

Aurora Tigon

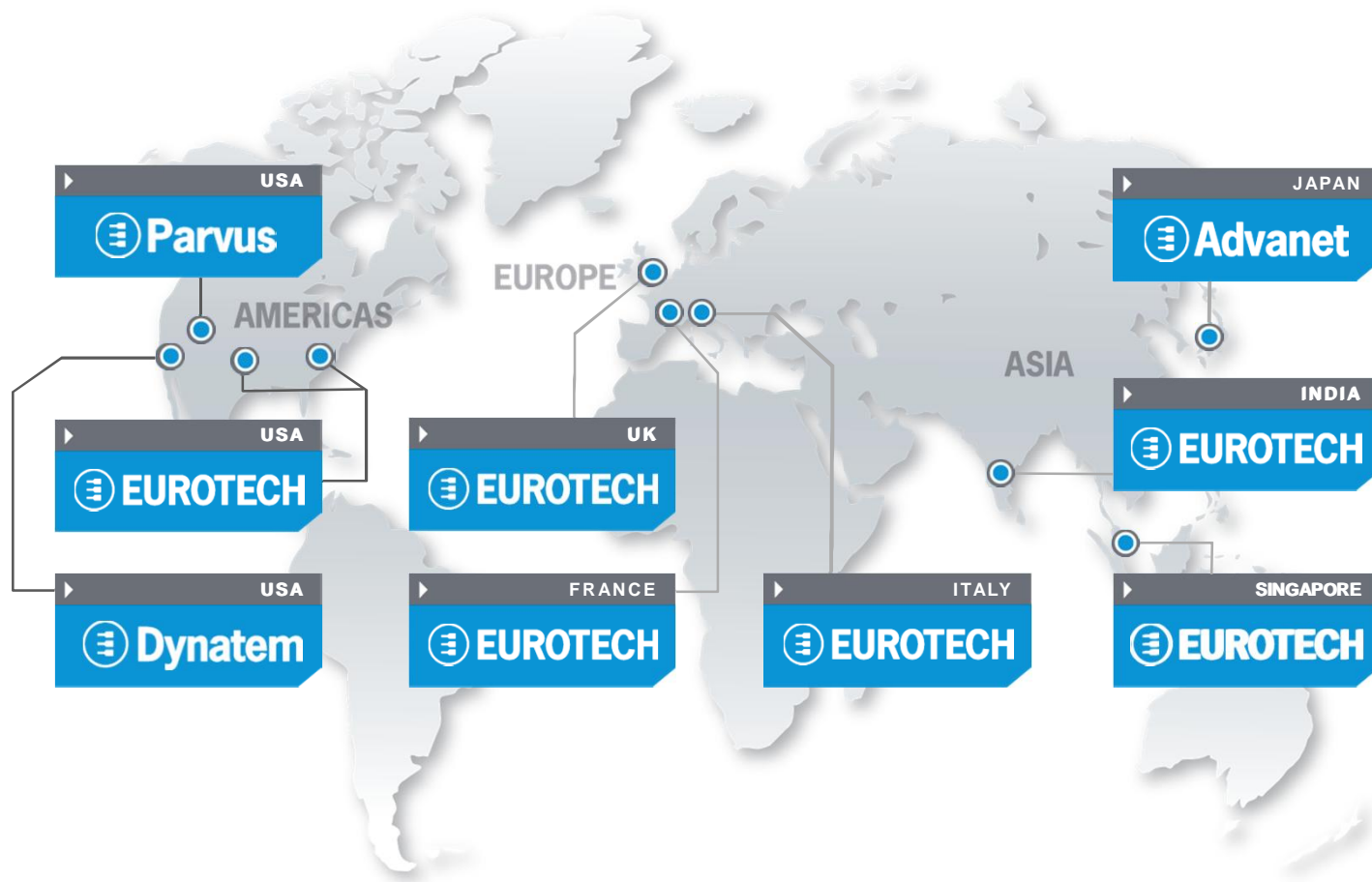
Green, Dense, Standard HPC

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Cineca, Bologna March, 30th 2013

Eurotech

HPC R&D and Operations

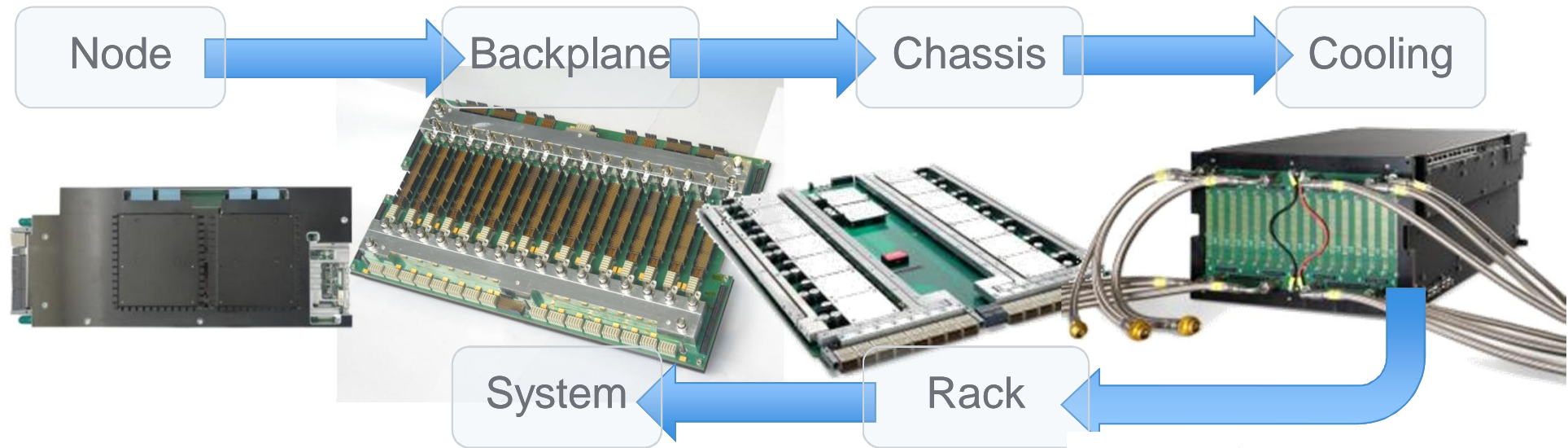




AURORA TIGON

Unleash the hybrid power

From 1 node to large petascale systems



The Aurora Tigon

Unleash the hybrid power

Key Features:

High Performance Density – 256 CPUs, 256 accelerators, up to 350 TFlops in just 1.5 m²

Energy efficiency– the Aurora direct cooling target datacenter PUE of 1.05, no need for air conditioning, up to 50% less energy

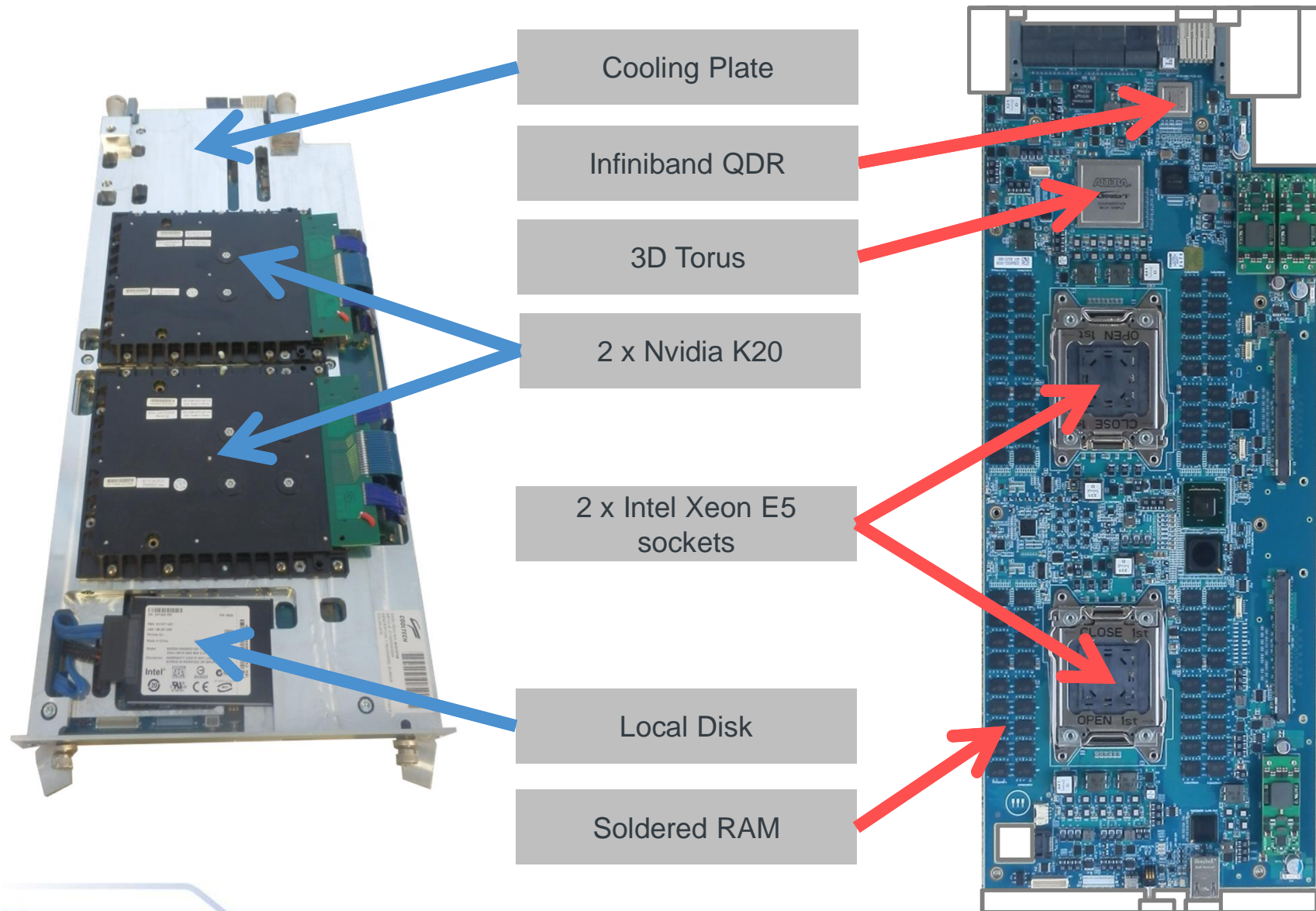
Programmability and compatibility – Based on standard HPC cluster architecture. 100% compatibility with existing applications.

Flexible Liquid Cooling– All components are cooled by water, temperature from 18°C to 52°C and variable flow rates

Reliability– 3 independent sensor networks, soldered memory, no moving parts, uniform cooling, quality controls



The Aurora Tigon node card



The Setup

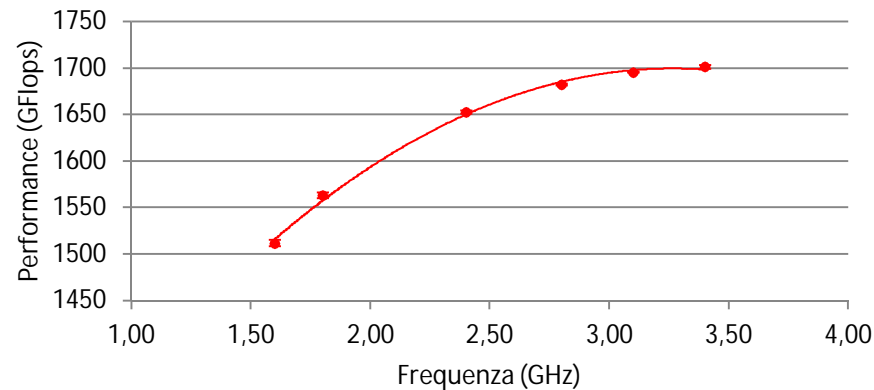
Energy efficiency measurements according to the Green500 guidelines

- All measurements made with a calibrated power meter with the system running HPL

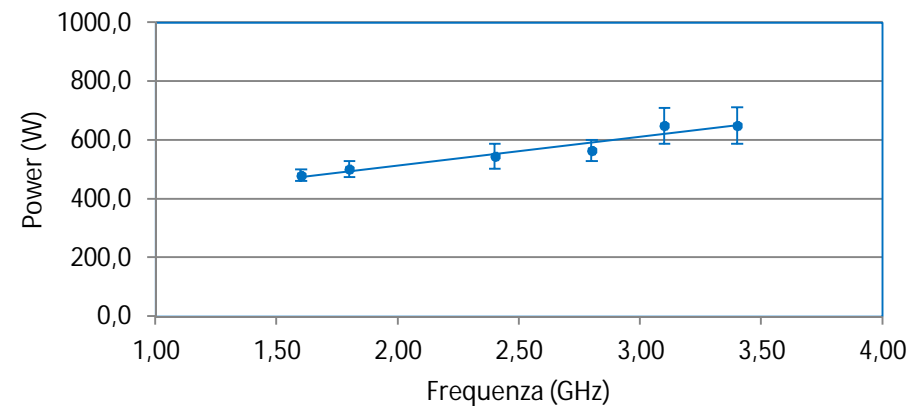
System	Eurora supercomputer: 64 nodes, 128 CPUs, 128 GPUs
Node Card	Intel Xeon E5-2687W (150W)
n.2 nVIDIA K20s, n.1 Infiniband QDR	NVIDIA® Tesla® K20
Ambient Temperature	20°C+/-1°C
Coolant Temperature	19°C+/-1°C
Coolant	water
Flowrate	120lph +/-7lph each EuroraBoard

HPL Benchmark Results

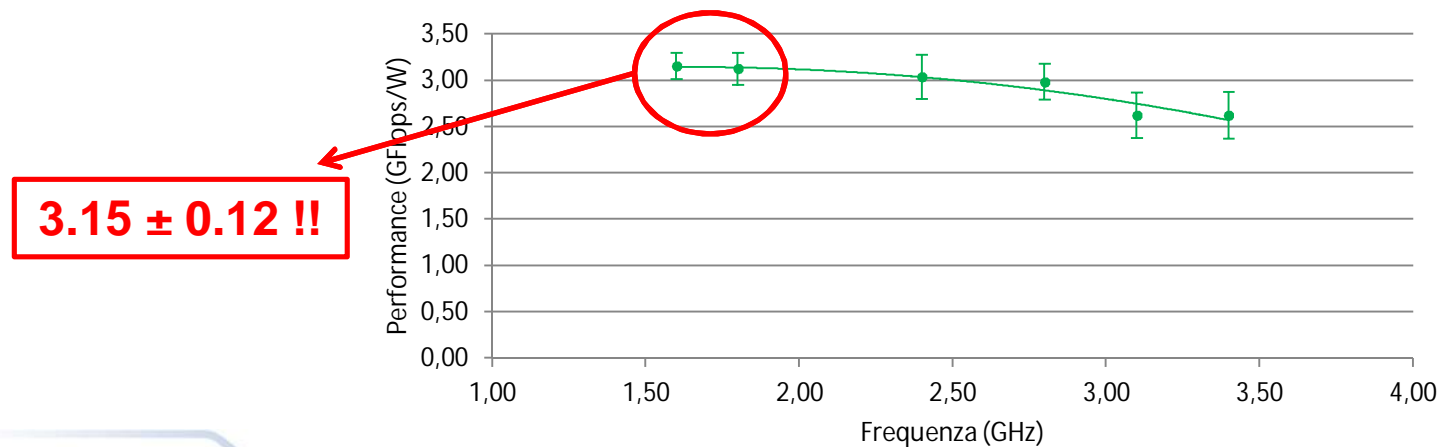
Performance Vs CPU Frequency



Power Vs CPU Frequency



Performance/Power Vs CPU Frequency



The Green500 List

Listed below are the November 2012 The Green500's energy-efficient supercomputers ranked from 1 to 100.

Green500 Rank	MFLOPS/W	Site*	Computer*	Total Power (kW)
1	2,499.44	National Institute for Computational Sciences/University of Tennessee	Beacon - Appro GreenBlade GB824M, Xeon E5-2670 8C 2.600GHz, Infiniband FDR, Intel Xeon Phi 5110P	44.89
2	2,351.10	King Abdulaziz City for Science and Technology	SANAM - Adtech ESC4000/FDR G2, Xeon E5-2650 8C 2.000GHz, Infiniband FDR, AMD FirePro S10000	179.15
3	2,142.77	DOE/SC/Oak Ridge National Laboratory	Titan - Cray XK7 , Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x	8,209.00
4	2,121.71	Swiss Scientific Computing Center (CSCS)	Todi - Cray XK7 , Opteron 6272 16C 2.100GHz, Cray Gemini interconnect, NVIDIA Tesla K20 Kepler	129.00
5	2,102.12	Forschungszentrum Juelich (FZJ)	JUQUEEN - BlueGene/Q, Power BQC 16C 1.600GHz, Custom Interconnect	1,970.00
6	2,101.39	Southern Ontario Smart Computing Innovation Consortium/University of Toronto	BGQdev - BlueGene/Q, Power BQC 16C 1.600GHz, Custom Interconnect	41.09
7	2,101.39	DOE/NNSA/LLNL	rzuseq - BlueGene/Q, Power BQC 16C 1.60GHz, Custom	41.09
8	2,101.39	IBM Thomas J. Watson Research Center	BlueGene/Q, Power BQC 16C 1.60GHz, Custom	41.09
9	2,101.12	IBM Thomas J. Watson Research Center	BlueGene/Q, Power BQC 16C 1.60 GHz, Custom	82.19
10	2,101.12	Ecole Polytechnique Federale de Lausanne	CADMOS BG/Q - BlueGene/Q, Power BQC 16C 1.600GHz, Custom Interconnect	82.19



30% more efficient than #1 in Green 500

Final results

3150 MFlop/s per WATT

1700 Sustained GFlop/s per node

What does it mean?

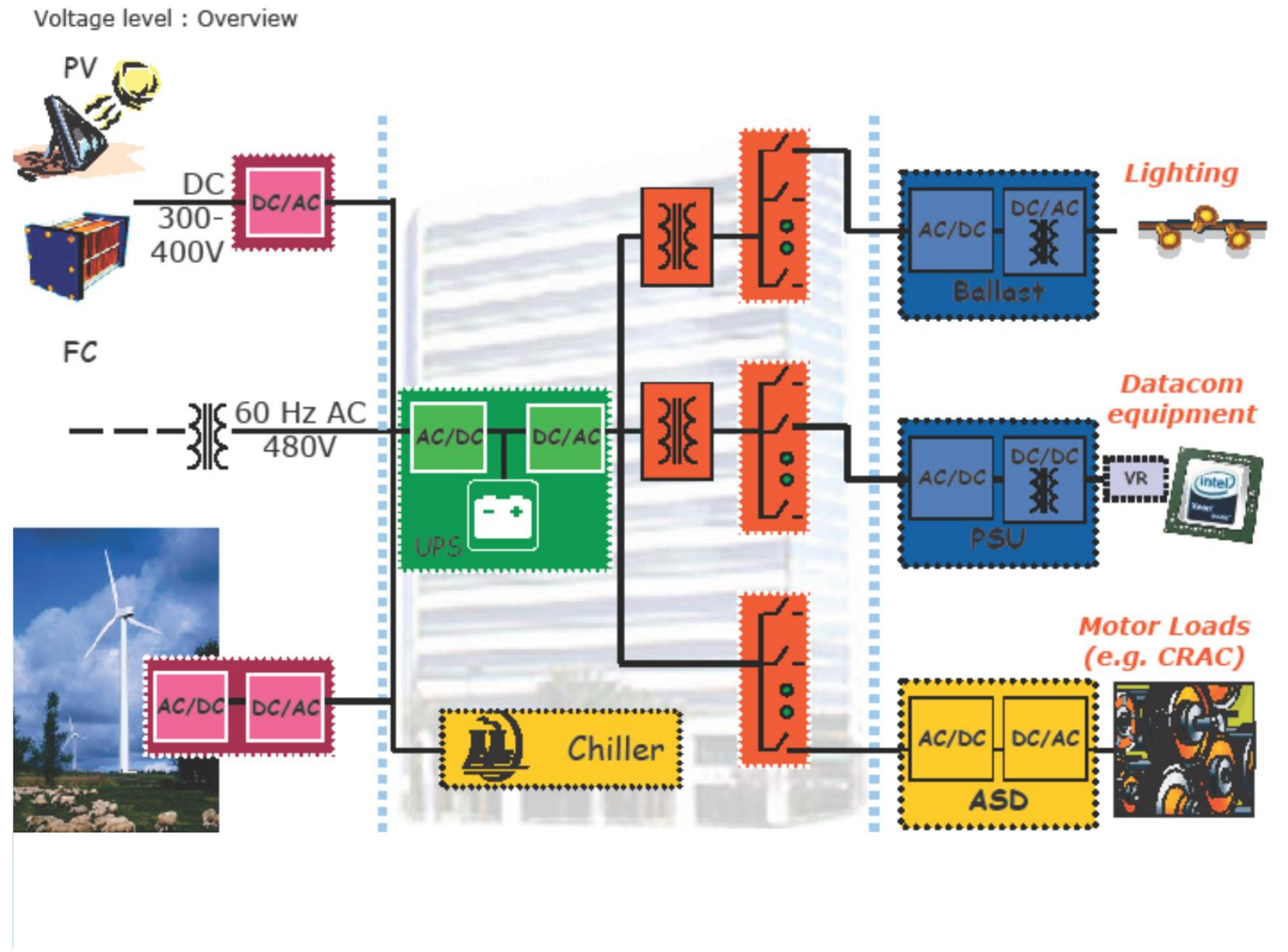
Each Eurora node (server) of the same size of a laptop is capable of performing 1.700.000.000.000 floating point operations per second, 30 times more than a desktop

The Eurora system is currently the most energy-efficient standard x86-based system of the world with 3150 Mflop/s per WATT. This is 15 times more efficient than an average desktop computer

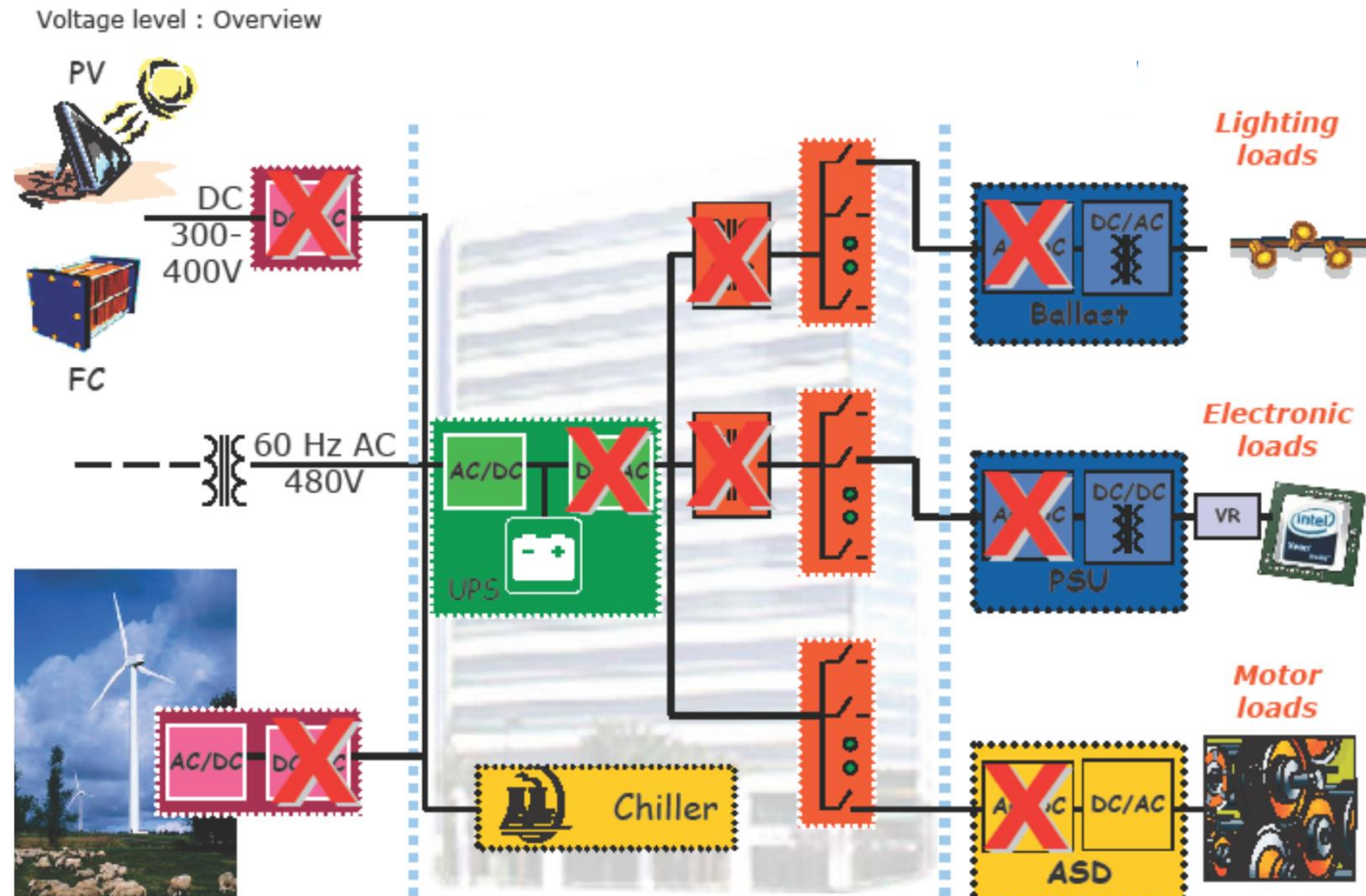
Tigon: an energy-aware design

- **GPUs**
- **Optimized design:**
 - No unused components
 - No fans
 - Soldered components
 - Dense architecture (with integrated interconnect)
- **Optimized power conversion chain**
 - To enable system level energy efficiency
 - To enable data-center level energy efficiency
- **Liquid Cooling**
 - To enable system level energy efficiency when cold water is used
 - To enable data-center level energy efficiency when hot water is used

“standard” power distribution conversion steps



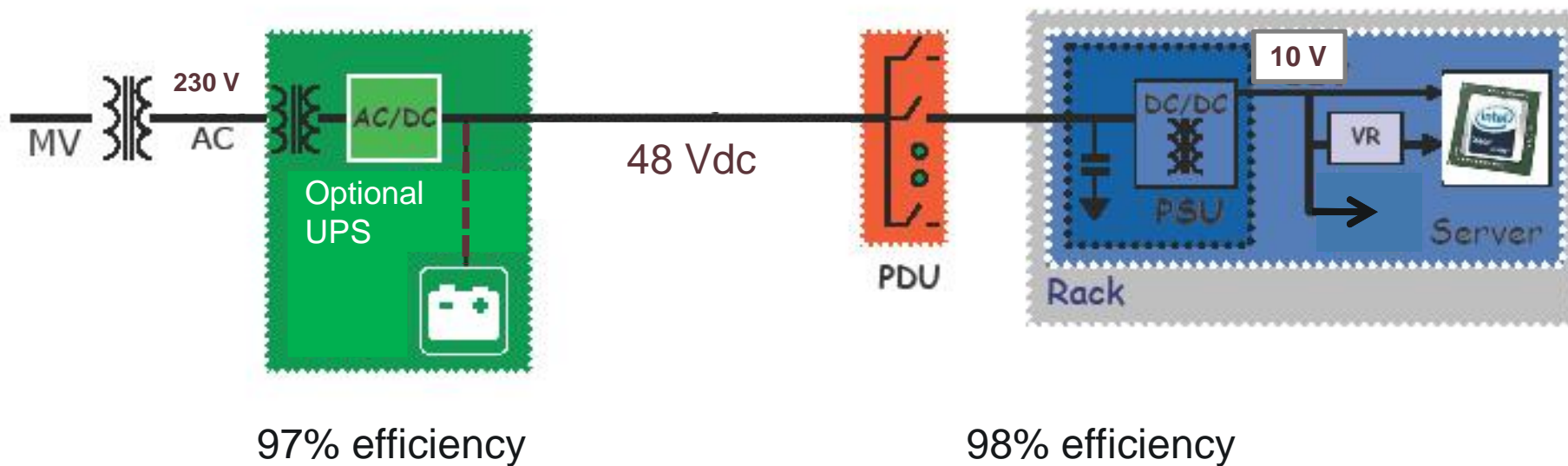
Moving towards DC reduces steps in power conversion



Aurora power distribution

Voltage level : Overview

Facility-level DC

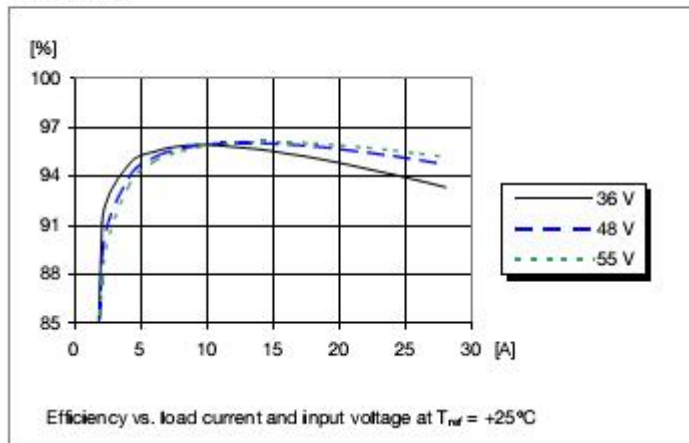


Gain DC/DC conversion efficiency

- In the DC/DC conversion a gain of over 2% in efficiency, from 95,5 % to 98%

9.6 V/27 A Typical Characteristics

Efficiency



Existing DC/DC conversion

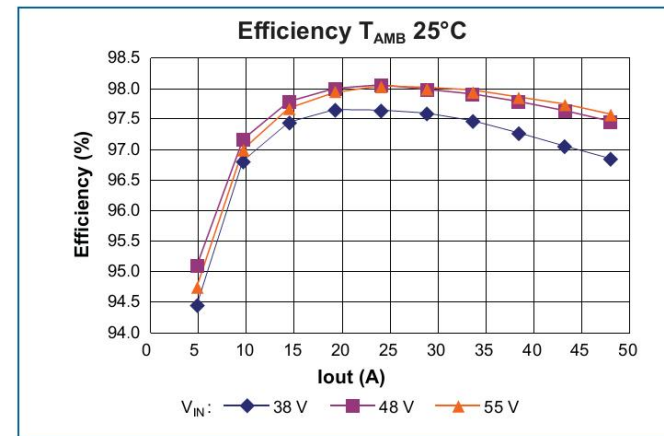
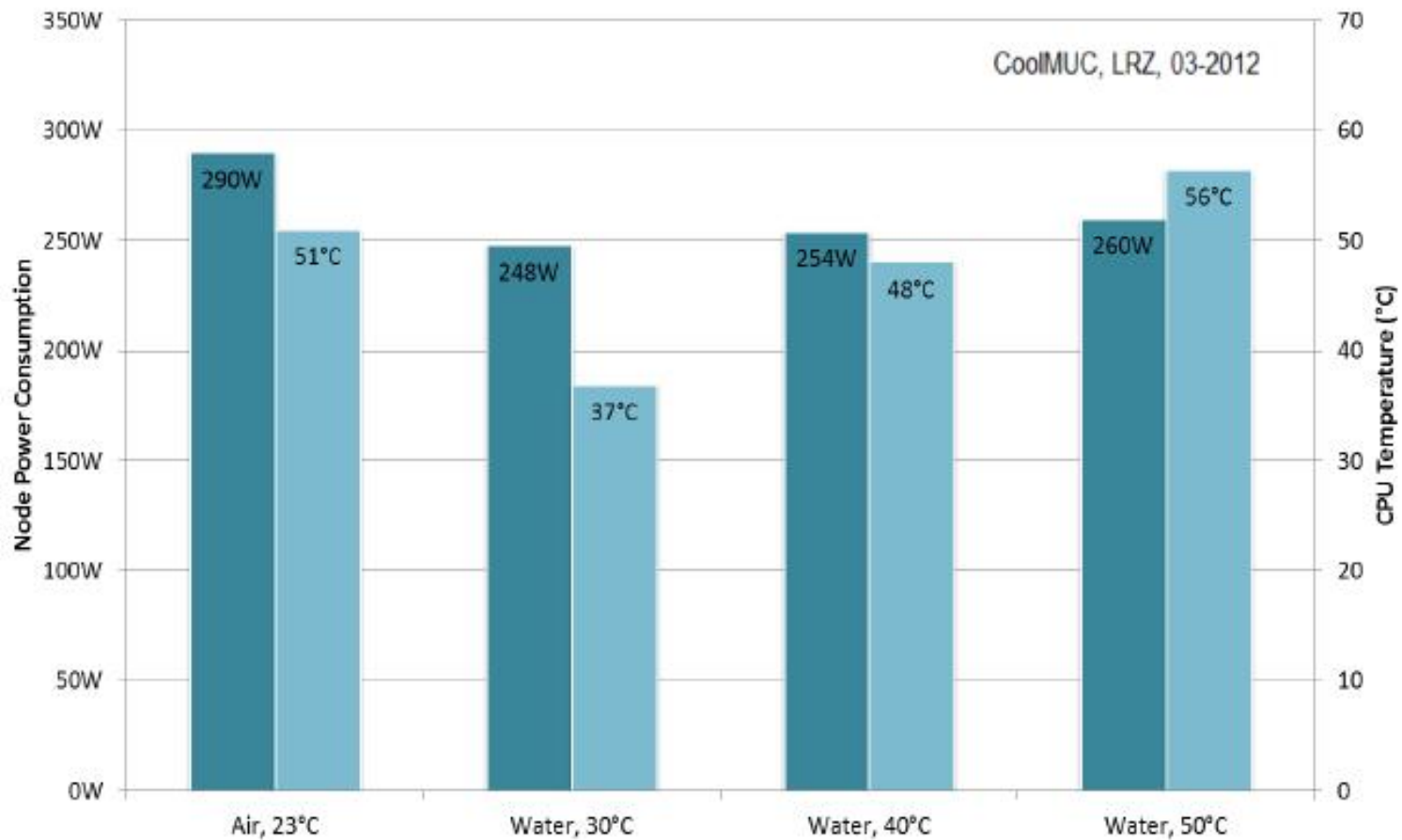


Figure 1 — Efficiency vs. output current, 25°C ambient

New upgraded DC/DC conversion

Liquid cooling and efficiency at system level

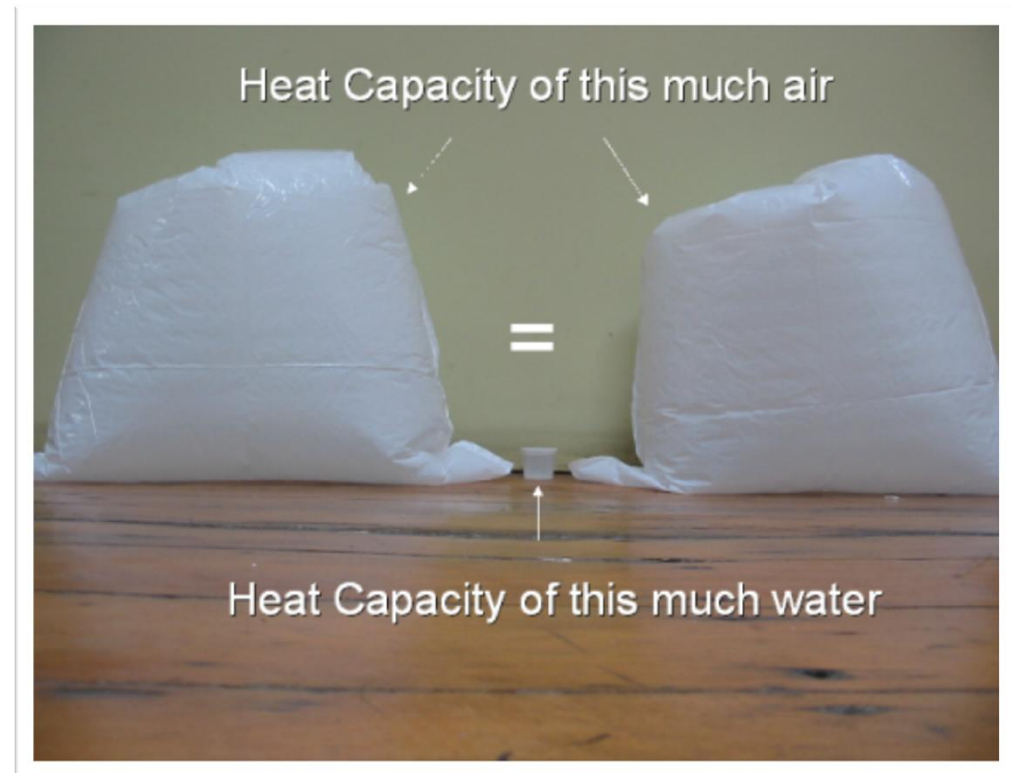
178 nodes – AMD Opteron 6128HE CPUs (Magny Cours) - 16GB RAM Measurements taken by LRZ



Why liquid cooling is better?

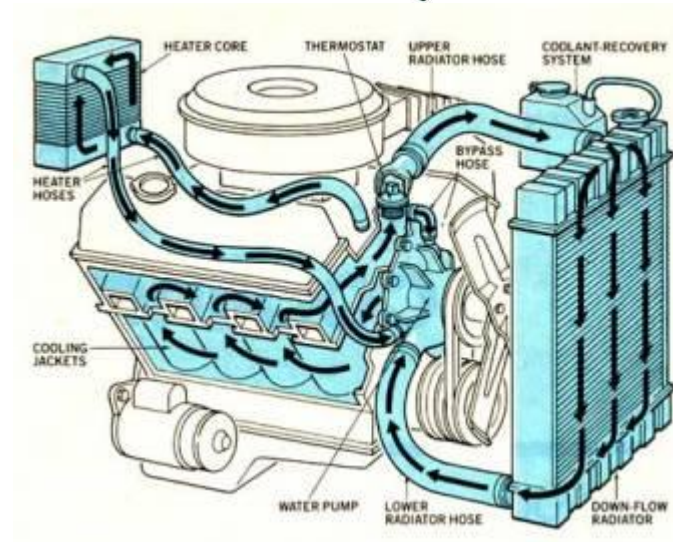
- Heat capacity:

- Air: 1
- Water: 3500

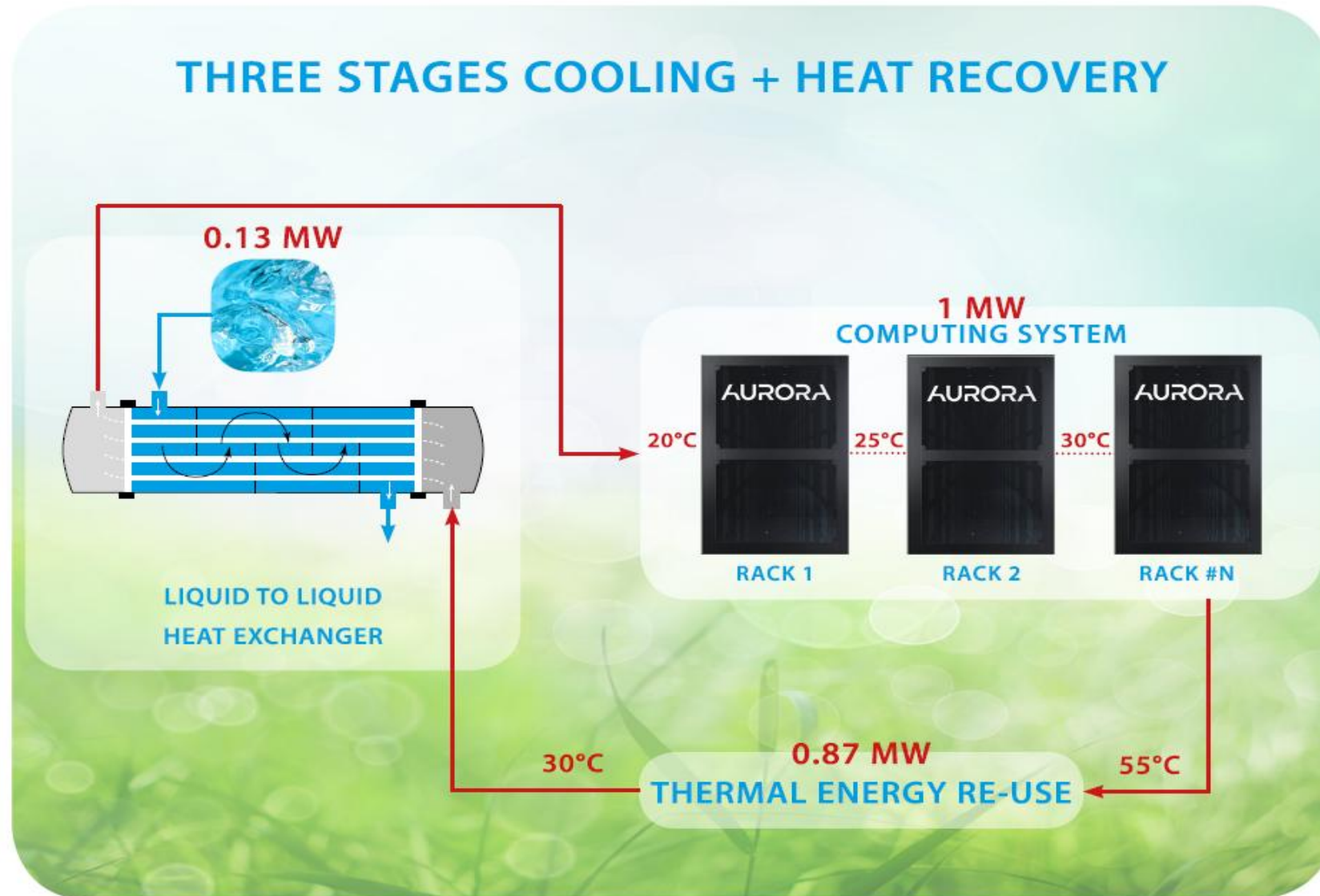


- Control over coolant flow and heat exchange
- Control over temperature

Ways of cooling car engines



Free cooling and energy re-use





11000 CO₂ tons saved!

1500 cars that do not circulate for 1 year
11500 saved trees
15 Km² of rain forest left untouched

*“Green is the prime color of the world, and that from which
its loveliness arises”*

Pedro Calderon de la Barca