Data Center Location Optimization

Project Proposal

EBGN645: Computational Economics

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Research Q: **From the economic viability point of view,** w**hat is the optimal location for a data center and how big should it be?**

Lawrence Berkeley Labs in their 2024 US Data Center Energy usage Report projected that energy demand from data centers will grow from 2023's 4.4% of US total and by 2028 will reach 6.7 to 12% of the US total energy demand. This demand growth reflects a future with many more data centers than what we see today.

Data centers require vast amounts of resources like energy and water so we would expect them to locate near where those resources are cheapest, however, reviewing the map of data center infrastructure from NREL shows there are areas of data center concentration where resource availability must not have been the only criteria for the decision of locating. Latency, or the speed of data transfer, between the data center and their clients (like the federal government) seem to also play a large role in location.

Given that the larger a data center is the more strain it puts on the region,

For simplicity, I would start with limiting the ability of a data center developer to build their own micro-grid but future work (or if it is simpler than I think) will incorporate the decision node of going off-grid.

Literature

Wang et al (2023) builds an optimization model for data center location also based on lowest cost but also minimizing power utilization associated with carbon emissions from a country level and that country s CHina. The authros provide a great jumping off point for model specification.

Goścień and Walkowiak (2017) optimize data center location with routing and spectrum allocation in survivable elastic optical networks. They show how the consequences on the network if a data center goes down due to natural disaster. This is key for adding welfare loss due to placing a data center in an area with a high probability of natural disaster.

Chang et al (2007) looks at the US Army's need to build out data centers and optimizes for application latency and having a minimum processing capacity available.

Model

Indices and Sets: Some set of potential site locations (i) and some set of geographic areas with demand for data centers (j)

Parameters:

- Demand from users in j
- Energy price in i
- New electricity transmission costs in i
- Water price in i
- Maximum electrical capacity available in i
- Latency between I and j (should address communications infrastructure issue)
- Variable capital costs, eg servers, racks and cooling equipment
- Natural disater likelihhod of i
- Government incentives of i
- Interconnection queue wait-time in i (may be a function of size)

Variables

- Yes/no variable for building in a location
- Some continuous variable for how big the data center built should be

Objective Function

- Miminimize costs and satisfy all data user demand

Constraints

- Demand satisfaction
- Latency must meet threshold
- Budget constraint

Potential Hurdles

Companies that build or operate data centers often conceal the details of their operations as trade secrets. So I may need to make assumptions about energy and water use.

Data

Electric power rates are available as an average by state through the EIA. Although I do not know if the industrial or commercial sectors shown take into account possible PPA's.