ETH Zurich Department of Architecture
ARCHITECTURE OF TERRITORY
Chair of Architecture
and Territorial Planning
Professor Milica Topalović

The Production of Cloud
Spring 2026

Atlas

Arctic Circle, Luleå, SE

Sara Pina Alves, Lilli Brändle, and Alexander Glattfelder

Over the past decade, Northern Sweden has emerged as an important location for hyperscale data centres. One of the most prominent examples is the Meta data centre campus in Luleå, located close to the Arctic Circle.

This project examines why this remote region has become attractive for large-scale digital infrastructure. The study focuses on the territorial conditions that enabled the development of a regional data centre cluster. Today, the area around Luleå is often referred to as the Node Pole cluster, including the cities of Luleå, Boden, and Piteå.

The project argues that this development is not accidental. Rather, it is closely connected to a combination of specific regional factors, including the Arctic climate, access to renewable hydropower, available land, and supportive political and infrastructural conditions. Together, these elements have made Northern Sweden an increasingly strategic location for cloud infrastructure.

By looking at the relationship between territory, energy, climate, and governance, the project shows that data centres are not simply technical buildings, but part of a much larger spatial and infrastructural system.

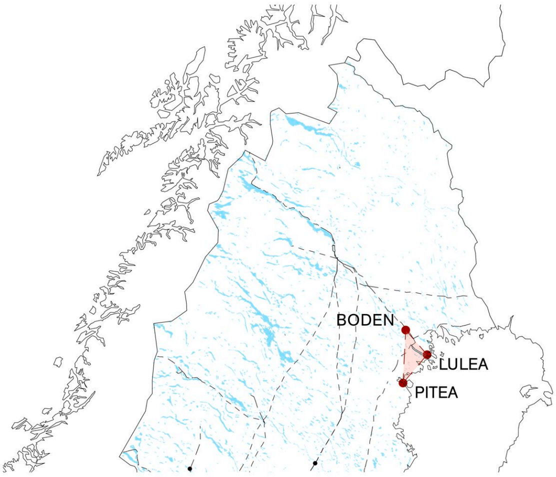
Meta's hyperscale data centre campus in Luleå, Sweden.
Source: Sisk, Northern Sweden Data Center, 2026.

Meta's data centre in Luleå, Sweden.
Source: LPI Group, Internal Earthing, 2026.

Interior cooling infrastructure of
Meta's data centre in Luleå, Sweden.
Source: Upsite Technologies, 2026.

A Data Centre Benefiting from Arctic Climate

Location of Luleå in Northern Sweden. Drawing: the authors, 2026.



Node Pole data centre cluster in Northern Sweden. Drawing: the authors, 2026.

GOVERNANCE

(POLITICAL & REGULATORY FRAMEWORK)

EUROPEAN UNION
- Energy and climate policy
- Digital single market
- Stable legal framework
- Data protection

SWEDISH GOVERNMENT
- National energy policy
- Industrial and investment policy
- National infrastructure policy
- Reduced electricity tax for data centers

MUNICIPALITY OF LULEA
- Land allocation for data centers
- Building permits / zoning
- Local infrastructure (roads, water)
- Fiber connectivity and local development

ENERGY INFRASTRUCTURE

(LOCATION PRECONDITION)

NORTHERN SWEDEN HYDROPOWER SYSTEM
- Very large electricity production
- Very low CO_2 emissions
- Stable energy supply

ENERGY PROVIDER VATTENFALL
- Operator of hydropower plants
- Electricity supplier for data centers
- Stable electricity prices
- Renewable energy supply

REGIONAL DATA CENTER CLUSTER

(NODE POLE - NORTHERN SWEDEN)

REGIONS
- Lulea
- Boden
- Pitea

META DATA CENTER

LULEA

TECHNICAL CHARACTERISTICS

OUTSIDE AIR COOLING
- Uses the cold climate

RENEWABLE ELECTRICITY
- Powered by northern Swedish hydropower

HYPERSCALE CAMPUS
- Multiple server buildings

GLOBAL USERS

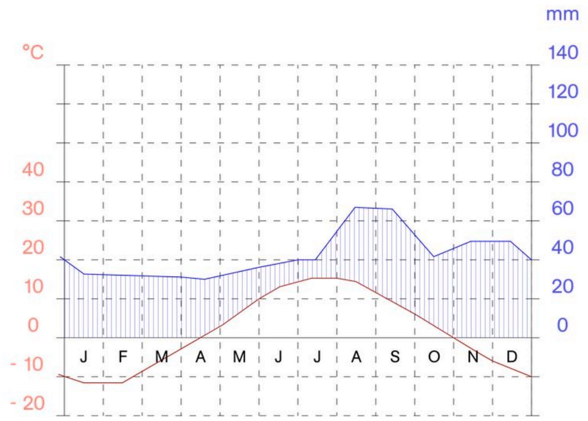
FACEBOOK

INSTAGRAM

WHATS APP

Northern Sweden is one of the most sparsely populated regions in Europe. While the municipality of Luleå has approximately 80,000 inhabitants, the surrounding region has a low population density. This spatial condition provides large areas of available land for infrastructure development. For hyperscale data centre campuses, which require extensive building complexes and technical infrastructure, such conditions are particularly advantageous.

The development of the data centre cluster in Luleå is shaped by multiple territorial conditions. At the European, national and municipal level, political frameworks support the development of digital infrastructure. At the same time, Northern Sweden provides a stable and renewable energy system based on hydropower. Together, governance structures and energy infrastructure create the foundation for the Node Pole data centre cluster.



Month	Temp. (° C)	Precip. (mm)
JAN	- 11.6	31
FEB	- 11.7	30
MAR	- 6.5	30
APR	- 0.6	28
MAY	5.7	32
JUN	12.4	36
JUL	15.1	39
AUG	13.8	65
SEP	8.6	64
OCT	2.7	40
NOV	- 3.7	48
DEC	- 8.4	47

Annual Mean Temperature: 2 °C

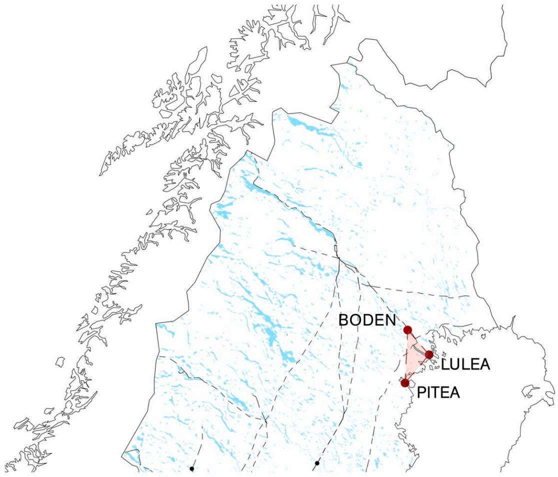
Annual Precipitation: 490 mm

Climate chart, Luleå. Drawing: the authors, 2026. Source: SMHI, 2026.

Meta established its first European hyperscale data centre in Luleå in 2011. Since then, the campus has expanded into one of the largest digital infrastructures in Northern Europe. Although Luleå is located far from major European urban centres, the region provides several important conditions for hyperscale infrastructure.

One of the most important factors is the Arctic climate. Luleå has an average annual temperature of around two degrees Celsius, with long cold winters and relatively mild summers. These climatic conditions allow data centres to use outside air cooling for most of the year. As a result, the energy required for cooling systems is significantly reduced. In this context, the climate itself becomes part of the technical infrastructure of the data centre.

Location of Luleå in Northern Sweden. Drawing: the authors, 2026.



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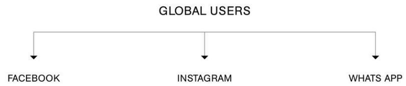

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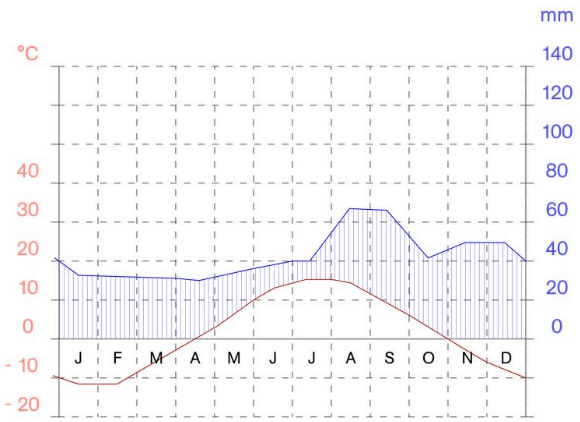

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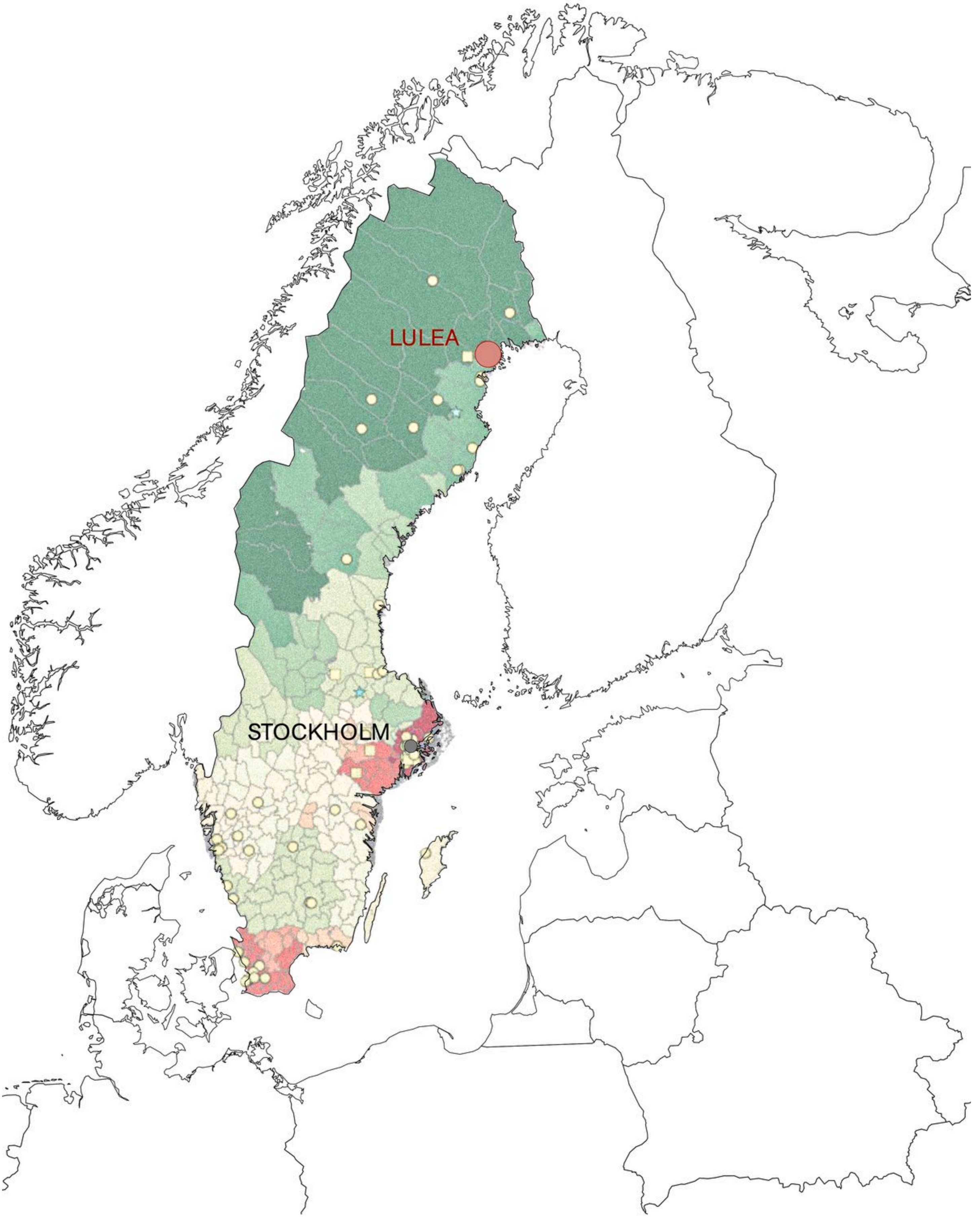
The North-South Divide


LULEA
STOCKHOLM

Site Suitability Index (SSI) for data centre locations. Drawing: the authors, 2026. Source: Jerleus et al., 2024.

SSI (%)
- 13–18
- 19–26
- 27–33
- 34–39
- 40–46
- 47–52
- 53–59
- 60–65
- 66–72
- 73–78

Data centres
- Planned
- Under construction
- Existing

North

- cold climate
- free cooling possible
- renewable / cheaper energy
- large areas available
- higher latency

- Location logic:
- Remote regions
- Far from users
- Energy- oriented data center

- Preferably suited for:

Large hyperscale data center campuses
AI / high- performance computing
Backup / disaster- recovery
Examples: Meta, Microsoft, Google

South

- warmer climate
- cooling more energy- intensive
- fossil / more expansive electricity
- urban infrastructure
- lower latency

- Location logic:
- Close to major cities, users and businesses
- User- oriented data center

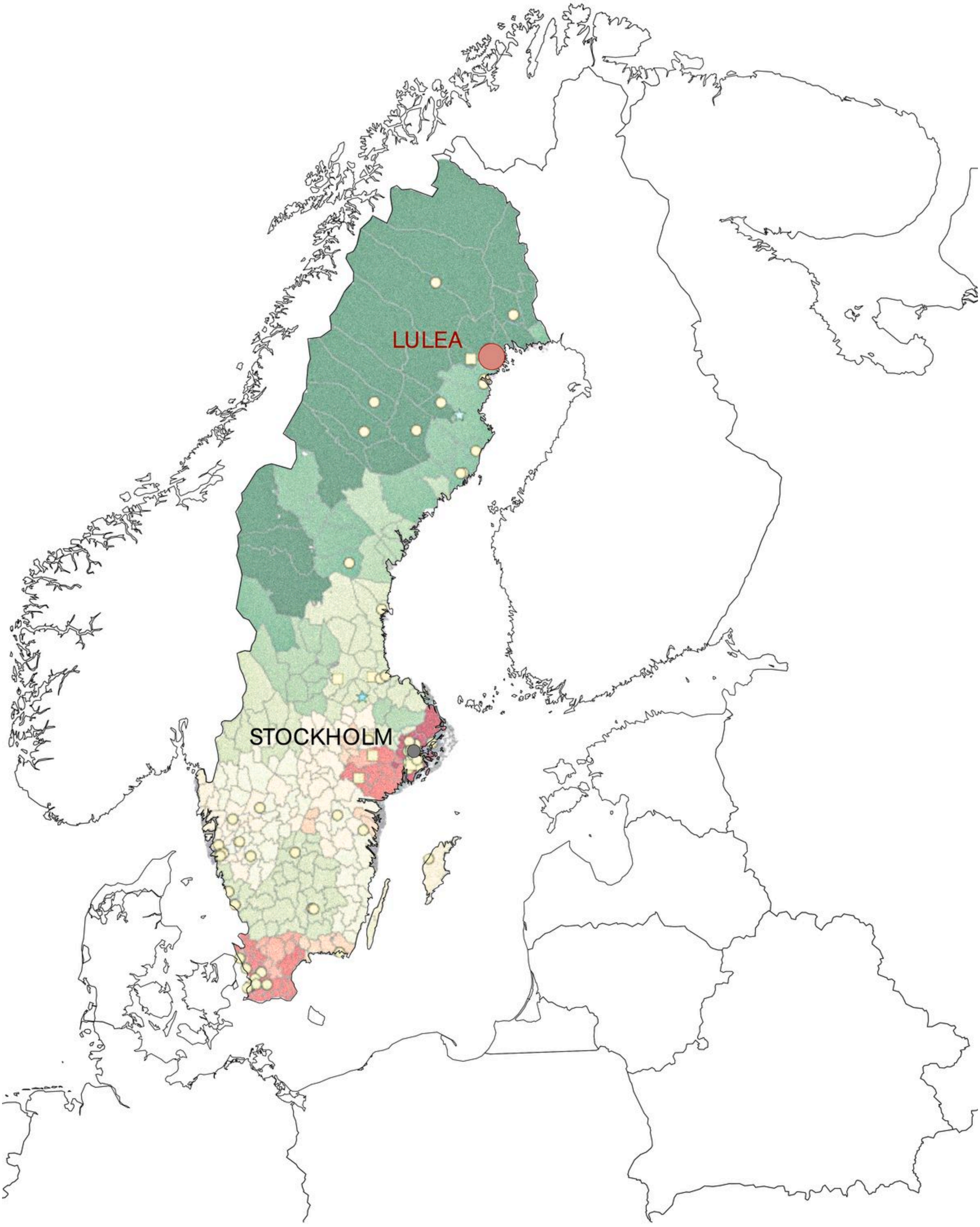
- Preferably suited for:

Smaller or medium- sized urban data centers
Colocation providers, telecom operators
Enterprise and edge services
Examples: Equinix, Telia

Comparison of typical data centre location strategies:
Source: Meta Platforms Inc., 2023; Equinix Inc., 2023.

Data centre locations generally follow two different territorial strategies. In northern regions, hyperscale data centres benefit from cold climates, renewable energy sources, and large areas of available land. These facilities are often located in remote regions and focus on large-scale computing and storage.

In southern regions, data centres are typically located closer to major cities and digital users. These urban facilities provide lower latency and faster connections. However, due to warmer climates, cooling systems in these locations require significantly more energy. This contrast illustrates the growing spatial divide between energy-oriented hyperscale facilities in the north and user-oriented urban data centres in the south.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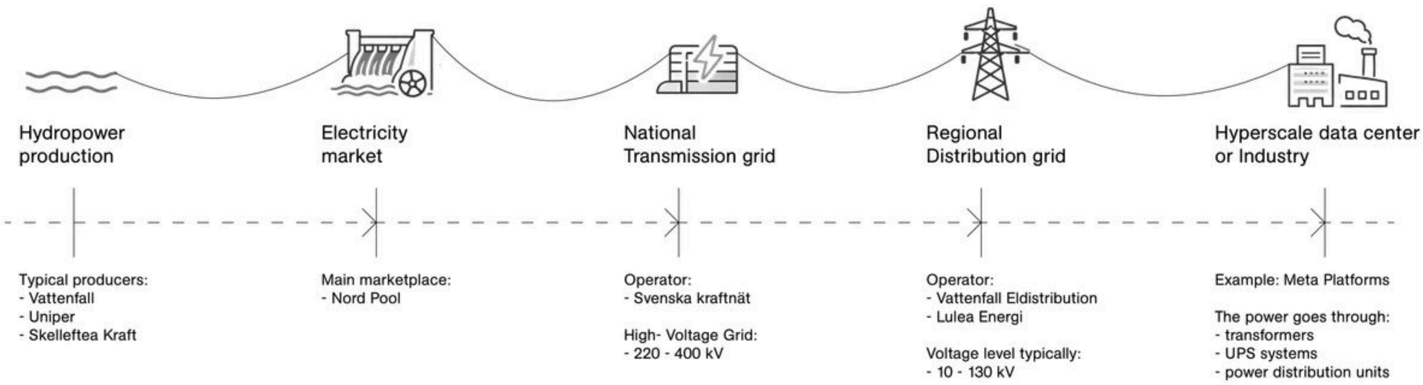
Hydropower Production in Northern Sweden

The Node Pole area with corresponding power sources. Drawing: the authors. Source: Node Pole, 2013.

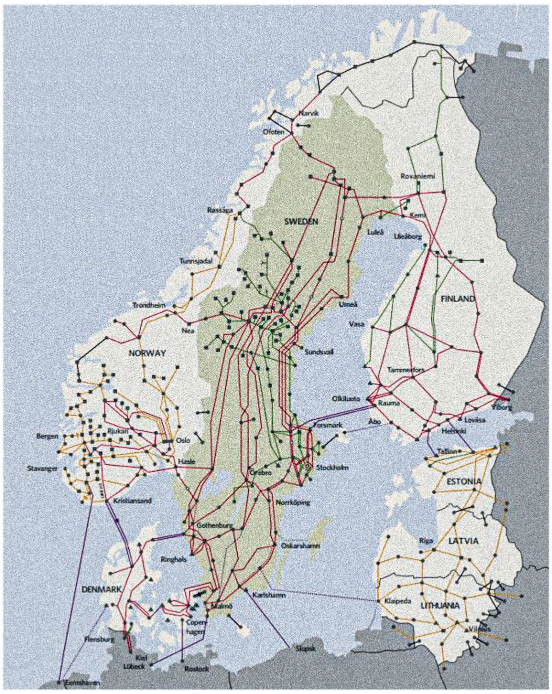
Laxede hydropower plant on the Lule River, Sweden. Source: VekuVaku, 2024.

Another key factor shaping the data centre cluster is the regional energy landscape. Northern Sweden produces a large share of its electricity through hydropower generation. Several large dams along the Lule River generate renewable electricity that feeds into the national power grid.



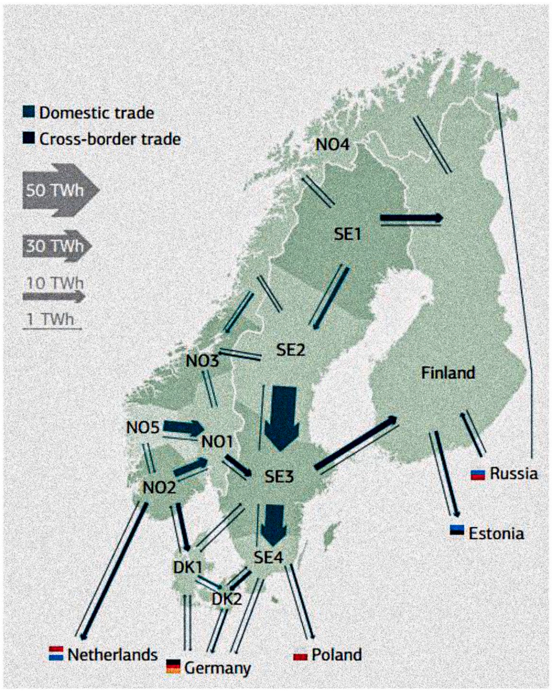
Electricity supply chain. Diagramme: the authors, 2026.

Electricity generated in hydropower plants enters the Nordic electricity market and flows through the national transmission grid. From there it is distributed through regional networks to large consumers such as steel plants, mining operations, or data centres.



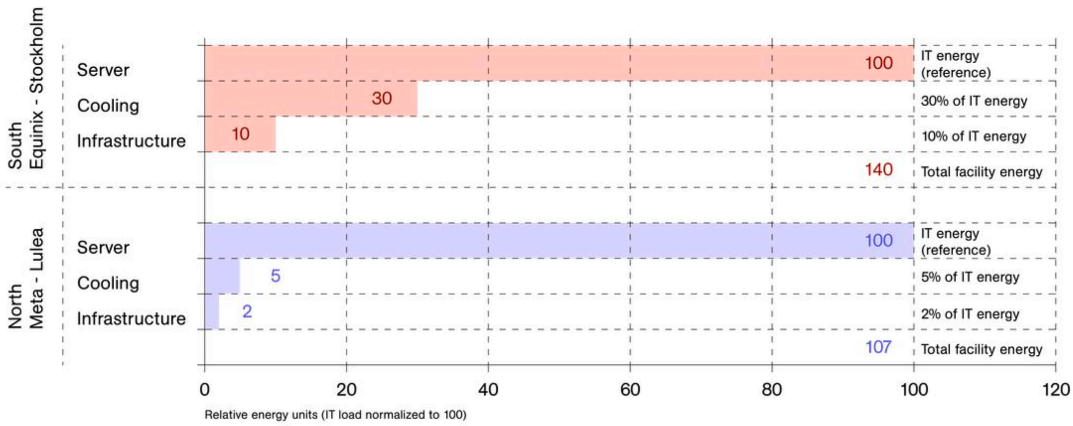
Nordic high-voltage electricity transmission network
Drawing: the authors, 2026. Source: Vié, 2017.

The hydropower plants of Northern Sweden are part of a larger Nordic electricity system. The first map shows the high-voltage transmission network that connects Norway, Sweden, Finland, and Denmark. This infrastructure transports electricity from energy production sites, particularly hydropower plants in Northern Sweden, to different regions across Scandinavia.



Electricity trading flows
Drawing: the authors, 2026. Source: Vié, 2017.

Northern Sweden, especially the electricity zones SE1 and SE2, produces large amounts of renewable electricity. Because of this surplus of hydropower, electricity can be supplied to large energy consumers such as steel plants, mining operations and hyperscale data centres. This demonstrates that the data centre cluster in Luleå is closely embedded within the wider Nordic energy infrastructure.



$$\text{PUE} = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}}$$

Power Usage Effectiveness

$$\text{PUE} = \frac{140}{100} = 1.4$$

Equinix Stockholm

$$\text{PUE} = \frac{107}{100} = 1.07$$

Meta Lulea

Comparison of data centre energy consumption. Diagramme: the authors, 2026. Source: Meta, Open Compute Project and Equinix sustainability reports.

The cold climate of Northern Sweden has a direct impact on the energy performance of data centres of the region. In most data centres located in warmer climatic zones, a large share of the total electricity demand is required for cooling systems. In some cases, cooling can account for up to thirty percent of the total energy consumption of the facility.

In contrast, the Meta data centre in Luleå uses outside air cooling, which allows servers to be cooled with cold Arctic air for most of the year. As a result, the energy required for cooling is significantly reduced. This improves the overall energy efficiency of the data centre and results in a much lower Power Usage Effectiveness (PUE) compared to many urban facilities.

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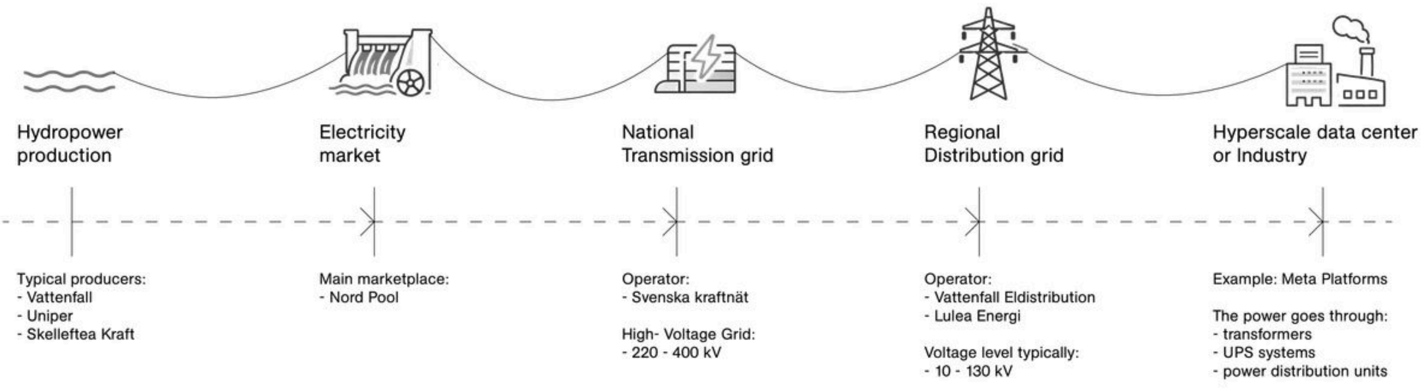

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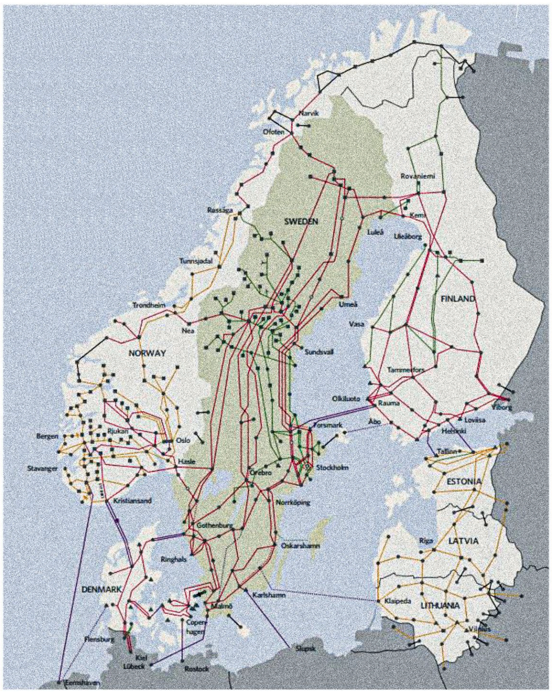

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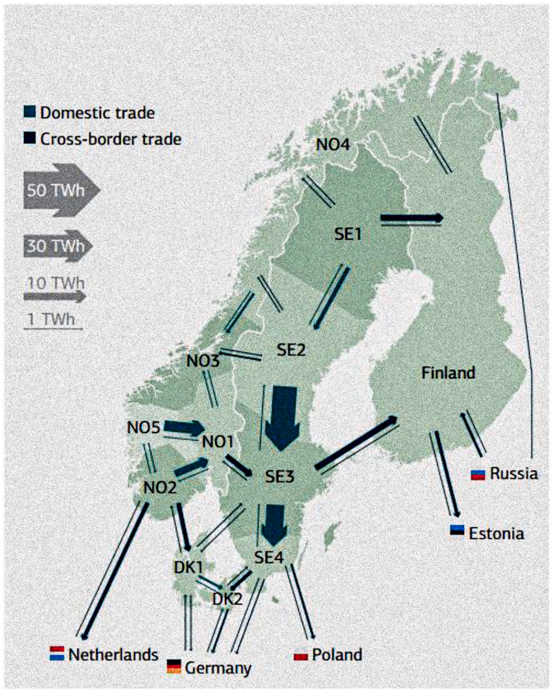

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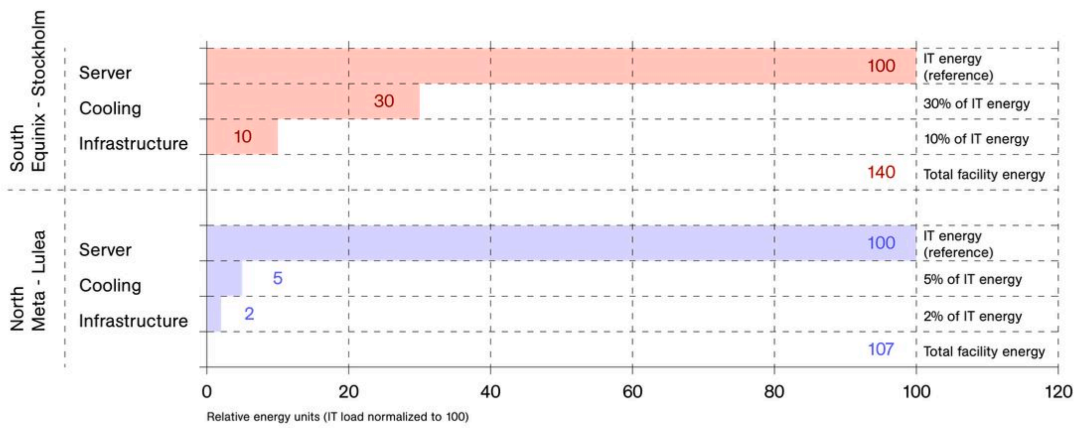

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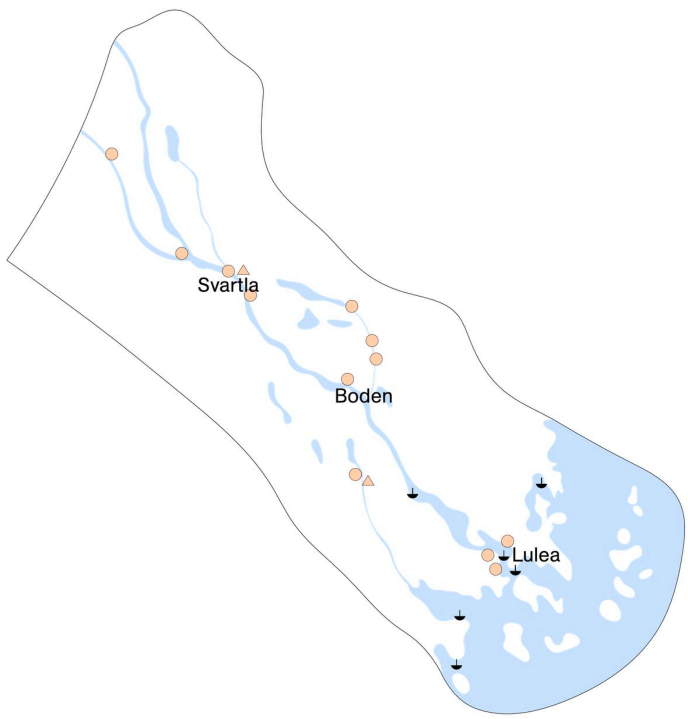
From Steel to Servers

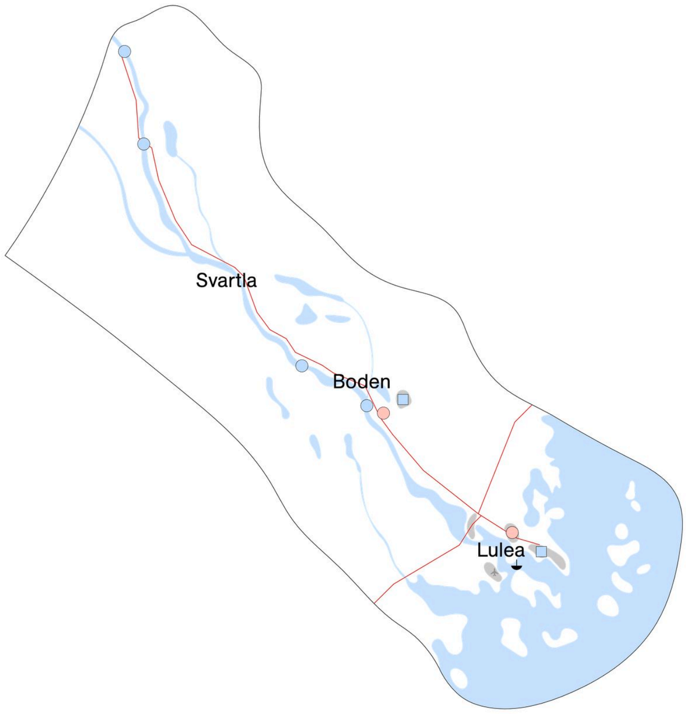


Early industrial development.

- Saws
- Bar iron works
- Shipyard

Energy infrastructure.

- Hydropower plants
- Steel production
- Saws
- 400 kV power line
- Shipyard



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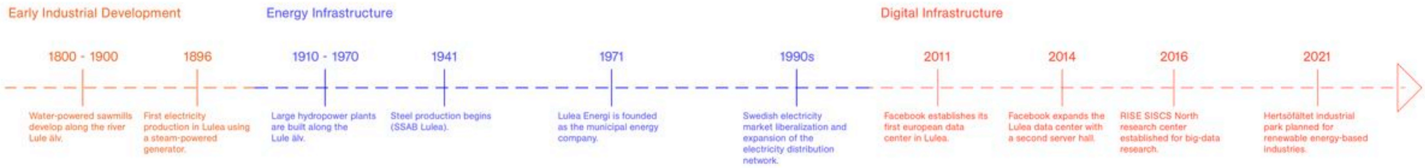
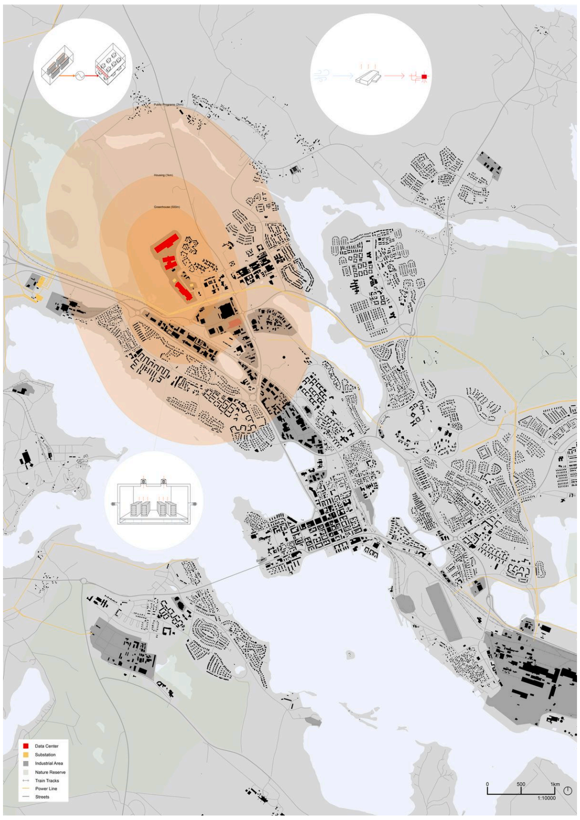


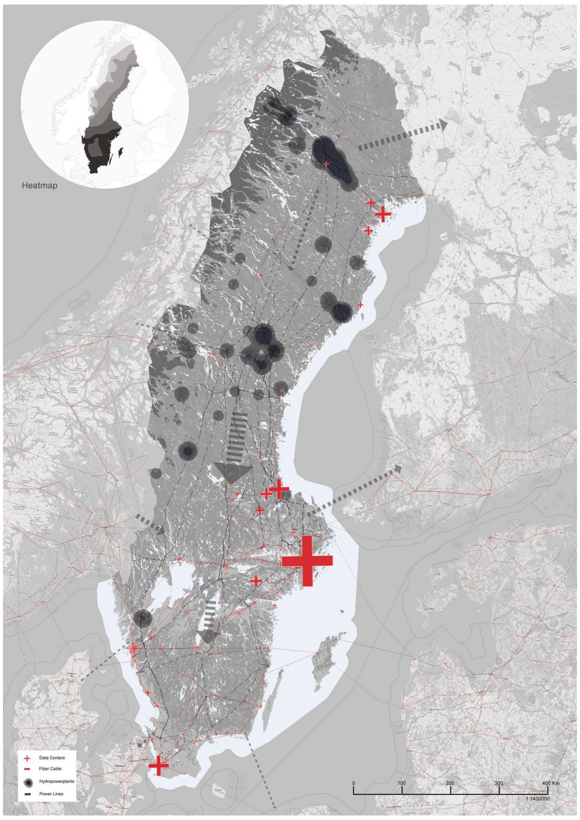
Industrial and infrastructural development of the Luleå region.
Illustration: the authors, 2026. Source: Meta, 2013; Harding, 2015.

The energy infrastructure of Northern Sweden was not originally developed for digital infrastructure. During the nineteenth century, rivers powered sawmills and early industrial production. In the twentieth century, large hydropower plants were constructed to support heavy industries, particularly steel production in Luleå.

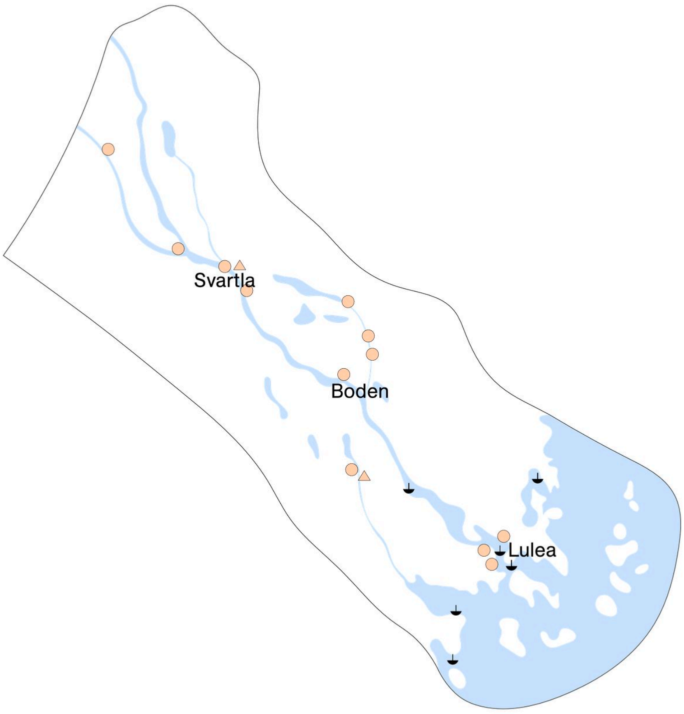
Today the region is undergoing a significant transformation. The same energy infrastructures that once supported heavy industry now also enable hyperscale digital infrastructures. This transition illustrates how industrial energy landscapes can be repurposed for new forms of digital production.



Urban context of a data centre in Luleå. Drawing: the authors, 2026.



Digital infrastructure and energy networks in Sweden. Drawing: the authors, 2026.



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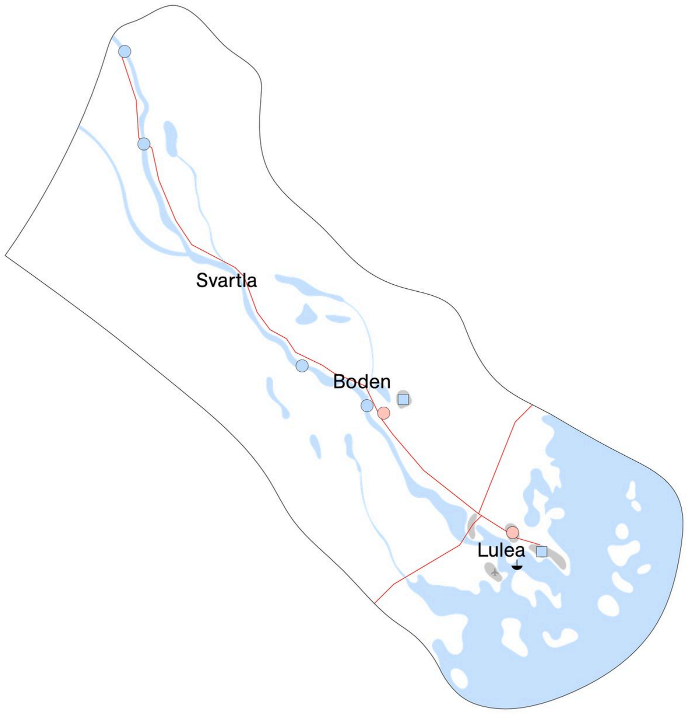

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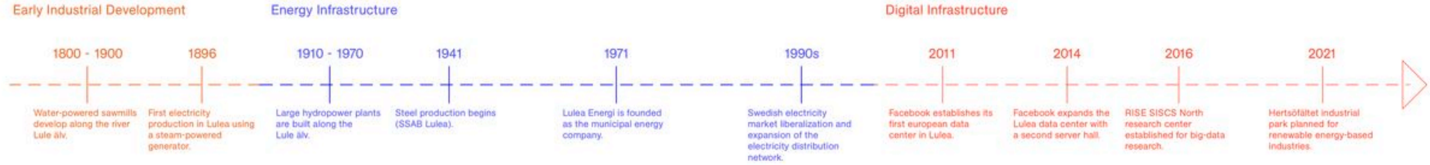

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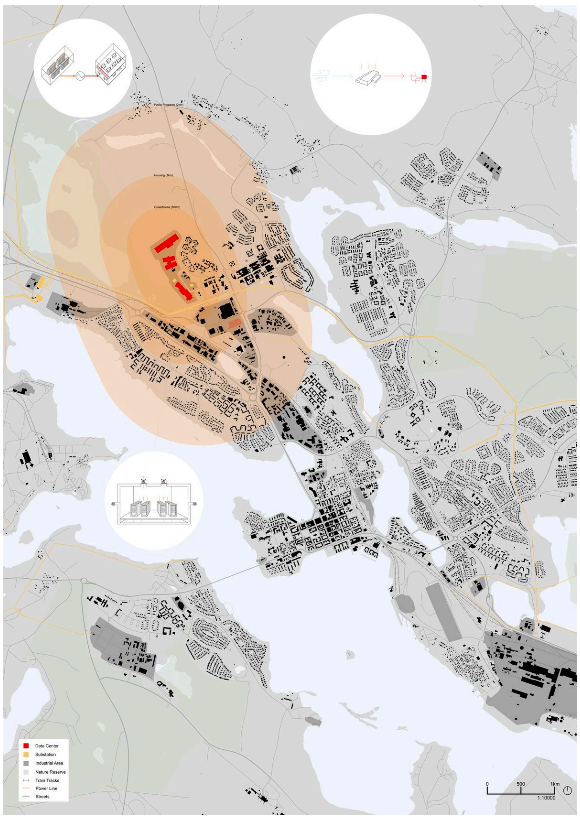

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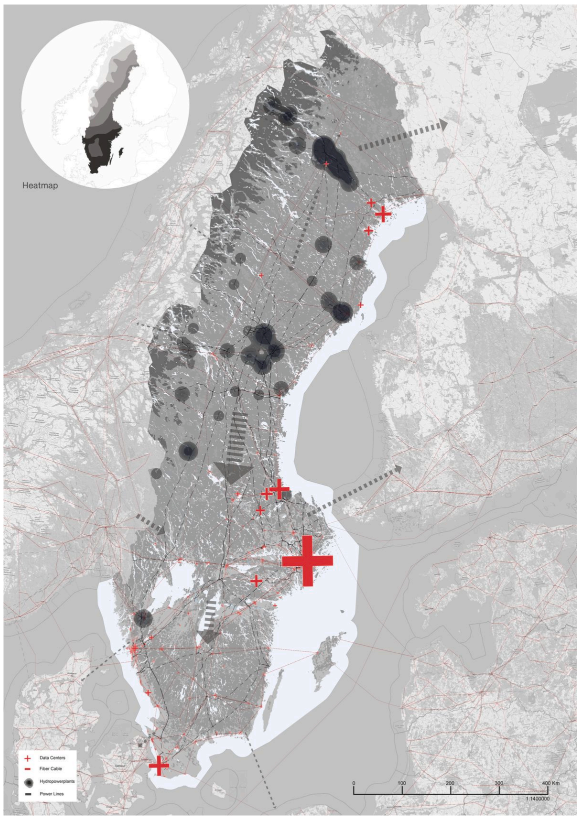

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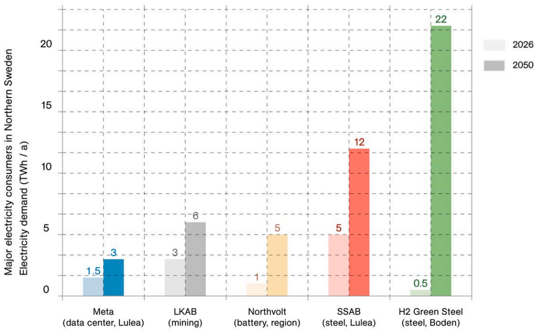
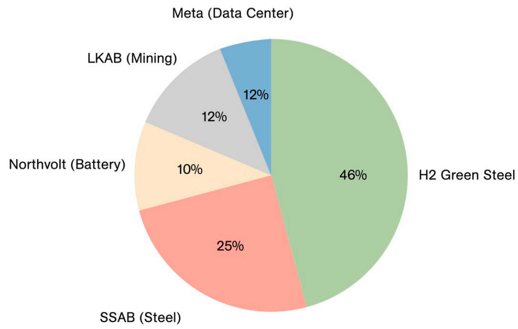
Growing Electricity Demand and Competition

SSAB Luleå Steel Plant. Source: The Beauty of Steel, 2026.



Major electricity consumers in Northern Sweden. Diagramme: the authors, 2026. Source: Svenska kraftnät, 2023.

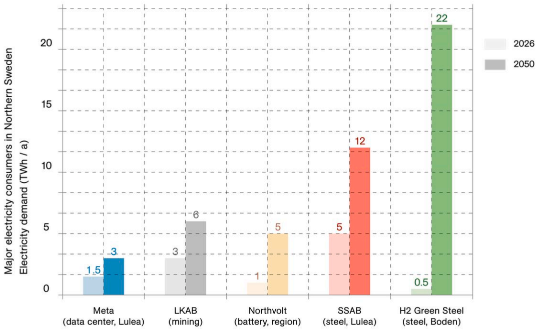


Projected electricity demand by major electricity consumers in Northern Sweden, 2050. Diagramme: the authors, 2026.

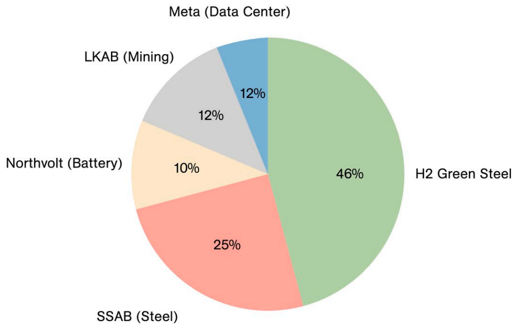
Northern Sweden is currently experiencing a rapid increase in electricity demand. Several new industrial projects are being developed in the region, including battery production, green steel manufacturing, and electrified mining. These projects require large amounts of renewable electricity.

Together with hyperscale data centres, these emerging industries place increasing pressure on the regional electricity system. Different infrastructures now compete for access to renewable electricity. As a result, Northern Sweden is becoming an increasingly important energy territory within Europe.

SSAB Luleå Steel Plant. Source: The Beauty of Steel, 2026.



Major electricity consumers in Northern Sweden. Diagramme: the authors, 2026. Source: Svenska kraftnät, 2023.

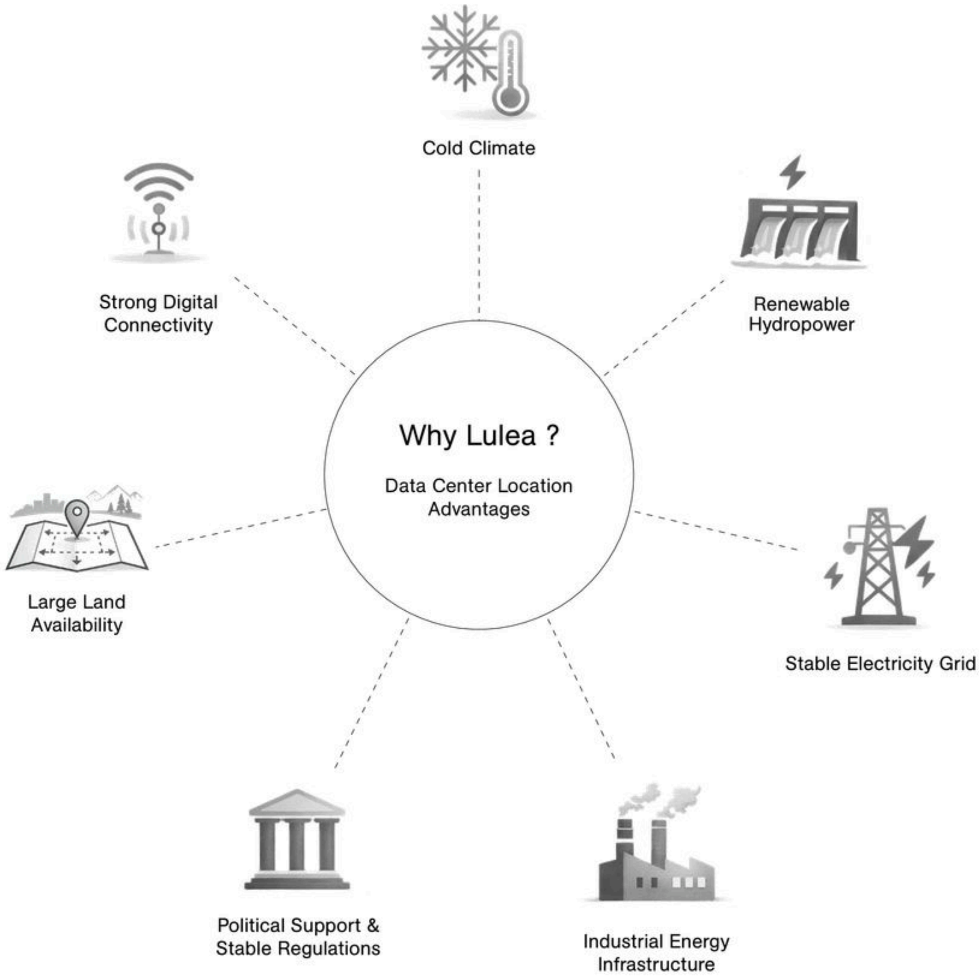


Projected electricity demand by major electricity consumers in Northern Sweden, 2050. Diagramme: the authors, 2026.

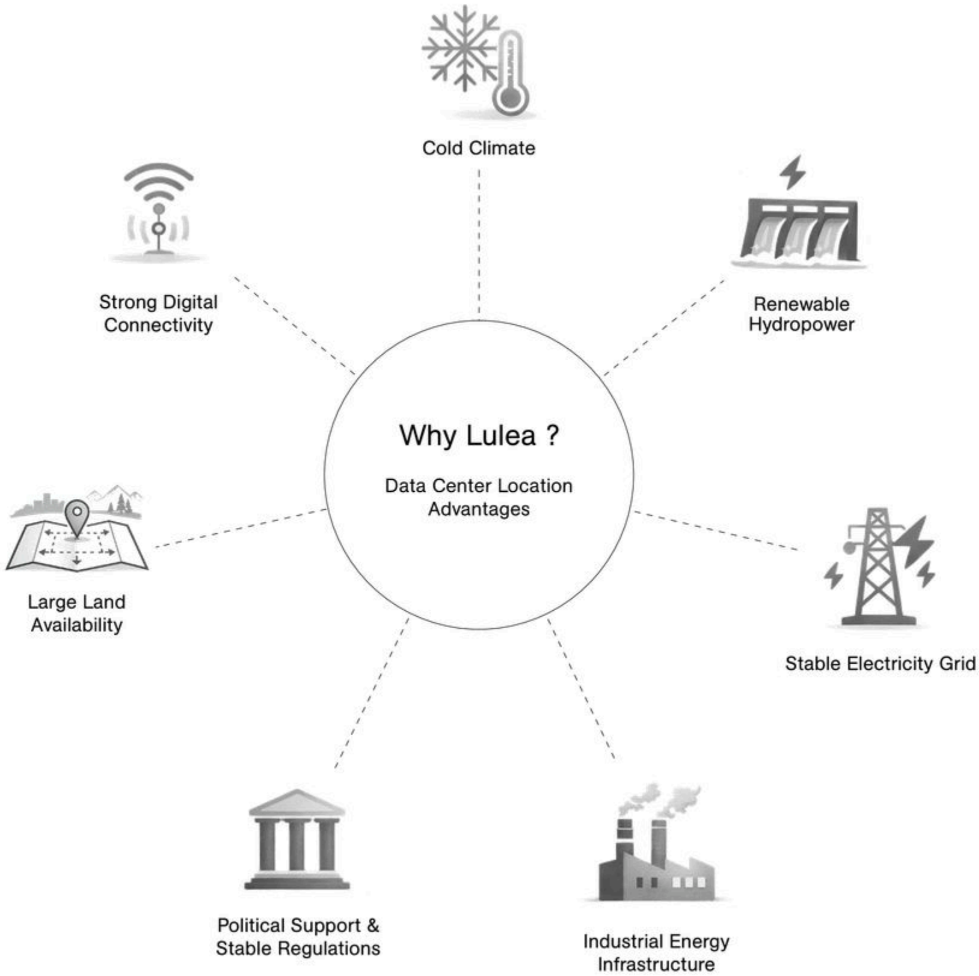
Northern Sweden is currently experiencing a rapid increase in electricity demand. Several new industrial projects are being developed in the region, including battery production, green steel manufacturing, and electrified mining. These projects require large amounts of renewable electricity.

Together with hyperscale data centres, these emerging industries place increasing pressure on the regional electricity system. Different infrastructures now compete for access to renewable electricity. As a result, Northern Sweden is becoming an increasingly important energy territory within Europe.

Conclusion



The development of the data centre cluster in Luleå can be explained by several overlapping territorial conditions: The Arctic climate enables highly efficient cooling. Northern Sweden provides abundant renewable hydropower. The region also offers strong industrial energy infrastructure, reliable connectivity and large areas of available land. Together, these factors have transformed the Arctic Circle region into a strategic location for hyperscale data centres.



The development of the data centre cluster in Luleå can be explained by several overlapping territorial conditions: The Arctic climate enables highly efficient cooling. Northern Sweden provides abundant renewable hydropower. The region also offers strong industrial energy infrastructure, reliable connectivity and large areas of available land. Together, these factors have transformed the Arctic Circle region into a strategic location for hyperscale data centres.

SOURCES

- Jerléus, Kim, Muhammad Asim Ibrahim, and Anna Augustsson. “Environmental Footprints of the Data Center Service Sector in Sweden.” *Heliyon* 10 (2024).
- Johansson, Per-Olov, Bengt Kriström, and Simon Falck. “Assessing the Welfare Effects of Electricity Tax Exemptions in General Equilibrium: The Case of Swedish Data Centers.” Swedish Agency for Growth Policy Analysis, WP 2023:04, 2023.
- LPI Group. “Internal Earthing.” Accessed 2026.
- Ramos Cáceres, Cristina, Marcus Sandberg, and Adolfo Sotoca. “Planning Data Center Locations in Swedish Municipalities: A Comparative Case Study of Luleå and Stockholm.” *Cities* 150 (2024).
- Sellheim, Nikolas, und Dwayne Ryan Menezes (Hrsg.). *Non-state Actors in the Arctic Region*. Springer Polar Sciences. Cham: Springer Nature Switzerland AG, 2022. https://link.springer.com/book/10\.1007/978-3-031-12459-4
- Sisk. “Northern Sweden Data Centre.” Accessed 2026.
- Upsite Technologies. “Understanding Cooling Diversity within Data Center.” Accessed 2026.
- Vié, Isaak. “Energy for Information: The Green Promise of the Node Pole Data Centres.” Master Thesis in Sustainable Development, No. /26, Department of Earth Sciences, Uppsala University, 2017.

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