Towards Sustainable Data Centers: Evaluating Policies for Energy Efficiency and Environmental Responsibility

Abstract

This research aims to develop policies for government agencies to effectively regulate and incentivize energy efficiency and sustainability in data centers. Leveraging innovative and rigorous economic modeling and empirical approaches, this interdisciplinary proposed research explores the intricate interplay between technological, economic, and environmental dimensions in data center operations. Given data centers' escalating energy consumption and environmental impact, coupled with the rise in popularity of AI applications, this research is timely and essential. The proposed models comprehensively consider the actions of different stakeholders, including government bodies, data centers, and consumers. By integrating data on energy usage profiles, carbon emissions, consumer preferences, and environmental costs, the proposed models are enriched to provide valuable insights to cultivate a sustainable data center ecosystem. The proposed research addresses pressing economic and environmental concerns and promotes interdisciplinary collaboration and innovation at Stony Brook University for the collective betterment of data center sustainability.

Intellectual Merit: The proposed framework lies at the intersection of sustainability and data center operations, a crucial area that has been overlooked in the existing literature. We aim to: (i) Analyze the impact of existing government policies on data center managers and consumer behavior. (ii) Develop a modeling framework capable of predicting the impact of government policies, such as the power usage effectiveness (PUE) requirements scheme and tax incentive scheme, on both data center managers and consumer behavior. (iii) Conduct sensitivity analyses to evaluate the effects of varying policy schemes and parameters on data centers and consumer behavior. (iv) Conduct a comparative analysis of the optimal policy schemes generated, offering valuable managerial insights for government agencies. These insights will assist in identifying the most beneficial policy given particular circumstances, considering factors such as data center scale, current energy efficiency levels, prevailing energy expenses, and other pertinent variables.

Broader Impact: Over the past two decades, the rapid expansion of data centers has been driven by the soaring demand for computation and storage, particularly fueled by the widespread adoption of cloud computing. The increasing use of resource-intensive technologies like Big Data and Artificial Intelligence has further accelerated this surge. However, this growth has come at a cost, with data centers now accounting for a significant portion of global energy consumption and greenhouse gas emissions. Recognizing the urgency of this issue, governments have begun implementing regulations to mitigate the environmental impact of data centers. Our proposal aims to examine the governmental policies for regulating data center operations. These policies hold the potential to yield far-reaching benefits, including the reduction of carbon footprint, the adoption of cleaner energy sources, and the enhancement of social welfare, fostering a more environmentally friendly and socially responsible approach to data center management.

Fit for Seed Grant: This project marks the initial steps toward developing a modeling framework to analyze the impact of governmental regulations on data center operations and environmental impacts. This framework can be further leveraged to assess the effectiveness of different policies and derive optimal policies. Given the societal significance of the project and the pressing nature of research on sustainable data centers, obtaining preliminary results through the seed grant will significantly enhance the team's ability to craft a competitive proposal for external funding. Moreover, the seed grant will facilitate the Principal Investigators (PIs) in aligning their research interests with the pertinent topic of sustainable data center operations, granting them access to a range of funding opportunities within the broader sustainability domain. Such funding avenues will bolster the PIs' career progression and advancements in sustainability research.