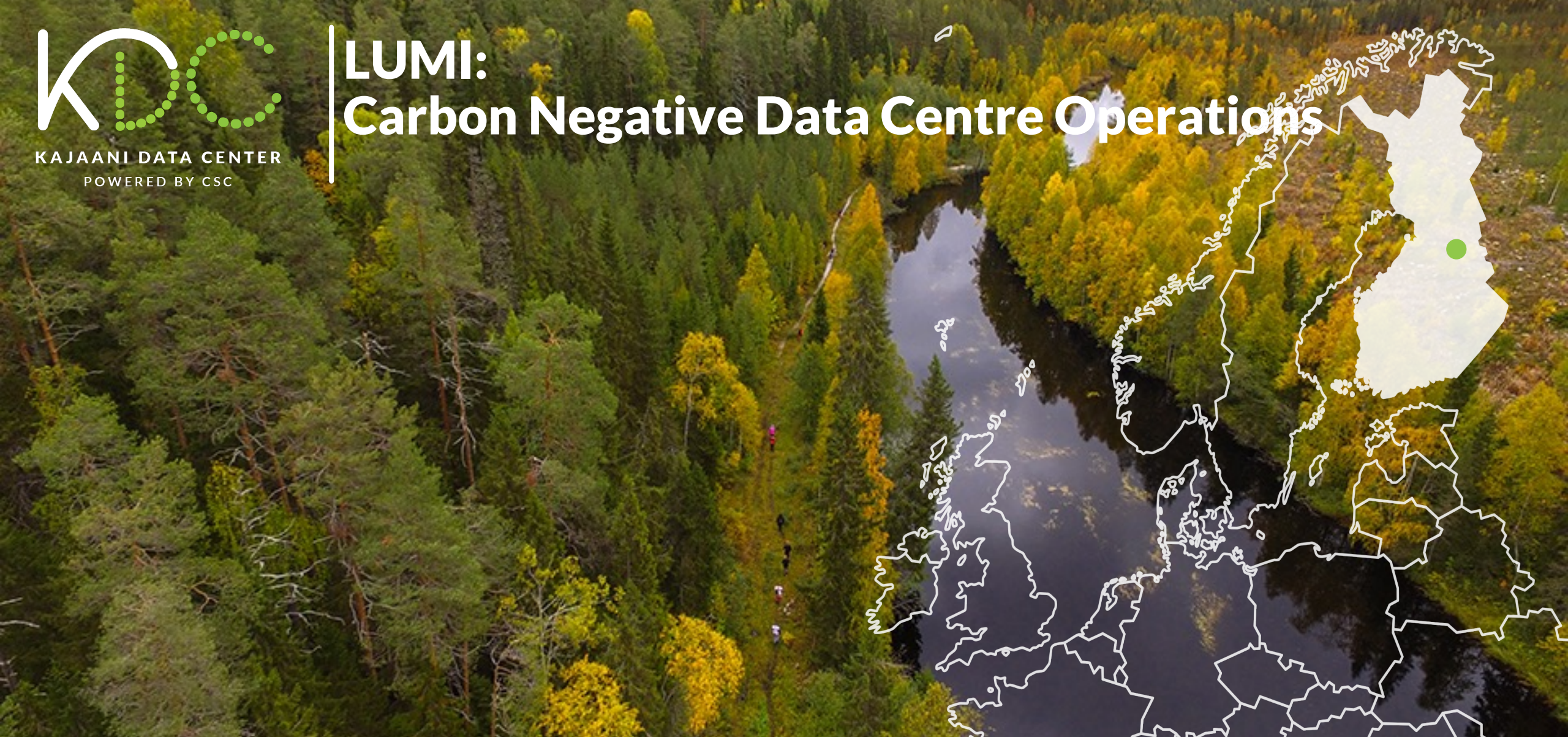




KAJAANI DATA CENTER  
POWERED BY CSC

# LUMI: Carbon Negative Data Centre Operations





# Considerations for a HPC system's carbon footprint



## Data center level choices

- Power:
  - Electricity emission factor, power-usage efficiency (PUE) and minimizing the transmission losses
  - Power reliability and the need for backup generators
- Waste heat reuse
  - District heating, sorption cooling, water preheating, desalination, biomass processing, greenhouses,...
  - Evaluate the most suitable cooling concept
  - Energy reuse effectiveness (ERE)
- Construction/retrofitting of the data center
- Environmental circumstances

$$\text{PUE} = \frac{\text{Total Facility Power (Cooling+Power+Lightning+IT)}}{\text{IT Equipment Power}}$$

$$\text{ERE} = \frac{\text{Cooling+Power+Lightning+IT-Reuse}}{\text{IT}}$$

# 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







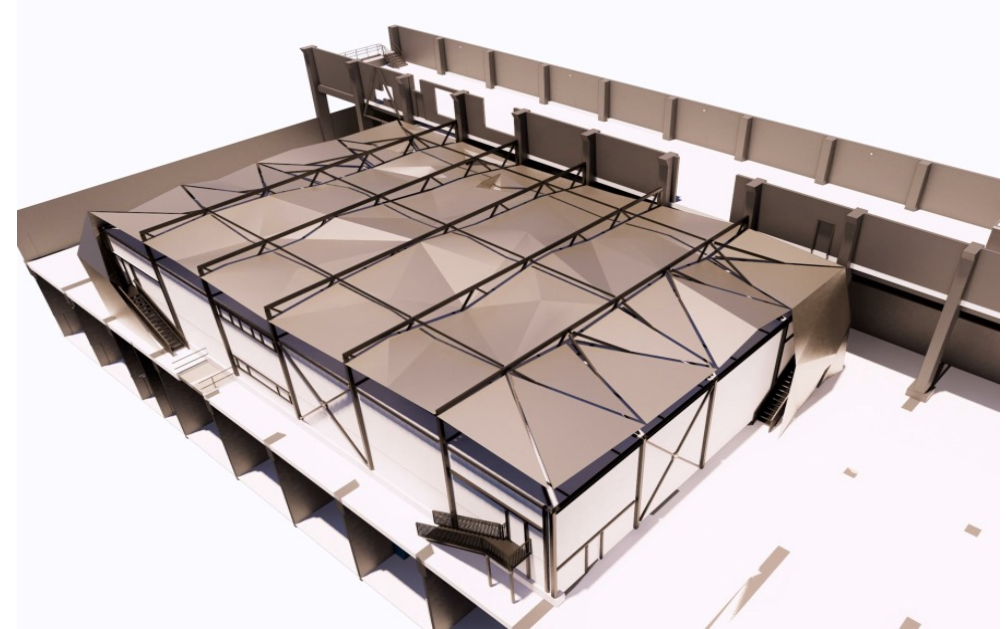
# LUMI WHY in Kajaani



# Project Summary



- LUMI project's key objectives were reasonable capital expenses and low total cost of ownership.
- One of the biggest challenges in the project design was the fact that the final technical requirements of the HPC was available only at the midpoint of the building phase.
- In order to reach the lowest total cost of ownership the primary cooling solution was designed to be the heat recovery and dry air cooling will act as a backup
- High capacity green power is provided with six independent feeds to on-site substation. Surplus of green energy production in the region, including three nearby hydro power plants and wind farms.
  - One outage during the last 39 years
- LUMI uses 100% certificated hydro power (with a close to zero carbon usage effectiveness) in all its data center production and office environments.





# Home of LUMI: Renforsin Ranta Business Park, Kajaani Finland





# Benefits of the brownfield solution



- We assume having **reduced the CO2 footprint of LUMI data center construction by over 80%** when comparing the brownfield solution vs. constructing an all-new building for LUMI
  - ~1000 tonnes
- Without the utilization of brownfield solution we couldn't have secured the project timeline

Materials - building shell 5,700 ft <sup>2</sup> (530 m <sup>2</sup> ) office facility	Tonnes of CO <sub>2</sub>	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%
<b>TOTAL</b>	<b>128.3</b>	<b>100%</b>

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



# LUMI: Excess Heat Utilization Process Overview



Annual CO<sub>2</sub> savings 12 400 tonnes



DRY AIR COOLING  
FOR BACK UP  
~ 10 MW

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

HEAT EXCHANGERS

HEAT PUMPS

Service demarcation point for the  
excess heat utilization

Heat pumps use renewable energy



HPC load

In addition of Direct Liquid Cooling  
there is approximately 1 MW of  
capacity for the air-cooled servers (e.g.  
storage and management servers). This  
load is free-cooled.



# Considerations of District Heat Operator



- LUMI projects supports the transition towards sustainable heat production
- Local ecosystem helped to design the project with clear interfaces and roles in the supply chain
- One of the main criteria for the heat is consistent and predictable load
  - Due to the closeness of the district heat plant, ability to adjust their own process according to received heat
- Connecting new big heat resources to the network is not feasible in all locations
  - Transfer routes might become a bottle neck
  - Distance from the district heat network
    - Expense increase to built the new network
    - Losses in heat transition
- Uncertainty for the possible future emission costs in heat production favor data center excess heat utilization
  - Potential cost savings solely ~10 €/MWh of heat created (emission costs)

# 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 and ability to utilize excess heat
- Carbon-neutral (even negative) HPC operations possible already today
  - Heating and cooling consumes 50% of EU's annual energy and 75% of the fuel used is from fossil fuels
  - Reusing excess heat or cooling can have huge impact and same time reduce the energy costs
  - Repurpose existing buildings and use brownfield solutions instead of building new DCs
- Important to include all the relevant organizations to the project from the start
  - Easiest to list and evaluate the different options and feasibility from everyone's point of view
- Kajaani had excellent conditions for data center operations and room to scale up, even to hyperscale needs.



# Contact Information



Kajaani data center location offering is promoted and negotiated by CSC - IT Center for Science Ltd. with the support of Kainuu Regional Council and City of Kajaani.

For more detailed information and promotion material contact:



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**CSC – IT Center for Science Ltd.**



City of **Kajaani**

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**LinkedIn:** <https://www.linkedin.com/company/csc---it-center-for-science/>  
**YouTube:** <https://www.youtube.com/c/cscfi>  
#KajaaniDClocation #lumieurohpc #CSC

# LUMI sustainability



- Immediate ability to utilize excess heat, process developed together with local district heat operator
  - Reduces annual CO<sub>2</sub> emissions equivalent to 6.8 M kilograms of burned coal
- CSC data centers in Kajaani are designed and operated to reduce global CO<sub>2</sub> emissions.
- Surplus of local green renewable energy sources available (wind & hydro)
  - **BEING GREEN** instead of **BUYING GREEN**

Renewable energy

**100 %**

Hydro +100 MW | Wind +400 MW



footprint

**-12 400T**

Co<sub>2</sub>eq/emissions

LUMI produces

**20 %**

of Kajaani's yearly  
district heat production



# Kajaani Total Cost of Ownership



- Low excess heat investment costs and excellent efficiency due to close proximity
- Extra cost savings offered by the existing infrastructure and private electricity network
- Surplus of renewable local energy enables low cost operations in the years to come
- Availability for long PPA contracts to secure stable electricity pricing

Typical data center electricity costs

**<50 €**

MWh

(<5 MW)

Excess heat utilization ready

**CARBON  
NEGATIVITY**  
**+ ASSETS FOR SALE**

PPA contract lowest 25% in 2020

**30 €**

MWh

Waste heat impact to total cost of  
energy

**UP TO 40%**

# LUMI time-to-market and future scalability



- Multiple brownfield and greenfield options from 10 MW to 200 MW immediately available
  - Use of brownfield buildings enabled project execution in harsh winter conditions
  - National grid substation capacity up to 1000 MW
- Proven expertise in delivering large and complex data center projects
  - Technical and constructional know-how and expertise to complete projects in time and on budget
- Built in security processes and no risk of natural hazards
- Ready existing infrastructure in place to secure fastest time to market

Brownfield  
**+50 000 m<sup>2</sup>**  
3 greenfield options  
**+200 ha**

Existing reference projects  
**4** data centers **with 30 MW**  
**allocated**  
on time and on budget

Ready electric infrastructure  
**200 MW**  
reduced capex and  
time-to-market

**ISO 27001**  
security certification



# Finland

**#1 – The Most Stable Country in the World – 14th year in a row**

Fund for Peace, Fragile States Index 2019

**#1 – No. 1 Business Environment in the World**

Global Innovation Index 2019

**#2– 2nd Most Skilled Workforce in the World**

World Economic Forum, The Global Competitiveness Report 2019

**#3– 3rd Most Innovative Country in the World**

Innovation Champion, The Consumer Technology Association 2019





# Finland & Kajaani

- Green and cheap energy
- Surplus of local energy
- HPC expertise & knowledge centralized only to CSC
  - Scientific Research Support to National Entities
- Infrastructure readiness & scalability
- District heating network ready to receive and pay for your excess heat
- Educating new talents for data center operations and data scientist roles from local University of Applied Science (KAMK)
- Only Nordic country in the eurozone € and lowest corporate tax

