Prospectus

Lancium Compute Redesign and Expansion
(Technical Topic)

Public Acceptance of Green Data Centers
(STS Topic)

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Green Data Centers

Though data centers may seem like self-contained systems that make little impact on their surroundings, they have a large effect on local and global communities. Building a data center brings jobs to the area, and their services can have immense reach by making the Internet faster and more reliable. Data centers are currently estimated to use about 1% of the world's electricity, and their impact on the environment cannot be ignored (Masanet, Shehabi, Lei, Smith, & Koomey, 2020). Green data centers provide reliable computing while reducing environmental impact, and one of the largest ways a data center can reduce its impact is by using renewable energy to power its operations. Facebook's data center in Odense, Denmark runs on renewable energy with excess heat going to 6,900 Odense homes and is expected to create up to 1,000 jobs (Henriksen, 2019). Over the past three years, Google has "purchased enough renewable energy to match 100 percent of [their] annual global electricity consumption" (Google, 2019).

According to the United States Energy Information Administration, the U.S. consumed more renewable energy in 2019 than ever before, totaling at 11% of total energy consumption for the year (EIA, 2019). U.S. wind power has tripled over the past decade, and there are now more than 60,000 wind turbines in the country (AWEA, 2020). Companies are taking advantage of this rapid expansion by powering their data centers directly with renewable energy rather than purchasing carbon offsets. One of these is Lancium, a carbon-neutral cloud provider powered by wind energy, with which I will be completing my technical project (Lancium, 2020).

This paper explores several ways companies gain public acceptance for their green data centers, and evaluates the effectiveness of one method, sustainability metrics and certifications. This is directly connected to our technical project, which focuses on expanding access to

computing resources at Lancium. Through this discussion a clearer understanding of sustainability initiatives in the data center space and their acceptance by the public will be honed.

Lancium Compute Redesign and Expansion

The rise of direct-to-consumer computing services such as Amazon Web Services and Google Cloud has allowed users to reap the benefits of computing without having to acquire or build servers locally. Specifically, these companies build massive data centers and rent processing power to customers. Since computing services became widely available, a limited number of people had the skills and resources to actually access these services. As a result, companies have made it a priority to expand access to computing services to even more social groups. For example, Google and Amazon tout educational programs to provide access to cloud computing resources to boost career prospects and inspire a passion for computing in groups who may have lacked access previously, including students, educators, and veterans (Google, 2020; Amazon, 2020).

My technical project tackles this issue of access with Lancium's high-throughput computing services that are available through their command-line interface (CLI) as well as their web interface. The CLI requires scripting skills that can often take time and technical experience to learn, whereas the web interface is accessible to anyone with a web browser and includes helpful tutorials and instructions. Moreover, the CLI contains the full set of functionalities Lancium offers, which is enumerated in their application programming interface (API). However, their web interface, which is currently built in Ruby on Rails, only offers a subset of these functionalities currently by duplicating parts of the API code instead of interacting directly with the API. This limits the range of people who can use Lancium's services as many users

don’t know how to use a CLI, and/or would prefer to use a streamlined web interface to schedule and check on their computing jobs.

This project will solve this problem by expanding the functionality of the web interface to use the underlying API in order to match the functionality of the CLI, while revisiting the look and feel of the site to provide a better user experience. The web interface will be implemented as a progressive web application (PWA) by replacing the Ruby front end with Vue.js, a JavaScript framework (Google Developers, 2020; Vue.js, 2020). This new framework will provide an app-like feel that many users are accustomed to and lays the foundation for other modern features such as push notifications, which are unavailable in the current site. The application will send requests to the API directly to send and retrieve information instead of duplicating the API’s logic in the application itself. In this way, the full functionality of the API is exposed, as opposed to the current web interface, which replicates only parts of the API and must be updated when the API is updated. Thus, our new PWA has the potential to provide the full functionality of the CLI with less code complexity, while encouraging users with less scripting experience to use Lancium’s services.

While larger companies such as Google strive for maximum output to achieve maximum profit, often by running their data centers at all times, Lancium is currently building in the ability to pause their operations on short notice to avoid paying peak demand prices for energy (Lancium, 2020). This will allow Lancium to only use energy when it is present and inexpensive, passing on cost savings to their customers and keeping a promise to obtain renewable energy directly from the source instead of purchasing renewable energy later to offset carbon power usage, even if it could take longer to complete a job at Lancium than elsewhere. Lancium will then offer an additional benefit for the local energy sector of helping to stabilize the power grid,

because their data centers can act as generators by releasing claimed energy back to the grid during a time of low supply (ibid). All of this will result in a more stable power grid with fewer strains at peak times. Expanding Lancium's web interface to include more potential users encourages more people to use their services, which can have a positive impact on the environment by shifting business from less sustainable cloud provider competitors.

Public Acceptance of Green Data Centers

Public acceptance of new technology is extremely important for the benefits to be realized, but the "public" is actually composed of several groups whose interests may not entirely overlap. Paying closer attention to the intertwining groups can benefit the companies, the climate, and the groups themselves. Social acceptance of green data centers can be broken down into socio-political acceptance, community acceptance, and market acceptance (Wüstenhagen, Wolsink, & Bürer, 2007). I will use the framework of Social Construction of Technology (SCOT) to analyze the relevant social groups and how they have influenced the development of sustainable data centers. The main argument Pinch and Bijker (1984) make is that technology is developed by a process of negotiation between various stakeholders that have differing needs for the technology to solve their problems. The following figure displays my graph of the social groups, problems, and artifacts to model this topic, see Figure 1. A key point of the SCOT framework is that development of a technological artifact is a "multidirectional" process, instead of a linear path where the final product directly came from its beginnings (Pinch & Bijker, 1984). Sustainability was not a priority for the first few generations of data centers, but rather an afterthought to the primary drivers of reliability and uptime regardless of energy usage (Beaty, 2013). However, metrics such as power use effectiveness (PUE), a measure of how green a data center is, have been a powerful driver for change in the data center industry (ibid).

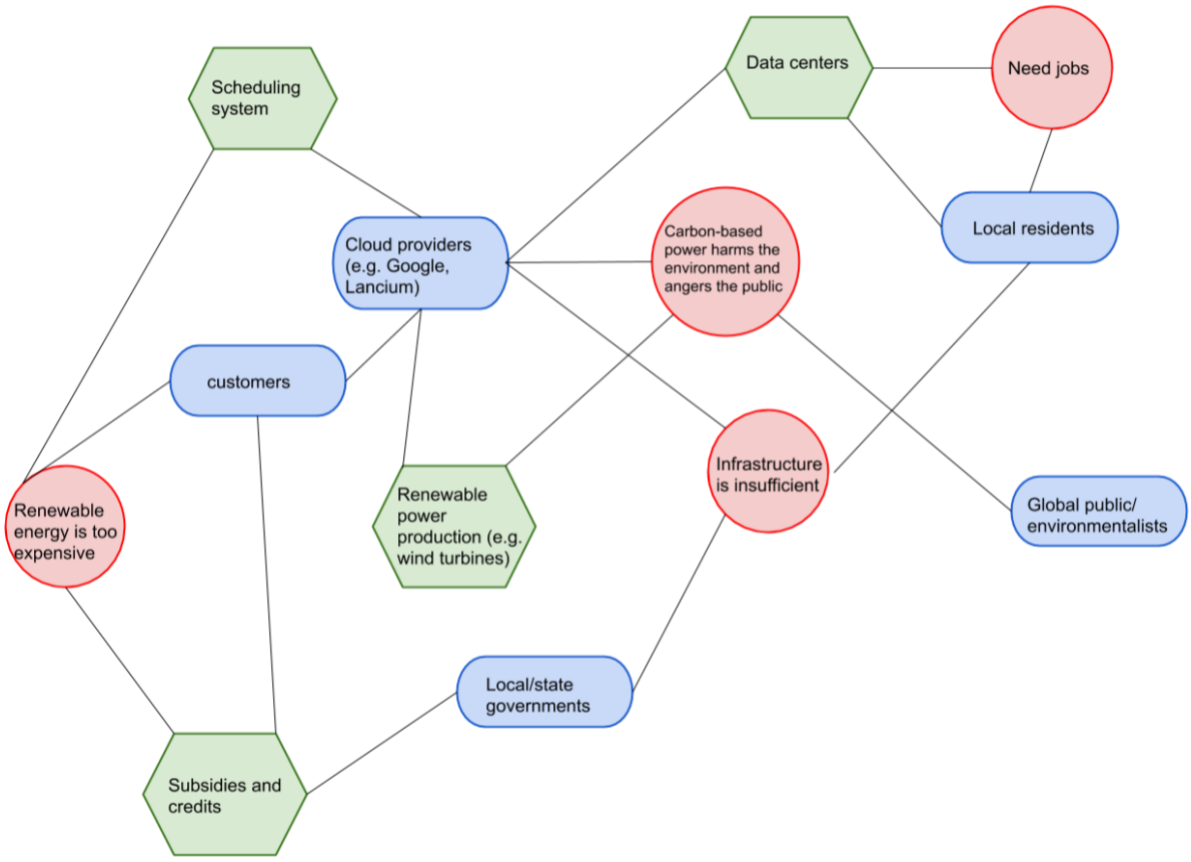

Figure 1. SCOT analysis graph of the various artifacts (green), social groups (blue), and problems (red) related to how data centers and society impact each other (Jacobs, 2020).

When discussing the social groups that impact a technology, it is imperative to acknowledge that not all groups have equal voices or power. As seen in Odense, perceptions of a particular project can be influenced by powerful incumbent forces like governments and special interest groups, in concurrence with dominant companies like Facebook. Stirling (2014) concurs that some representations have more legitimacy than others and are valued more in society, especially when it comes to sustainable energy, which undergirds green data centers. These agents have a disproportionate effect on where and how data centers are built, and they often affect the way research is done to asymmetrically favor pathways approved by the institutions,

limiting creativity and plurality in the field in order to boost their public image (ibid). Recognizing different types of institutions can further contextualize the social groups as not only having different interests, but different levels of power to influence the technology to move in their desired directions. These types include hierarchies, markets, and community self-governance, and can be characterized by formal enforcement, such as penalties and government sanctions, or informal enforcement, such as social pressures and incentives to follow the rules (Dietz, Ostrom, & Stern, 2003). "Command and control" methods of governance, where one institution has centralized control over resources, has been shown to fail, and multiple levels of redundant governance exerted by several institutional types tends to be more effective (ibid). These different institutional types further support the categorization of public acceptance of green data centers into Wüstenhagen, Wolsink, and Bürer's (2007) types of social acceptance discussed above.

Certifying Sustainability

Eco-friendliness has become a marketing tool to convince customers that companies are ethical and responsible. Companies can use the changes they implement to attract more media attention, quell customer and shareholder concerns, and stay in the good graces of governments and industry groups. Thus, making the public aware of sustainability initiatives just makes good business sense. I will be pursuing the research question: How do environmental metrics and certifications for data centers encourage companies to make sustainability a top priority? This question is imperative to understanding the future of sustainable data centers because formal institutions such as governmental regulations have affected the development of sustainability measures, but informal institutions may allow companies to self-govern to an extent, which could help accelerate progress. Informal institutions such as voluntary disclosures, of which

certifications and metrics are an example, need "incentives that benefit leaders in volunteering over laggards and … incentives for compliance" in order to successfully influence change (ibid). Thus, it is important to consider if and how certifications can create powerful enough incentives to supplement more formal institutions in encouraging sustainable changes in data centers.

As discussed earlier, metrics like PUE can be prominently displayed in marketing materials to consumers and can potentially help companies jockey for relative "greenness." It has been shown that sustainability ratings influence how consumers feel about a company's corporate social responsibility (CSR) efforts, which influences their evaluation of a company and its motives (Parguel, Benoît-Moreau, & Larceneux, 2011). On the positive side, this capitalistic competition can have the side effect of actually helping the environment. Yet companies that choose to spend the money on a costly CSR report tend to have better metrics (Mahoney, Thorne, Cecil, & LaGore, 2013). Part of this trend can be signaling, where companies release reports primarily to show stakeholders and competitors their superiority, whereas part can be greenwashing, where companies attempt to manipulate perceptions that they are more concerned with CSR issues than they really are (ibid). In the second case, these reports are equivalent to buying the company a better image without having to make responsible investments or forgo profits in the name of sustainability. Adams (2004) goes further to say that reports are likely no more than "a legitimating tool and insurance policy" and that negative aspects are missing from reports in a way that would not be tolerable in more regulated.

I will examine several certifications and metrics currently used in the data center industry, and analyze how several top cloud providers and data center companies have measured over time. These companies will be selected by using financial metrics such as market share and annual revenue from their data centers to avoid selection bias based on brand recognizability. I

will then examine promotional materials and press releases from the companies using content analysis to rank the most commonly reported metrics, and record the frequency of externally versus internally measured metrics. I will use the change in companies' performance over time to evaluate whether the scores are creating enough competition. I will round out my analysis by discussing environmental laws and regulations that apply to these companies and their data centers to determine the difference in strictness, if any, between metrics and governmental regulations. This analysis aims to illuminate the meshing of formal and informal institutions in making sustainability a top priority for data centers.

The technical project will be completed in December 2020. I will complete the first draft of the technical and sociotechnical portions by February 2021. I will compile the list of companies and metrics to be used, conduct the analysis, and create figures by March 2021. All parts will be finalized by April 2021.

Conclusion

Both the project deliverables aim to improve understanding of how society and green data centers affect each other. The data analysis will potentially show that third-party certifications and sustainability reviews are losing their effectiveness as informal institutions and agents of competition because the top companies in the world have almost identical scores on the few standardized metrics they choose to share, leaving little room for comparison. In Lancium's case, the technical deliverable of a fully functional website will expand access to groups that may not otherwise choose to participate due to a steep learning curve or high prices. These deliverables will make headway toward the overarching goal of understanding and the factors that drive data center sustainability.

References

Adams, C. A. (2004). The ethical, social and environmental reporting-performance portrayal gap. *Accounting, Auditing & Accountability Journal*, *17*(5), 731–757. https://doi.org/10.1108/09513570410567791

González, Á. (2016). Amazon gets an 'F' from the Carbon Disclosure Project. Retrieved from: https://www.seattletimes.com/business/amazon/amazon-reluctant-to-share-carbon-emissions-data/

Amazon (2020). AWS Educate. Retrieved from: https://aws.amazon.com/education/awseducate/

Beaty, D. L. (2013). Power Usage Effectiveness (PUE): Data Center Energy Metric. *ASHRAE Journal; New York*, *55*(1), 61–62.

Craighill, C. (2019, February 13). Greenpeace Finds Amazon Breaking Commitment to Power Cloud with 100% Renewable Energy. Retrieved from: https://www.greenpeace.org/usa/news/greenpeace-finds-amazon-breaking-commitment-to-power-cloud-with-100-renewable-energy/

Dietz, T., Ostrom, E., & Stern, P. C. (2003). The Struggle to Govern the Commons. *Science*, *302*(5652), 1907–1912. https://doi.org/10.1126/science.1091015

Google (2019). Environmental Web Report. Retrieved from: https://sustainability.google/reports/environmental-report-2019/

Google (2020). Google Cloud for Higher Education. Retrieved from: https://edu.google.com/programs/

Google Developers (2020). What are Progressive Web Apps? Retrieved from: https://web.dev/what-are-pwas/

Henriksen, K. (2019). *Odense data center– economic impact and community benefits.* Datacenter Industrien. https://datacenterindustrien.dk/odense-data-center-economic-impact-and-community-benefits/

Jacobs, C. (2020). Prospectus Work.

Lancium (2020). Lancium and MP2 Energy Offer Unique Energy Demand Response Solution For High- Throughput Computing And Cryptocurrency Miners. Retrieved from: https://lancium.com/lancium-mp2-demand-response/

Mahoney, L. S., Thorne, L., Cecil, L., & LaGore, W. (2013). A research note on standalone corporate social responsibility reports: Signaling or greenwashing? *Critical Perspectives on Accounting*, *24*(4), 350–359. https://doi.org/10.1016/j.cpa.2012.09.008

Masanet, E., Shehabi, A., Lei, N., Smith, S., & Koomey, J. (2020). Recalibrating global data center energy-use estimates. *Science*, *367*(6481), 984–986. https://doi.org/10.1126/science.aba3758

Parguel, B., Benoît-Moreau, F., & Larceneux, F. (2011). How Sustainability Ratings Might Deter 'Greenwashing': A Closer Look at Ethical Corporate Communication. *Journal of Business Ethics*, *102*(1), 15. https://doi.org/10.1007/s10551-011-0901-2

Pinch, T. J., & Bijker, W. E. (1984). The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. *Social Studies of Science*, *14*(3), 399–441. Retrieved from: https://www.jstor.org/stable/28535

EIA (2020). The United States consumed a record amount of renewable energy in 2019. Retrieved from: https://www.eia.gov/todayinenergy/detail.php?id=45516

Vue.js (2020). Vue.js. Retrieved from: https://v3.vuejs.org/

AWEA (2020). Wind Energy Facts at a Glance. Retrieved from: https://www.awea.org/wind-101/basics-of-wind-energy/wind-facts-at-a-glance

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, *35*(5), 2683–2691. https://doi.org/https://doi.org/10.1016/j.enpol.2006.12.001