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Stranded Power in Data Centers: Identification, Utilization Strategies, and Opportunities for Sustainable Energy Development

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Abstract

Stranded power is electricity or electrical capacity that exists but goes unused. In the context of data centers it takes two forms: renewable generation on the grid that is curtailed because it cannot be delivered, and power capacity inside facilities that is provisioned but rarely drawn. Both forms are growing in importance as data center demand rises. The International Energy Agency (IEA, 2025) projects that global data center electricity use will more than double from about 415 TWh in 2024 to around 945 TWh in 2030, while grid connection delays threaten about 20% of planned projects. This article examines how stranded power can be identified, the strategies available to use it, and the opportunities it creates for sustainable energy development. Drawing on Anioke's (2026) analysis of stranded power and its possible uses, alongside studies of power provisioning, dispatchable computing, and load flexibility, it argues that stranded power is one of the most practical and least costly resources for meeting data center demand. It concludes with recommendations for operators, utilities, and policymakers.

Keywords: Stranded power; data centers; renewable curtailment; power capacity; demand flexibility; sustainable energy

1. Introduction

The rapid growth of data centers, driven largely by artificial intelligence (AI), has placed new pressure on electrical grids. Anioke (2025) shows that data centers raise total electricity demand, create new risks for grid stability, and complicate the transition to sustainable energy. In many regions, new data centers must wait years for grid connections because generation and transmission cannot be built fast enough.

Yet at the same time, a significant amount of electricity and electrical capacity is going to waste. Wind and solar farms are regularly told to reduce output because the grid cannot absorb or transport their power. Inside data centers, large amounts of capacity are reserved for redundancy and worst-case peaks, and much of it is never used. Anioke (2026) describes both as stranded power and argues that finding productive uses for it can ease grid pressure and support sustainability goals.

This article examines how stranded power can be identified, the strategies available to use it, and the opportunities it creates for sustainable energy development.

2. Understanding Stranded Power

Anioke (2026) distinguishes between two broad forms of stranded power relevant to data centers.

Grid-side stranded power. This is electricity that is generated, or could be generated, but cannot be used. It arises most often with wind and solar power. When output exceeds local demand and transmission lines are congested, grid operators curtail generation, ordering plants to reduce output. Kim

et al. (2017) showed that significant stranded power persists in power systems and that it grows as the share of wind power increases.

Facility-side stranded capacity. Data centers are designed for reliability. Their electrical systems include redundant feeds, backup generators, and uninterruptible power supply (UPS) systems sized to carry the full load if a main supply fails. Power capacity is also allocated to each rack and server based on nameplate ratings or worst-case estimates. In practice, servers rarely draw their maximum power at the same time. Fan et al. (2007), studying large Google server clusters, found a consistent gap between the power provisioned and the power actually consumed, even at peak. They showed that careful power management could allow substantially more servers to be deployed within the same provisioned power budget. This unused headroom is stranded capacity: infrastructure that has been paid for but does not do useful work.

Both forms represent value that is lost. Grid-side stranded power wastes clean energy and depresses the revenue of renewable generators. Facility-side stranded capacity raises the cost of building data centers and leads operators to request more grid capacity than they truly need. Anioke (2025) notes that such over-requests add to the planning uncertainty that utilities already face.

3. Identifying Stranded Power

Using stranded power begins with finding it. Different methods apply to each form.

Grid-side identification. The clearest indicators are curtailment records and market prices. Grid operators publish data on how much wind and solar output they curtail and where. Locations that frequently experience zero or negative prices, or persistent transmission congestion, are strong candidates for stranded power. Grid models can also be used to estimate how much curtailment will occur as new renewable projects come online. Kim et al. (2017) used such modeling to show where data center loads could absorb surplus power most effectively.

Facility-side identification. Inside a facility, the key tool is detailed power monitoring. Metering at the rack, row, and room levels shows how actual consumption compares with allocated capacity over time. Analyzing this data reveals where headroom is consistently unused. Fan et al. (2007) demonstrated that modeling the combined power use of large groups of servers gives a far more accurate picture than adding up individual nameplate ratings.

Combining both views. The greatest opportunities arise where the two forms meet. A data center with flexible workloads, located in a region with frequent renewable curtailment, can use both its internal headroom and the grid's surplus power at the same time.

4. Strategies for Utilizing Stranded Power

4.1 Recovering Stranded Capacity Inside the Facility

The first strategy is to make better use of the capacity a data center already has. Fan et al. (2007) showed that by measuring actual power use and setting limits on peak consumption, operators can safely deploy more servers within the same power budget. This practice, known as power oversubscription, depends on reliable power capping, so that servers can be slowed briefly if total demand approaches the limit.

Software efficiency plays an important role. Lakavath (2023) examines serverless computing on Microsoft Azure Functions, in which applications run only when triggered and resources scale automatically with demand. Lakavath (2023) assesses the model's performance, scalability, and cost efficiency. Because computing resources are allocated only when needed and released when demand falls,

serverless and similar cloud designs raise the utilization of shared hardware. Higher utilization reduces idle capacity and allows more useful work to be done within the power a facility already has.

Anioke (2026) notes that recovering stranded capacity in this way can defer the need for new grid connections. For utilities facing long queues of data center requests, this is a direct benefit: every megawatt recovered inside an existing facility is a megawatt that does not have to be added to the grid.

4.2 Absorbing Stranded Renewable Power

The second strategy is to use surplus renewable energy from the grid. A data center that can increase its computing when wind or solar output would otherwise be curtailed can turn wasted energy into useful work.

Kim et al. (2017) studied this approach in detail. They found that simply building data centers next to wind farms did not reliably reduce stranded power and could even increase it in some cases. The benefit appeared when data centers were treated as dispatchable loads, able to raise or lower demand in response to grid conditions, and placed optimally across the system. With this approach, dispatchable data center loads were able to reduce stranded power, lower system costs, and operate at a large share of their full capacity using power that would otherwise be wasted.

Anioke (2026) highlights several uses for such power, including flexible computing placed near renewable sites. Suitable workloads include AI model training, scientific simulations, data processing, and other batch tasks that do not require an immediate response.

4.3 Shifting Workloads in Time and Place

The third strategy uses intelligent scheduling to align computing demand with the availability of surplus clean power. Radovanović et al. (2023) describe Google's carbon-intelligent computing system, which uses forecasts of grid carbon intensity and computing demand to set hourly limits on capacity at each data center cluster. Flexible tasks are delayed to hours when cleaner power is available. The same forecasting approach can be used to anticipate curtailment events and direct flexible work toward them.

4.4 Providing Flexibility to the Grid

The final strategy treats data center flexibility as a service. Norris et al. (2025) examined the 22 largest U.S. balancing authorities and found that existing grids could integrate about 76 GW of new load if that load accepted curtailment for an average of just 0.25% of the year. Data centers willing to reduce demand briefly during peak periods can therefore connect sooner, using grid capacity that is otherwise left idle most of the time. In this sense, the grid's own spare capacity outside peak hours is another form of stranded power that flexible data centers can unlock.

5. Opportunities for Sustainable Energy Development

Using stranded power creates benefits that extend well beyond individual data centers.

Improving the economics of renewable energy. When renewable output is curtailed, generators lose revenue. A flexible data center that buys this power gives wind and solar projects a new source of income, improving their financial case and encouraging further investment in clean energy.

Reducing the need for new infrastructure. Every megawatt of stranded capacity recovered inside a facility, and every megawatt of grid headroom unlocked through flexibility, reduces the generation and transmission that must be built. The IEA (2025) notes that grid constraints could delay about 20% of planned data center projects. Stranded power offers a faster path for some of them.

Lowering emissions. Data centers that run flexible workloads on surplus renewable energy reduce their reliance on fossil generation.

Supporting grid stability. Flexible demand helps operators balance supply and demand, particularly in grids with a high share of variable renewable energy. Anioke (2025) argues that this kind of grid-supportive behavior is central to making data center growth sustainable.

6. Challenges and Limitations

Several challenges limit how far stranded power can be used.

First, stranded renewable power is intermittent. It is available only at certain times and in certain places, and it can be hard to predict. Workloads that rely on it must tolerate interruptions.

Second, AI data centers are very capital-intensive. The IEA (2025) notes that their high cost makes operators reluctant to leave hardware idle. Facilities built mainly to use stranded power may struggle to achieve high enough utilization to justify their cost.

Third, recovering stranded capacity inside a facility carries some risk. Oversubscription depends on accurate monitoring and reliable power capping, and errors could affect service reliability (Fan et al., 2007).

Fourth, many sites with abundant stranded renewable power are remote. They may lack the fiber networks, water supply, and skilled workforce that data centers need.

Finally, market and regulatory rules often do not reward flexible demand or allow data centers to buy curtailed power directly. Without suitable contracts and price signals, much of the opportunity remains untapped.

7. Recommendations

Six steps would help unlock the value of stranded power:

1. **Measure stranded power systematically,** through detailed facility metering and public grid data on curtailment and congestion (Fan et al., 2007; Kim et al., 2017).
2. **Recover stranded capacity inside facilities** using power capping, oversubscription, and high-utilization cloud designs (Lakavath, 2023).
3. **Site flexible computing where stranded renewable power is abundant,** and operate it as a dispatchable load (Anioke, 2026; Kim et al., 2017).
4. **Schedule flexible workloads with grid forecasts,** directing them toward periods of surplus clean power (Radovanović et al., 2023).
5. **Offer flexible interconnection agreements** that let data centers connect sooner in exchange for limited curtailment (Norris et al., 2025).
6. **Reform markets and tariffs** so that data centers can buy curtailed power and are rewarded for flexibility (Anioke, 2025; IEA, 2025).

8. Conclusion

Stranded power is a hidden resource at the center of the data center energy challenge. On the grid, it appears as wind and solar output that is curtailed because it cannot be delivered. Inside facilities, it appears as capacity that is provisioned but never used. Both can be identified through better data, and

both can be put to productive use through power management, flexible computing, intelligent scheduling, and new grid agreements. Doing so can lower costs, reduce the need for new infrastructure, improve the economics of renewable energy, and cut emissions. The obstacles are real, including intermittency, cost, location, and outdated market rules, but none is insurmountable. With coordinated action by data center operators, utilities, and policymakers, stranded power can become a practical foundation for more sustainable data center growth.

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