Energy Aware Simulations

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HPC Advisor SURF
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https://ondemand.snellius.surf.nl/

https://github.com/sara-nl/energy-efficient-computing

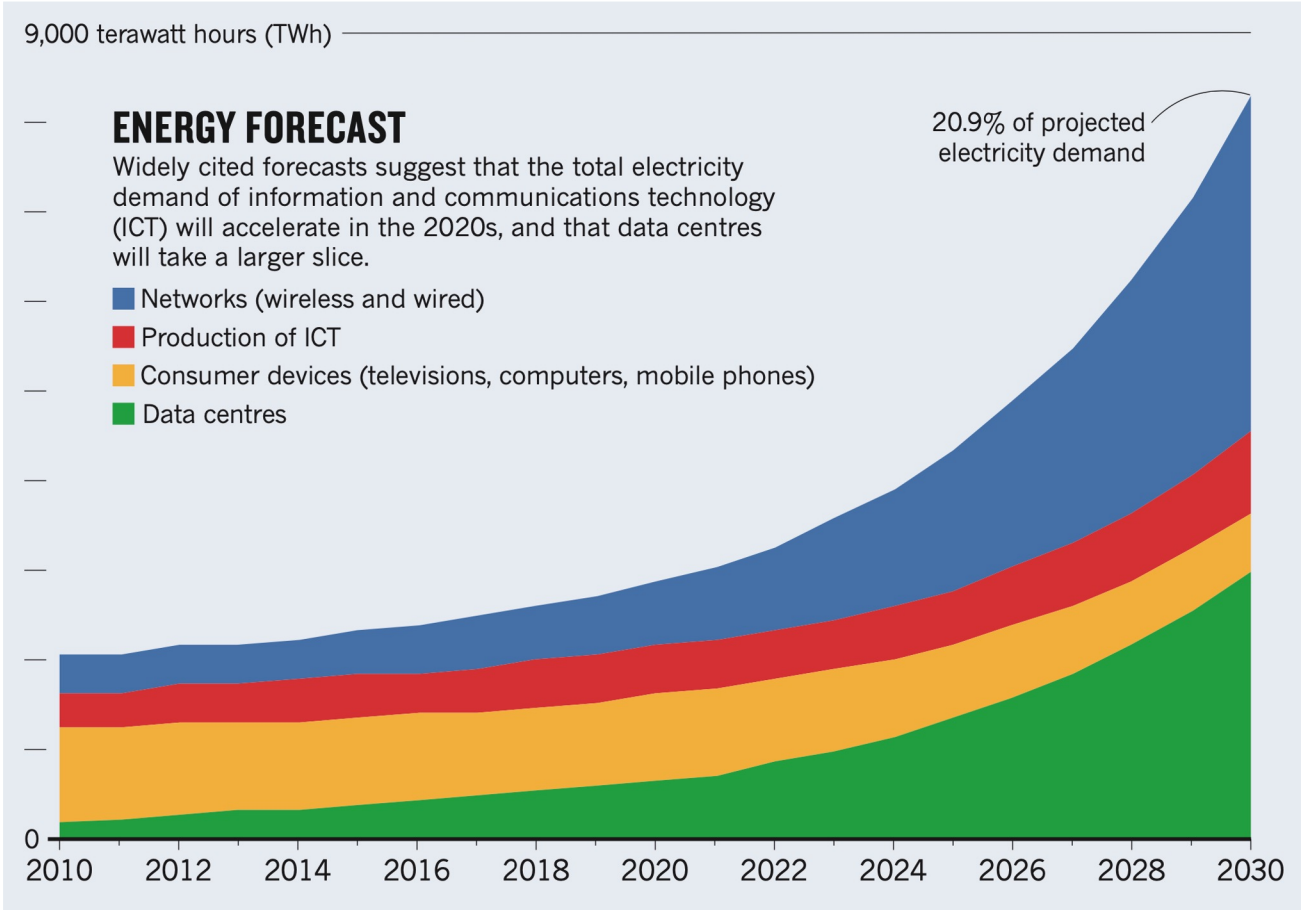
login: scur0311

Reservation:
jupyterhub_course_jhssrf009_2024-04-18

scur0311

ICT/Data center energy forecast

- Data centre energy usage:
  - ~ 200 TWh for data centres in 2018
  - ~ 3000 TWh in 2030
- Dutch Data Center Usage (2019)
  - 1300 MW installed capacity
  - 0.3 % electricity usage of the Netherlands (CBS)
  - 3x as much power than the NS



The chart above is an 'expected case' projection from Anders Andrae, a specialist in sustainable ICT. In his 'best case' scenario, ICT grows to only 8% of total electricity demand by 2030, rather than to 21%.

- Jones, Nicola. "How to stop data centres from gobbling up the world's electricity." *Nature* 561.7722 (2018): 163-166.
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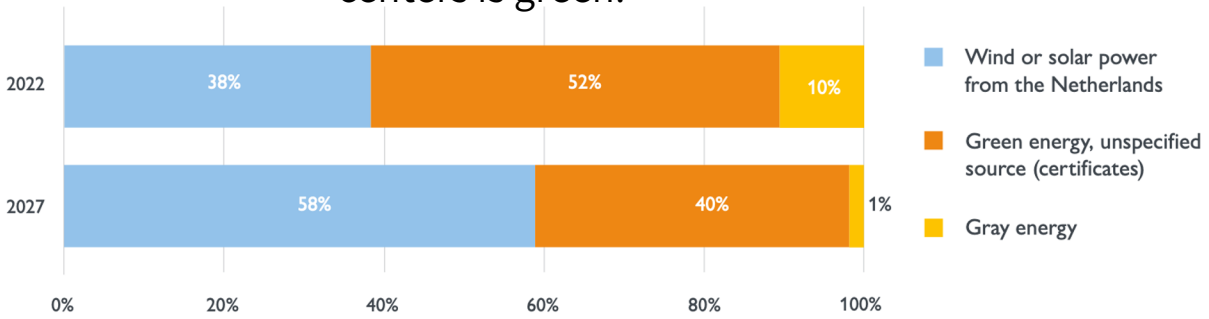
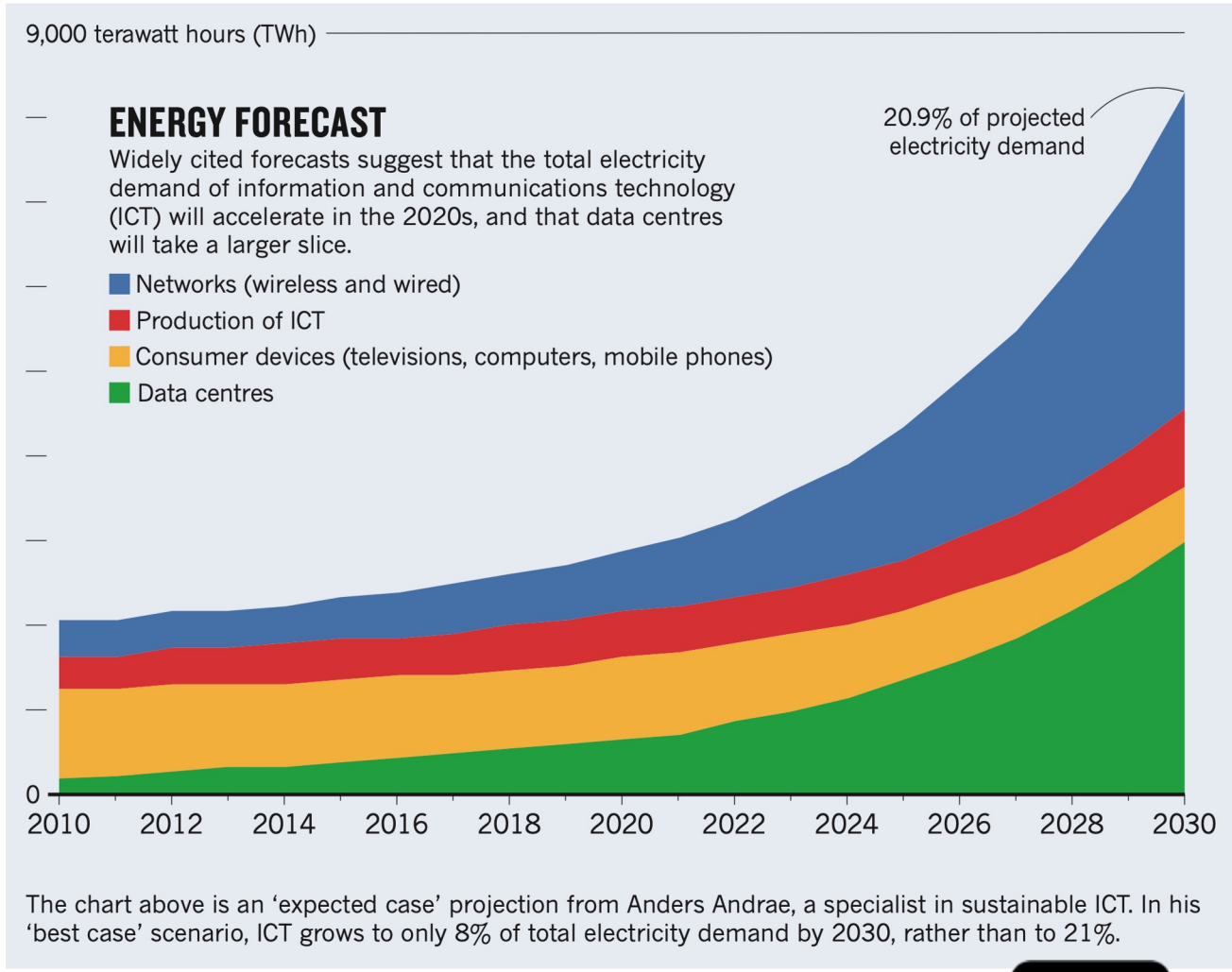
- Dutch Data center energy consumption (2022)
  - 90% of all energy consumed by colocation data centers is green.





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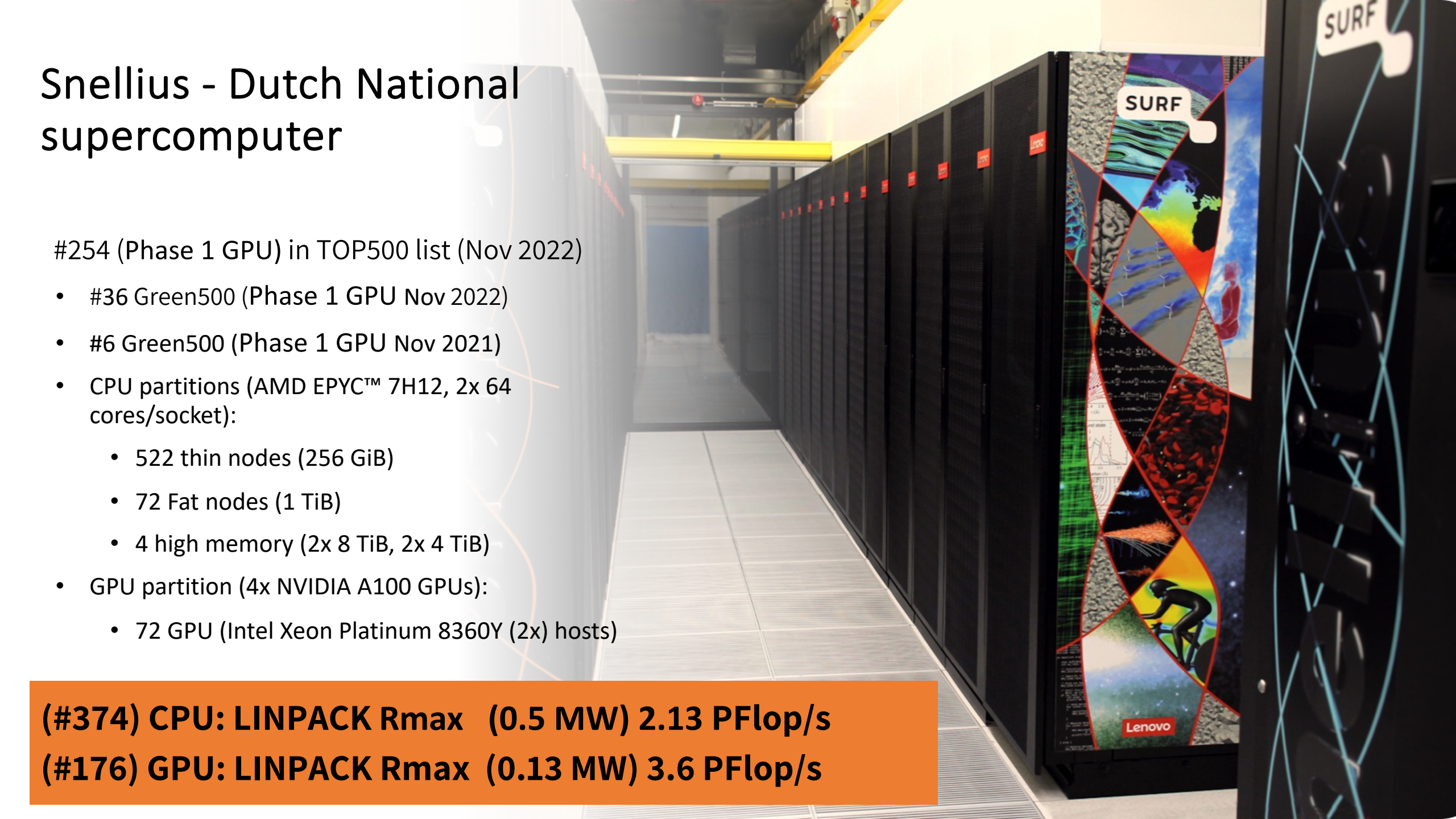
Snellius - Dutch National supercomputer



#254 (Phase 1 GPU) in TOP500 list (Nov 2022)

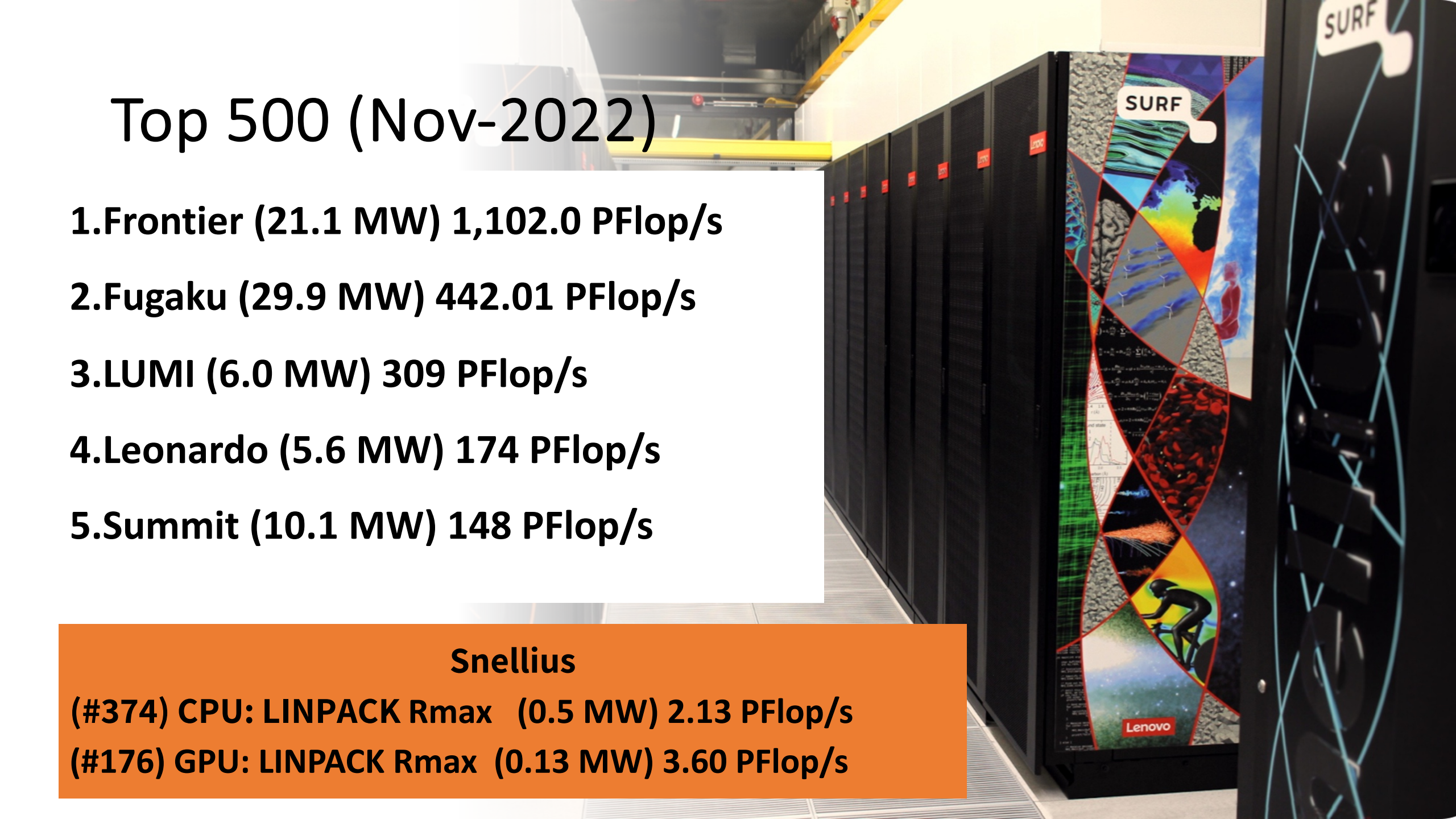
- #36 Green500 (Phase 1 GPU Nov 2022)
- #6 Green500 (Phase 1 GPU Nov 2021)
- CPU partitions (AMD EPYC™ 7H12, 2x 64 cores/socket):
  - 522 thin nodes (256 GiB)
  - 72 Fat nodes (1 TiB)
  - 4 high memory (2x 8 TiB, 2x 4 TiB)
- GPU partition (4x NVIDIA A100 GPUs):
  - 72 GPU (Intel Xeon Platinum 8360Y (2x) hosts)

(#374) CPU: LINPACK Rmax (0.5 MW) 2.13 PFlop/s

(#176) GPU: LINPACK Rmax (0.13 MW) 3.6 PFlop/s

Top 500 (Nov-2022)

1. Frontier (21.1 MW) 1,102.0 PFlop/s
2. Fugaku (29.9 MW) 442.01 PFlop/s
3. LUMI (6.0 MW) 309 PFlop/s
4. Leonardo (5.6 MW) 174 PFlop/s
5. Summit (10.1 MW) 148 PFlop/s

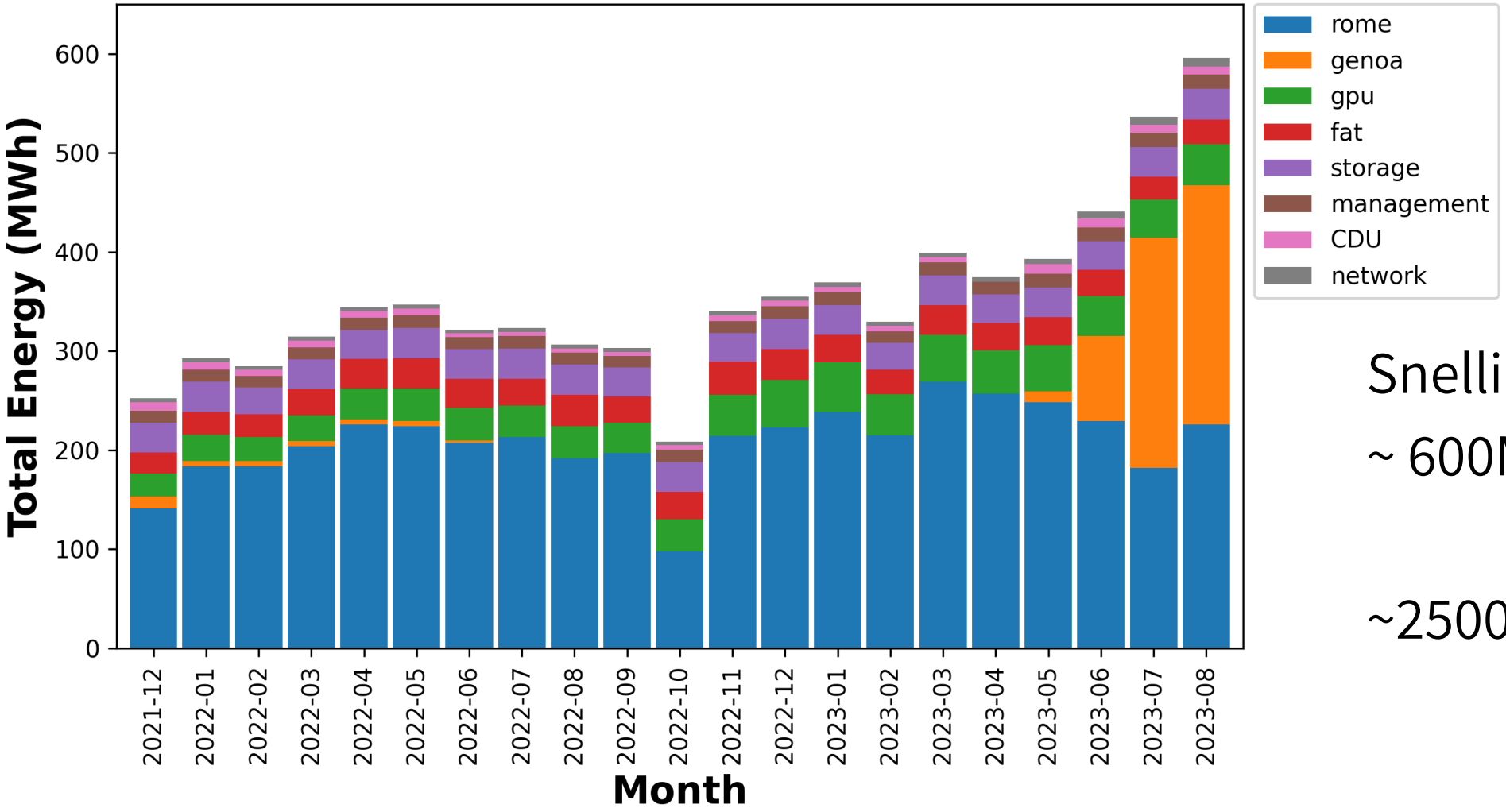


Snellius

(#374) CPU: LINPACK Rmax (0.5 MW) 2.13 PFlop/s

(#176) GPU: LINPACK Rmax (0.13 MW) 3.60 PFlop/s

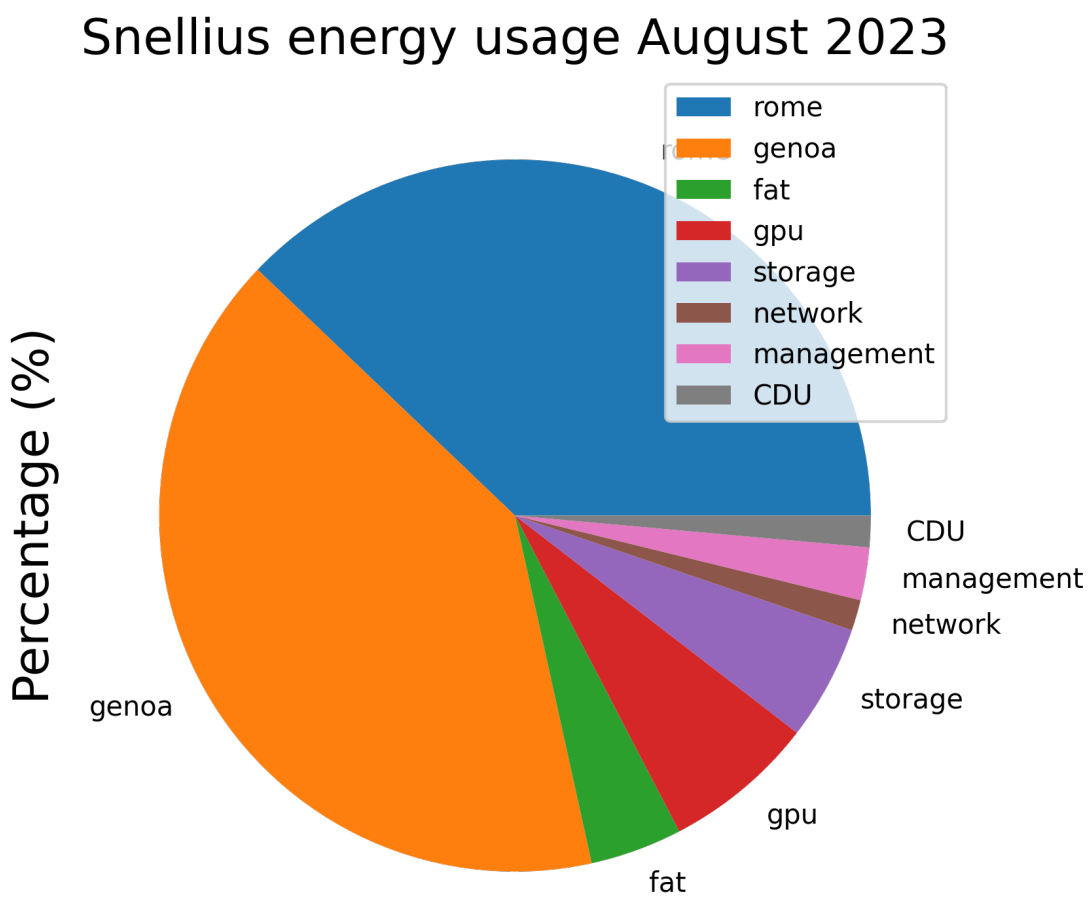
Snellius - Total Energy Usage



Snellius in August used ~ 600MWh of energy.

~2500 house holds worth

Snellius - Energy usage per partition

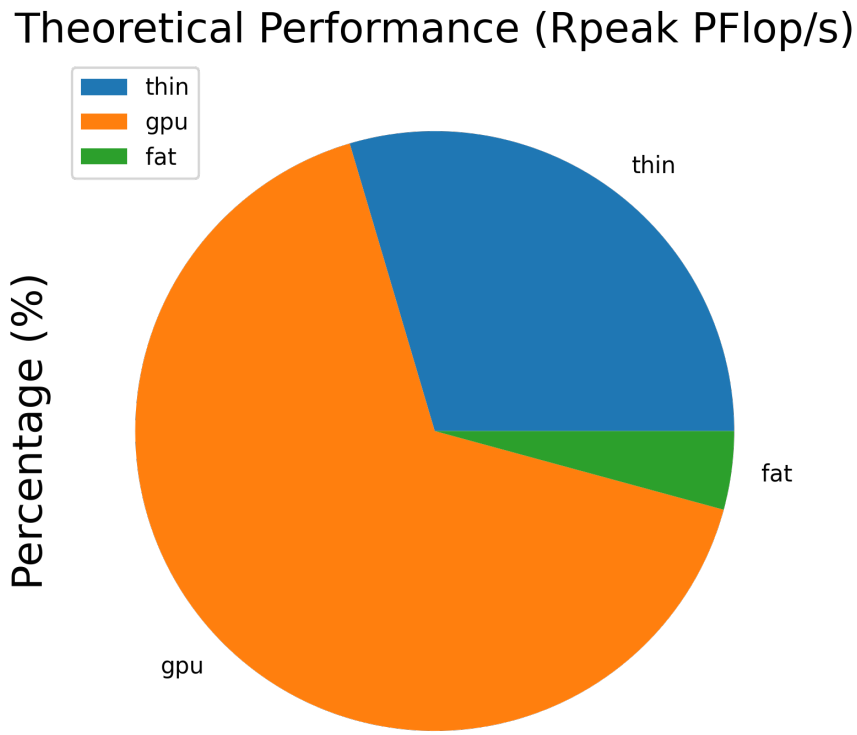


- 90% Compute
  - 80% CPU
    - 39% Rome
    - 41% Genoa
  - 7% Gpu
  - 3% Fat

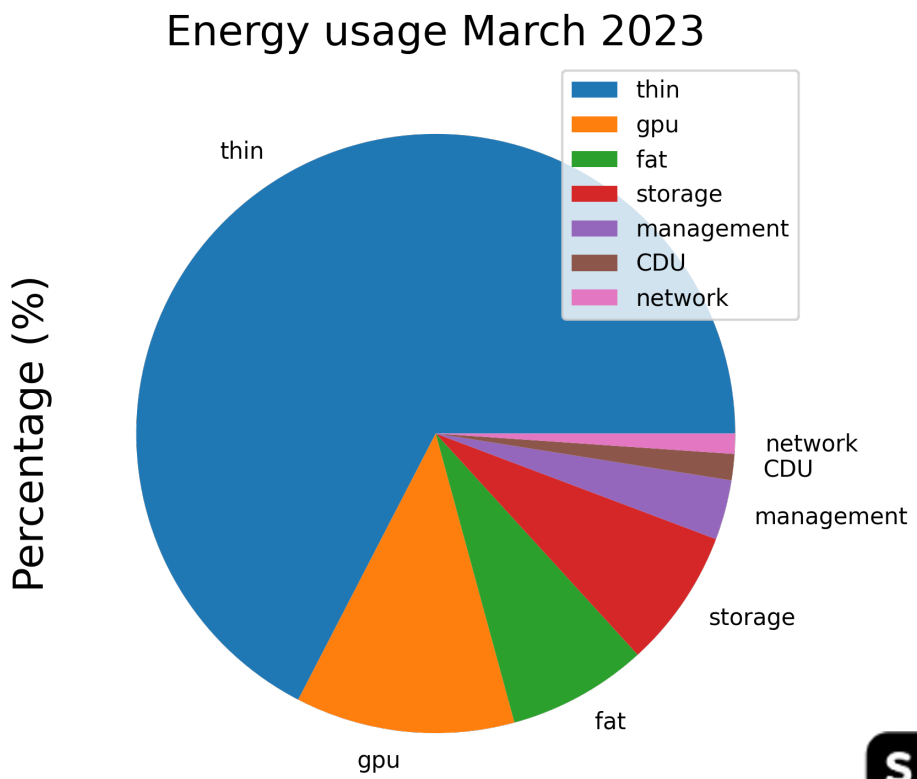
- 10% Other
  - 5.0% Storage
  - 2.4% Management
  - 1.5% Cooling
  - 1.1% Network

Performance vs Energy

- **Thin** (Rpeak) **– 2.86 PFlops**
- **Fat** (Rpeak) **– 0.38 PFlops**
- **GPU** (Rpeak) **– 6.01 Pflops**

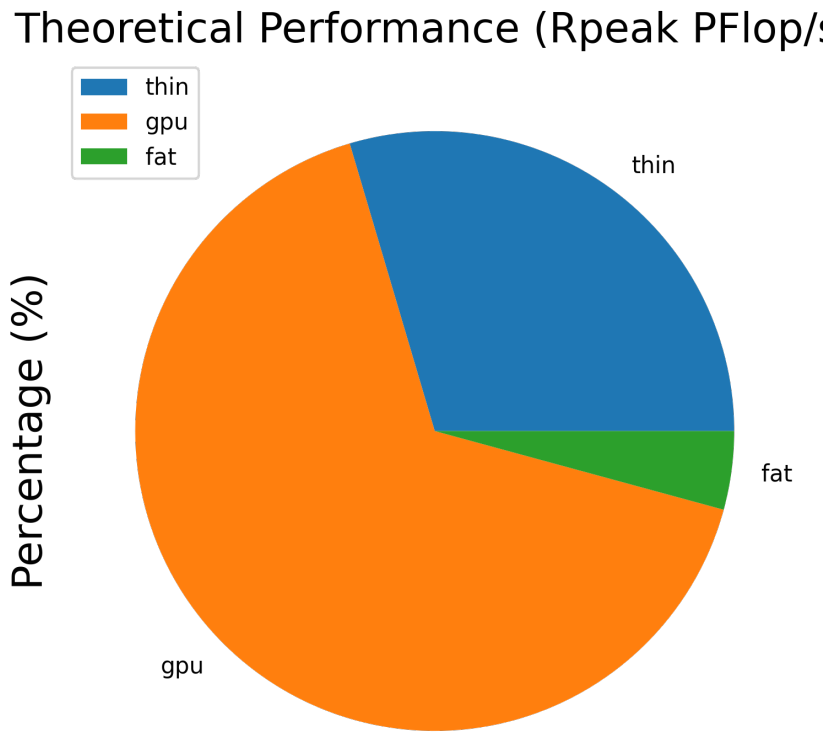


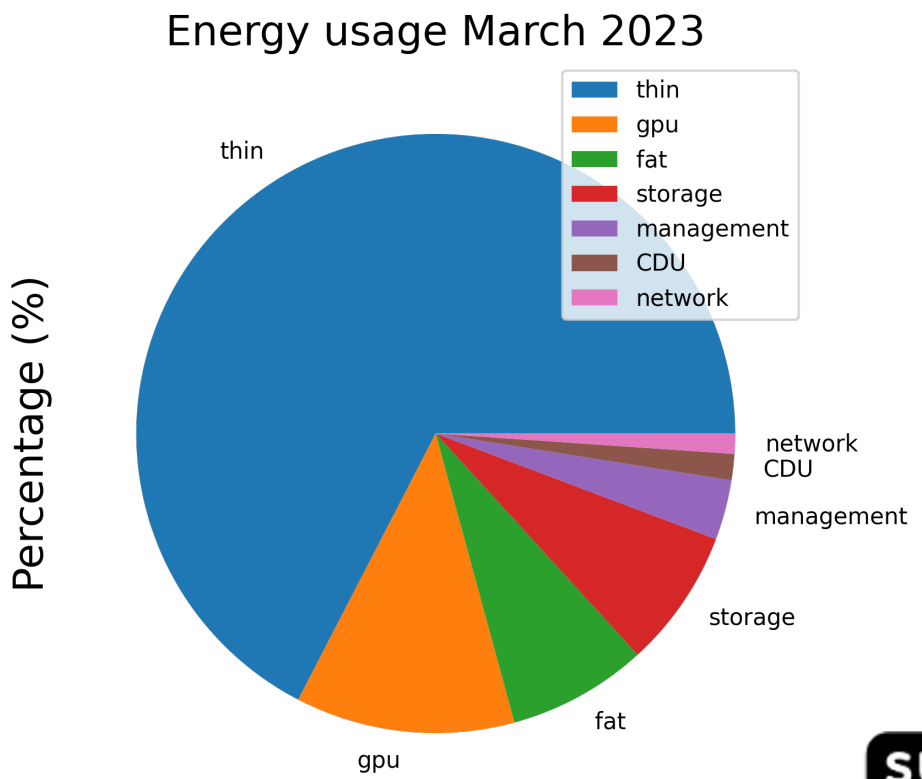
- **Thin – 269 MWh**
- **Fat – 30 MWh**
- **GPU – 47 MWh**



Performance vs Energy

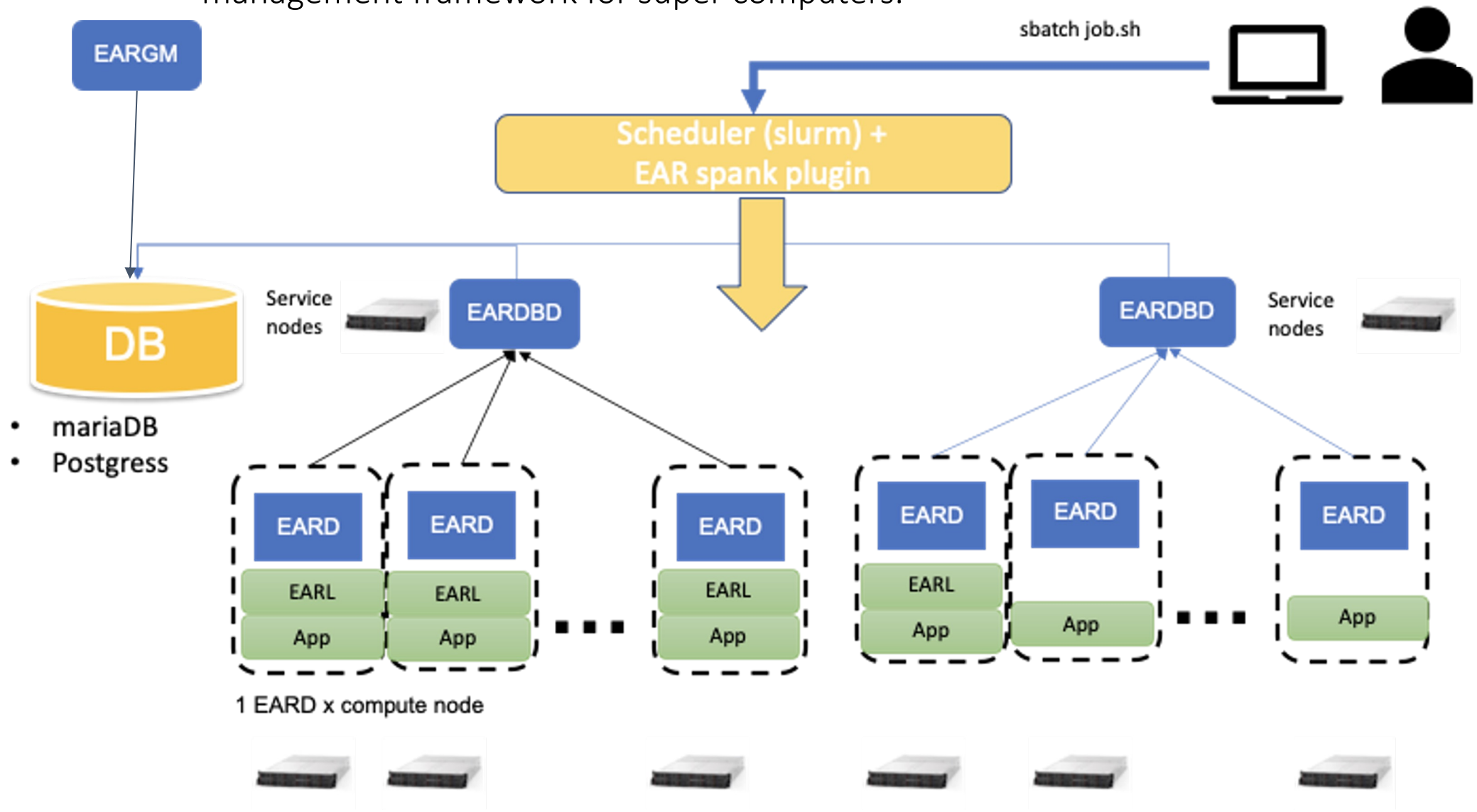
GPU ~ same compute for 1/5 the energy (March 2023)





Energy Aware Runtime (EAR)

Energy Aware Runtime (EAR) package provides an energy management framework for super computers.



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Energy Aware Runtime (EAR) package provides an energy management framework for super computers.

- **EAR Node Manager (EARD) “Daemon”**
  - Energy metrics via the RAPL (Running Average Power Limit) function
  - Global energy limits or just offer global cluster monitoring
- **EARL** is a library that is loaded next to the application
  - Offers application metrics monitoring
  - Can select the frequencies based on the application behavior on the fly.
  - Integrated with SLURM on Snellius.
  - Intercepts the MPI symbols through the PMPI interface to provide “traces” of MPI applications.

```
#!/bin/bash

#SBATCH --ntasks=256
#SBATCH --time=24:0:0
#SBATCH -p thin --exclusive

#SBATCH --ear=on
#SBATCH --ear-policy=monitoring

module load 2021
module load foss/2021a
module load CMake/3.20.1-GCCcore-10.3.0
module load VASP6/6.2.1-foss-2021a-CUDA-11.3.1

srun vasp_std
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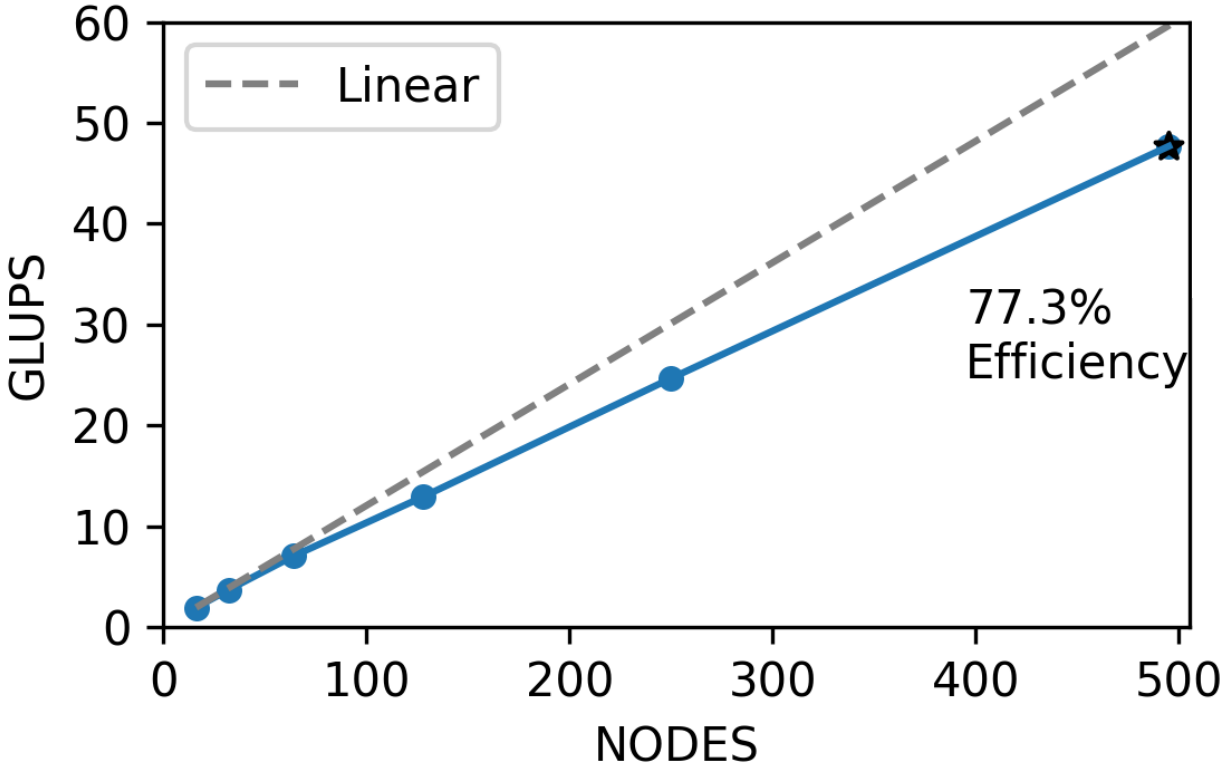
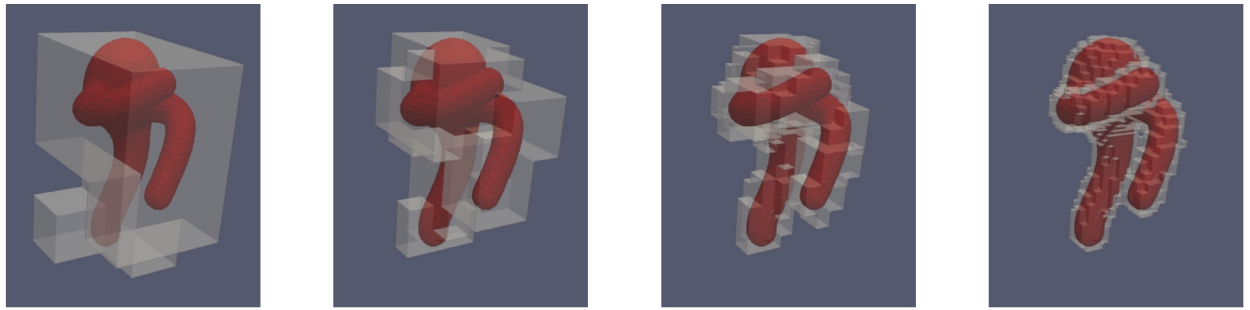
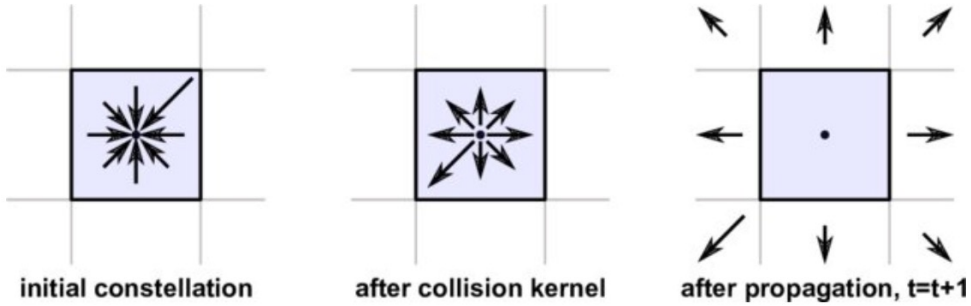
Palabos: Lattice-Boltzmann Solver

Strong Scaling Benchmark





J. Latt, O. Malaspinas, D. Kontaxakis et al. / Computers and Mathematics with Applications 81 (2021) 334–350



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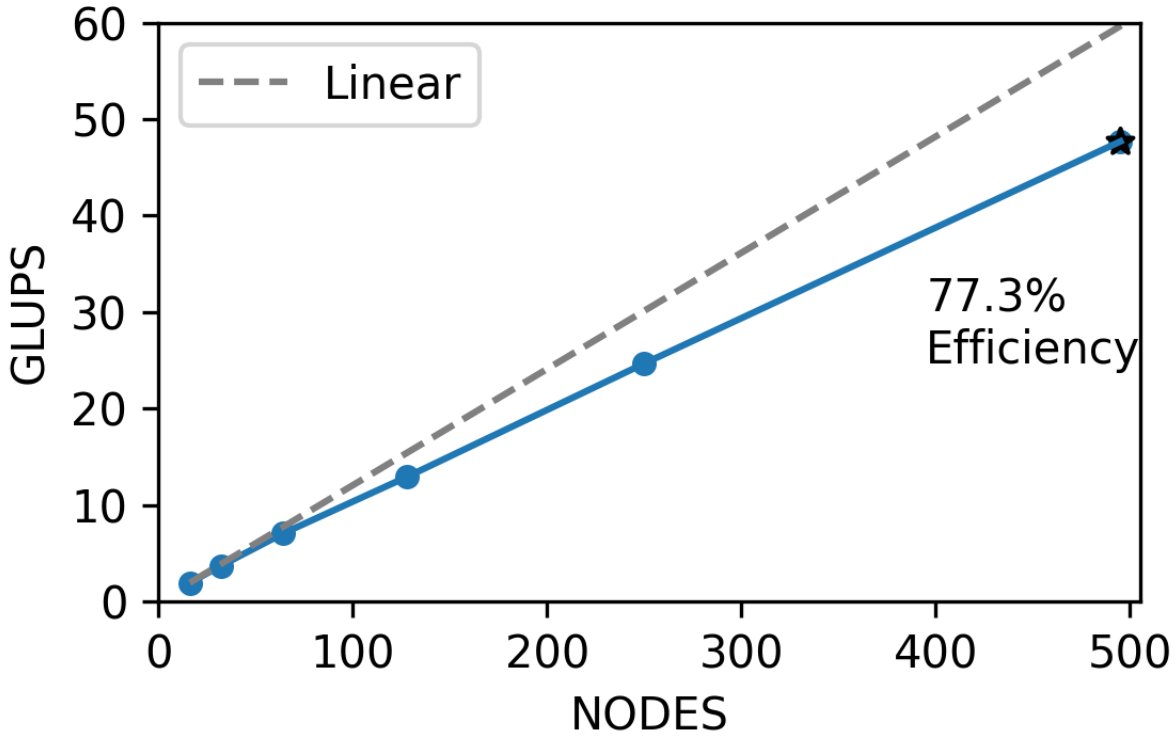

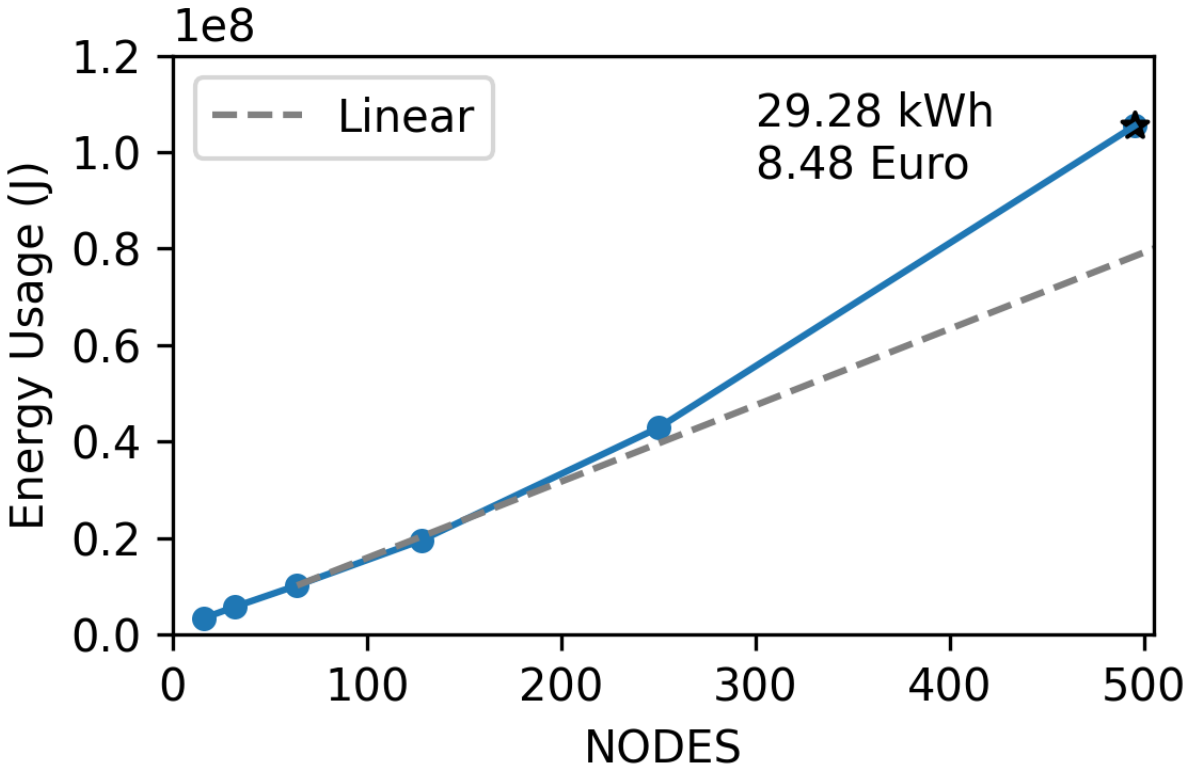

- An average electric car consumes about 0.2 kwh/km
- 495 node case (which ran for 9 minutes) just drove a car to Leeuwarden (149km from SP)!

Palabos:

Strong Scaling Benchmark

- Per-node, Per-iteration ”traces”

- Node Power
- Avg CPU Freq (node)
- Main memory BW (GB/s)
- CPI (Cycles per instruction)
- MPI% (percentage spent in MPI calls)
- I/O (network communication)