peak (13MW) power consumption throughout the year."

*Woong Shin, Vladyslav Oles, Ahmad M. Karimi, J. Austin Ellis, Feiyi Wang, "Revealing Power, Energy and Thermal Dynamics of a 200PF Pre-Exascale Supercomputer", SC'21, best paper

# DATA MOVEMENT MIDDLEWARES

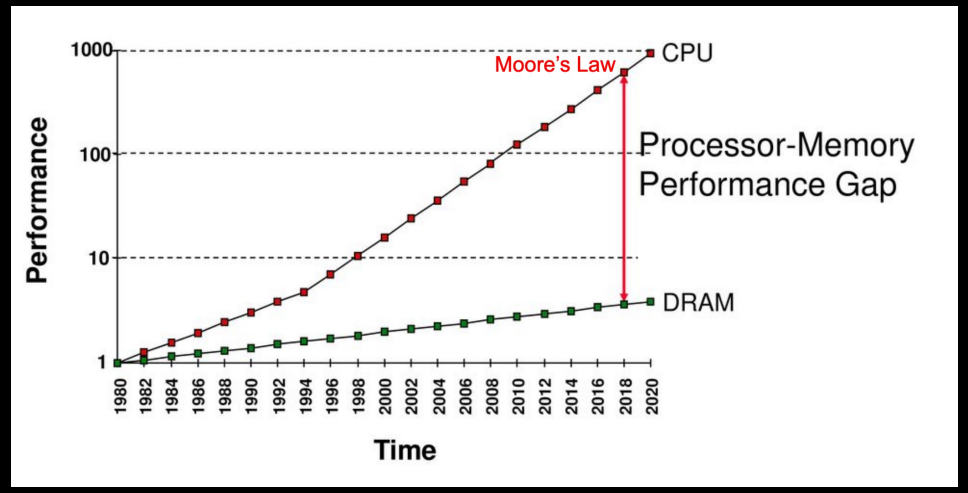
## Data movement is expensive




Energy cost of data movemen:

pJ per 64-bit FP op

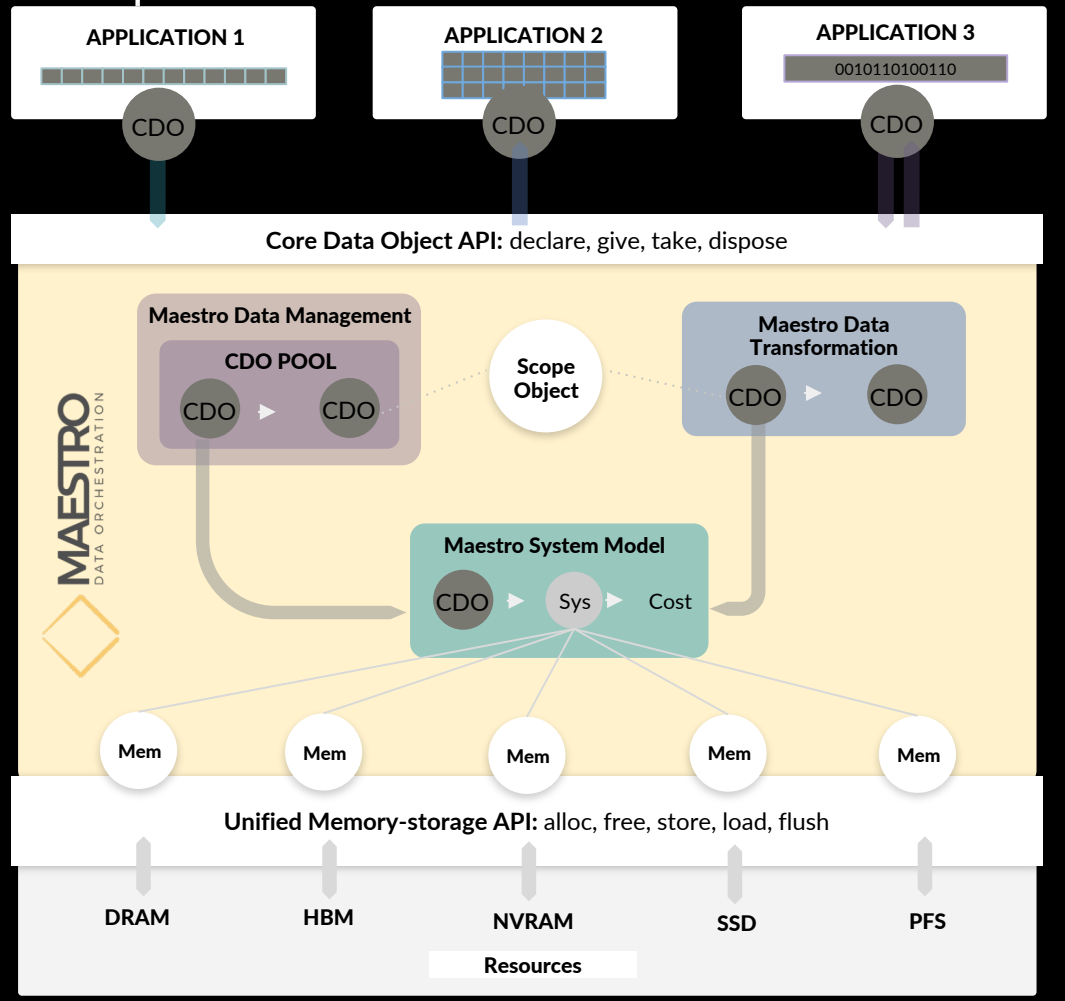
Leland et al, SAND2016-9583




Patterson, UC Berkeley

## Need data object abstraction

- Across applications, across memory tiers, across compute nodes




https://maestro-data.eu/

# THANK YOU

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