

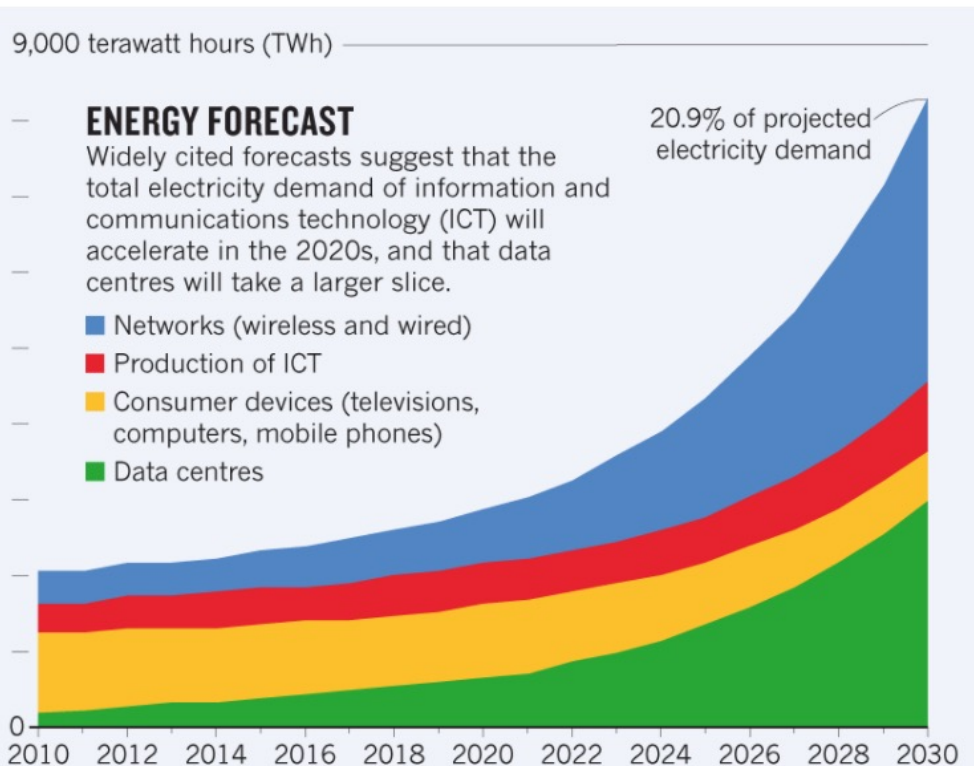
LUMI

A white wolf is the central focus, standing in a futuristic, blue-toned digital environment. The background is filled with vertical lines, data streams, and server racks, creating a high-tech, cybernetic atmosphere. The wolf is looking slightly to the right with a calm expression.

Reaching Zero-Carbon Footprint in HPC Operations

Dr. Pekka Lehtovuori
Director, Services for Computational research
CSC – IT Center for Science, Finland

Data centers & CO₂ emissions



Nature **561**, 163-166 (2018)

- Data center operations already use more than 2% of the world's electricity, and contribute to 2% of world's CO₂ emissions.
 - Equivalent to the world's entire airline industry
- European Green Deal's goal is to make data centers climate neutral by 2030.

Considerations for a HPC system's carbon footprint

- Data center and operations level choices
 - Power: used electricity, power-usage efficiency, PUE
 - Waste heat reuse, ERF
 - District heating, sorption cooling, water preheating, desalination, biomass processing, greenhouses,...
 - Construction/retrofitting of the data center
- System level choices
 - ICT manufacturing
 - Eco-efficiency of the hardware and software ("science per watt")



Case study: EuroHPC LUMI, Kajaani, Finland

LUMI: one of the fastest supercomputers in the world

- LUMI is owned by EUROHPC JU, operated by CSC in Kajaani
- HPL performance over **375 petaflop/s** makes the system one of the world's fastest
Partial system listed 11/22 with 309 Pflop/s, #3 Top500, #7 Green500 (#2 of the big systems)



1 system

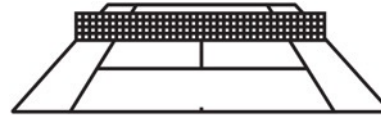
375
Pflop/s

Sustained performance

Computing power
equivalent to

1 500 000

Modern laptop computers



Size of two tennis
courts

Modern platform for

High-performance
computing,
Artificial intelligence,
Data analytics

Based on GPU technology

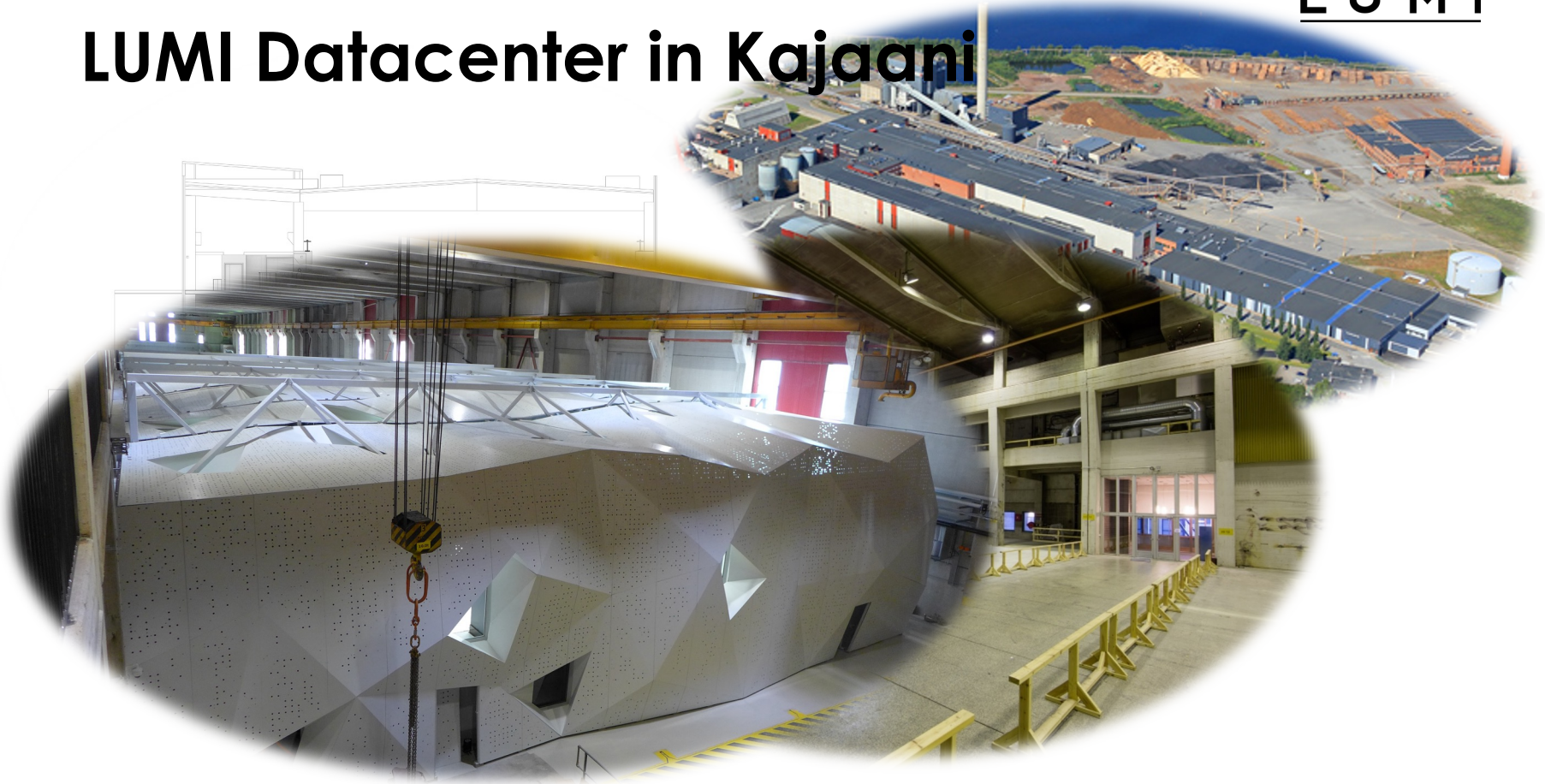
LUMI Consortium

- Unique consortium of 10 countries with strong national HPC centers
- The resources of LUMI will be allocated per the investments
- The share of the EuroHPC JU (50%) will be allocated by a peer-review process (cf. PRACE Tier-0 access) and available for all European researchers
- The shares of the LUMI partner countries will be allocated by local considerations and policies – seen and handled as extensions to national resources



LUMI

LUMI Datacenter in Kajaani





RENFOR SIN RANTA

RATA

LUMI

KONE

Benefits of the brownfield solution

We assume having reduced the CO₂ footprint of LUMI data center construction by over 80% with the brownfield solution vs. constructing an all-new building for LUMI

Materials - building shell 5,700 ft ² (530 m ²) office facility	Tonnes of CO ₂	Percentage of total
Foundation (concrete)	4.7	4%
Flooring (concrete slab, insulation)	39.9	31%
Ceilings (plaster board)	2.3	2%
Structure (steel beams)	15.4	12%
External walls (brick, insulation)	32.1	25%
Internal walls (wood frame and plasterboard)	8.7	7%
Stairs (concrete)	1.1	1%
Windows (glass and frame)	0.59	0.4%
Internal doors (particle board)*	-0.4	-0.3%
External doors (plastic)	0.6	0.5%
Roof (wood, concrete, insulation)	23.4	18%
TOTAL	128.3	100%

For a 1 MW DC, source: Schneider-Electric white paper 66

Green electricity & waste heat utilization

- **High capacity green power** is provided with **six links to the national grid**. Green energy production in the region, including three local hydro power plants, solar power and wind farms.
- LUMI uses **100% certificated hydro power** (with a Carbon Usage Effectiveness of close to zero) in all its data center production and office environments.
 - Kajaani DC area features green power up to 200 MW
 - Being green, not “buying green”
 - One outage during the last 39 years

Waste heat utilization

- **95% of LUMI's waste heat can be re-used in the district heating system of Kajaani**
 - Energy costs go down by 37% as local energy company pays for the waste heat.
 - As an alternative, 100% free cooling available, PUE 1.04
- With LUMI's heat, the local energy company can reduce the use of budned coal that corresponds in CO₂ emissions to removal of ~3000 cars from traffic

100 %

Carbon-neutral energy



-12 400T

Co₂ eq/emissions

LUMI produces up to

20 %

of Kajaani's district heating needs



DRY AIR COOLING FOR BACK UP
~ 9 MW

DISTRICT HEATING NETWORKS ~ 10 MW
-Renforsin Ranta Business Park
-CITY of Kajaani

LUMI

HEAT EXCHANGERS

HEAT PUMPS



HPC load
Max. 9 MW



+31 °C

+45 °C

+60 °C

+80 °C

+32 °C

+44 °C

+32 °C

+44 °C

Maximum heat production approximately 10 MW

Electricity to heat pumps is CO₂ free.

In addition of DLC there is approximately 1 MW of capacity for the air-cooled servers (e.g. storage). This IT is free-cooled.

LUMI DESIGN IMPACT

PUE 1.04 & 1.24

Support to Excess Heat Utilisation

Carbon Negative Operations

Use of Local Renewable Energy



20 % of annual need
40 % impact to
total cost of energy

Footprint:
-12 400 tonnes

LUMI system level choices

- ICT equipment life cycle
 - Responsibility and sustainability required and rewarded in the CfT
- Operations and energy efficiency
 - Chosen GPU solution (and LUMI) will be at the top of Green500 over multiple lists to come
- Other considerations
 - LUMI is strongly positioned as an instrument for climate research, especially EU's Destination Earth programme
 - The "Climate Adaptation" digital twin will provide vital insight for how to mitigate the climate change

Concluding remarks

- Carbon footprint of ICT, HPC included, **does** matter!
- Green-ness of a HPC installation is fully dependent on the **data-center level choices**, especially contracted source of energy
- HPC systems **do not need to physically locate** in the country where it is being used or who owns it
- Carbon-neutral (even negative) HPC operations possible already today
 - Use 100% carbon-neutral energy (wind, nuclear, solar, hydro)
 - Reuse the excess heat, it is a big amount of energy (in big picture)
 - Repurpose existing buildings and use brownfield solutions instead of building new DCs



Acknowledgement:
Dr. Pekka Manninen ja Jukka-Pekka Partanen for the slides



Pekka Lehtovuori

Director,
Services for computational research

CSC – IT Center for Science Ltd.

phone.:09 457 2293
Firstname.lastname@csc.fi

PL 405, 02101 Espoo

www.csc.fi



facebook.com/CSCfi



twitter.com/CSCfi



youtube.com/CSCfi



linkedin.com/company/csc---it-center-for-science



github.com/CSCfi