



Introduction to LUMI EuroHPC Data Center and Kajaani Datacenter Ecosystem



Non-profit state
organization with
special tasks



Turn over
in 2021
56M€



Headquarters in
Espoo,
datacenter in
Kajaani



Owned by state **(70%)**
and all Finnish higher education
institutions **(30%)**



About
550
employees

The Queen of North

LUMI

European flagship
supercomputer

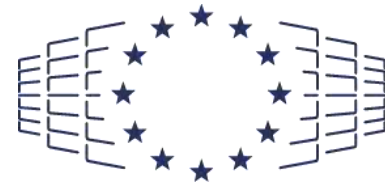
Powered by



www.lumi-supercomputer.eu

#lumisupercomputer #lumieurohpc

The EuroHPC Joint Undertaking (JU)



EuroHPC
Joint Undertaking

- **The EuroHPC Joint Undertaking** will pool EU and national resources in high-performance computing (HPC)
 - **acquiring and providing a world-class supercomputing and data infrastructure** for Europe's scientific, industrial and public users
 - supporting an ambitious **research and innovation agenda**
- The EuroHPC declaration has been signed by **32 European countries**
- The first generation of EuroHPC systems announced in June 2019
 - 3 pre-exascale systems to Finland, Italy and Spain
 - 5 petascale systems to Czech Republic, Bulgaria, Luxembourg, Portugal and Slovenia
- Next generations of systems planned for 2023-2024 and 2026-2027



LUMI Consortium

- **LUMI research infrastructure** provides a high-quality, cost-efficient and environmentally sustainable HPC ecosystem based on true European collaboration.
- **LUMI consortium** members are Finland, Belgium, Czech Republic, Denmark, Estonia, Iceland, Norway, Poland, Sweden and Switzerland.
- 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 and available for all European researchers
- LUMI (Large Unified Modern Infrastructure) means **snow in Finnish**

■ Countries which have signed the EuroHPC Declaration
■ LUMI Consortium countries

LUMI

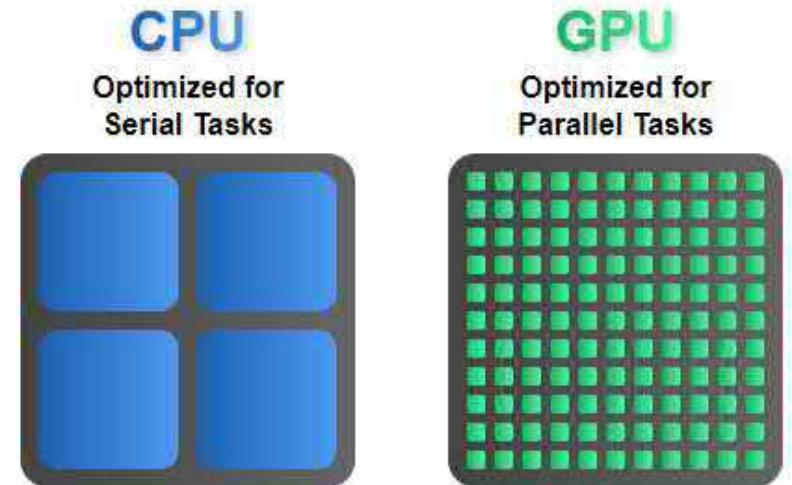
CSC Datacenter in Kajaani



What is Supercomputing?

L U M I

- Supercomputing is based on parallel computing in which several computing units are executing tasks simultaneously
- Earlier, computing was based mostly on CPUs (Central Processing Unit) enabling serial computing, i.e., executing commands one by one
- Nowadays GPUs (Graphics Processing Unit) are becoming more common. A GPU can divide computing task simultaneously to even hundreds of cores it has.
- High-Performance Computing (HPC) is often used as synonym for supercomputing



What is a Supercomputer

LUMI

Its powerful processors can perform millions of calculations simultaneously, so it can operate millions of times faster than conventional computers and help us solve highly complex problems.



LUMI is an **HPE Cray EX Supercomputer**


Hewlett Packard
Enterprise

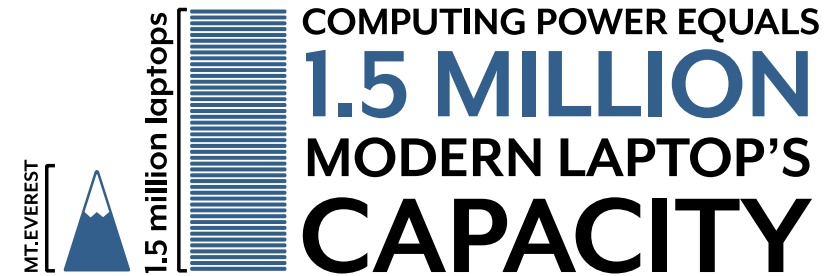
LUMI is 3rd Fastest Supercomputer in the World Operating 2022-2026

LUMI

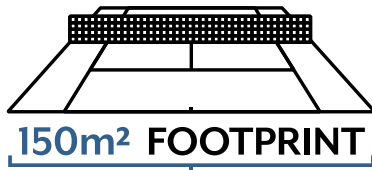
SUSTAINED PERFORMANCE

375 PETAFLP/S

= performs 375×10^{15} calculations per second



2 x

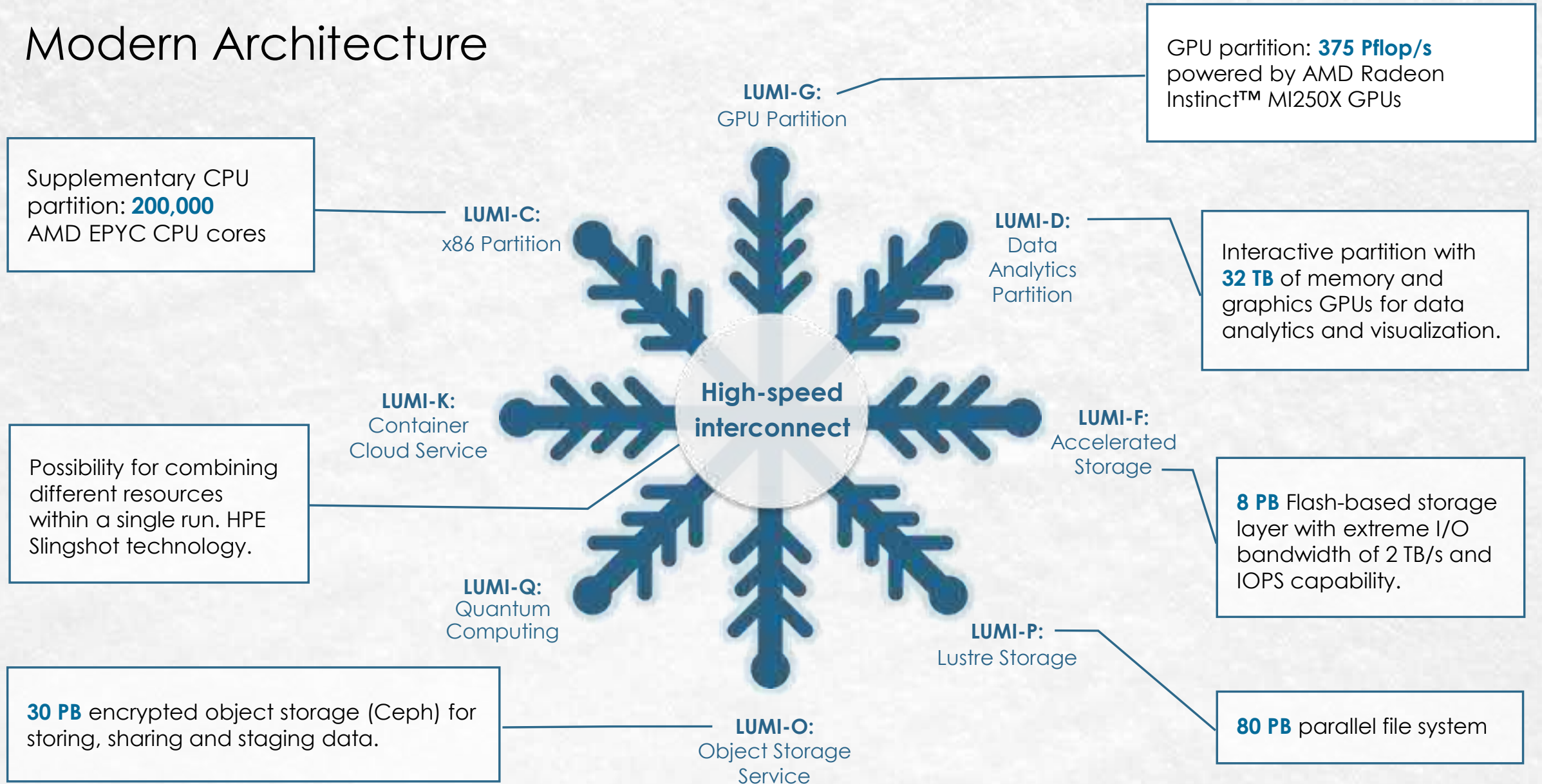


High-
performance
computing

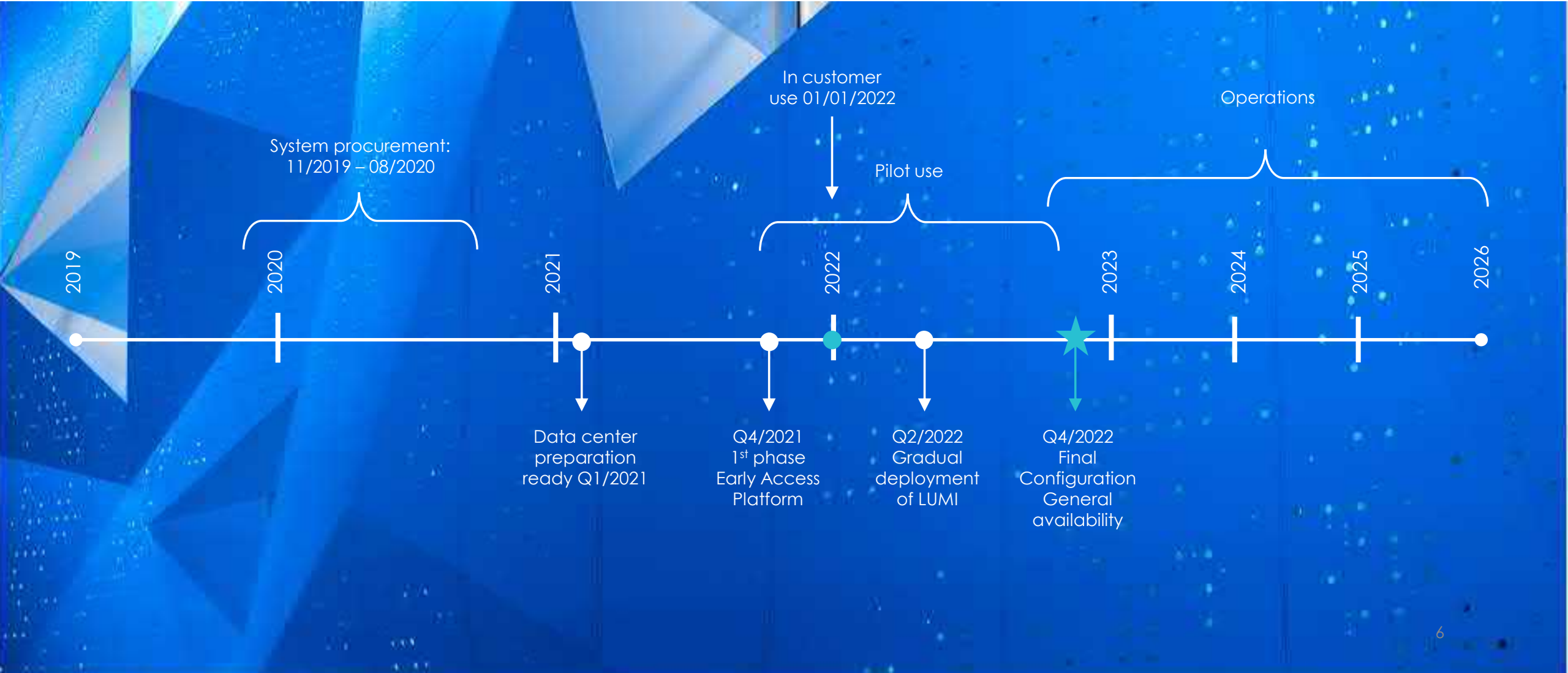
AI

Data
analytics

Modern Architecture

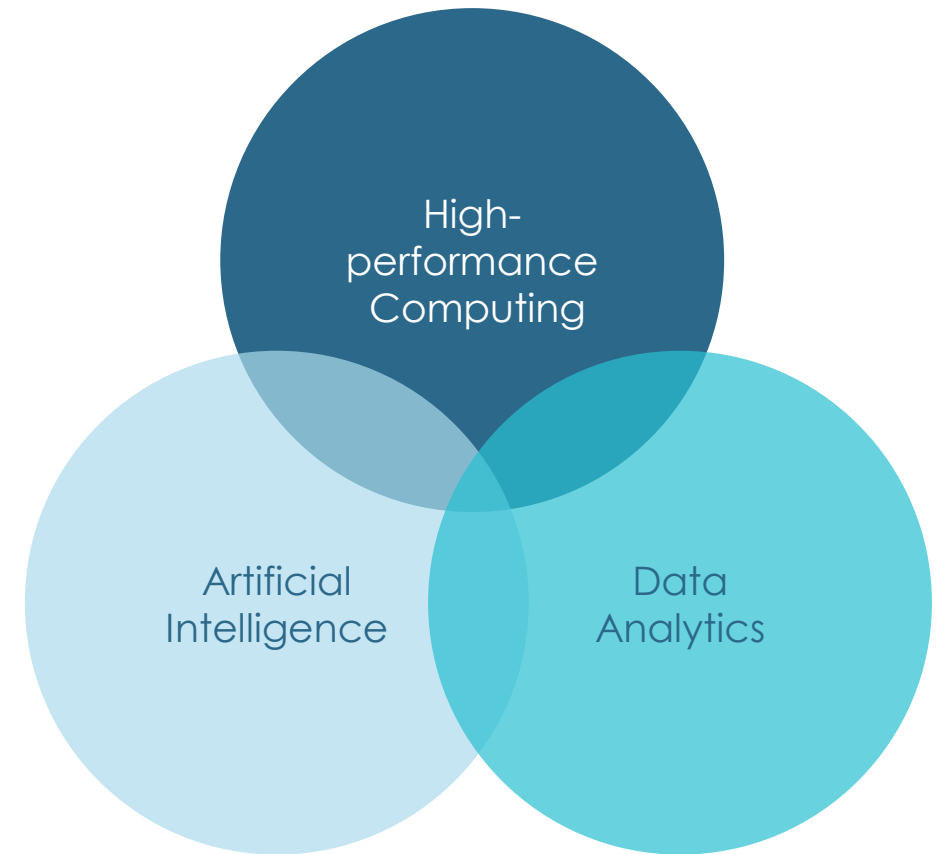


LUMI timeline





• The convergence of High-performance Computing, Artificial Intelligence and Data Analytics will be key for solving the great scientific and societal challenges.



Enabling top research
and scientific breakthroughs

- Climate change
- Climate simulations
- Digital modelling (e.g. Destination Earth)
- Treatment of diseases
- Personalized medicine
- Life sciences
- Time-critical modelling
- Artificial Intelligence: self-driving vessels and cars, natural language processing (NLP)
- Data analytics



Climate simulations

Climate simulations are critical in climate modelling to understand climate change and to reduce the impact of climate change by finding the most appropriate and cost-efficient counter-actions.



https://videos.files.wordpress.com/wp0yIzsV/elmerice_simulation_dvd.mp4

Digital modelling

Destination Earth (DestinE) aims to develop – on a global scale – a highly accurate digital model of the Earth to monitor and predict the interaction between natural phenomena and human activities.





TREATMENT OF DISEASES


Shedding light on the causes of illness and improving personalized medicine: sequencing and analyzing of full genomes combined with data analysis and correlations to clinical data.



Life Sciences

Advanced computing plays a key role in all levels of modern medicine and health, and will have tremendous impact for personalised medicine.

Researchers are already able to rapidly identify genetic disease variants, and it will become possible to identify diseases that are caused by combinations of variants, with treatments and drugs tailored both to the individual patient and the exact state of the disease.



TIME CRITICAL MODELLING

Fast-track for urgent computing needs in time- and mission-critical simulations, e.g., related to national or EU threat or other major crisis, e.g., pandemics.

A decorative graphic of white and light blue dots of varying sizes is positioned to the left of the section header. The dots are arranged in a pattern that suggests a network or data flow, with some dots appearing to trail off to the left.

ARTIFICIAL INTELLIGENCE

LUMI is a one of the worlds leading research platforms for AI.

LUMI enables the convergence of high-performance computing, artificial intelligence, and high-performance data analytics.

A decorative graphic consisting of a cluster of white and light blue dots of varying sizes, arranged in a roughly circular pattern.

Self-driving vessels and cars

Research and teaching of algorithms for self-driving cars and ships with unprecedented computing power.





Natural language processing (NLP)

Artificial intelligence already plays an invisible role in everyday life. It works e.g. in speech recognition systems (e.g. smart speaker).

How to start using LUMI in RESEARCH?



A potential LUMI user has two routes to apply for the resources:

1. National capacity in Finland is free for Finnish academic users affiliated to Finnish higher-education or research institutes
 - Read more about the Access Modes and Open Calls at <https://www.lumi-supercomputer.eu/get-started-2021/users-in-finland/>
2. Half of the LUMI resources are allocated by the EuroHPC Joint Undertaking.
 - Researchers in European countries can apply for the resources in this pool.
 - For more information, see "Users in Europe" at <https://www.lumi-supercomputer.eu/get-started-2021/users-in-europe/>



Up to 20%

of LUMIs capacity
is reserved for
European industry
and SMEs

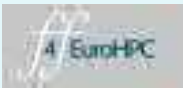


LUMI

For companies LUMI offer

- **A world-class supercomputing capacity with cost-efficient pricing**
- **Superfast product development and new business opportunities** in areas such as data analytics and AI
- **Top expert support and competence development as a service** from LUMI User Support Team
- **A way to initiate or strengthen cooperation with universities and research institutes**
- **Data security based on ISO/IEC 27001 standard**

How to start using LUMI in a COMPANY?



PRIVATE-PUBLIC ENGAGEMENT	PAY PER USE	BUSINESS FINLAND FUNDING
<ul style="list-style-type: none">• Project in cooperation with Finnish university or research organization (academic partner)• Project lead (PI) assigned from academic partner• Free of charge if results are published• Market price charged if results are closed	<ul style="list-style-type: none">• National LUMI capacity: Company pays market price to CSC• EuroHPC JU capacity Company pays market price to JU. Funding possible through PRACE SHAPE and EuroHPC JU programs for SMEs  	<ul style="list-style-type: none">• Start-up and SMEs can request HPC grant at a value of 20,000-80,000€. Can be added to an already running project.• Large and mid cap companies can include computing capacity into their R&D project budget, 40% of costs covered• Capacity is valued at market price 

More information at
<https://www.csc.fi/en/solutions-for-business>

LUMI



LUMI WHY in Kajaani



Some Basics of DC Business



Greenfield vs. Brownfield:

- With **greenfield** investing, a company will build its own, brand new facilities from the ground up.
- **Brownfield** investment happens when a company purchases or leases an existing facility.

Electricity consumption:

- **Datacenter capacity (and size)** is primarily measured by electricity consumption in kilowatts (kW) or **megawatts (MW)**
- **Main cost in datacenter operations**

Power Usage Effectiveness (PUE):

- PUE measures the total energy use of the data center compared to the energy used by IT equipment.

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

Energy Reuse Factor (ERF):

- The ERF of a data center reflects how much energy is exported for reuse outside of data center operations

$$\text{ERF} = \frac{E_{\text{Reuse}}}{E_{\text{DC}}}$$

White space:

- White space is the area dedicated to IT equipment and infrastructure

Key Elements for Datacenter Location



Electricity:

- Availability
- Reliability
- Price
- Green and renewable energy sources

Heat reuse possibility

Connectivity:

- Latency, time it takes data to travel between two points

Ecosystem support:

- Personnel
- Education
- Vendors, operators
- RDI partners

Other:

- Reachability of the location (airport and flights)
- Stability and security of the area/country

Home of LUMI

Renforsin Ranta Business Park, Kajaani Finland


Greenfield (200 ha)


National grid
substation (1000 MW)

Excess heat utilisation to
district heat network

3 hydropower plants
In Kajaani river

3x  →

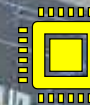
230 MW existing
transformer capacity



LUMI Euro HPC



CSC's national
supercomputers



Kajaani Advantages as DC Location



Low total cost of ownership:

- Attractive electricity price, even 50% lower compared to Central and southern Europe
- Excess heat sales opportunity reduces total cost of operations

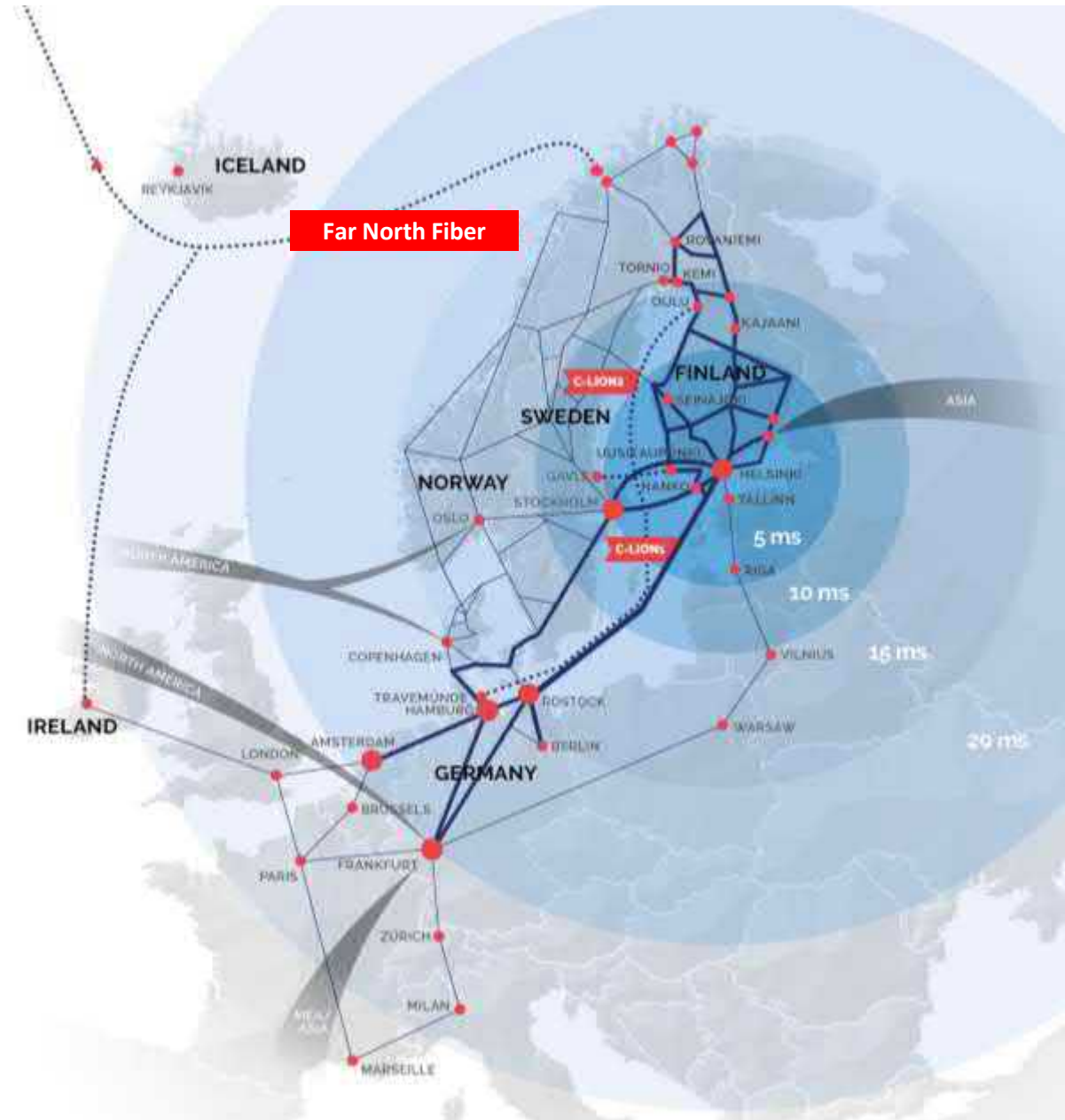
Sustainability:

- Surplus of local 100% green renewable energy sources available (wind & hydro)
 - 200 MW ready for use in Renforsin Ranta
- Excess heat utilization reduces CO2 emissions

Existing infrastructure and ecosystem:

- 4 existing reference projects, including LUMI the 3rd fastest supercomputer globally
- Local presence of HW vendors (HPE ja Atos) and education from Kajaani University of Applied Science
- Infrastructure ready for fast project start and implementation
 - Multiple brownfield (up to 50.000 m²) and greenfield options (up to 200 ha)

Kajaani Connectivity



- Funet, NORDUnet & GÉANT research networks in place
- Operator neutral business park with multiple physical connectivity routes to the site
- Cinia PoP in place (multiple 100G)
 - Direct C-Lion connectivity
 - Future connectivity to Asia and US via “Far North Fiber”
- All the national operators in place

CITY	Kajaani	Helsinki	Frankfurt	Hamburg	Amsterdam	London	Berlin	Stockholm
Helsinki	6,7							
Frankfurt	26,4	19,7	-	-	-	-	-	-
Hamburg	21,9	15,2	5,6	-	-	-	-	-
Amsterdam	26,4	19,7	12,1	6,5	-	-	-	-
London	32,8	26,1	16,4	10,8	6	-	-	-
Berlin	22,7	16	11,5	5,8	12,3	16,6	-	-
Stockholm	11,9	5,2	22,4	12,4	19	23,2	17,1	-
Moscow	18,4	11,7	31,4	26,9	33,4	37,7	27,7	16,9
Tokyo	137,5	130,8	150	146	152,5	156,8	146,8	136
Hong Kong	139,5	132,8	152	148	154,5	158,8	148,8	138

**Unbolded values are estimates and bolded values are measured*



Cinia



DNA



Telia



elisa

Greenfield vs. Brownfield



HPC System's Carbon Footprint



- **Building phase**
 - Greenfield vs. Brownfield
- **Operations**
 - Design & Efficiency (PUE)
 - Consumed electricity
 - Waste Heat utilisation (ERF)
 - Hardware "Science per watt"



Benefits of the Brownfield Solution



- 80% reduction of CO2 footprint in LUMI data center construction project
- Saved ~1 000 tonnes of CO2eq
- Flexibility to start whenever
- Cost savings

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

LUMI DESIGN IMPACT

PUE 1.04 & 1.24

Support of Excess Heat Utilisation

Carbon Negative Operations

Use of Local Renewable Energy

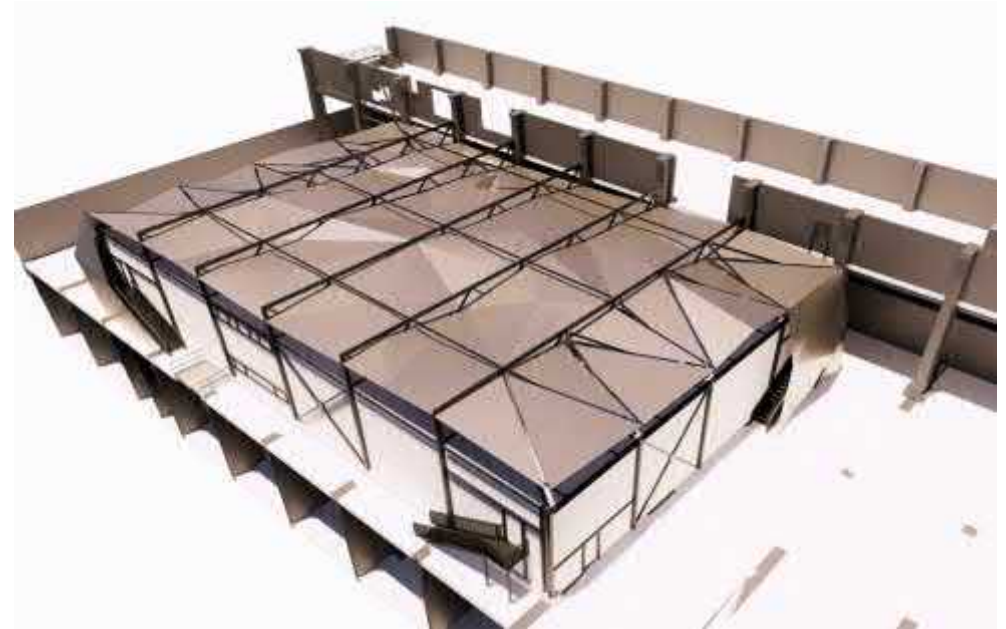
20 % of annual need
40 % impact to
total cost of energy

 Footprint:
-12 400 tonnes

Project Summary



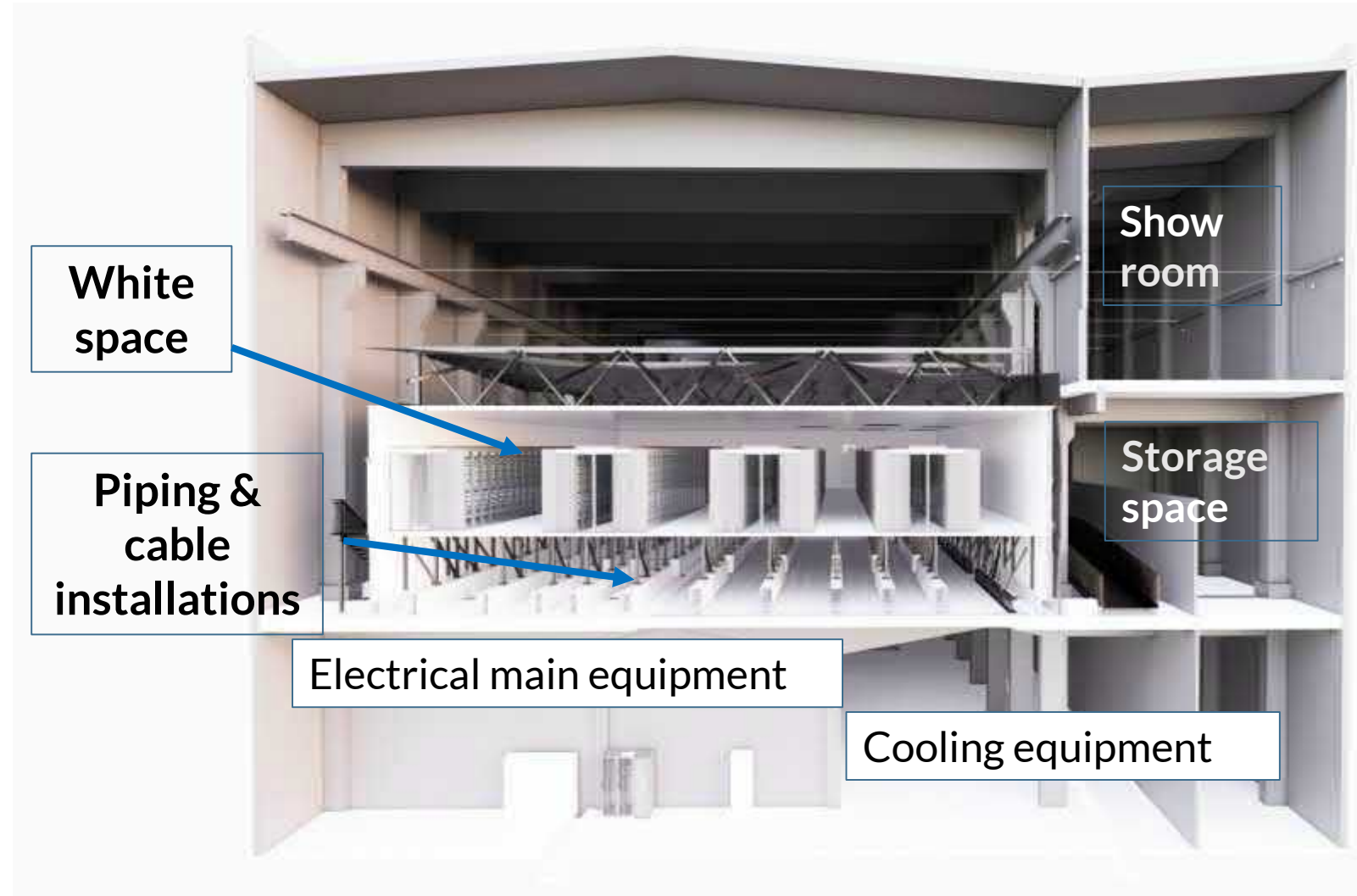
- Key objectives in **reasonable capital expenses and low total cost of ownership (TCO)**
- Big challenge: the final technical requirements of the HPC was available only at the midpoint of the building phase.
- To reach the lowest TCO **heat recovery** was selected as a **primary cooling solution**
 - 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.



LUMI Design Innovations



- Heat recovery for the IT- load
- UPS- devices connected to the demand respond market (FFR)
- Three floor arrangement:
 - Ground floor for the main equipment
 - 1st floor for the piping and cable distribution
 - 2nd floor for the DC- equipment only!
- Availability is calculated equivalent to TIER-3 level
- Unique shape of the DC → demonstrates snow
- Cooling production is simulated with native digital twin



LUMI: Excess Heat Utilization Process Overview



Annual CO₂ savings 12 400 tonnes



DRY AIR COOLING
FOR BACK UP
~ 10 MW

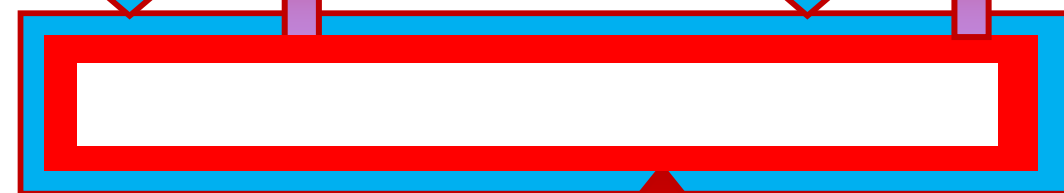
DISTRICT HEATING
NETWORKS ~ 10 MW
-Renforsin Ranta Business Park
-CITY of Kajaani

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).

Starting point for LUMI project



LUMI and Future Scalability

LUMI

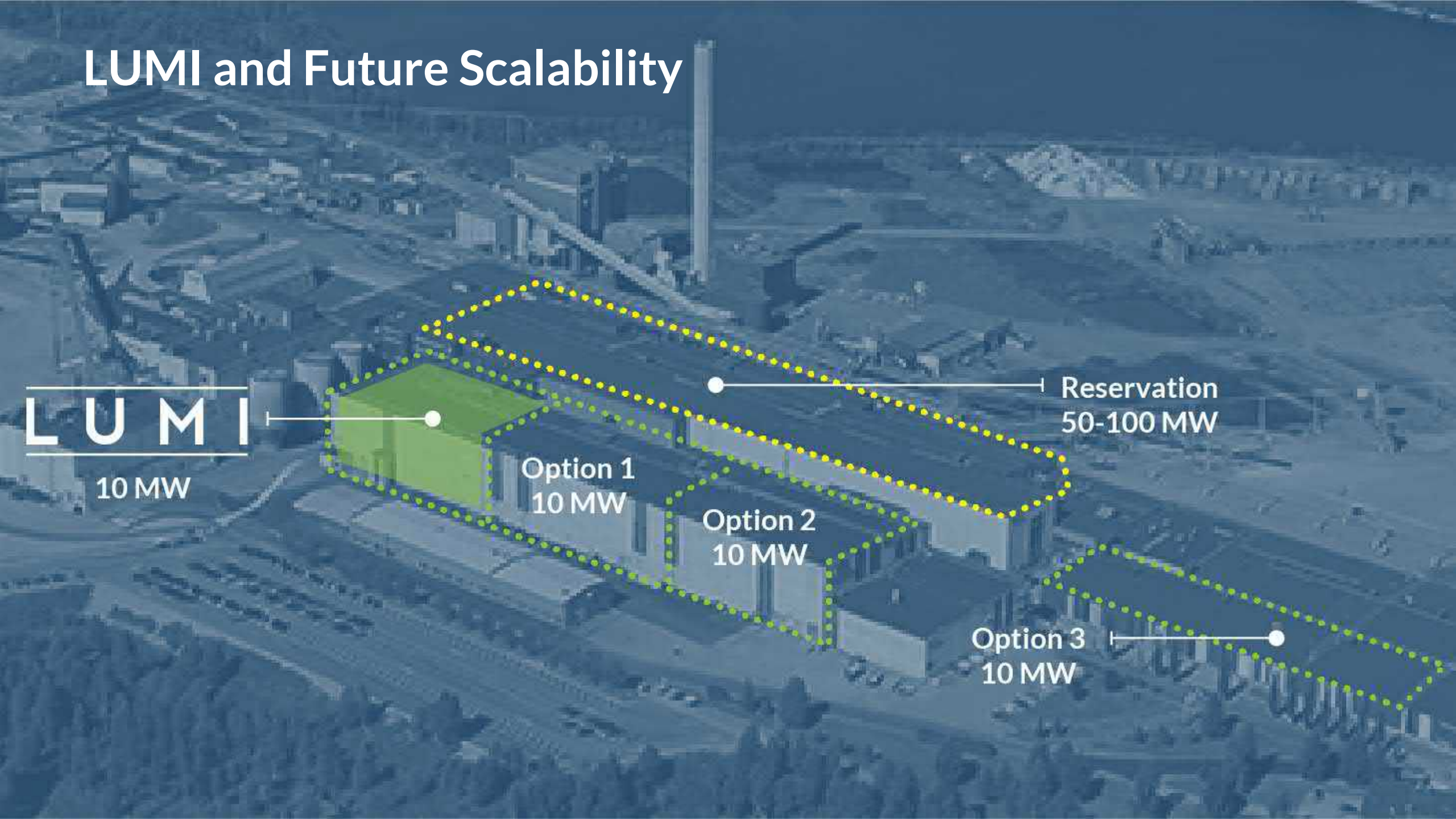
10 MW

Option 1
10 MW

Option 2
10 MW

Option 3
10 MW

Reservation
50-100 MW



Kajaani site & LUMI EuroHPC videos



Kajaani:

[Kajaani data center sustainability](https://www.youtube.com/watch?v=GUCVB0Z4B0s)

<https://www.youtube.com/watch?v=GUCVB0Z4B0s>

[Kajaani Renforsin Ranta Business park](https://www.youtube.com/watch?v=IMC6zXQM4Uo&t=2s)

<https://www.youtube.com/watch?v=IMC6zXQM4Uo&t=2s>

LUMI:

[Making of LUMI part-1](https://www.youtube.com/watch?v=covoiGPdAwY)

<https://www.youtube.com/watch?v=covoiGPdAwY>

[Making of LUMI part-2](https://www.youtube.com/watch?v=N0z0_6skUG8)

https://www.youtube.com/watch?v=N0z0_6skUG8

[Making of LUMI part-3 & installation](https://www.youtube.com/watch?v=pWxBS_vcofA)

https://www.youtube.com/watch?v=pWxBS_vcofA

[LUMI 1st phase system arrival](https://www.youtube.com/watch?v=g1laWuOZ26A&t=24s)

<https://www.youtube.com/watch?v=g1laWuOZ26A&t=24s>

[LUMI data center](https://www.youtube.com/watch?v=YJ63BqpHqpw)

<https://www.youtube.com/watch?v=YJ63BqpHqpw>

[LUMI world-class supercomputer](https://www.youtube.com/watch?v=gZrw58_Cu4g&t=39s)

https://www.youtube.com/watch?v=gZrw58_Cu4g&t=39s



Contact Information



Kajaani Data Center Program executed by CSC - IT Center for Science Ltd. with the support of Kainuu Regional Council and City of Kajaani.

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