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Data centers and energy poverty in the United States: Assessing distributional implications of rapid load growth in an era of artificial intelligence

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HIGHLIGHTS

- Four mechanisms potentially linking data center expansion to energy poverty risks are identified.
- Large load growth can translate into affordability stress through infrastructure expansion needs.
- Highly concentrated load growth and water dependence can amplify risks for reliability and service continuity.
- Backup generation can create localized exposure burdens that may worsen energy service adequacy risks for vulnerable households.
- Emerging responses focus on cost allocation and transparent planning, but uncertainties remain.

Accelerated by the current surge in artificial intelligence applications, the expansion of data centers is now a significant driver of electricity demand growth in the United States, with potential implications for household energy poverty. This paper synthesizes the latest available evidence to identify four possible mechanisms through which rapid data center load growth may pose energy poverty risks. These mechanisms concern affordability pressures related to large load growth, service continuity risks associated with the high geographic concentration and water dependence of data centers, and service adequacy risks linked to backup generation. In response to these concerns, emerging institutional and policy developments focus on cost allocation and tariff design, interconnection and reliability planning, and environmental oversight. Outcomes will depend on implementation, transparency, monitoring, and adaptation in an era of rapidly evolving conditions.

Globally, the rise of artificial intelligence (AI) and digital services is accelerating the expansion of data centers, making them one of the most significant drivers of electricity demand growth [1]. A single AI-focused data center can use as much electricity as 100,000 households, and the newest mega facilities being built are expected to require 20 times that amount [1]. Approximately 45% of global data center electricity consumption occurs in the United States (U.S.) [1], where several regions are now planning for unprecedented AI-driven load growth [2, 3].

While the aggregate benefits of digital infrastructure are clear, important concerns remain about potentially uneven distribution of costs and risks. Existing evidence indicates that recent data center growth is geographically concentrated [3] and can overlap with overburdened communities [4]. These overlaps may be especially consequential in places where energy poverty is already concentrated among vulnerable households [5, 6]. At the same time, the emergence of energy-intensive data centers may affect nearby energy systems through several pathways, including electricity prices, grid constraints, and environmental impacts. Yet, whether these pathways introduce new dynamics and risks for energy-burdened households has not yet been systematically examined.

In light of these uncertainties, the objective of this paper is to answer an urgent question:

How does the rapid expansion of U.S. data centers shape energy poverty risk through electricity prices, grid constraints, environmental impacts, and other system-level pressures?

To achieve its objective, this paper synthesizes the latest available evidence to define four plausible mechanisms through which data center growth may intersect with manifestations of energy poverty related to affordability, service continuity, and service adequacy. The first mechanism concerns large load growth, expansion needs, and tariff design; the second one concerns highly concentrated load growth and reliability stress; the third concerns water dependence and simultaneous constraints for heat and power, and; the fourth concerns backup generation, local exposure, and siting. Each mechanism includes a data center characteristic as a starting point, a primary stressor, a mediator, and an energy poverty manifestation as an endpoint. These mechanisms are distinct as they are organized around different starting characteristics of current U.S. data center

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development that give rise to different immediate stressors; at the same time, they are interconnected at certain decision points. Figure 1 provides an illustrative summary of these mechanisms and their interconnections.

This review is based on peer-reviewed studies, national assessments, grid stakeholder reports, and regulatory filings. Overall, the analysis presented herein is descriptive and integrative rather than causal, as this work aims to illuminate plausible pathways and decision points, rather than to establish single-factor causation. As research on the nexus of data centers and energy poverty remains limited, there is value in a framework that outlines distinct yet interconnected mechanisms. It is hoped that this will support future empirical work on how the expansion of digital infrastructure can reshape household affordability, service continuity, and energy adequacy in the U.S.

Characteristics and growth trajectory of U.S. data centers

A data center is a physical facility that operates large computer systems [7], and typically comprises servers, data storage systems, network connections, environmental controls, and backup generators (see Figure 2). Driven by the current surge in AI and digital services, data centers are now one of the most important sources of electricity demand growth in the U.S. [1].

For planners and policymakers, four characteristics of that development become particularly salient. Firstly, growth is occurring at exceptional speed and scale: nationwide data center electricity consumption increased from approximately 76 TWh in 2018 to 176 TWh in 2023 [8], and is projected to reach up to 580 TWh in 2028, equivalent to twice the current electricity consumption of California [9]. Secondly, growth is highly geographically concentrated [8] (see Figure 3): Northern Virginia, which hosts the so-called "Data Center Alley" in Loudoun County [10], is the largest market in the world, and larger than the following five largest U.S. data center markets combined [3]. Thirdly, data centers are increasingly notable for their dependence on water for cooling: On average, a 100 MW data center is estimated to consume 2 million liters of water per day, a consumption equivalent to that of 6,500 homes [1]. Finally, data centers commonly rely on backup generators to maintain operations during reliability events [11]. Often, these generators run on diesel, and emit pollutants such as nitrogen oxides (NO_x) and fine particulate matter ($PM_{2.5}$) [11].

These four characteristics make data center expansion not only a question of increased electricity demand, but also of how large, concentrated, water-dependent, and backup generator-enabled facilities interact with local infrastructure and surrounding communities. Accordingly, these characteristics provide the analytical foundation for the mechanisms discussed in the remainder of this paper.

Proximity to vulnerable communities

In documented cases, data center development occurs in areas already hosting marginalized and vulnerable communities facing significant environmental burdens. In California, for instance, a recent study demonstrates that data centers are situated in locations with diesel PM, hazardous waste, and groundwater threats [4]. In addition, many data centers are situated in areas experiencing water stress and heatwaves, most notably in Texas [12]. Existing data centers have also been found to overlap with areas experiencing frequent outages [13], the likelihood of which can increase in locations with extreme heat [12]. While such burdens may be offset by anticipated community benefits, such as new jobs, those benefits might not always materialize in the near term. For instance, evidence from Northern Virginia demonstrates that local data center employment currently accounts for less than 0.5% [14]. These siting patterns may therefore influence where environmental exposures and affordability risks concentrate. In this context, energy poverty can serve as a salient analytical framework for assessing the distributional implications of data center growth.

Defining energy poverty in the U.S. context

Energy poverty (also described as energy insecurity in the literature [15]) is a multidimensional phenomenon defined as the inability of households to meet their energy needs [16, 17], for instance, for space heating, cooling, and other essential household energy services. The 2024 Residential Energy Consumption Survey reveals that 33% of U.S. households experienced some form of energy insecurity, up from 27% in 2020 [18]; these indicators include foregoing necessities to pay for residential energy, unhealthy indoor temperatures, disconnection notices, and inability to use heating or cooling equipment.

Energy burden, i.e., the share of household income spent on energy services, is an energy poverty metric widely used in the U.S. and elsewhere, with determinations often based on thresholds of 6% to 10% [19, 20]. Nevertheless, some manifestations of energy poverty are hidden [16], as low-income households may resort to risky coping strategies that intentionally limit energy use to reduce their bills [15]. This can pose severe health risks, for instance, when household members endure unsafe indoor temperatures or use space heaters or ovens improperly [15, 21, 22]. Metrics based solely on burden can miss these behaviors [17]; thus, scholars suggest combining income-based metrics with indicators of coping behaviors [16], disconnections, dwelling condition, and self-declared inability to keep one's home adequately warm or cool [17, 21].

Furthermore, the literature suggests that energy burdens are spatially concentrated and most often experienced in particular locations [5, 23, 24], often overlapping with race, income, and gender disparities. For instance, minority or female-headed households, renters, and low-income families have been found to face higher energy burdens [5, 20, 24].

These dynamics suggest that localized disruptions may interact with energy poverty and amplify its consequences. In this context, this paper explores potential connections

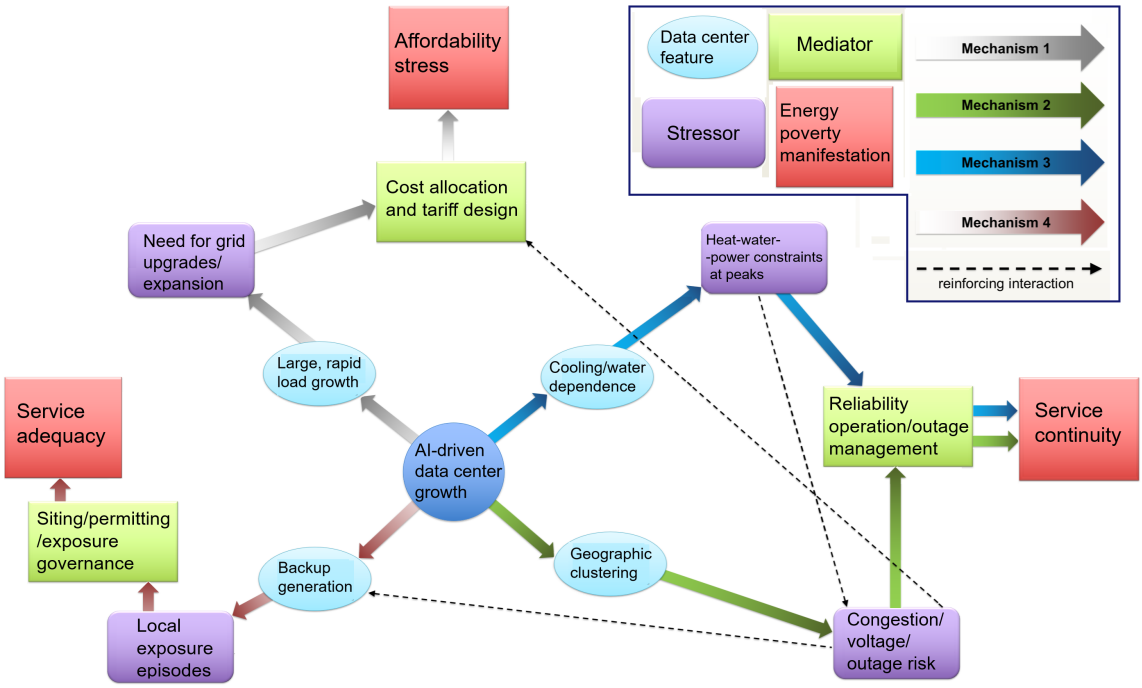

Figure 1: Conceptual model of the mechanisms potentially linking rapid data center growth to energy poverty risks. Solid arrows indicate primary pathways, while dashed arrows denote reinforcing interactions.

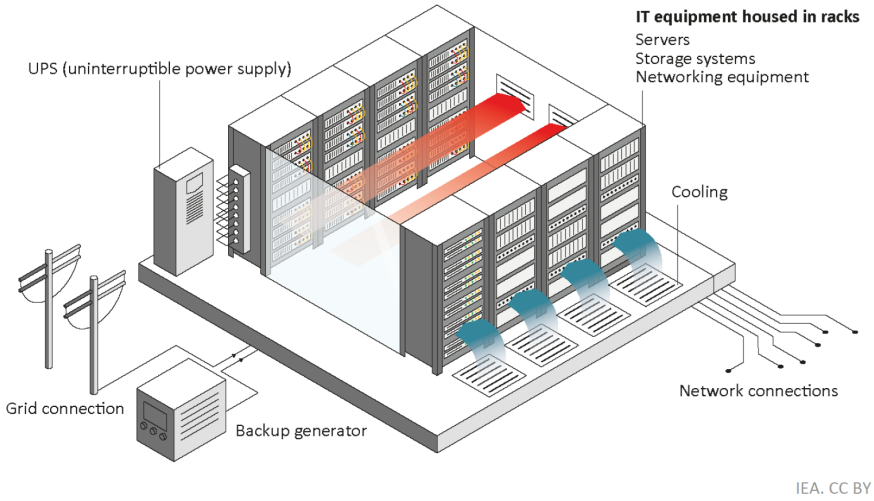

Figure 2: Typical data center components. Source: [1].

between data center development and three manifestations of energy poverty: affordability stress, reflected in high energy burdens [19] and bill trade-offs [23]; service continuity, reflected in disconnections, outage duration, and the unequal consequences of service interruption [18, 25, 26]; and energy service adequacy, understood here as the ability to maintain thermally and medically necessary household energy services [21, 27]. Service continuity and service adequacy can be associated with each other, but remain distinct: the former concerns interruptions to electricity supply, while the latter concerns whether households can secure sufficient energy service to maintain critical services, even when electricity remains technically available. Together, these three manifestations capture complementary financial, continuity, and adequacy dimensions of U.S. energy poverty. This operationalization is based on the identification of the phenomenon's economic, physical, and behavioral dimensions in the literature [27], and expands that framework into specific endpoints of distinct mechanisms originating from key characteristics of data center growth (see Figure 1). These mechanisms are analyzed in the following section.

Mechanisms linking data center growth to energy poverty manifestations

Mechanism 1: Load growth, expansion, tariff design. Existing evidence supports a pathway through which

data center-induced increases in demand can translate into expansion proposals and, subsequently, into broader system cost pressure: Regional Transmission Organizations and Independent System Operators (RTOs/ISOs, key organizations that manage the U.S. electricity grid) are already treating data center growth as an emerging consideration in their system planning [28], and utilities are updating their integrated resource plans to accommodate their growing commitments. For instance, Dominion Energy reported approximately 40 GW in contracted data center capacity in December 2024, up from about 21.4 GW in July of the same year [29]. Georgia Power forecasts approximately 8,200 MW of load growth through winter 2030-2031 and proposes expanded transmission planning together with additional storage and other supply-side assets to safeguard operationality in light of that growth [30].

This growth is often accommodated by large infrastructure additions [30, 31]: for instance, the PJM Interconnection (a major RTO serving all or parts of 13 states and Washington, D.C.) estimates that several billion dollars in expansion investments will be required to accommodate load growth [32]. Accordingly, the Independent Market Monitor (IMM) of PJM regards data center load growth as the primary driver of recent tight conditions and high capacity market prices [33]. Furthermore, recent modeling work suggests that data center growth can increase wholesale electricity costs, particularly where transmission constraints intensify localized price impacts [34].

This stressor of expansion needs and associated cost pressure may then affect retail prices [34] via cost recovery and customer cost allocation [7, 35]. The extent to which this pathway affects retail prices remains context-specific. For instance, recent LBNL work emphasizes that load growth can either lower or raise retail prices depending on existing asset use, the cost of new assets, and tariff design [36]. In the more favorable cases highlighted by that work, North Dakota, New Mexico, and Nebraska increased load while lowering retail prices, largely by spreading fixed costs over greater sales. The same work also presents the opposite possibility in PJM, where states experienced sizeable nominal retail price increases from December 2024 to December 2025, with rising PJM capacity prices identified as one significant contributor, and load growth listed among the factors behind those capacity price increases [36]. Similarly, a recent Virginia study suggests that, while data centers are currently paying their costs of service, their increased energy demand will require new assets to be built, potentially increasing the generation and transmission charges of a typical Dominion Energy residential customer by up to $37 per month by 2040 [37].

While the direction of price impacts varies across contexts, retail prices may increase when load growth is accommodated through new investments that are recovered through rates [7]. This pathway can have distributional impacts, and the translation of system costs into household bills can be mediated by tariff design [35]: residential tariffs in the U.S. typically rely mainly on volumetric charges even though many generation, transmission, and distribution costs are fixed [38, 39]. Therefore, changes in the balance between fixed charges, volumetric charges, and time-varying prices can redistribute impacts across households. For instance, a study employing interval meter data indicates that transitions to more economically efficient tariffs that recover residual costs through uniform fixed charges tend to increase bills for low-income households on average [39]. However, the same study demonstrates that alternative fixed charge designs in two-part tariffs can mitigate those disparities while sustaining much of the efficiency gain [39]. Another study indicates that residential demand charges do not disproportionately harm low-income customers in all settings [40], but distributional effects depend on the specific tariff design.

Baseline energy burdens are also uneven, especially among low-income and minority households in the South, in rural America [41], and in urban settings [6]. A recent study covering New York City, Boston, Cambridge, Seattle, and Washington, D.C. finds that the average energy cost burden is 2% of income for high-income households, but 7% of income for low-income households [6]. Thus, even modest rate increases can translate into energy affordability stress that is proportionally larger for vulnerable populations. Such stress can force risky coping strategies [15] or increase disconnection risks, thereby worsening energy insecurity for already vulnerable households [27, 41].

Mechanism 2: Geographic clustering, reliability, service continuity. Data center growth that is highly concentrated in a limited number of locations can exacerbate broader reliability risks [42, 43]. The North American Electric Reliability Corporation (NERC, the key electric reliability organization in North America) identifies AI data centers as a significant driver of projected demand over the next decade [2] and emphasizes that large loads are creating new reliability challenges [44]. The Electric Reliability Council of Texas (ERCOT) associates projected large load concentration with high regional flows [43]. In PJM, planning materials report reliability issues in the Dominion Energy service area, driven in part by heavier load concentration in Northern Virginia [45]. Taken together, the evidence supports a pathway through which geographically clustered data center development can create a localized stressor of congestion, voltage stress, and outage risk.

These stresses can be mediated through reliability operations and outage management actions, including dispatch adjustments, reserve deployment, emergency procedures, and restoration practices. NERC's 2025 industry recommendation on large loads states that major and rapid load swings pose risks to frequency, voltage regulation, and grid stability, and proposes strengthened interconnection requirements, real-time monitoring, operational communication, and disturbance protocols to safeguard reliability [46]. A concrete example is provided by a July 2024 Eastern Interconnection incident involving a loss of approximately 1,500 MW of data center load [47], which required emergency system adjustments to restore voltage

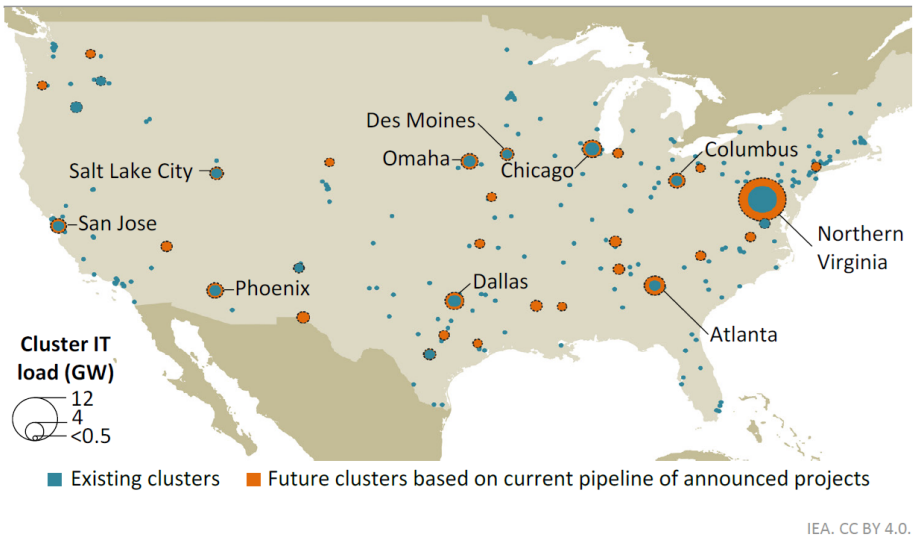

Figure 3: Locations of data center existing and announced capacity in the contiguous United States (2024). Source: [1].

to normal levels. In parallel, recent studies suggest that data centers can adjust their operations to contribute to grid stability without compromising computational performance [48].

When power outages occur, they can disrupt the continuity of thermal safety, food storage, medical care, communications, and other essential services, with especially serious consequences for individuals who rely on medical equipment and for households with fewer resources to cope with outages [26, 49]. Reliability disruptions are also not experienced uniformly across communities: restoration procedures focus on critical infrastructure first, then on commercial and industrial functions, and finally on households; this can potentially leave vulnerable households with extended disruptions [25]. The latter can interact with differences in coping capacity, access to food and medical services, transportation, and exposure to extended disruption, all of which shape households' ability to maintain basic energy services during outages [26, 49]. At the same time, if costs associated with reliability investments [43, 45] enter broader cost recovery processes [35], this mechanism can also be linked to the affordability pathway discussed previously.

Mechanism 3: Water stress, peak constraints, service continuity. A data center's total water footprint is location-dependent and shaped by cooling technology, local climate, and the electricity mix supplying the grid. "Wet" cooling systems can consume on the order of 1.8 L of water per kWh of on-site electricity use, while "dry"/air-cooled systems consume minimal amounts of water, but can increase indirect water needs through higher electricity consumption [50, 51]. The indirect water component often constitutes a large share of the total, thus accounting only for the direct on-site component can significantly underestimate total use [51, 52]. To capture this, engineers often employ metrics such as the Water Use Effectiveness, which includes direct and indirect water use [51], and the Water Scarcity Usage Effectiveness (WSUE), which additionally accounts for regional scarcity [53].

The critical step for households is when water stress and extreme heat translate into power system operating constraints. Water-energy nexus studies suggest that droughts and heatwaves can cause water constraints that translate into energy constraints [54] and, eventually, to reliability issues [55, 56]. For instance, a study in Illinois demonstrated that cooling water shortages during heat and drought conditions can lead to 10-15% daily load curtailment, severe congestion, and large reductions in electricity generation [56]. Similarly, a study in ERCOT and the Southwest Power Pool demonstrated that short-term water constraints can trigger fuel switching and localized generation shifting, even when total load loss is avoided [55]. These are analogous to the system pressures discussed in Mechanism 2, mediated by reliability operations and outage management, as system operators manage strained conditions through dispatch, curtailment, and congestion under stress [44, 46, 55]. Some of these combined heat-water-power constraints can affect reliability operations directly, for instance, by reducing available generation, prompting fuel switching or localized generation shifting, and, in more severe cases, contributing to curtailment and congestion. At the same time, these constraints may also reinforce the local stresses emphasized in Mechanism 2, especially congestion under severe cooling water shortages [56], and broader reliability stress under strained conditions [55]. Given the aforementioned dependence of impacts on cooling technology, electricity mix, and climate, some locations may face greater reliability pressures than others under heat and water constraints. In line with the previous section, this risk pathway matters for service continuity, with potentially disproportionate consequences for households already facing fragile energy conditions [25, 26].

Mechanism 4: Backup generation, local exposure, service adequacy. During outages and reliability events, data

centers commonly maintain their operations through backup generators [11]. Using such generators can emit substantial amounts of pollutants, especially during extended runs [57]. These emissions have been associated with worsening local air quality and generating health burdens if not properly controlled [58]. Furthermore, during reliability events, diesel backup generators have been found to contribute to high ozone periods and account for a substantial fraction of (NO_x) emissions from electricity generation [59].

Location matters for who bears these added exposures. For instance, a modeling study suggests that the social cost of uncontrolled diesel backup generation is substantially higher in densely populated areas, but falls sharply when emission control measures are applied [58]. Furthermore, it has been demonstrated that the health relevance of emissions depends on their rate, location, and timing, with the largest benefits from emission reductions occurring near densely populated and already overburdened communities [60]. This is consistent with broader evidence that disadvantaged communities face higher pollution exposure [61]. Accordingly, siting, permitting, and exposure governance are the mediators that can shape how backup generation affects already burdened communities, how long generators may run, how transparently operations and exposure are monitored [57], and what emissions controls are applied locally [58].

While this pathway can be reinforced by reliability events such as those discussed in Mechanism 2, it remains analytically distinct: once backup generation is used, the stressor can shift from interruption risk to localized exposure episodes. The latter can matter for energy poverty when it interacts with pre-existing household vulnerability. Recent work demonstrates that multiple energy insecurity indicators are associated with respiratory, mental health, and cardiovascular conditions, as well as dependence on electric medical devices [21]. Low-income households living in poor housing and households that require electronic medical devices are more likely to experience energy poverty, disparities that are especially pronounced among racial and ethnic minority populations [62]. At the same time, power interruptions can have important health consequences, especially for individuals who rely on electricity-dependent medical devices [26]. Taken together, the evidence suggests a plausible pathway whereby exposure from backup generators during outages may heighten risks to energy service adequacy in vulnerable households, particularly regarding safe indoor temperatures and the use of electric medical devices.

Institutional and policy developments

The risks identified above are situated within a suite of institutional and policy developments ranging from planning discussions to enacted measures. Certain developments explicitly target data center load growth, while others stem from broader energy system concerns, but become increasingly relevant to how household impacts can be mitigated.

In relevance to Mechanism 1, recent policy designs invoke cost causation principles that assign a greater share of the infrastructure and interconnection burden to large load customers. For instance, in PJM areas, the IMM recommends that new data center loads bring their own new generation to limit cost shifts to other consumers [33]. In Georgia, a 2025 rule allows new customers that use more than 100 MW of electricity to be billed under special terms that address the risks associated with their usage [63]. In Virginia, the 2025 rate case order [64] establishes a new rate class for large load customers, with minimum demand charges, collateral, and exit fees. In Texas, Senate Bill 6 establishes interconnection standards and cost recovery obligations for large loads [65]. In Maryland, a House bill concerning new data center tariffs was proposed in 2025, but not enacted [66]. At the same time, state consumer advocates are raising cost causation concerns through formal Federal Energy Regulatory Commission (FERC) channels [67]. Finally, not all responses targeting affordability are specific to data centers: two prominent examples are the Department of Energy's Weatherization Assistance Program (WAP) and the Low Income Home Energy Assistance Program (LIHEAP), which provide energy assistance to qualified households [68, 69]. Similarly, Community Choice Aggregation (CCA) programs use local procurement to provide expanded access to clean energy, often at lower prices [70].

Responses relevant to Mechanism 2 are becoming more explicit in planning and reliability governance, even if many remain under refinement or debate. NERC emphasizes that emerging large loads pose distinct issues for system restoration, transmission adequacy, and long-term planning, and points toward improved planning and interconnection procedures tailored to large loads [2, 44]. These concerns are receiving regulatory attention, and FERC's 2025 technical conference on resource adequacy in RTO/ISO regions included data centers in its framing of emerging adequacy challenges [71]. In parallel, recent work demonstrates that AI data center workloads can reduce power demand during peak periods without undermining performance [48]; such flexibility could contribute to grid stability, but encouraging these practices is likely to depend on what incentives are provided [72].

Regarding Mechanism 3, data center water demand is already an important concern in certain jurisdictions [7]. Recent studies suggest that environmental evaluation and oversight should take into greater account local climate conditions, regional water scarcity, and indirect water consumption associated with electricity generation [53, 73]. This is why indicators accounting for water scarcity have been proposed to inform siting and decision-making, especially in water-stressed areas [53].

Responses relevant to Mechanism 4 include emerging proposals for backup generator oversight, disclosure, monitoring, and environmental siting. For instance, a recent California report highlights an emerging policy agenda that includes tighter air quality monitoring and

enforcement, advance disclosure of projected water and electricity use, and stronger local zoning and permitting oversight in decisions concerning already overburdened communities [4]. More broadly, relevant work suggests that transparency, monitoring, reporting, and closer scrutiny of siting and permitting decisions are likely to remain important governance issues [4, 57].

Several developments become relevant to more than one mechanism, and one cross-cutting example is the set of federal actions affecting data center efficiency: while there are no legally binding federal standards that apply explicitly to private data centers, the Department of Energy regulates the efficiency of certain equipment (such as computer room air conditioners) and has issued guidance for optimizing energy use in federal data centers [7]. Moreover, the voluntary ENERGY STAR program certifies data centers based on the energy efficiency of their buildings and infrastructure [7]. In this paper's framework, such measures could plausibly moderate Mechanism 1 by reducing electricity demand and thus some cost pressures, Mechanism 2 by easing grid strain, and Mechanism 3 by lowering electricity needs for cooling and water.

Another cross-cutting example is corporate clean energy procurement: while natural gas is currently the major source of electricity from data centers (accounting for 40% of the mix [1]), a significant part of new data center demand is expected to be met by renewables, especially solar and wind (which currently generate approximately 24% of the electricity used by data centers [1]), increasingly supported by corporate buyers [74]. This development can influence where new clean generation and associated infrastructure is developed, where system costs arise, and whether additional clean supply can ease pressure on more constrained system resources [1, 74, 75]. In this sense, clean energy procurement becomes relevant to Mechanism 1, because of its potential implications for system cost allocation, and to Mechanism 2 as the timing and location of new supply can influence adequacy and flexibility needs.

These developments are not unique to the U.S., and international examples of data center-focused policies include the European Union (EU)'s new scheme requiring data centers to report their energy and water use [76]. Examples at the EU member state-level include Germany's efficiency and waste-heat obligations for data centers [77], and Ireland's connection policy for large energy users [78]. Such responses indicate that data center governance is evolving through explicit measures across several jurisdictions.

Persisting challenges

While institutional and policy responses are emerging, uncertainties remain about whether, when, and how equitably they will mitigate energy poverty risks. For the affordability pathway (Mechanism 1), a key challenge is that distributional outcomes can depend not only on whether large load customers bear a greater share of system costs, but also on how tariff design will translate residual costs into retail rate structures [39]. Existing work suggests that this is not straightforward: more economically efficient residential tariffs can improve cost reflectiveness, but they can also increase bills for some low-income households when residual costs are recovered through uniform fixed charges instead of more progressive designs [39]. At the same time, the distributional effects of particular rate instruments can be context-specific. For example, a Vermont study found that residential demand charges did not disproportionately burden low-income customers on average, although a portion of customers still experienced bill increases [40].

A related challenge concerns existing limitations in targeting and access: LIHEAP allocations remain largely unchanged since the 1980s [23], and significant gaps are reported between eligibility and participation [69]. This is particularly important in regions facing rising cooling demand [69, 79], where additional extreme heat days can lead to measurable increases in bills [80]. WAP is reported to save participating households about $375 per year on average, but extensive application requirements and administrative complexity associated with braiding (i.e., leveraging multiple funding sources [81]) can hinder access [68]. Similarly, participation in demand response programs can be hindered by communication gaps, lack of trust, uneven access to enabling technologies [82], and limited energy literacy [83].

For the pathways that include service continuity as their endpoint (Mechanisms 2 and 3), the unresolved question is whether future reliability and restoration reforms will improve service continuity for socioeconomically vulnerable households with lower coping capacity and longer restoration times, or whether unequal restoration burdens will persist. More generally, the evidence base for evaluating these effects remains incomplete because many settings lack sufficiently granular and widely available data needed to connect vulnerability with outage duration and recovery processes [25, 26]. Furthermore, while data centers can contribute to grid reliability through operational flexibility, it remains uncertain what incentive designs will be needed to induce these practices [75].

Pertaining to the water use component of Mechanism 3, a key challenge concerns measurement, monitoring, and transparency; the same broad challenges extend to the service adequacy pathway (Mechanism 4), in relation to backup generation, localized emissions, and electricity use. Without better facility-level data on these functions, it remains difficult to identify where exposure burdens are most acute and how they intersect with existing environmental and social vulnerability [4, 57]. To that end, recent studies highlight the need for transparent evaluation of data center consumption and associated impacts through expanded data collection, improved emissions monitoring, and more consistent public disclosure [4, 7, 57]. Reflecting on this need, a recent federal proposal (namely, the Clean Cloud Act of 2025) would expand federal authority to collect annual electricity use data from data centers [7]. In that context, an additional challenge would concern data quality, as the accuracy of estimates derived

from different reporting sources may vary depending on the methods used [7].

Another cross-cutting challenge arises when clean energy procurement opportunities are distributed unevenly: large corporations are often better positioned to influence the addition of clean resources to the grid [74], but smaller or less affluent municipalities face greater resource and expertise challenges in procurement-based models, such as CCA [70]. Furthermore, the aggregate contribution of corporate renewable initiatives to wider system transformation may be more limited than what aggregate commitments across jurisdictions might suggest [84].

These challenges mean that the distributional effectiveness of the current wave of developments has not yet been proven. What these developments ultimately mean for household affordability, continuity, and adequacy will depend on implementation, monitoring, evaluation, and revision over the next several years. In that sense, the central challenge is not only institutional innovation itself, but whether those innovations can be translated into measurable protection for the households most vulnerable to the potential distributional impacts of data center load growth.

Conclusions and the way forward

This paper synthesized system-level evidence and distributional insights to identify potential energy poverty risks associated with the rapid expansion of AI data centers in the U.S. The analysis highlights multiple plausible mechanisms linking large and geographically concentrated load growth, water dependence, and backup generator use to affordability, service continuity, and service adequacy stresses. These mechanisms are distinct in their starting points and immediate stressors, but also interconnected, as some can reinforce others, while certain stressors, mediators and energy poverty manifestations can overlap. In that sense, a key contribution of this paper is to identify plausible pathways linking data center growth to household energy poverty, rather than to claim single causal effects.

This paper also identifies how these concerns are situated within the broader policy landscape. Current developments include debates over cost causation and rate design, large load interconnection standards, reliability planning, data center flexibility, and transparent disclosure. However, uncertainties remain regarding effective targeting, program access, disclosure capacity, and the societal benefits of current and proposed reforms. As conditions evolve, tangible outcomes will depend on how institutional innovation on tariff design, interconnection frameworks, and environmental oversight is translated into verifiable protection for vulnerable households. This can be particularly important in locations of current and future data center clustering, and more broadly in hot climate regions. In the latter type of regions, all three manifestations of energy poverty considered in this paper may simultaneously become more critical, as extreme heat can intensify cooling-related affordability stress, raise disconnection risks, increase the practical consequences of outages, and heighten the importance of maintaining adequate cooling and medical services at home.

Overall, as research on the nexus of data centers and energy poverty is still developing, a framework that proposes critical mechanisms and their points of overlap can help guide future empirical research toward testing, refining, and, where appropriate, validating the pathways identified here. Therefore, the value of this paper lies not only in synthesizing current evidence, but also in providing a timely structure for future scholarship as digital infrastructure expands and questions of energy affordability, continuity, and adequacy become more pressing.

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