10 Things to learn from the Nordic Data Center industry

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Data centers are at the intersection of cyberspace and physical space, playing a crucial role in both the green (GX) and digital (DX) transformations. They are an instrumental part of the infrastructure upon which modern societies depend on and a rapidly growing and highly internationalized industry. While data centers consume large amounts of electricity, they also help save energy. Data centers are facilities designed to enable concentrated and efficient usage of software and hardware in one place and thus their energy consumption is much less than the consumption would be if the computing power and servers were run in small loads and distributed between various ill-suited locations. Although the effects of the rapid development of facilities designed to support the infrastructure and computational needs of artificial intelligence (AI) applications and workloads remain to be analyzed, it is worth pointing out that data centers' overall energy consumption has increased less than expected thanks to innovations and implementation of more efficient solutions as well as smart location choices. The growth of industry has led to the development of major data center clusters, some of which have emerged in northern regions with a colder climate.

Over the past 10-15 years, the Nordic countries have attracted significant data center investments and emerged as leaders in promoting sustainable solutions, efficient technologies, and ambitious regulatory frameworks. Data centers have evolved into a new type of mission-critical infrastructure, complementing the energy-intensive industries that have long been present in the region. The Nordic data center market is the largest in Europe outside the FLAPDs (Frankfurt, London, Amsterdam, Paris, and Dublin), and it is growing fast. This Briefing Paper analyzes recent and ongoing developments in the Nordic data center market, providing fresh insights and actionable recommendations. While this study has been prepared with Japan and, in particular, Hokkaido (which shares many environmental and societal characteristics with the Nordic countries) in mind, many of the findings and recommendation should also be applicable to other geographical and socio-economic contexts.

Statement 1: Utilize the assets you have

Cooling and ventilation systems typically consume 30-55% of the total energy used by data centers. The idea of using cold outside temperatures to reduce the need for artificial cooling is not new, and it has long been recognized that cold climate regions, such as the Nordic countries, are in a favorable position for developing direct and indirect air-cooling systems. However, the Nordics have not simply relied on this natural advantage. While cooling and energy efficiency R&D has been conducted globally, the Nordics have been pioneers in research focused on leveraging cold climates. The industry's partial shift toward liquid cooling technologies does not diminish the importance of cold climates. For more information, please refer to Statement 3. Besides cold air, abundant cold water resources have also been utilized in the cooling processes. Questions concerning the availability and price of electricity are crucial in determining the location of data centers, as they significantly impact operational costs, profitability, and expected returns on investment. In addition to reducing costs, using electricity in areas where it is produced (such as the Nordics) is also beneficial for the environment. Besides avoiding unnecessary grid losses, significant savings can be achieved, as building infrastructure to transfer data is much cheaper than constructing infrastructure for electricity transfer. While regional discrepancies in electricity production and consumption have also been an issue in some Nordic countries, the data center industry has been able to identify and utilize sites with available local surplus energy.

Statement 2: Develop the whole data center ecosystem

The data center industry is not an isolated sector; rather, it is interconnected with various industries and supporting infrastructures, ranging from power plants, grids and fiber-optic cables to district heating networks and other off takers of waste heat. These interconnections must be considered when understanding the needs of the data center industry and how it can support the development of other sectors and regional economies. In addition to providing renewable energy at highly competitive prices, the Nordic countries are also known for their highly developed national grids. The reliability of these grids, often originally designed to support other electricity-intensive industries that rely on an uninterrupted power supply, has for example allowed data centers to reduce investments in backup generators. The unique characteristics of renewable energy production, which depends on natural conditions, and the need for flexible power reserves, have been recognized in the Nordics. In these countries, data centers can generate revenue by assisting the national grid during service disruptions by temporarily disconnecting from the grid. In addition to a supportive regulatory framework, the integration of data centers into the national and regional energy supply-demand systems is another key feature of the R&D activities in the Nordics. The infrastructural assets in Nordic countries extend beyond the production and distribution of electricity. While district heating networks are not directly tied to the core functions of data centers, they can contribute to making data centers more cost-effective and environmentally friendly.

Statement 3: There is no "waste heat"

Data centers consume electricity and produce both computing power and heat. This heat is often misleadingly referred to as "waste heat." While the term "waste" might apply in some contexts, the low-grade heat (typically 30–40 degrees Celsius, but potentially higher, especially when using liquid cooling) that can be collected and, if needed, primed to higher temperatures with heat pumps, has long been recognized as a valuable resource in the Nordic countries. While efforts to reuse heat discharged from data centers have been made in other parts of the world, the highly developed district heating networks in the Nordics have enabled the cost-efficient and large-scale utilization of this resource, particularly in Finland, Sweden, and Denmark. In addition to fo-

cusing on increasing the temperature of the heat coming from data centers, many Nordic stakeholdershave been involved in efforts to enhance the efficiency of heat pumps and to develop district heating networks better suited for the utilization of lower-temperature waste heat. While the Nordic model can serve as a prime example of re-utilization through district heating, the Nordic countries also offer promising examples for regions lacking such infrastructure. Other potential applications for reusing the heat generated by data centers include greenhouses, fish farms, and biomass drying, among others. Although the large-scale implementation of these initiatives has taken longer than district heating-based models, the Nordic countries are gradually shifting from concept development and pilot projects to self-sustaining business ventures. It is also noteworthy that regulatory frameworks and public policies have both pulled and pushed the industry toward more sustainable practices by requiring companies to at least explore possibilities for heat reuse, while also fostering a supportive attitude toward the re-utilization of heat as an important part of the broader decarbonization process.

Statement 4: Identify and use your hidden assets

While some data centers in Nordic countries have been established in buildings and industrial locations that reflect the region's past economic activities, the connection between past and present goes beyond just the reutilization and transformation of physical facilities. Attention should also be given to societal practices, the accumulation and transfer of knowledge, and existing institutions that can potentially facilitate the development of new industrial activities. In other words, the rapid growth of the data center industry in the Nordic countries has been closely tied to infrastructures that were established decades earlier, as well as to local expertise and collaborative frameworks that have supported or originated from previous economic and industrial activities. Even if other regions do not have district heating networks, old paper mills or mines to convert into data centers, or energy-intensive industries that have attracted a workforce with relevant skill sets, they may possess other valuable assets and competencies.

The success of the Nordic data center industry thus challenges other regions and countries to reconsider whether they have hidden assets that, if identified and utilized wisely, could contribute to the development of the industry.

Statement 5: Connectivity matters

Data centers and fiber-optic cables form the two infrastructural pillars upon which global communication networks and modern societies rely. At the same time, the development of data centers and fiber-optic cable networks are closely interconnected. International connectivity and the possibility to have multiple fiber-optic cables arriving at a data center site to ensure redundancy and network resilience are key factors influencing locational decisions. Geographical distances from global marketplaces and customers have often posed challenges for many traditional Nordic export industries. However, for the data center industry, distances are not measured in kilometers but in milliseconds and latency. Nordic stakeholders have traditionally ensured that they are well connected to Central Europe and to each other. Recent improvements in direct fiber-optic cable connections to the US and the UK, and the dramatic impact these developments have had on the growth of the data center industry in Norway, further underscore the importance of international connectivity. Ongoing efforts to connect the Nordic countries with Japan and North America via submarine cables through the Arctic Ocean, where both public and private stakeholders from various Nordic countries have played instrumental roles, are expected to significantly impact the global topology of submarine cable networks.

Statement 6: Site development and the right type of promotion are the key to success

Several national and regional players are working to attract new data center investments globally. While the availability of reasonably priced land with good fiber-optic connectivity and abundant green energy resources is an excellent starting point, it's not enough if potential investors are unaware of the opportunities a country or region offers. Many Nordic success stories emphasize the importance of pre-developing individual sites with comprehensive information packages that introduce all the key details. However, one must not overlook the (often long-term) work required to attract the right types of companies and investors, especially to new or emerging data center markets. Starting something new or establishing operations in a new location brings both opportunities and uncertainties. Although there may still be business leaders who prefer to keep their IT equipment nearby (the so-called "server huggers"), even when more economically and environmentally feasible options exist elsewhere, Nordic stakeholders have successfully convinced many international companies of the opportunities they can offer. This process has involved a range of actors, from local governments and national agencies promoting innovation, trade, and investment, to private companies and active data center associations. Ultimately, the development of the data center industry is not only influenced by measurable technical, economic, or environmental factors, but also by human perceptions and attitudes.

Statement 7: Invest in R&D and cross-sectoral collaboration

While the cold climate partially explains the high energy efficiency of data centers located in the Nordic countries and other colder climate regions, the role of various research and development activities also deserves emphasis. The studies conducted in the Nordic countries have often focused on the prevailing conditions. In other words, both academic and company-led R&D activities have explored ways to utilize cold temperatures for cooling, district heating networks for heat reuse, and the characteristics of power production and grids for demand-response, among other things. The research on data centers has built upon an existing knowledge base. The researchers involved in data center research, as well as the personnel who have started working in the data centers, are experts from a wide range of fields, including architecture, construction, fire protection, power distribution, energy systems, and software development. Cross-sector collaboration in the Nordic countries has involved universities, universities of applied sciences, vocational schools, research institutes, private companies, and various levels of government, leading to the establishment of advanced research infrastructures (such as the ICE Datacenter, Infrastructure, and Cloud Research & Test Environment in Luleå, Sweden) and tailor-made training programs to educate future employees in the industry.

Statement 8: Make sure that you are attractive in the eyes of the skillful workforce

As the data center industry has grown rapidly, global competition for talent has intensified in recent years. Although educational systems can be mobilized to better meet the demands of the data center sector, the establishment of new educational programs takes time, even if there is agreement on their necessity and funding can be secured. Therefore, the rapid growth of the industry may require the ability to attract employees with the appropriate skill sets from outside the region. This ability is linked to issues concerning family members' employment opportunities, the availability of schools, and services for foreign staff, for example. Potential inter-sectoral mobility, which is familiar to many Nordic companies, as well as labor mobility between local firms leading to knowledge transfer and fostering innovation, can be beneficial for the development of the data center cluster. However, one must avoid a situation where skilled workers leave the region as soon as they have earned their credentials and become attractive candidates in national or global labor markets. While the Nordic countries can offer examples of solutions, they can also serve as examples of the workforce shortage and recruitment challenges faced in different northern regions.

Statement 9: Ensure the support of local people and decision-makers

Political decisions cannot guarantee data center investments, but they can both increase the chances of success and negatively impact competitiveness. National and EU regulations have restricted some of the incentives and aggressive promotional activities used by regional entities elsewhere when competing for investments. However, national regulations regarding the level of energy taxes paid by data centers have played a significant role in defining the attractiveness of the Nordic countries when compared to one another. Furthermore, municipalities' readiness to assist in the construction of supporting infrastructure, as well as flexibility in zoning and land pricing, are examples of their involvement in attracting and developing the data center industry. While many countries and regions actively attempt to attract data center investments, there are also international examples that emphasize that local support should not be taken for granted. Local movements have emerged to resist individual projects in various parts of the world, and governments in the Netherlands and Singapore, for example, have imposed temporary moratoriums on the construction of new data centers. While public authorities' attempts to attract new data center investments to the Nordic countries have generally been met with a positive attitude among citizens, first protest movements and critical voices have also begun to appear in some Nordic countries. Furthermore, when municipalities with abundant renewable energy resources have compared the pros and cons of various energy-intensive industries from the perspective of regional economics, the data center industry has not always been the most preferred option. Therefore, the Nordic countries can be seen as both an example of a region where the industry has successfully communicated its needs and offerings to local communities and as a reminder that local support should not be taken for granted.

Statement 10: The tighter the regulation the better

Both the EU and individual Nordic countries have been forerunners in implementing strict regulations that impact the carbon footprint and environmental sustainability of data centers. While this regulation creates additional work and burdens for data centers in the Nordic countries, it also provides a significant competitive advantage compared to regions like Central Europe. Whether it's about energy efficiency or the reuse of surplus heat, it is typically easier and cheaper to meet stricter requirements in the North. As sustainability has been recognized as a competitive advantage, the data center industry has proactively advanced policies that exceed the demands of existing regulations. Some Nordic countries also sell green electricity certificates, which generate revenue but simultaneously allow data centers in Central Europe to make sustainability claims that can obscure the actual competitive advantage of data centers in the Nordics. However, some Nordic companies have pioneered the development of tracking systems to ensure that companies committed to 100% renewable energy can always verify the origin of their power. It is hoped that such systems will eventually become a global industry standard, increasing transparency.

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