MIT Climate Policy Center

MIT CEEPR Center for Energy and Environmental Policy Research

POLICY BRIEF

Data Centers and the Grid:

Temporal Flexibility Can Lower Costs, But May Increase Emissions

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Data center temporal flexibility (the ability to shift computing workloads across time) can reduce power system costs by up to 5%, but the climate impacts depend on the availability of renewable energy. In regions with abundant wind and solar, temporal flexibility accelerates decarbonization; in fossil-heavy grids, it may entrench coal plants and increase emissions by up to 3%.

Policy Considerations

- Market-based incentives (dynamic pricing, demand response programs, performance-based incentives) or requirements that induce data center temporal flexibility can capture cost savings and protect the grid by reducing peak demand. For example, charging high rates during peak demand would encourage flexibility.
- If policymakers wish to ensure grid benefits, cost reductions, and emissions reductions, policies for data center temporal flexibility should be coupled with strong renewable energy policies such as carbon pricing, investment incentives, or renewable portfolio standards.
- Policies that incentivize or require data centers to provide their own electricity generation can reduce impacts on peak demand and costs borne by other users. But if this generation is not co-located with the data center, the transmission and distribution components of the grid will incur additional strain.
- Regional grid characteristics matter: temporal flexibility supports decarbonization in renewable-rich systems but may increase fossil generation in coal-heavy grids.
- Modest temporal flexibility (12-hour shifting, 60% workload share) delivers substantial benefits; full temporal flexibility is not required for significant cost and operational improvements.

The Policy Problem

Data centers are projected to increase their share of U.S. electricity demand by 7-12% by 2030, driven by artificial intelligence and cloud computing growth. This surge threatens grid reliability and climate goals, particularly as new data center demand could add the equivalent of a mid-sized state's electricity demand to some regional systems. However, data centers typically operate at only 80% capacity, creating an opportunity to shift workloads to times when electricity is cleaner or cheaper. The critical policy question is whether incentivizing this flexibility will reliably reduce emissions while managing costs, or whether it could inadvertently prolong fossil fuel dependence in some regions.

The Findings

Our modeling of three U.S. regions (Texas, the Mid-Atlantic, and the Western Interconnect) reveals that data center temporal flexibility always reduces system costs but produces different emissions outcomes. Because temporal flexibility reduces peak demand, it either increases the integration of renewable energy where there is abundant supply, or it supports baseload generation where coal and nuclear are prevalent.

In Texas, where wind and solar supply 54% of generation, high temporal flexibility reduces emissions by up to 40%, reduces costs by up to 5%, and accelerates coal and nuclear retirements (see Figure 1). But in the Mid-Atlantic and Western Interconnect, where renewable penetration is lower, temporal flexibility increases coal plant utilization, raises emissions by up to 3%, but reduces costs by 4% and 2%, respectively. These findings indicate that the emissions benefit of temporal flexibility is highly dependent on the economics of renewable energy in a region.

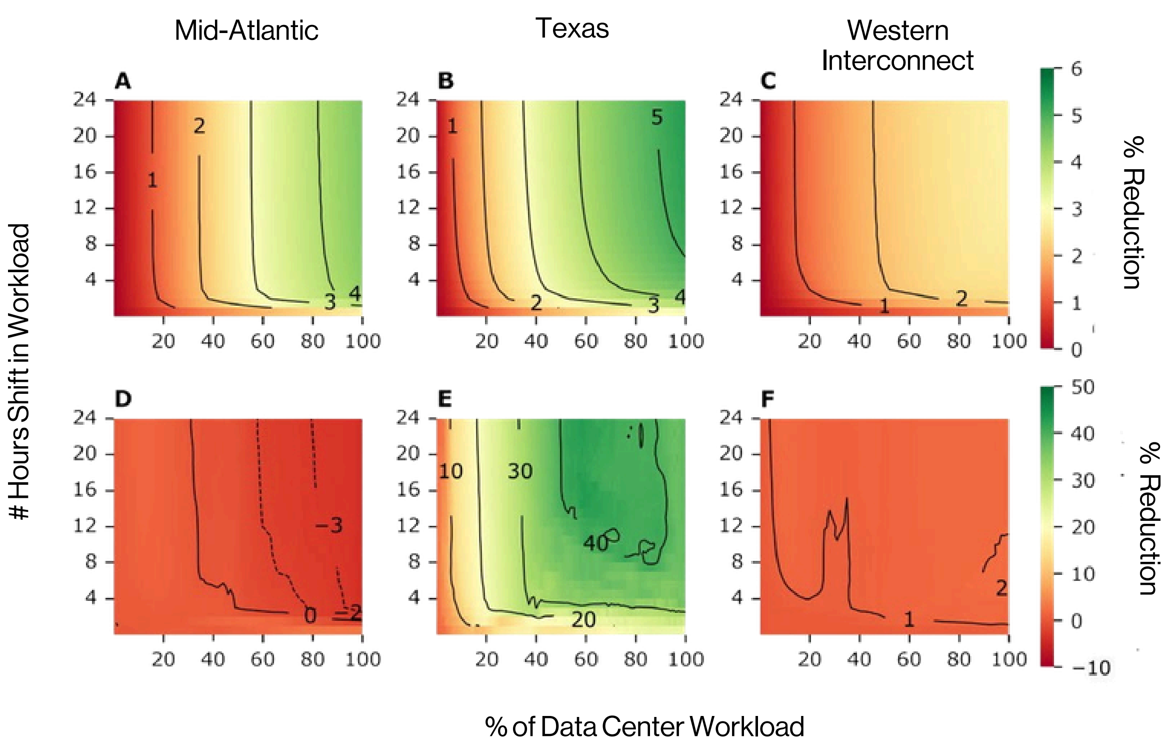

Figure 1. Cost and Emissions Impacts of Temporal Flexibility of Data Centers

The Research

We used the Gen X capacity expansion model to simulate power system planning and operations with varying levels of data center temporal flexibility. We compared flexible data center operations against a reference operation with constant, inflexible demand by shifting varying amounts of data center electricity demand up to 24 hours into the future. The model co-optimizes generation investments, retirements, and hourly dispatch decisions to minimize total system costs while meeting demand and technical constraints. Our three study regions collectively host 82% of projected U.S. data center demand in 2030.

Future Work

We used the Gen X capacity expansion model to simulate power system planning and operations with varying levels of data center temporal flexibility. We compared flexible data center operations against a reference operation with constant, inflexible demand by shifting varying amounts of data center electricity demand up to 24 hours into the future. The model co-optimizes generation investments, retirements, and hourly dispatch decisions to minimize total system costs while meeting demand and technical constraints. Our three study regions collectively host 82% of projected U.S. data center demand in 2030.

We are also moving beyond modeling the impacts of data centers and we are beginning a study to measure the impacts on locational marginal prices of electricity when a data center enters a market.

Source: Knittel,C.R., Senga, J.R.L., and Wang, S. (2025). Flexible Data Centers and the Grid: Lower Costs, Higher Emissions? MIT CEEPR Working Paper 2025-14.

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