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Date center Workload Power Efficiency (DWPE)

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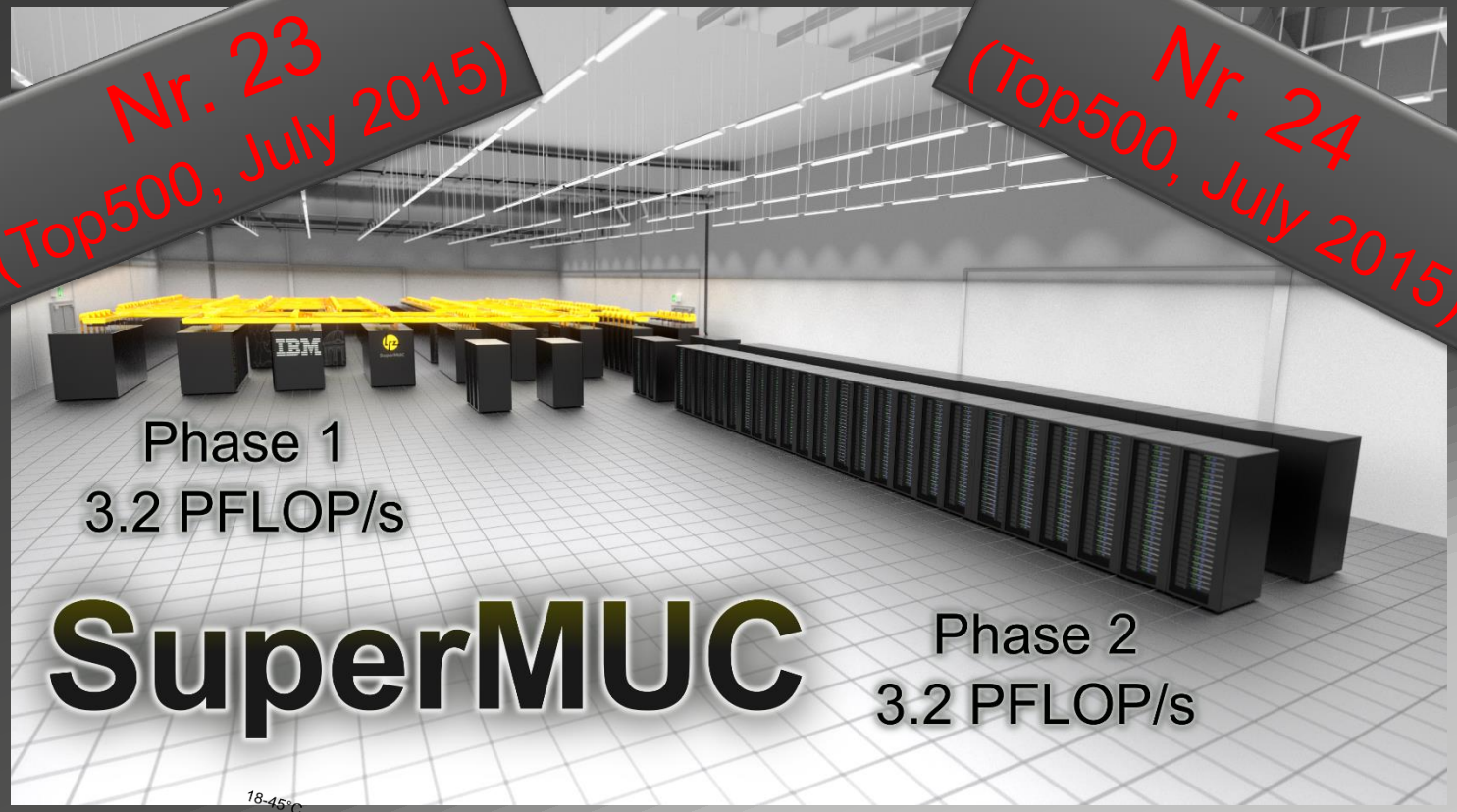
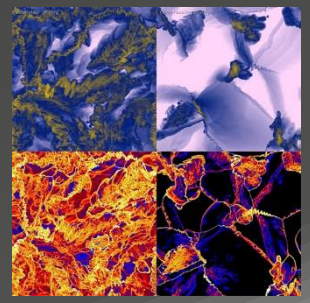
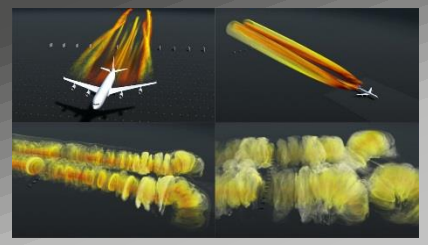
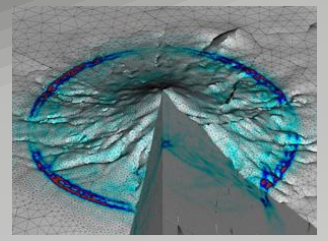
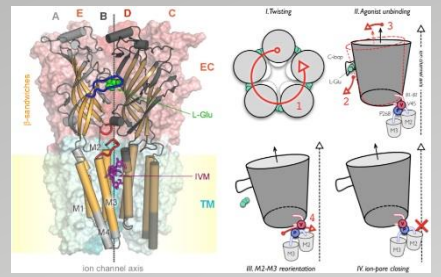
Scientific Computing at LRZ

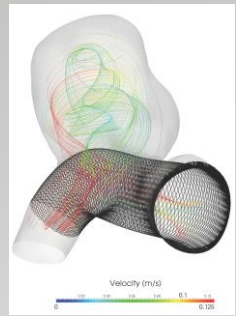


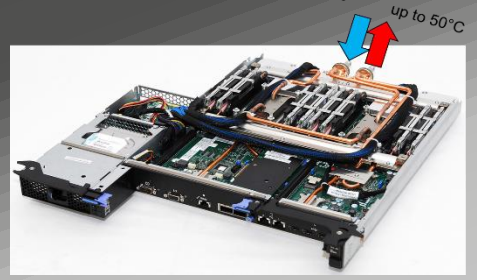


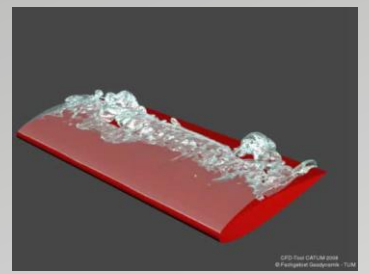


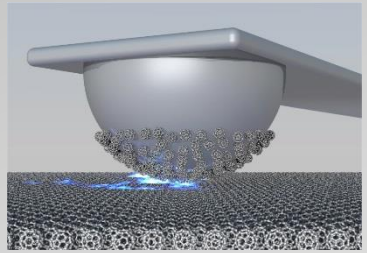


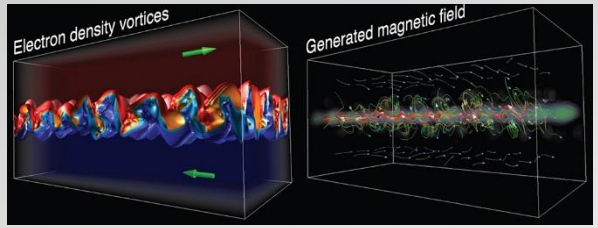












http://www.lrz.de/services/compute/supermuc/magazinesbooks/2014_SuperMUC-Results-Reports.pdf

http://www.gauss-centre.eu/gauss-centre/EN/Projects/projects_node.html

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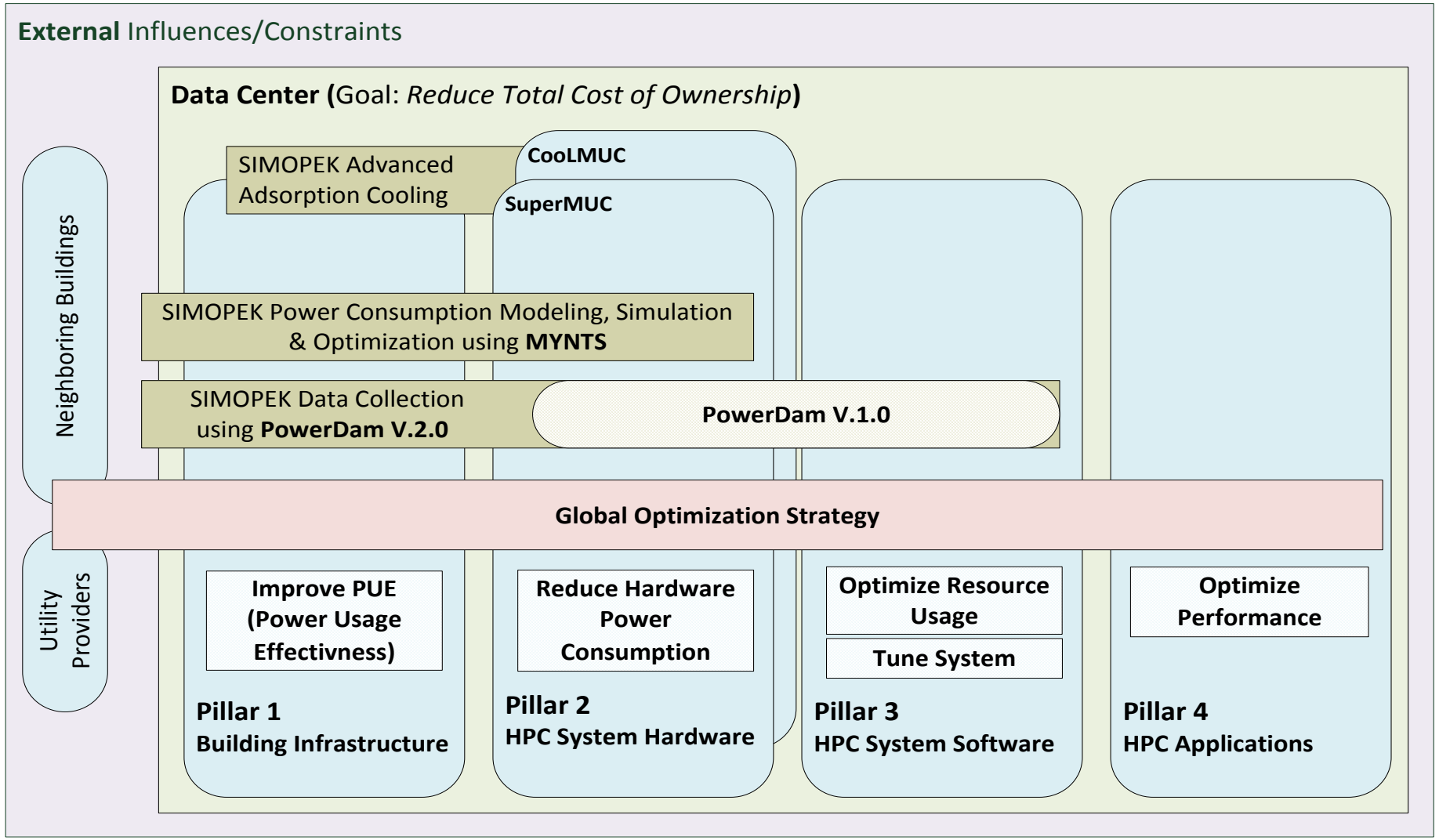
SIMOPEK Project Coverage



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

DWPE (Data center Workload Power Efficiency)

Common Metrics Used By HPC Data Centers

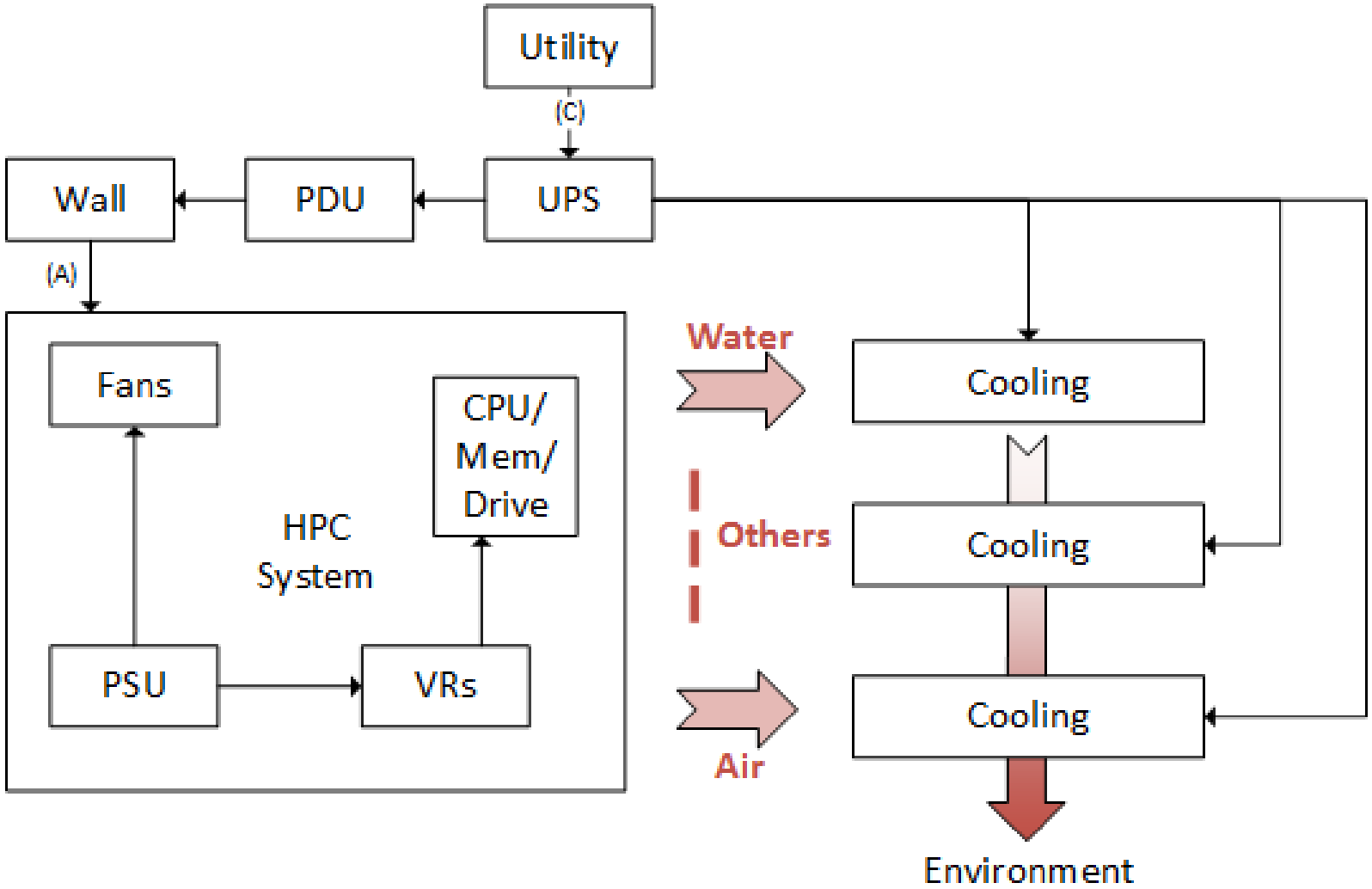
$$PUE = \frac{\sum P_i}{P_{IT}}$$

- Good to access overall data center overhead
- Does not determine if the IT power is efficiently used by IT systems
- Worst case:
  - One can very effectively waste a lot of energy
  - PUE ≠ Efficiency (Costs)

$$Workload\ Power\ Efficiency = \frac{Performance_{IT}}{Watt_{IT}}$$

- Good to assess the energy efficiency of HPC technology for solving a specific benchmark
  - Green500, GreenGraph …. - a good indicator for HPC application energy efficiency?
- Doesn't capture cost of cooling
  - Having the compute room as cold as possible will improve WPE, additional energy costs from the data center cooling infrastructure is not captured
- Worst case:
  - The compute technology is very efficient but the complete system is not
  - Ranking covers IT technology only (system design or cooling technology is ignored)

Importance of Data Center Cooling Infrastructure



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Adding Data Center Cooling COP to the Mix

$$PUE = \frac{P_{IT} + P_{PDCL} + P_{Cooling}}{P_{IT}} = 1 + \frac{P_{PDCL}}{P_{IT}} + \frac{P_{Cooling}}{P_{IT}} = 1 + Overhead_{PDCL} + \frac{P_{Cooling}}{P_{IT}}$$

$$P_{IT} = Q_{IT} = Q_{air} + Q_{water} \qquad P_{Cooling} = P_{air} + P_{water}$$

$$PUE = 1 + Overhead_{PDCL} + \frac{P_{air} + P_{water}}{Q_{IT}} \qquad COP = \frac{Q}{P} \qquad P = \frac{Q}{COP}$$

$$PUE = 1 + Overhead_{PDCL} + \frac{Q_{air}}{Q_{IT}} * \frac{1}{COP_{air}} + \frac{Q_{water}}{Q_{IT}} * \frac{1}{COP_{water}}$$

$$sPUE = 1 + Overhead_{PDCL} + \sum_{k=1}^{n} \left(w_k * \frac{1}{COP_k}\right) \qquad 1 = \sum_{k=1}^{n} w_k$$

Legend

P_{IT}: IT equipment power

P_{PDCL}: Power distribution and conversion losses

$P_{Cooling}$: Cooling power

Q_{IT}: IT equipment generated heat

$Q_{Air/Water}$: Heat removed by Air/Water cooling

P_{Air}: Power for air cooling

P_{Water}: Power for water cooling

COP: Coefficient of performance

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Data center Workload Power Efficiency

$$DWPE = \frac{WPE}{sPUE}$$

- New metric that takes system cooling technology into account
- Shows real world energy efficiency for a particular workload (Performance/W) for a specific HPC system if installed in a specific data center

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DWPE Example

	LRZ
Power Distribution and Conversion overhead	0.075
Air cooling overhead	0.5
W1 Chiller supported water cooling overhead	0.4
W4 Hot water cooling overhead	0.05

Table 1: LRZ data center overheads

HPC system	SuperMUC (LRZ)	PLX (CINECA)
Heat removed via air	10%	100%
Heat removed via W1	18%	0%
Heat removed via W4	72%	0%

Table 2: Example systems cooling removal technologies

	SuperMUC (LRZ)	PLX (CINECA)
Green500 rank (Nov 2013)	95	98
WPE (MFlops/W)	908	892
DWPE (MFlops/W)	736	566

Table 3: Green500 list (High Performance Linpack (HPL)) rank for two different HPC systems and DWPE when installed at LRZ

DWPE paper at: http://www.simopek.de/

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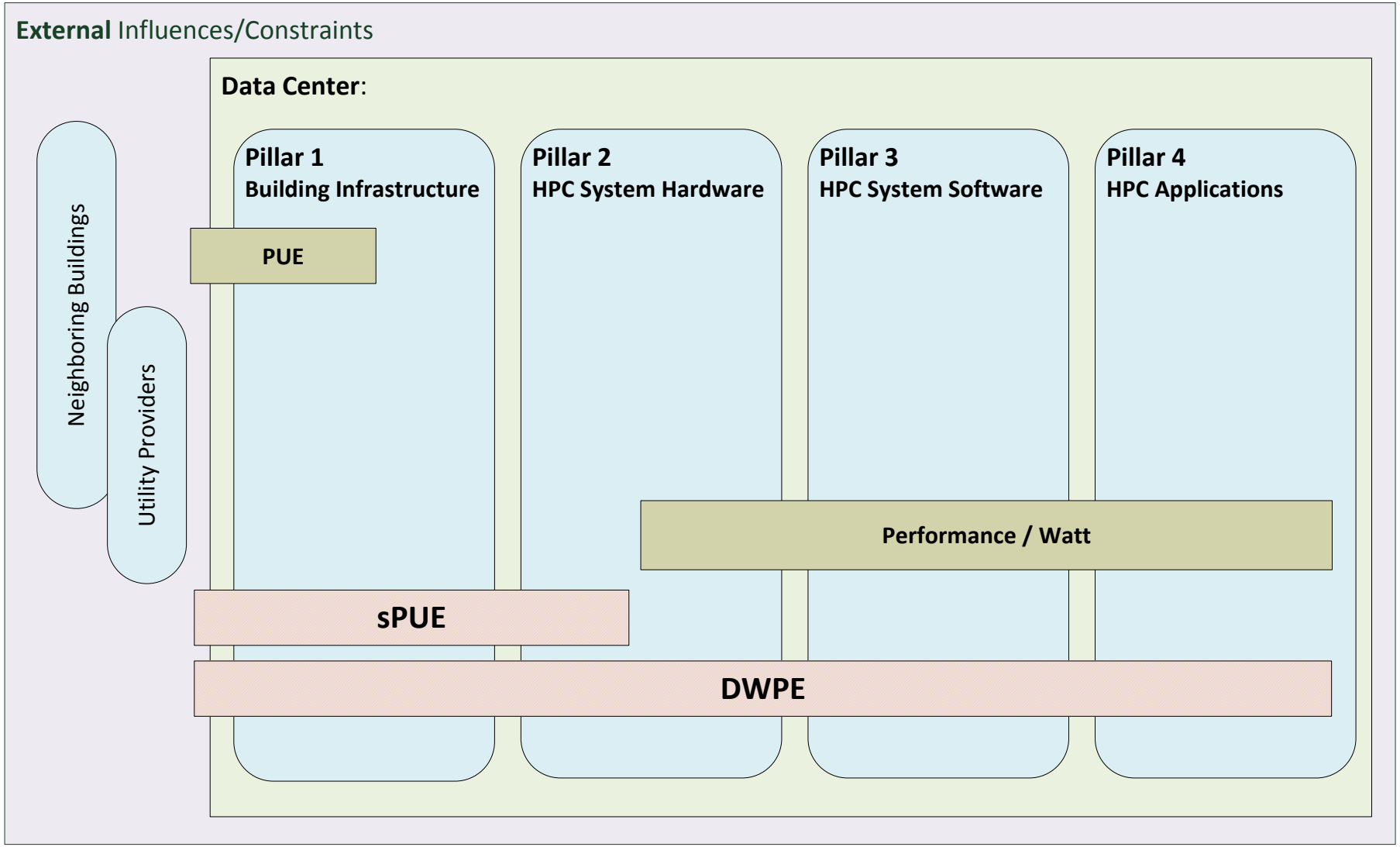
The New Metrics and the 4 Pillar Framework



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