



# Total Cost of Ownership in High Performance Computing

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Wissenschaftliches Rechnen

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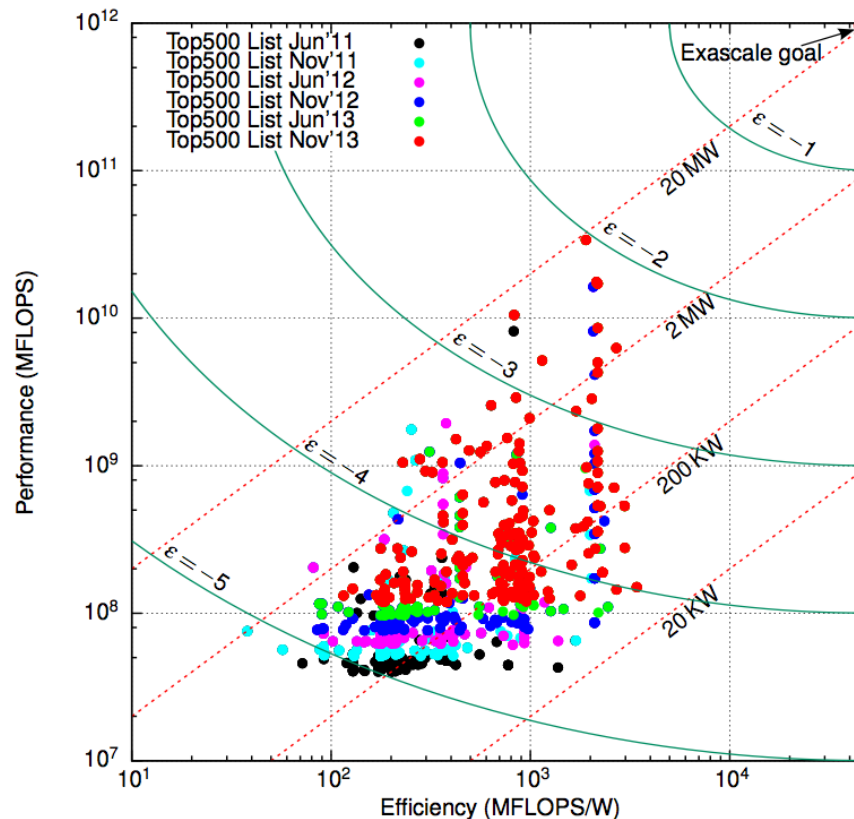
# Motivation

- High Performance Computing
  - Optimization of algorithms applied to solve scientific complex problems
- Technological advance  $\Rightarrow$  Performance improvement
  - More computing power and storage space
  - Multicore processors, accelerators (GPUs) and coprocessors
- HPC data centers  $\Rightarrow$  High energy consumption!
  - Growth of the Total Cost of Ownership (TCO)
  - Power wall towards exascale computing

# Performance and efficiency trends

- Goal  $\Rightarrow$  Build and Exascale system ( $10^{18}$  FLOPS) without exceeding 20 MW

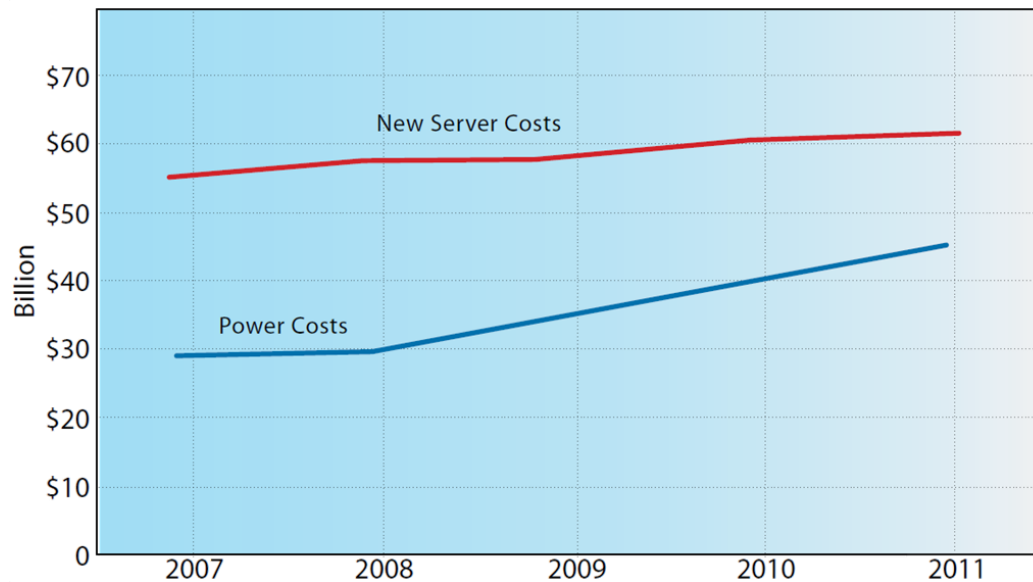
Performance-Efficiency scalar graph for the Top500 supercomputers from 2011 to 2013



Power trends of some supercomputers have almost reached the power wall being 100 away of the Exascale goal!

# The increasing HPC costs

- Costs of powering and cooling HPC data centers are increasing to levels that equal the investment costs ⇒ **data center costs would be unfeasible!**

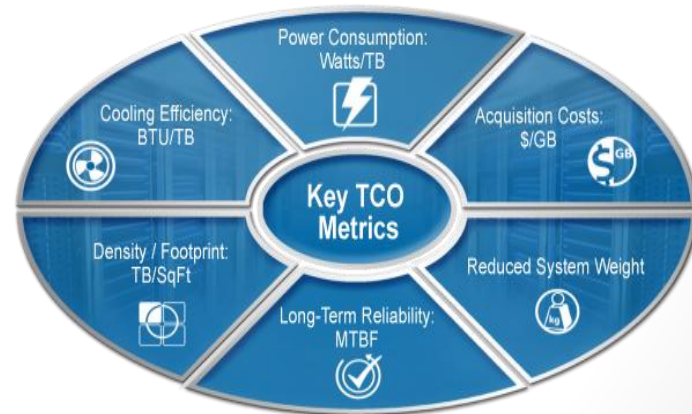


Solutions to reduce the TCO and increase the benefits are required!

Energy efficient HPC data centers are needed  
for green IT and economic sustainability!

# What is TCO in HPC?

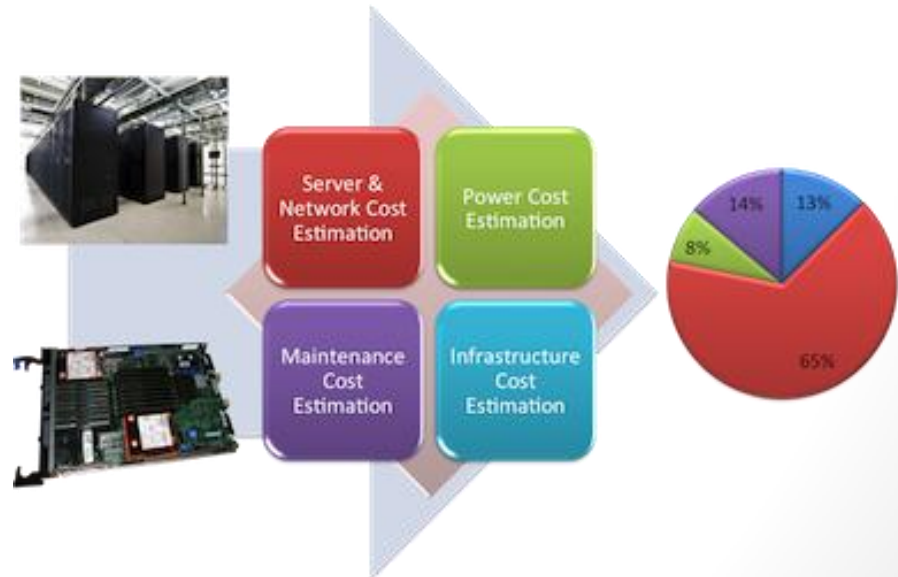
- It is the sum, adjusted for the time value for money, of all of the costs that a customer incurs during the lifetime of a technology solution.
- In the High Performance Computing (HPC) field, the **Total Cost of Ownership** is normally referred to the data center costs.
- Cost to the owner to build, operate and maintain the data center.



# Which costs are considered?

- Investment, operation and maintenance costs:
  - Hardware: servers, storage, networking, cabling, etc.
  - Electrical equipment: power distribution units, UPS, generators, etc.
  - Cooling systems: air conditioners, water cooling, etc.
  - Infrastructure for the data center, power adaptation issues, etc.
  - Energy consumption of the hardware and cooling systems
  - Software licences
  - Human resources
  - Maintenance

- Consider the trade-off between TCO and benefits!



# Evaluation of the seminar

- A topic for each student will be assigned
  - Individual presentations:
    - 25 slides (approx.)
    - 60 minutes + discussion
    - The slides should contain notes that clarify their content
- More information at:
  - [http://wr.informatik.uni-hamburg.de/teaching/sommersemester\\_2014/total\\_cost\\_of\\_ownership\\_in\\_high\\_performance\\_computing](http://wr.informatik.uni-hamburg.de/teaching/sommersemester_2014/total_cost_of_ownership_in_high_performance_computing)
- Contact and supervision:
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