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**

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

**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.
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

For a 1 MW DC, source: Schneider-Electric white paper 66
LUMI: Excess Heat Utilization Process Overview

Annual CO₂ savings 12 400 tonnes

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
- Unclear 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.
LUMI sustainability

- Immediate ability to utilize excess heat, process developed together with local district heat operator
  - Reduces annual CO\(_2\) emissions equivalent to 6.8 M kilograms of burned coal
- CSC data centers in Kajaani are designed and operated to reduce global CO\(_2\) emissions.
- Surplus of local green renewable energy sources available (wind & hydro)
  - BEING GREEN instead of BUYING GREEN

<table>
<thead>
<tr>
<th>Renewable energy</th>
<th>CO(_2) footprint</th>
<th>LUMI produces</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>-12 400T</td>
<td>20%</td>
</tr>
<tr>
<td>Hydro +100 MW</td>
<td>Co(_2) eq/emissions</td>
<td>of Kajaani's yearly district heat production</td>
</tr>
<tr>
<td>Wind +400 MW</td>
<td></td>
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</tbody>
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Kajaani Total Cost of Ownership

- Low excess heat investment costs and excellent efficiency due to close approximation
- 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

<table>
<thead>
<tr>
<th>Typical data center electricity costs</th>
<th>Excess heat utilization ready</th>
<th>PPA contract lowest 25% in 2020</th>
<th>Waste heat impact to total cost of energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50 € MWh (≤5 MW)</td>
<td>CARBON NEGATIVITY + ASSETS FOR SALE</td>
<td>30 € MWh</td>
<td>UP TO 40%</td>
</tr>
</tbody>
</table>
# 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

<table>
<thead>
<tr>
<th>Brownfield</th>
<th>Existing reference projects</th>
<th>Ready electric infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>+50 000 m²</td>
<td>4 data centers with 30 MW allocated on time and on budget</td>
<td>200 MW reduced capex and time-to-market</td>
</tr>
<tr>
<td>+200 ha</td>
<td>ISO 27001 security certification</td>
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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

#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