Energy Research & Social Science 88 (2022) 102493

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

The "whole systems" energy sustainability of digitalization: Humanizing the community risks and benefits of Nordic datacenter development

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ARTICLE INFO

Keywords:
Greenland
Iceland
Norway
Cryptocurrency mining
Sustainable development goals
Datacenters
Server farms
Bitcoin

ABSTRACT

Digital platforms and the online services that they provide have become an indispensable and ubiquitous part of modern lifestyles, mediating our jobs, hobbies, patterns of consumption and forms of communication. However, no one is steering this development, or closely looking at the impacts that it may have on remote communities in the Arctic and Nordic region, a hotspot for datacenter development. Moreover, unlike other areas of energy consumption or technology adoption prone to rich, qualitative assessments, such work on datacenters involving local stakeholders and environmental concerns is less common, particularly at a larger scale. In this study, based on novel mixed methods—including corporate data, expert interviews, focus groups, and extensive site visits—across three countries, we offer a geographically and technologically bounded assessment looking at the sustainability impacts of datacenters on local communities. We ask: What impacts are occurring as part of datacenter development or planning proposals in Greenland, Iceland, and Norway? What is the actual and anticipated scale of those impacts on local Arctic communities? Finally, what impacts to datacenter development occur at the "whole systems" level? We examine not only impacts onsite at existing or proposed datacenters, but an entire range of consequences including the manufacturing of equipment, the laying of data cables, the construction of buildings, and issues of the dark web, cryptocurrency mining, hacking, spying, waste and decommissioning. Moreover, we humanize risks and benefits not only across scales, but also categorical types, including local impacts such as boom and bust cycles, the displacement of indigenous groups for land – particularly for power supply - and impacts on employment, especially after datacenters may close.

1. Introduction

Online services and their related infrastructure (such as digital devices and internet data centers) currently account for roughly 10% of global electricity demand, and approximately 3% of global greenhouse gas emissions – making them equivalent to the global emissions from the much more visible airline industry. In the UK and globally, there have been concerns about how electricity supply can sustainably support the growth of data centers and data traffic [1]. They continue to rapidly expand, with growth in internet traffic of about 20% annually. Even conservative models predict that online services and devices will rise to 20% of global electricity by 2030. Andrae [51,52] projects internet infrastructure as constituting a significant bulk of global electricity consumption by 2030, with utlization ranging from lows of 8% to more than 50% depending on method of evaluation and breakthrough technology. The global Covid-19 pandemic has further necessitated the need for more remote working (leading to more need for data capability) – balancing growth of datacenters (and attendant issues) with supporting daily life and economies [2].

Datacenters have impacts beyond power consumption. As of 2019, the global footprint of datacenters was estimated at 63.4 million square-feet, with another 4.3 million square-feet under construction [3]. Across Europe, JLL [4] reports that planning applications for datacenters in 2020 far exceeded those made in 2019, with expectations for increased growth in 2021 over 2020. According to these reports, the expected roll-out of 5G, demand for edge computing, quicker downloads, greater efficiency, more devices being connected to the internet, the popularity of online gaming, and a rise in streaming services (among others) were creating exponential growth in both data volumes and processing [3,4].

Yet, no one is steering this development, nor always adequately attending to its impacts on global sustainability [5,6]. Reliable information on internet related energy use, carbon emissions, and the energy

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https://doi.org/10.1016/j.erss.2022.102493
Received 29 September 2021; Received in revised form 9 December 2021; Accepted 3 January 2022
Available online 17 January 2022
2214-6296/

profiles of internet data centers is fragmented and often inadequate [7]. Most national regulations and global governance regimes focus on growing information infrastructure, rather than curtailing it or making it more sustainable. All the while, much of industrialized society is in danger of becoming “addicted” to the internet and smart phones [8,9]. Moreover, Hargreaves and Wilson [10] note that many of the energy savings that are made through these devices are instead counteracted by the more, or new, energy-intensive forms of demand that they enable – an unintended consequence. When one undertakes a whole systems lifecycle assessment, the networks and datacenters supporting smart phones and computers consume more energy than the devices supported [53]. Hischier et al. [11] estimate that data networks account for as much as 90% of the total energy consumption of tablets and smartphones. As Corcoran and Andrae, note: “there is a strong tendency to push electricity consumption onto the network and data center infrastructure where energy costs are less transparent to consumers” ([12]: 1).

Even though energy efficiency improvements have been applied to information networks, and proposals and pathways for green data centers exist [13], the IEA have indicated that: “energy use over the long run will continue to be a battle between data demand growth versus the continuation of efficiency improvements” ([14]: 2). As Murugesan [15] warned: “computers and other IT infrastructure consume significant amounts of electricity, placing a heavy burden on our electric grids and contributing to greenhouse gas emissions.”

But what value does such expansion of data centers, and digitalization, bring to local communities and households? The latter is an increasingly important question, the burgeoning literature of which we seek to add to. Authors such as Von Bargen and Fish [16] have addressed the multi-scale politics of data ownership. Fish [17] offers an evocative “experimental documentary” of Iceland's oceanic internet connection. Starosielski [18] addresses the technological, cultural, political and geographical aspects of undersea networks for another location, the South Pacific.

In this study, based on a wide range of mixed methods—including corporate data, expert interviews, focus groups, and site visits—across three countries, we offer a qualitative, geographically and technologically bounded assessment looking at the impacts of data centers on local communities in the next big energy frontier, the Arctic [19]. We ask: What impacts are occurring or being anticipated as part of datacenter development or planning proposals in Greenland, Iceland, and Norway? What impacts to datacenter development occur at the “whole systems” or multi-scalar level well beyond the Nordic region?

In exploring these questions, we aim to make three contributions. First, our “whole systems” approach enables us to examine not only impacts onsite at existing or proposed datacenters, but their entire suite of lifecycle impacts, including mineral extraction and waste. Secondly, our mixed methods research design enables us to capture and humanize risks and benefits across scales and types, including local impacts such as boom-and-bust cycles, the exclusion of indigenous groups, or impacts on employment, especially after datacenters may close. Thirdly, our focus on the Arctic brings into focus various salient geopolitical issues including autonomy and independence for Greenland, regional plans for Nordic industrial strategy, and even proposals to invest in infrastructure to counter major shifts in global power such as a current concentration of data infrastructure among China and the United States. Connected to this theme is an investigation of how blockchain technology and the growth of cryptocurrencies can expand in contexts of crisis in peripheral societies, as they have in rural areas of the United States or Venezuela [20–22].

2. Mixed methods research design

Unlike other areas of energy consumption or technology adoption prone to rich, qualitative assessments (such as electric vehicles, household solar panels or heat pumps), there is less close, qualitative work on datacenters involving local stakeholders and environmental concerns, at least at a larger scale. To improve both validity and triangulation, and to address the fact that limited qualitative data was available on data center development in the Arctic to begin with, we employed a mixed methods research design centered on original data collection. Our four primary sources of data were corporate benchmarking information, semi-structured research interviews, focus groups, and site visits. A supplemental method was documentary photography. More details on our methods are offered in our Supplementary Online Materials (see Appendix A).

Firstly, we relied on *corporate benchmarking data* to identify the number of datacenters (and other digital infrastructure such as colocation centers) in the Arctic. This resulted in a list of 31 data centers in Norway (as of late 2021), 7 in Iceland, and 1 in Greenland (see Table 1). We utilized this list to identify particular communities or locations experiencing datacenter development, and also to identify the names of key firms that we could approach for our second method of data collection, the interviews. We also utilized these sources to publish a second study that benchmarks datacenter performance across key quantitative metrics (see [13]).

In terms of *data collection* via *interviews*, we approached, largely by email, some 100 potential organizations and individuals considered to have a stake in datacenter development in Iceland and Norway. These include some of the companies in Table 1, but also ministries, state agencies, datacenter developers, municipal authority planning and economic departments, environmental NGOs and others (see Table 2). The conversion rate through to actual interviews was around 20%. Although we have captured a variety of views, we do not claim wide

Table 1
List of datacenters and colocation centers in Norway, Iceland and Greenland (as of 2021).

No.	Name	Country
1	AQ Compute: NO-DC1	Norway
2	Availo DC0	Norway
3	Basefarm Oslo OSL3	Norway
4	Basefarm Oslo OSL5	Norway
5	Blix Gullhaugveien	Norway
6	Bulk: Oslo Internet Exchange (OS-IX)	Norway
7	DigiPlex Fetsund III	Norway
8	DigiPlex Hobel	Norway
9	DigiPlex Oslo Fetsund	Norway
10	DigiPlex Oslo Fetsund II	Norway
11	DigiPlex Oslo Rosenholm	Norway
13	DigiPlex Oslo Ulven	Norway
14	EVRY AS Gjøvik	Norway
15	Fujitsu Oslo	Norway
16	Green Mountain DC3-Oslo	Norway
17	IP-Only HMG9	Norway
18	Level3 Oslo	Norway
19	SSC Forskningsparken Oslo	Norway
20	StoreSpeed Fredrikstad DC1	Norway
21	TaliaSonera Oslo	Norway
22	Verizon Oslo	Norway
23	Lefdal Underground Mine	Norway
24	Northern Data Lefdal	Norway
25	Arctic Circle Data Center Mo i Rana	Norway
26	Avure Bergen	Norway
27	Bulk Kristiansand N01	Norway
28	Green Mountain DC1-Stavanger	Norway
29	Green Mountain DC2-Telemark	Norway
30	Green Mountain Gismarvik	Norway
31	Troll Housing	Norway
1	Advania Thor ICE-01	Iceland
2	atNorth ICE02	Iceland
3	Etix Fitjar #1	Iceland
4	Opin Kerfi Korputorg	Iceland
5	Verne Global	Iceland
6	Vodafone Reykjavik	Iceland
7	Etix Blönduós #1	Iceland
1	Tele Greenland Nuuk	Greenland

Table 2
Summary of 20 semi-structured expert interviews for this study.

Norwegian municipal development agency	NO1
Large Norwegian datacenter	NO2
Mid-sized Norwegian datacenter	NO3
Small Norwegian datacenter	NO4
Small Icelandic internet exchange operator	IS1
Icelandic investment agency	IS2
Icelandic ministry	IS3
Icelandic investment agency	IS4
Icelandic environmental impact assessor	IS5
UK datacenter consultant	UK1
Arctic Economic Council	A1
Greenlandic university	G1
Greenlandic investment agency	G2
Greenlandic ministry	G3
Greenlandic ministry	G4
Greenlandic business association	G5
Telecommunications and internet service provider	G6
Greenlandic energy supplier	G7
Greenlandic energy supplier	G8
Greenlandic contractor	G9

representativeness from the interviews alone. The interviews were conducted in English from March to May 2021 over Zoom video-call, made necessary by the Covid-19 pandemic, followed by selected in-person interviews in June and July 2021. We asked respondents the following, among other questions:

1. What are the positive impacts, if any, of datacenters on local communities in Greenland, Iceland, and Norway?
2. What are the negative impacts, if any, of datacenters on local communities in Greenland, Iceland, and Norway?
3. Who may be impacted by datacenters in Europe or even across the whole sociotechnical system?

All interviews were recorded and transcribed for anonymity, with interviewees giving informed consent. Coding was assisted by Nvivo, with high level codes informed by the interview question themes and sub-codes added as more specific themes became evident [23]. The quotations cited here have been given light editing to aid comprehension, clarity, or readability.

In terms of *focus groups*, we used both in-person and online workshops. Two online focus groups of eight people each were held in Iceland and Norway at the end of June 2021 (i.e. four groups and 32 people in total). All participants were recruited by market research firms (Norstat in Norway, Maskina in Iceland). Facilitation was by Maskina in Iceland and the researchers in Norway; the online platform was Brainstork. Participant characteristics were broadly matched to country demographics in terms of age, gender and socio-economic class, with the proviso that selection filtered for the ability to speak and understand fluently in English and for those who owned a computer with a camera. The choice of online rather than physical focus groups was partly determined by the social distancing requirements of Covid-19; however online groups are also more amenable to achieving a rural/urban split, given recruitment patterns and the particular geographic distribution of citizens in these countries. Two in-person focus groups were conducted in Greenland, one urban one in the capital city of Nuuk, and one rural one in the fishing village of Sisimiut, also with a total of 16 participants (to match the size of the online focus groups). Focus groups per se can also compare well with individual interviews in terms of eliciting a wide range of comments on a topic [24]. Similar to the interviews, all focus groups were transcribed and allocated to pre-determined themes. Those themes reflect a wider project theme of "energy justice", taking into account the life cycles and spatial impacts of the processes involved [25].

Fourthly, in terms of *site visits*, members of the research team visited Akureyri and Reykjavík, Iceland; Oslo, Bergin, Stavanger and Sogndal in Norway; and Kangerlussuaq, Nuuk, and Sisimiut, Greenland. Again, a mix of urban and rural locations was chosen to maximize diversity. The site visits were conducted to both offer context and background, and enable some site visits and in-person interviews. These site visits enabled the "unstructured observation" of datacenter or community activity and enabled an examination of events in real-time in the real-world [26]. Strengths to this approach include stronger validity, with more authentic actions captured by researchers, including spontaneous ones; minimal influence of respondent or researcher bias; and witnessing events in their total complexity and context.

Finally, and as is partly obvious by Fig. 1, we present in this paper a large number of relevant (and original) documentary photographs as a supplemental method, to both further enhance our analysis and also present visual arguments that many readers may find helpful, interesting, or illustrative.

Despite these strengths, our study does have some shortcomings. For our expert interviews, we utilized a critical stakeholder approach to select participants, meaning we wanted those not only "for" or "against" internet datacenter infrastructure, but also respondents from a mix of the private sector, civil society, government, and academia. Thus, our final sample has only a small number ($N = 4$) of respondents from within the actual industry of datacenter operators and firms. This number is counterbalanced by insights from other key stakeholders. Given the richness of the original data we were working with, we elected to execute a narrative structure to the paper, so that it tells a story, rather than a more inductive structure organized only around academic themes, or a deductive structure organized around a particular concept or theory. Additionally, we present our data below anonymously, to protect the identity of our respondents. In terms of site visits and research interviews, we had to collect data in Iceland and Norway during the peak of the Covid-19 pandemic, meaning our access was more circumscribed and many interviews and visits were done virtually over Zoom. However, for Greenland, we had the benefit of traveling during a window when their economy opened up and had fewer restrictions on travel, making our interviews and site visits richer. This creates a slight imbalance in our data in favour of Greenland. Finally, we took an ethnographic approach that did not correct or problematize responses, so we present the data unfiltered, even if our respondents may have had misperceptions on specific points. In simpler terms, we dispassionately collected our data and present our results without "taking sides," aiming for a more neutral and balanced positionality as researchers.

3. Case study selection and background: grappling with datacenter development in the Arctic

Although definitions vary, we conceptualize a "datacenter" as "a structure, or group of structures, dedicated to the centralized accommodation, interconnection and operation of IT and network telecommunications equipment providing data storage, processing and transport services, together with all the support facilities for power supply and environmental control with the necessary levels of resilience and security required to provide the desired service availability" [27]. The industry relies generally on three different business models for datacenters:

- Enterprise: ownership of the facility, IT equipment and software systems is common. Typical example is a bank, university or hospital data center.
- Co-location: ownership of the facility is separate from the one of IT equipment, software systems and their immediate accommodation. Thus, the owner of the data center rents the infrastructure to allocate IT equipment.
- Hosting: ownership of the facility and the IT equipment is common, but the software systems are dedicated by others. Thus, the owner rents both the infrastructure and the IT equipment to host information, servers, etc.