Executive Summary: Data Center Impacts & Examples of Local Government Actions

Data center development is accelerating rapidly due to increasing digital service use and the growing energy and cooling demands associated with artificial intelligence. While these projects can generate economic benefits, they also present substantial impacts to electricity infrastructure, water resources, land use compatibility, air quality, noise, and neighborhood health.

Charlotte's current moratorium provides critical space to assess cumulative impacts, refine local review processes, engage state and regional partners, and consider additional tools to ensure future proposals align with community priorities, environmental sustainability, and long-term resilience.

The document compiles national research and cross-jurisdictional examples to help Charlotte evaluate how best to manage these impacts within North Carolina's statutory environment.

This is a compiled reference on data center impacts and how other local governments have responded, prepared for Charlotte's consideration. It explicitly does not endorse or recommend any policy. The report is intended to inform discussion during Charlotte's temporary data center moratorium, not to advocate a specific path.

General Findings on Data Center Impacts

Data center growth is a global phenomenon: McKinsey projects nearly $7 trillion in capital investment in data center infrastructure worldwide by 2030. Impacts of data centers span energy and water use, noise, air quality, land use, jobs, tax revenue, and community investment. There is no "one size fits all" approach — impacts depend on facility size and type, site design, cooling technology, climate, and workload (conventional cloud vs. AI training). Decisions made during development present genuine trade-offs, and there is no universally "ideal" data center design.

Water – Energy Trade-off and National Scale

- **Cooling trade-offs:** Water-cooled systems run more energy-efficiently but consume far more water through evaporation, while air-cooled systems use little water but more electricity. Closed-loop liquid systems can sharply cut water use, often at the cost of higher energy use.
- **AI vs. traditional workloads:** Traditional cloud/enterprise racks typically draw under 20 kW and can be air-cooled; AI training racks can draw 100–130+ kW, requiring liquid cooling. This distinction largely determines which cooling technologies are even feasible before climate or local resources are considered.
- **National water consumption:** Lawrence Berkeley National Laboratory (LBNL) estimates data centers directly consumed 17.4 billion gallons of water in 2023 (equivalent to ~160,000 American households' annual use), with hyperscalers' direct consumption projected to grow by 39–74 billion gallons by 2028. The International Energy Agency estimates that a 100 MW hyperscale facility may consume ~530,000 gallons/day, with roughly 40% used on-site and 60% consumed indirectly through electricity generation — indirect water use is about 12 times greater than direct cooling use nationally.

Energy Demand and Costs

- **Scale of growth:** U.S. data center electricity use is projected to reach ~649 TWh by 2030, representing 11.8% of forecasted U.S. electricity use and roughly 33% of total national load growth over 2024–2030.

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- **Price impacts:** EIA data show no statistically significant correlation to date between the number of data centers in a state and current retail electricity prices, and data centers modestly lowered average U.S. retail rates from 2015–2024. However, forward-looking studies estimate existing data centers have already raised wholesale electricity prices 3–5% nationally (with larger impacts in major data center corridors), and under high-utilization build-out scenarios, wholesale prices could rise by as much as 50% by 2028.
- **Emissions risk:** One study projects power-sector emissions could increase up to 30% (275 million metric tons of CO_2 annually) compared to scenarios without data center-driven load growth, partly because approximately 25 GW of coal capacity may be kept online longer than it otherwise would be to serve new demand.

Air Quality, Noise, and Urban Heat Island

- **Air quality:** Diesel backup generators can produce 200–600 times more NOx per unit of electricity than natural gas plants. One national study estimated over $6 billion in public health damages in 2023 tied to data center electricity generation, with grid-supplied electricity driving over 90% of those modeled costs. A pre-print study estimated Virginia's data centers could be responsible for 14,000 asthma symptom cases and 13–19 deaths annually from backup generators alone.
- **Noise:** Facility noise stems from HVAC systems, cooling towers, chillers, transformers, and backup generators. Acoustic studies in Northern Virginia measured sound levels of 40–59 dB(A) near facilities that generated community complaints. Even though these levels generally complied with local ordinances, illustrating that regulatory compliance does not always eliminate community concern, particularly around continuous low-frequency or tonal noise (measured by dB(C) rather than the more commonly used dB(A)).
- **Urban heat island:** Emerging research shows measurable localized warming: a 12 MW facility in Pando, Uruguay was associated with temperatures 3.8°F warmer than surrounding areas, and an Arizona State University study found temperatures downwind of four Phoenix-area data centers averaged 1.3–1.6°F higher (up to 4°F at maximum), detectable as far as 500 meters away.

How Local Governments Are Responding Nationally

Local governments across the country are managing these impacts through five general categories of action, each illustrated with examples in the full report:

- **Requiring impact assessments or studies** (e.g., Tucson's water conservation plans, Fairfax County's noise studies).
- **Instituting additional permitting requirements** such as Conditional or Special Use Permits (e.g., Harrisonburg, Atlanta).
- **Amending zoning laws** — buffer zones, overlay districts, stricter noise requirements (e.g., Frederick County's overlay zones, Tempe's 500-foot setbacks).
- **Setting performance standards or transparency requirements** such as renewable energy or closed-loop cooling mandates (e.g., Aurora IL, Birmingham AL).
- **Leveraging revenue for community investment** (e.g., Henrico County directing data center equipment tax revenue to a community housing fund).

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Charlotte-Specific Impacts and Findings

Siting & Land Use

North Carolina's statutory framework limits how much municipalities can restrict previously permitted land uses, so Charlotte's approach works through its existing Unified Development Ordinance (UDO) such as buffering, setbacks, screening, lighting standards rather than a data-center-specific ordinance.

- The UDO establishes a comprehensive framework governing site design, buffering, landscaping, lighting, transportation access, stormwater management, environmental protection, and utility infrastructure. These are applied broadly to all large-scale commercial and industrial development, not just to data centers.
- Charlotte's development review process coordinates across transportation, stormwater, utilities, emergency access, environmental permitting, and Charlotte Water, among other reviewing agencies.
- The City has discretionary planning tools available under North Carolina law (i.e. conditional zoning (N.C. Gen. Stat. § 160D-703), development agreements (N.C. Gen. Stat. Article 10), that can incorporate site-specific considerations (infrastructure sequencing, transportation improvements, open space, buffering, construction phasing) into individual project approvals.
- Mechanical noise, exterior lighting, tree preservation, landscaping, stormwater, and erosion control standards apply to data centers through the same ordinances used for other large-scale facilities, rather than through data-center-specific requirements.

Water

Charlotte draws from the Catawba River basin, which spans 11 North Carolina counties and 5,610 square miles, holds over 60,000 acres of open reservoirs, and contains more than 8,900 miles of waterways. Over 2.5 million people rely on the watershed, which has experienced droughts in 2001, 2007–09, and 2026. Charlotte Water is the largest public water and wastewater utility in the Carolinas, serving more than a million customers across Charlotte and greater Mecklenburg County, including Matthews, Mint Hill, Pineville, Huntersville, Davidson, and Cornelius.

- **Current usage is small:** existing small-scale data centers use approximately 64,000 gallons/day, roughly 0.4% of total system demand; total demand from the industrial and irrigation customer class is approximately 11 million gallons per day (MGD).
- **Review process:** Proposed large water users, including data centers, are evaluated through Charlotte Water's engineering review process to assess system capacity and necessary infrastructure improvements. Developers fund the infrastructure required for new sites, and Charlotte Water incentivizes, or requires when feasible, the use of reclaimed water and advocates for high-efficiency cooling technologies to limit potable water demand.
- **Under active study:** Water demand is listed as a topic the moratorium is meant to study further.

Energy

In May 2025, Charlotte City Council adopted the Strategic Energy Action Plan Plus, targeting a 72% reduction in community-wide GHG emissions by 2035 and net-zero emissions by 2050 — including

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a goal of installing 600 MW of distributed renewable energy generation in Charlotte by 2035. The document notes that data center growth "may make achieving this goal significantly more difficult."

- **Limited direct leverage:** Charlotte is served by an investor-owned utility (Duke Energy), giving it limited direct influence over system-level generation, transmission, and ratemaking decisions — these are regulated at the state level by the NC Utilities Commission and at the federal level by FERC.
- **Available engagement channels:** To influence broader energy decisions, Charlotte would need to engage through bilateral conversations or formal intervention in proceedings such as Integrated Resource Planning (IRP), rate cases, and large-load tariff dockets.
- **Local authority retained:** The City does retain local zoning and permitting authority over on-site generation which is relevant since almost all data centers operate backup generators (most often diesel-fueled), and some projects plan for part or all of primary generation needs to be met on-site with natural gas.
- **Regional context:** Duke Energy's Carbon Plan and Integrated Resource Plan (CPIRP), filed October 2025, projects a significant upward trajectory in regional energy needs through 2040, driven in part by "significant economic development activity" and "strong residential customer growth and electrification."

Air Quality

Air quality in Charlotte is regulated primarily through the Mecklenburg County Air Pollution Control Ordinance (MCAPCO), which generally defers to state and federal standards like the Clean Air Act. Mecklenburg County Air Quality (MCAQ) operates 13 monitoring stations tracking air quality 24 hours a day, 365 days a year, though this program is not specific to or focused on data centers.

- **Current compliance status:** As of 2024, Mecklenburg County meets federal health-based air quality standards, but the American Lung Association gave the county a failing score for ozone and particle pollution for 2022–2024 — the worst score in the state among counties with available data.
- **Asthma data:** 2023 data from the Greenlink Equity Map and the CDC's National Health Interview Survey show some Charlotte neighborhoods experience asthma rates nearly double the national average of 8.4%. All nine Mecklenburg census tracts with an existing data center (built 2023 or earlier) had 2023 asthma rates exceeding the national average, ranging from 9.3 percent to 13.8 percent. It is important to note that this does not establish causation and does not include a comparison to census tracts without data centers.

Noise

Charlotte regulates noise through both the UDO and the City Code of Ordinances. Mechanical noise (excluding exempt activities like construction, lawn maintenance, refuse collection, and parking garage operations) is generally limited to 70 dB(A), measured at the complainant's property line. Enforcement is complaint-driven, administered through the Charlotte-Mecklenburg Police Department (CMPD) and Code Enforcement, with violations subject to civil penalties.

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- Charlotte relies on standardized A-weighted [dB(A)] measurements, consistent with most municipal noise ordinances nationally, because they approximate the range of sound most readily perceived by human hearing and provide a practical basis for field enforcement.
- Acoustical literature notes this may not fully capture low-frequency or tonal sounds from large fan arrays, cooling equipment, and transformers. Characteristics some other jurisdictions evaluate separately using a dB(C) filter or octave-band analysis.
- During development of the temporary moratorium, City planning staff voiced that a previous field visit by residents to a nearby hyperscale data center did not identify significant noise concerns at that location — though noise was raised repeatedly as a topic of interest during public hearings on the proposed moratorium.
- Because enforcement is complaint-driven and occurs after a facility is operational, some other jurisdictions supplement this with predictive acoustical studies during development review — an approach Charlotte does not currently require.

Urban Heat Island

Charlotte's warm-humid climate, rapidly developing urban landscape, and exposure to climate change make extreme heat a critical local concern. The document notes that, without mitigation, large industrial developments like data centers may exacerbate heat impacts through two mechanisms: exhausted waste heat from cooling operations, and heat trapped by campus construction materials (concrete roofs, parking lot pavement, etc.). Charlotte does not yet have data-center-specific research or policy addressing this locally, though the document flags it as an area for potential future consideration alongside citywide heat mitigation efforts.

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Data Center Impacts & Examples of Local Government Actions

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Data Centers Overview

Although data centers, which provide key infrastructure for digital services that individuals, businesses, and government institutions rely on, are not a new industry, the speed and scale of data center growth is accelerating due to increased demands for these services and innovations in artificial intelligence (AI) technology. In fact, analysis from McKinsey indicates a significant capital investment, nearly $7 trillion globally, in data center infrastructure by 2030. **With this investment comes increased demands on infrastructure, the potential for increased environmental and community impacts, and trade-off considerations around energy demand, water consumption, land use, and economic development priorities.**

Data Centers Have Known Environmental and Community Impacts

Like other industrial economic development projects, data center developments have documented impacts on the environment and the surrounding community. Impacts of data centers are outlined below, and encompass energy and water use, noise, air quality, land use, jobs, tax revenue, and community investment.

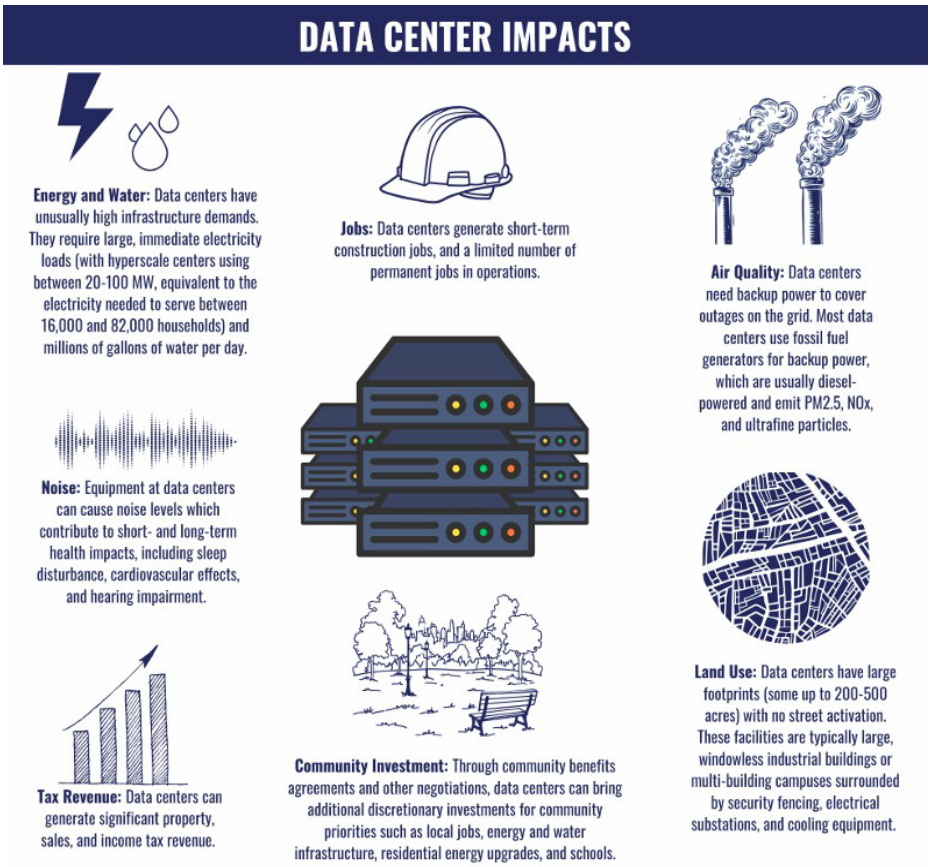

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Figure 1: Data center impacts. Source: Data Centers and the Climate Landscape: An Actionable Resource for US Mayors

The impacts of a specific data center depend on a variety of factors, including the size and type of data center, where the data center is located, site design, technology choices, and efforts by the developer and other decision-makers to mitigate impacts. However, there are clear national trends and forecasts regarding data center impacts. These impacts are discussed in more detail in subsequent sections.

Data Center Impacts Vary by Size, Site Design, and Technologies and Present Trade-Offs

There is no "one size fits all" approach to understanding the impacts of data centers. Many of the impacts rely on decisions made during data center development, including but not limited to:

- The efficiency of the building and IT infrastructure
- The type of cooling system used and the efficiency of the cooling system
- The climate where the data center is sited, which impacts the need for data center cooling
- Whether the data center has on-site power generation, and the type and anticipated use of the power generation
- Available water, energy, and infrastructure to serve a data center's needs, or whether additional infrastructure is required
- How heat is generated, and whether the waste heat is reused
- Site design decisions that impact noise, aesthetics, and land use
- Whether additional investments are leveraged to address community concerns and priorities

Decisions made during data center development present trade-offs for impacts; there is no universally "ideal" data center. The right cooling and water strategy depends on the match between a facility's design and its location's climate, water basin, and grid mix. Recent peer-reviewed analysis of 2,400+ U.S. data centers frames sustainability as a "systems challenge," meaning local governments and communities may consider evaluating any proposal against its local heat, water-stress, and grid-emissions profile rather than against a single efficiency number.

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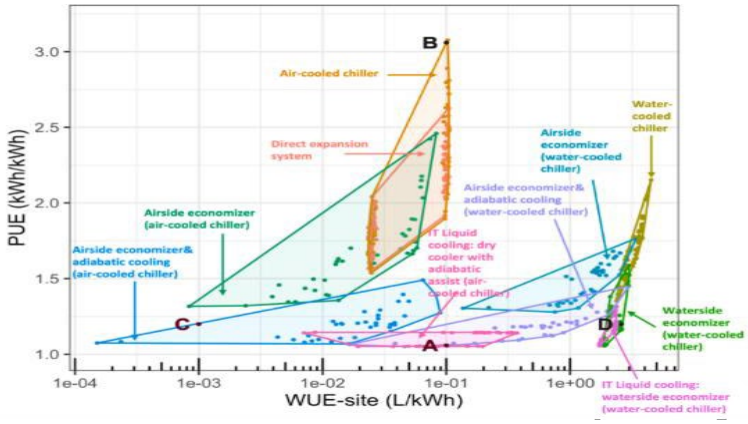

Figure 2: Water Usage Effectiveness (WUE) vs Power Usage Effectiveness (PUE) for commercially available cooling systems. Source: [The water use of data center workloads: A review and assessment of key determinants - ScienceDirect]

A core tradeoff in choosing the "best" cooling type for a data center will be between on-site water and energy use. The choice of cooling system fundamentally trades off energy use against water use: designs that use less energy tend to use more water, and vice versa. Both a 2024 LBNL report and a 2025 study in *Resources, Conservation and Recycling* found that water-cooled systems run more energy-efficiently but consume far more water (through evaporation), while air-cooled systems use little water but more electricity. Some designs soften this tradeoff: pairing liquid cooling with economizers or adiabatic cooling can lower both at once (Figure 2) and closed-loop liquid systems recirculate the same fluid rather than evaporating it, sharply cutting on-site water use—though often at the cost of higher energy use.

The type of data center (i.e. conventional cloud versus AI) drives very different cooling needs. The amount of heat a facility must remove depends on how densely power is packed into each server rack, and that varies enormously by workload. Traditional cloud and enterprise racks typically draw well under 20 kilowatts (kW) and can be cooled with air alone. AI hardware is far denser: a single modern AI training rack can draw 100–130+ kW, well beyond what air cooling can handle, which is why new AI facilities increasingly rely on liquid cooling. Within AI, there is a further distinction depending on whether the facility is training workloads (sustained high intensity and the highest densities) or responding to user queries (lower, more variable loads and can sometimes use less intensive cooling). In short, a facility's workload largely determines which cooling technologies are even technologically feasible before climate or local resources are considered.

For Charlotte, given the warm, humid climate, the cooling technology a data center chooses will depend on the data center's chip/server operating temperature, the local design wet-bulb temperature, and how much water the facility is designed to consume. Given Charlotte's summer design conditions (~94°F dry-bulb, ~75°F wet-bulb), some form of mechanical or water-based cooling will be needed. Ultimately, this means that the operating

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temperature of the data center servers will influence the selection of cooling type, with multiple cooling options available to fit needs.

Local governments may consider asking questions and requesting information from data center developers early in the process to gauge the most significant anticipated impacts from a project. Additionally, local governments can request assessments, studies, and projections of impacts across energy, water, noise, or other critical considerations during the project development stage. **Collecting these project-specific projected impacts will inform potential management measures.**

Local Governments Are Taking Proactive Approaches to Manage Data Center Impacts

Across the country, local governments are taking steps to better understand and manage impacts from data center developments in their communities. While data centers are not a new industry, the speed and scale of development and the impacts that can impose on communities prompt a changed approach. Some general categories of local government approaches are described below. *Note that this list is not exhaustive of all potential actions a local government could take. The examples of local government actions provided herein are intended for illustrative purposes only. The authority of a local government to undertake any particular action varies by state and may be limited by state constitutions, statutes, regulations, or judicial decisions. As a result, some examples may not be applicable or permissible in all jurisdictions. Local governments may consult applicable state law and legal counsel to determine the extent of their authority before pursuing any action.*

Local Government Approach	Description	Example(s)
Requiring impacts assessments or studies	Local governments may require data center developers to provide assessments or studies regarding the impacts of the development. This could include energy use, water use and conservation, noise, or other impacts.	• Tucson, AZ requires a Sustainable Water Service Application and Water Conservation Plan for large-scale data centers • Lake County, IN requires an energy efficiency plan and water management plan • Fairfax County, VA requires a noise study to confirm compliance with the noise ordinance
Instituting additional local permitting requirements	Local governments may require data centers above a certain threshold to obtain a Conditional Use Permit or Special Use Permit to construct. Leveraging additional permitting allows the local government to put site - or	• Harrisonburg, VA requires a special use permit for all data centers • Atlanta, GA requires a special use permit for data centers

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	project-specific conditions in place.	
Amending zoning laws	Local governments may update their zoning laws to reduce community impacts. This could include increasing the buffer zone for development around residential areas or other sensitive developments, updating the types of zones that data centers may develop in, instituting overlay zones, or imposing stricter noise requirements.	• Frederick County, MD developed overlay zones for data center development (as of July 1, 2026, the county is pausing new data center development through December 31, 2026) • Tempe, AZ instituted a 500 foot setback from residential and sensitive use zones
Setting performance standards or transparency expectations	Local governments may require certain water or energy performance standards be met, such as restricting water cooling to be only closed-loop. Local governments may also require transparent reporting of energy or water use, or public notice for the use of on-site generators.	• Aurora, IL requires data centers to use on-site renewables (25% of peak load) or have on-site battery storage (50% of peak load for 15 minutes), with alternative compliance available • Birmingham, AL prohibits the use of backup power generators other than for outages, emergencies, and daytime testing. They also require closed-loop cooling systems.
Leveraging funds for community investments	Local governments may set aside a portion of revenue generated from data centers to manage impacts and support community investments. Additionally, local governments may consider better aligning economic development incentives with criteria that address data center impacts, such as meeting sustainability standards or aligning with other local goals.	• Henrico County, VA is using revenue generated from a tax on equipment for data centers for a community housing fund.

Table 1: Summary of local government approaches to data center impacts.

For a detailed list of city-led actions and examples that can be taken to address land use planning and design, energy use, water consumption, air quality and noise, and economic development and community investment, see Climate Mayors resource: Data Centers and the Climate Landscape: An Actionable Resource for US Mayors. Note that there are several approaches to manage data center impacts that can be taken at the state or federal level, which are not explicitly covered in this report due to the focus on examples of local government approaches.

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Siting & Land Use

Data center siting and land use considerations involve balancing the operational characteristics of these facilities with surrounding development patterns, existing infrastructure, and long-term community planning objectives. Because data centers can vary substantially in their size, utility demands, building form, and supporting equipment, local governments have adopted a range of approaches to evaluating where these facilities are appropriate and what development standards to apply. To institute these changes, local governments have taken several approaches including defining data centers, setting certain standards or conditions for development, or prohibiting certain types of development.

In North Carolina, local land use authority is exercised within a statutory framework that limits the extent to which municipalities may reduce or eliminate previously permitted land uses. As a result, local approaches generally focus on objective site design, infrastructure coordination, operational performance, and compatibility with adjacent land uses rather than broad restrictions on the use itself.

Siting & Land Use: Impacts

Data centers are generally developed as industrial or infrastructure-intensive uses. Individual facilities may consist of one or more large buildings together with cooling equipment, emergency generators, substations, security fencing, service areas, and related utility infrastructure. The resulting land-use characteristics can resemble those of warehouses, advanced manufacturing facilities, or utility installations, although data centers differ from many industrial uses in their limited freight activity and comparatively small permanent on-site workforce. The extent of their land-use impact depends on the scale of the campus, the equipment used, and the relationship between the facility and surrounding development.

Site location is a primary determinant of compatibility with neighboring uses. Facilities located within established industrial areas may have relatively limited interaction with residential neighborhoods. By contrast, development near residences, schools, parks, historic resources, or other sensitive uses may raise concerns related to building scale, noise, lighting, equipment placement, and the visibility of associated electrical infrastructure. A 2024 review by Virginia's Joint Legislative Audit and Review Commission found that 29 percent of operational data center properties in the eight Virginia localities studied were located within 200 feet of residentially zoned land. This finding illustrates the importance of evaluating the relationship between a proposed site and adjoining uses and understanding development impacts.

Building form can also affect the surrounding development pattern. Data center buildings typically have large footprints, limited windows, secured perimeters, and relatively few publicly accessible entrances. Cooling equipment may be located on rooftops or beside buildings, while generator yards, substations, fuel systems, and transmission connections may occupy

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additional portions of a site. Depending on site design and topography, these elements can be visible from neighboring properties and public rights-of-way. Landscaping, setbacks, building orientation, façade treatments, equipment screening, and the preservation of existing vegetation can affect how prominently a facility is experienced from surrounding areas.

The placement of equipment within a site can be as consequential as the location of the overall development. Locating generators, cooling equipment, substations, loading areas, and service drives toward the interior of a campus may increase the distance between those activities and neighboring properties. Principal buildings, grade changes, vegetation, and purpose-built barriers may also provide visual or acoustical separation. Conversely, equipment placed near a shared property line may produce localized effects even when the principal building satisfies applicable setbacks. For this reason, some jurisdictions evaluate both the external location of a data center and the internal arrangement of its buildings and supporting equipment.

Siting decisions may extend beyond the boundaries of the data center property. Large facilities require access to high-capacity electrical service and may be accompanied by new substations, transmission lines, utility easements, water or sewer improvements, or roadway construction. These associated improvements can affect additional properties and may be reviewed by different public agencies or utilities under separate approval processes. Evaluating the anticipated full build-out of a campus (including later phases and supporting infrastructure) can therefore provide a more complete understanding of its potential land-use footprint than reviewing the initial building phase alone.

The available evidence does not indicate that every data center produces the same land-use effects. Impacts vary according to the existing character of the site, the intensity and arrangement of the development, proximity to neighboring uses, and the design measures incorporated into the project. Site-specific information is therefore necessary to evaluate whether a proposed facility is compatible with its surroundings and how its buildings, equipment, and supporting infrastructure may affect the broader development pattern.

Siting & Land Use: Local Considerations

Charlotte's UDO establishes a comprehensive framework for regulating how new development relates to surrounding land uses through standards governing site design, buffering, landscaping, lighting, transportation access, stormwater management, environmental protection, and utility infrastructure. These provisions apply broadly across development types and provide an established process for considering compatibility between new development and existing neighborhoods, public facilities, and infrastructure. As a result, data center proposals are reviewed within the same broader land use framework used to evaluate other large-scale commercial and industrial developments rather than subject to additional requirements.

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Because data centers typically include large buildings (can reach hundreds of thousands of square feet), extensive utility infrastructure, and supporting mechanical equipment, site planning may influence how a facility interfaces with surrounding properties. Building orientation, setbacks, preservation of existing vegetation, placement of generators and cooling equipment, loading and service areas, and the use of landscaping, screening, or topography can all affect visual character, operational impacts, and the relationship between a development and adjacent land uses. These considerations are already reflected throughout the UDO's development standards and site design provisions but are not unique for data centers.

Charlotte's development review process also coordinates multiple aspects of public infrastructure. Depending on the scale and location of a development proposal, review may involve transportation, stormwater, utilities, emergency access, environmental permitting, and coordination with Charlotte Water and other reviewing agencies. Duke Energy's role in data center development is discussed in the "Energy Demand" section. For projects developed in phases, evaluating the anticipated full build-out, including supporting electrical infrastructure, utility improvements, and future expansion, may provide additional context for understanding cumulative infrastructure demands over time.

The City's land use framework also includes several discretionary planning tools that may be used in circumstances authorized under North Carolina law. These include conditional zoning, development agreements, subdivision review, and other established review processes that allow site-specific considerations to be incorporated into project approvals where appropriate. Depending on the nature of the application, these mechanisms may address matters such as infrastructure sequencing, transportation improvements, open space, landscaping, buffering, environmental features, utility coordination, construction phasing, and other site design elements associated with a proposed development.[1,2]

Charlotte's Code of Ordinances and Unified Development Ordinance also separately regulate a number of operational characteristics that may accompany all large-scale facilities, without being specific to data centers. Standards governing mechanical noise, exterior lighting, tree preservation, landscaping, stormwater management, erosion control, and environmental protection are administered through existing regulatory processes and apply independently of the underlying land use designation. Together, these provisions provide multiple points during development review at which operational characteristics and compatibility with surrounding properties may be evaluated.

[1] N.C. Gen. Stat. § 160D-703. Conditional District Zoning.
[2] N.C. Gen. Stat. Article 10, Development Agreements (G.S. §§ 160D-1001–1012). https://www.ncleg.gov/EnactedLegislation/Statutes/HTML/ByChapter/Chapter_160D.html

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The approaches adopted by other jurisdictions illustrate a range of ways local governments have incorporated these considerations into development review, zoning standards, and site planning while operating within their respective statutory and regulatory frameworks.

Siting & Land Use: Example Local Government Actions

Local governments are addressing siting and land use impacts through a variety of mechanisms including amending zoning ordinances, adopting stricter setbacks, adding overlay districts or boundaries, and adding other land use protections. *Note that this list is not exhaustive of all potential actions a local government could take. The examples of local government actions provided herein are intended for illustrative purposes only. The authority of a local government to undertake any particular action varies by state and may be limited by state constitutions, statutes, regulations, or judicial decisions. As a result, some examples may not be applicable or permissible in all jurisdictions. Local governments may consult applicable state law and legal counsel to determine the extent of their authority before pursuing any action.*

Jurisdiction	Local Approach	Land Use and Siting Objective
Fairfax County, Virginia (2024)	Fairfax County amended its zoning ordinance to establish data-center-specific permissions and development standards. The adopted provisions address where data centers may be permitted by right, through a development plan, or by special exception. They also require screening or enclosure of mechanical and power equipment, architectural treatment of building façades, visual-impact information for discretionary applications, and pre- and post-construction noise studies. The ordinance further considers proximity to residential uses and Metro stations when determining applicable review requirements.	Evaluate data centers as a distinct large-scale land use and address their relationship to residential areas, transit-oriented locations, public streets, and surrounding development through use permissions, building design, equipment placement, screening, and site-specific review.
Loudoun County, Virginia (2023–2025)	Loudoun's current zoning ordinance applies enhanced standards where data centers adjoin residential property. These include building setbacks, enhanced landscaped buffers and berms, screening of mechanical and refuse areas, façade treatments, sound attenuation, noise studies, and limits on generator testing. In 2025, the County also amended its comprehensive plan and zoning ordinance to require special-exception approval for data centers in several industrial districts where the use had previously been permitted by right, subject to grandfathering provisions for qualifying pending applications.	Combine generally applicable site-design standards with discretionary review in designated districts so that the location, scale, design, infrastructure, and compatibility of individual facilities may be evaluated in relation to neighboring uses and adopted land use policy.

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Prince William County, Virginia (2016; amended 2019)	Prince William County established a mapped Data Center Opportunity Zone Overlay District to direct by-right data center development toward areas with office or industrial land-use designations and access to high-voltage electrical infrastructure. A 2019 amendment refined the overlay boundaries by removing areas considered more appropriate for prominent employment uses, adding areas considered suitable for data centers, adjusting boundaries where mapping and existing land uses were inconsistent, and adding design standards. Outside the overlay, data centers generally require special-use approval in eligible commercial, office, industrial, or mixed-use districts.	Concentrate data center development in predefined areas with supporting infrastructure while preserving case-specific review outside the overlay and distinguishing data center locations from land intended for other employment, residential, agricultural, or community uses.
Henrico County, Virginia (2025)	Henrico County incorporated Data Center Design Guidelines into its comprehensive plan for use when reviewing new proposals. The guidelines call for coordinated large-site industrial planning, adequate utilities, shared access, pedestrian and bicycle connections, preservation of cultural and environmental resources, mechanical-equipment screening, substation screening, and pre- and post-construction noise studies. They also identify a 100-foot landscaped buffer and a recommended 500-foot building setback where a data center adjoins existing or planned residential uses.	Use comprehensive-plan review and site-design guidance to coordinate large industrial campuses with transportation and utility systems while increasing separation, screening, and compatibility at residential and environmentally sensitive edges.
Mesa, Arizona (2025)	Adopted a zoning ordinance establishing a formal definition for data centers and limiting new facilities to Heavy Industrial and General Industrial zoning districts. Projects require Planned Area Development (PAD) approval and are subject to development standards addressing setbacks from residential districts, building orientation, sound studies, utility coordination, mechanical equipment, and compliance with the City's Quality Development Design Guidelines.	Integrate data center development into the City's existing industrial planning framework while addressing compatibility with adjacent land uses through coordinated site planning, design standards, and infrastructure review.

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Nashville, Tennessee (2026)	Adopted a zoning ordinance adding definitions and conditions related to data centers. Among other measures, Nashville set standards for setbacks depending on data center size, requiring the following setbacks from a residential use, day care home, day care center, religious institution, community education use, park, zoo, correctional facility, or other data center: • Small data center (20,000 square feet or less and/or a maximum utilization capacity of 5 MW of electricity): 100 feet • Medium data center (larger than 20,000 square feet and less than 100,000 square feet and/or a maximum utilization capacity between 5 MW and 20 MW of electricity): 500 feet; also, 2,640 feet from the centerline of a Choose How You Move All-Access Corridor • Large data center (larger than 100,000 square feet and less than 500,000 square feet and/or a maximum utilization capacity between 20 MW and 100 MW of electricity): 2,640 feet; also 2,640 feet from the centerline of a Choose How You Move All-Access Corridor	Institute setbacks based on data center size (small, medium, and large).
Atlanta, Georgia (2024)	Adopted a zoning ordinance amendment to define data centers and institute certain conditions. Prohibits data center development within 2,640 feet of a high-capacity transit stop and prohibits data center development within the Beltline Overlay District.	Disallow data center development near specific areas or within an overlay district.

Table 2: Siting and land use examples from other jurisdictions.

Planning Practice Example: The American Planning Association highlighted Mount Pleasant, Wisconsin, as an example of a community proactively evaluating the long-term land use implications of hyperscale data center development, including utility coordination, infrastructure planning, and compatibility with surrounding development. While the Village has not adopted a standalone data center zoning ordinance comparable to Fairfax County or Mesa, Arizona, its planning process has been cited as an example of integrating data center development into comprehensive community planning.

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Water Consumption

Data centers' daily operations rely heavily on access to steady water resources, directly for cooling computer servers and indirectly for electricity generation. For each data center location, the exact amount of water consumed varies considerably depending on facility design, cooling technology, local climate, and computer workload. However, national forecasts project continued growth in water demand as computing needs, cloud services, and AI applications expand.

Water Consumption: Impacts

Data centers consume an enormous amount of water resources, both directly and indirectly. According to a study by LBNL, data centers directly consumed an estimated 17.4 billion gallons of water in 2023, which is equivalent to roughly 160,000 American households' annual water use. Hyperscale and colocation data center facilities consumed the most water resources. Under modeled scenarios, LBNL projected that hyperscalers' direct water consumption could increase between 39 billion and 74 billion gallons by 2028.

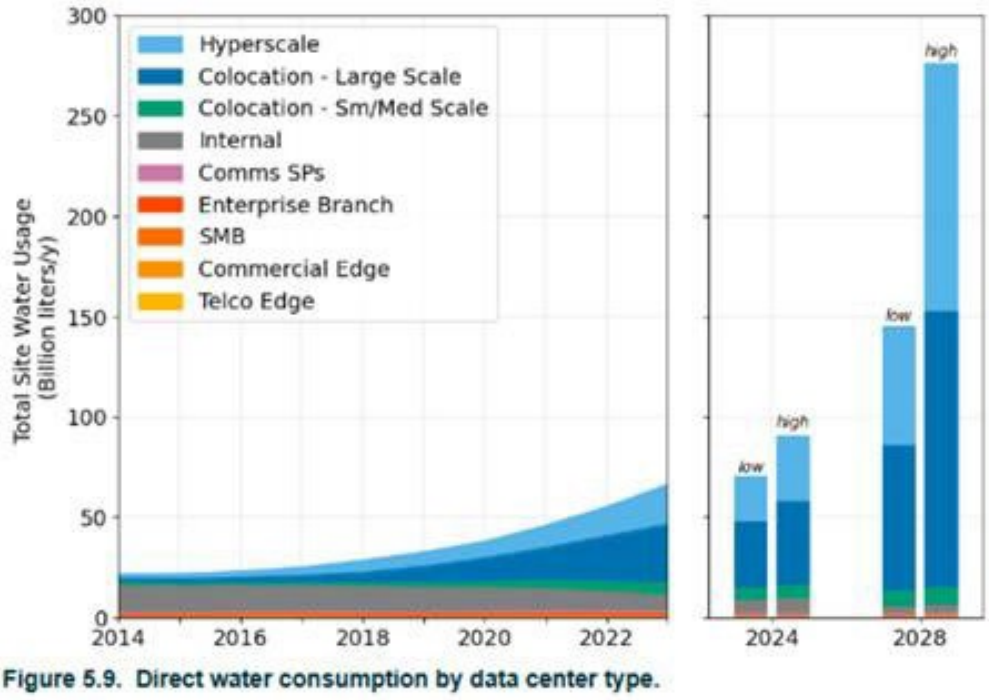

Figure 5.9. Direct water consumption by data center type.

Figure 3: Direct water consumption by data center type. Source: Data Centers and Water Fact Sheet

The International Energy Agency (IEA) estimates that a 100 MW data center in the United States (hyperscale) may consume roughly 530,000 gallons per day. This figure is averaged across the various cooling strategies. By comparison, Charlotte Water's daily water system

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capacity is approximately 100-150 million gallons per day (MGD). **Out of this total estimate, IEA estimates that approximately 40% of the usage is on-site and 60% of the water consumption is through indirect water use, or water used to generate electricity for the data center.** The study also found that indirect water resource consumption, tied to electricity generation, was about 12 times greater than for direct cooling use. Researchers estimated that the electricity used by U.S. data centers in 2023 consumed nearly 800 billion liters, or approximately 211 billion gallons, of indirect water resources.[3]

Water consumption varies by the size and design of the facility. A medium-sized data center may use about 300,000 gallons per day, while a hyperscaler can use up to 5 million gallons daily. For example, in 2024, Google's Council Bluffs, Iowa, data center consumed about 1.3 billion gallons of potable water in 2024, which was roughly 3.7 million gallons per day. Google reported their data center water consumption increased from 4.3 billion gallons in 2021 to 6.1 billion gallons in 2024. In total, the company withdrew 7.8 billion gallons of water in 2024, consuming 78%. Of 24 individual data centers in the U.S. and Canada, Google reported that nine withdrew less than 500,000 gallons per day, and three withdrew more than 2 million gallons per day. This measurement is consistent with Google's own environmental reports showing that together, its offices and data centers use tens of billions of gallons of freshwater annually.

In data centers, the cooling system design is a major determinant of direct water consumption. Cooling towers use water through evaporation and through the discharge of water needed to control mineral buildup. Dry coolers and other air-based systems can reduce or eliminate cooling tower water use, although some water-saving configurations may use more electricity than evaporative systems. The relationship between water and energy use is therefore a design trade-off rather than a uniform outcome.

Water consumption also varies over time due to weather conditions and facility factors such as AI-generation demand. Cooling demand may increase during hot weather, and computing workloads can change by hour, season, or facility. **As a result, annual averages may not reflect peak daily demand or demand during periods when a local water system is already under stress.**

Comparisons between facilities remain difficult because publicly available information is limited and reporting practices differ. Information reported by data center operators varies widely across water consumption usages and is not often interchangeable (e.g., water withdrawals, water consumption, potable water use, reclaimed water use, or companywide totals that combine data centers with offices and other facilities). Therefore, site- and operator-specific information is necessary to evaluate the potential water demand associated with an individual development.

[3] The exact amounts of indirect water consumption depended on the type of power plants serving each region and did not account for facility-specific power purchase agreements or on-site generation sources.

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Water Consumption: Local Considerations

The City of Charlotte's water supply originates from the Catawba River basin, which includes 11 North Carolina (NC) counties, covers a total of 5,610 square miles (the NC portion is 3,300 sq mi), holds over 60,000 acres of open reservoirs, and contains more than 8,900 miles of waterways. Over 2.5 million people rely on having access to water from the Catawba River watershed.

The City has its own water utility, Charlotte Water, that operates under a state-issued interbasin transfer (IBT) certificate, which limits transfers of water from the Catawba River basin into neighboring river basins. Charlotte Water has applied to expand its authorized interbasin transfer capacity to accommodate projected regional population and economic growth. The Catawba River basin has experienced multiple periods of prolonged drought, including events in 2001, 2007–2009, and 2026. During drought conditions, the Catawba-Wateree Drought Management Advisory Group coordinates drought monitoring and conservation measures among water utilities and other stakeholders throughout the basin.

Charlotte Water's long-range planning focuses on the direct water demands placed on its drinking water and wastewater systems. The agency's planning documents and engineering review processes evaluate the direct demand placed on the municipal water system and do not separately quantify the indirect water associated with electricity generation. Proposed large water users, including data centers, are evaluated through the utility's engineering review process and incorporated into water supply planning using projected customer demand and anticipated growth. Large industrial customers may also be considered as part of broader long-range water supply planning and future interbasin transfer evaluations alongside projected residential, commercial, and industrial development.

Data centers also have an indirect water footprint associated with electricity generation. **Depending on the electricity-generating plants serving the regional utility grid, electricity production may require additional water resources for cooling or other generation processes.** Charlotte Water's water accounting responsibilities do not include the indirect water demand. Indirect water consumption is influenced primarily by regional utility operations, electricity markets, and state energy planning. Although indirect water use is commonly evaluated in research on data center sustainability, it is generally distinct from the direct water demand considered in municipal water supply planning.

According to estimates presented to the Charlotte City Council, existing direct water use by small-scale data centers is approximately 64,000 gallons per day. Total demand from the industrial and irrigation customer class is approximately 11 million gallons per day (MGD). City staff estimated that existing data centers currently account for approximately 0.4% of total system demand. For comparison, Charlotte Water's Stage 2 drought response plan seeks to reduce systemwide demand by approximately 16 MGD during drought conditions. The City's

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temporary data center moratorium identifies water demand as one of several topics warranting additional study during the moratorium period.

Charlotte Water reviews proposed large water users through its engineering review process to evaluate available system capacity, identify any necessary infrastructure improvements, and assess the anticipated direct demand on the utility's water and wastewater systems. Developers are generally responsible for funding the infrastructure required to serve new development. Charlotte Water has also identified reclaimed water catchment systems and water-efficient cooling technologies as approaches to reduce potable water demand. **While Charlotte Water provides technical review during the development process, the agency does not establish zoning regulations or land use approvals.** As a result, decisions regarding facility location and permitted land uses are made through separate planning and zoning processes, each within its own silo. Increased coordination between the two entities will be an important consideration for addressing water use concerns holistically.

Compiled together, the water implications of data center development extend beyond a facility's direct water use. **Overall water demand depends on facility design, local water supply conditions, utility planning, regional electricity generation, and future development patterns. Consequently, evaluating potential water demand requires consideration of both facility-specific characteristics and Charlotte's broader water resource planning framework.**

Water Consumption: Example Local Government Actions

Local governments are addressing water consumption impacts through a variety of mechanisms including requiring water conservation plans during project proposal, establishing parameters on the types of water or technologies that can be used to cool data centers, or instituting other sustainability measures. *Note that this list is not exhaustive of all potential actions a local government could take. The examples of local government actions provided herein are intended for illustrative purposes only. The authority of a local government to undertake any particular action varies by state and may be limited by state constitutions, statutes, regulations, or judicial decisions. As a result, some examples may not be applicable or permissible in all jurisdictions. Local governments may consult applicable state law and legal counsel to determine the extent of their authority before pursuing any action.*

Jurisdiction	Local Approach	Water Management Objective
Tucson, Arizona (2025)	Adopted a Large Quantity Water User Ordinance requiring new large water users, including data centers, to disclose projected water demand, submit water conservation plans, identify opportunities to use reclaimed water, and obtain City approval before connecting to the municipal water system. The	Increase transparency regarding large water demands, incorporate conservation planning into project review, and provide additional information for utility

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	ordinance also established public reporting requirements and enforcement provisions for noncompliance.	planning and public decision-making. (Ord. No. 12188, § 3, 8-19-25).
James City County, Virginia (2025)	Amended its zoning ordinance to establish data centers as a defined land use subject to a Special Use Permit. As part of the County's adopted Data Center Policy, proposals are expected to use public water where available, avoid groundwater withdrawals for cooling, and demonstrate consistency with available utility infrastructure.	Coordinate data center siting with existing public utility infrastructure and reduce reliance on groundwater resources for cooling.
Warrenton, Virginia (2021)	As part of its 2021 zoning amendment establishing standards for data centers, the Town requires data centers to use recycled water or air chillers used in conjunction with recycled water for cooling. The ordinance specifies that potable water may not be used for cooling. These requirements are incorporated into the Town's Special Use Permit standards for data centers.	Reduce demand for potable drinking water used in industrial cooling and coordinate data center operations with the Town's available water resources.
Fauquier County, Virginia (2023)	The Board of Supervisors adopted a Data Center Policy to guide review of future proposals. Among its sustainability provisions, the policy encourages minimizing impacts on water resources through stormwater management, protection of water bodies and riparian buffers, and consideration of renewable energy and other site design measures. The policy is intended to inform future data center review alongside the County's land use and development processes.	Integrate water resource protection and site sustainability considerations into the local review of future data center development.
Marana, Arizona (2025)	Adopted development standards for data centers that prohibit the use of potable water for evaporative cooling except under limited circumstances and encourage alternative cooling technologies where feasible.	Reduce long-term demand for potable water in an arid region while allowing flexibility in facility design.

Table 3: Water consumption examples from other jurisdictions.

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Energy Demand

Electricity is the lifeblood of data centers. Data centers are often measured by their theoretical maximum power consumption in megawatts or gigawatts, acting as a rough proxy for the amount of computing power the data center can provide. Electricity is required for two purposes: operating the IT equipment and cooling**. However, the amount of electricity consumed at a single data center facility depends on a number of factors, including but not limited to the data center's workload; its size; the efficiency of individual chips; building design efficiency; local climate; and the cooling technology utilized (air vs liquid).**

Energy Demand: Impacts

As of July 2026, there is limited data available to describe precisely how much electricity is consumed at individual data centers. Despite this lack of specific data, projections of estimated energy use by data centers broadly indicate that they will have significant energy usage needs over the next several years. This demand will be met either through grid-connected service provided by a utility provider, or through behind-the-meter energy generation, or a combination of the two.

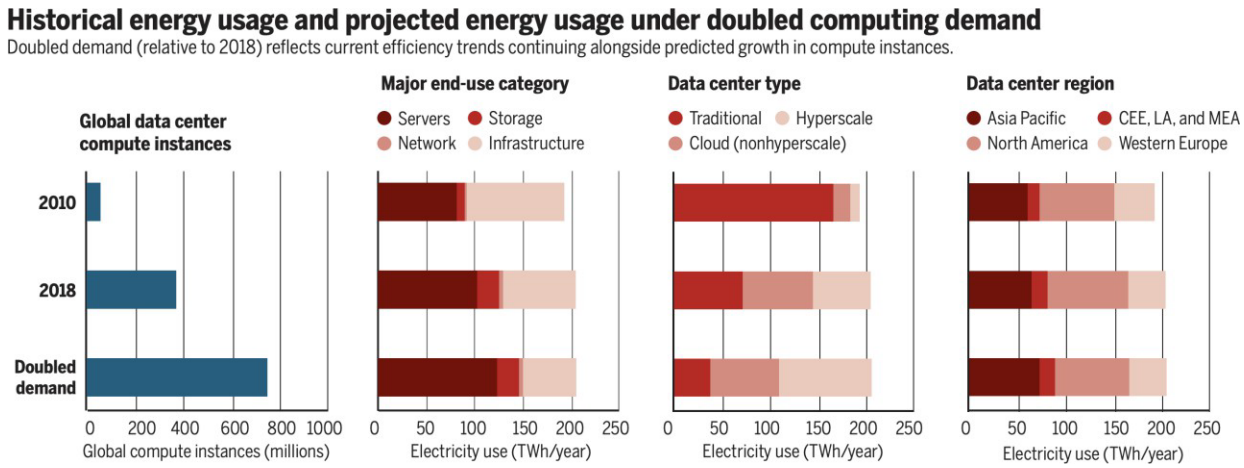

Figure 4: Historical and projected energy usage of data centers by end-use category, data center type, and region. Source: [Recalibrating global data center energy-use estimates]

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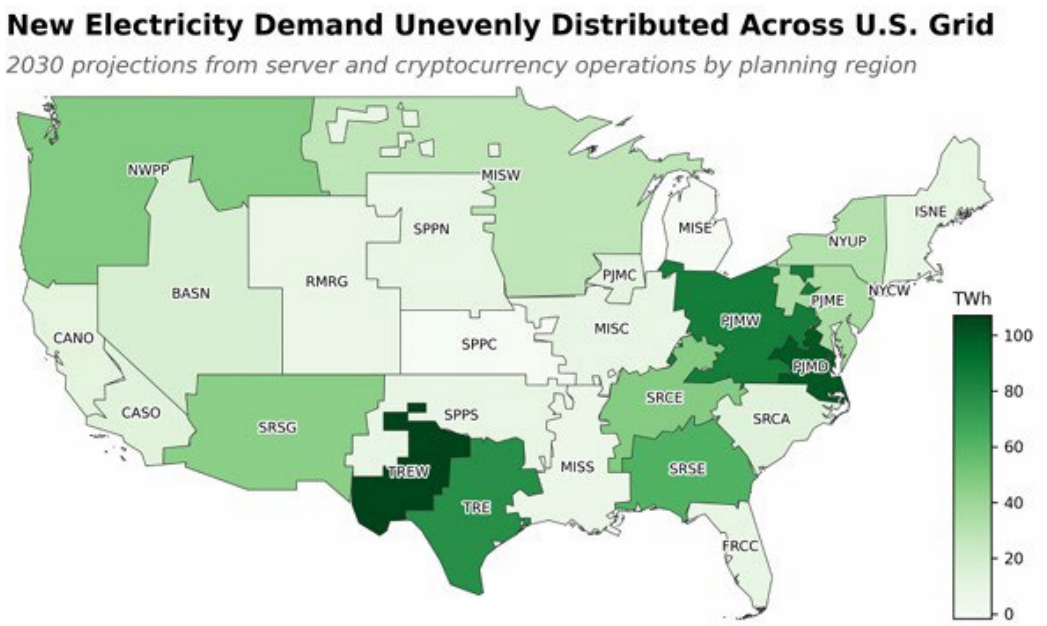

Figure 5: Projected electricity demand increases by 2030. Source: [Electricity Grid Impacts of Rising Demand from Data Centers and Cryptocurrency Mining Operations]

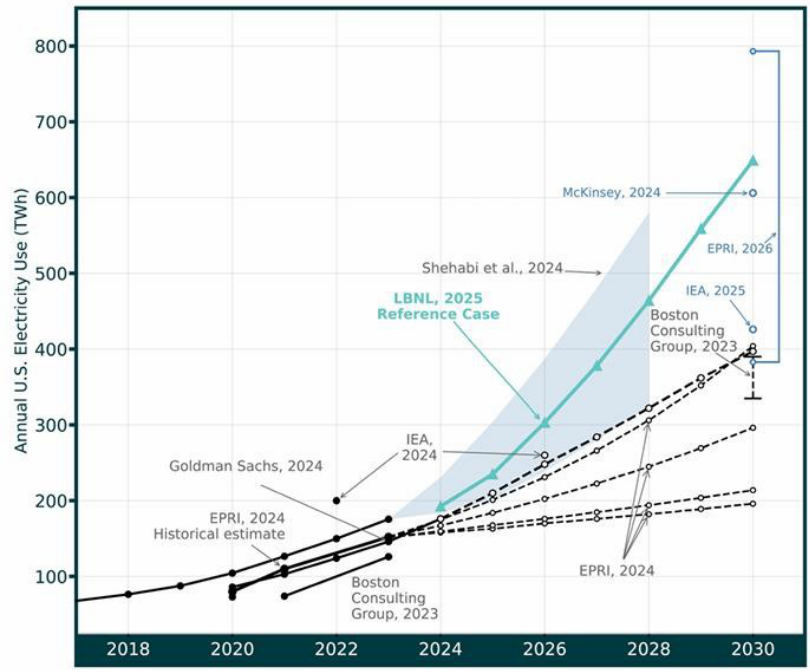

Figure 2. Updated academic and industry estimates of U.S. data center electricity use
This plot includes historical estimates (solid lines) and future projections (dashed lines) from multiple sources including LBNL's 2024 Report (Shehabi et al., 2024). The Reference Case from this 2025 Update is shown as a solid green line. Projections for calendar year 2030 from other sources developed after the publication of the 2024 Report are shown in blue.

Figure 6: Projections of U.S. data center electricity use. Source: [United States Data Center Energy Usage]

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The Reference Case estimate for 2030 data center electricity use is 649 TWh, representing 11.8% of forecasted 2030 U.S. electricity use as presented in the 2025 North American Electric Reliability Corporation (NERC) Long-Term Reliability Assessment (NERC, 2026). Assuming the NERC values include data center energy use consistent with our analysis, their forecasts imply that non-data center load growth will increase 926 TWh (24%) from 2024–2030. **This would result in data centers being responsible for 33% of total load growth over the six-year period.**

If there is not existing capacity and appropriate infrastructure to serve the new data center loads, utilities need to invest in additional generation capacity or transmission and distribution infrastructure. **Without appropriate protections, these investments may have negative impacts on electricity costs for existing ratepayers, increase system costs, and result in increased greenhouse gas (GHG) emissions.** Conversely, if appropriate protections are in place and new generation needed to meet the demand is primarily clean resources, data center-driven load growth can drive down system costs through needed investments paid for by data center companies, increasing system resilience and reliability. Additionally, data center companies can leverage funds to invest in community energy projects with communitywide benefits, as was seen in a June 2026 announcement between Google and Voltus, a Virtual Power Plant (VPP) operator. Under this framework, Voltus will aggregate 100 MW of distributed energy resources (DERs) annually into a VPP funded by Google, providing direct financial benefit to participating customers.

It is difficult to project exactly how data center-driven load growth will impact energy prices and costs, as it depends on factors including how much existing headroom is available on the grid in the area, whether the data center can operate flexibly, how much additional transmission or distribution infrastructure is needed to service the data center, and whether there are sufficient protections for existing ratepayers to avoid shouldering the costs for serving a new data center load.

Given the magnitude of projected needs to meet data center load demands, especially hyperscale data centers, there will likely need to be investment in new energy generation. **In North Carolina, Duke Energy's Carbon Plan and Integrated Resource Plan (CPIRP), filed in October 2025, indicates a significant upward projection in energy needs through 2040, being driven primarily by "significant economic development activity" and "strong residential customer growth and electrification."** Decisions driving the type of energy generation to meet the demand, and how the costs of new generation and infrastructure are allocated, will dictate the price impacts for existing ratepayers.

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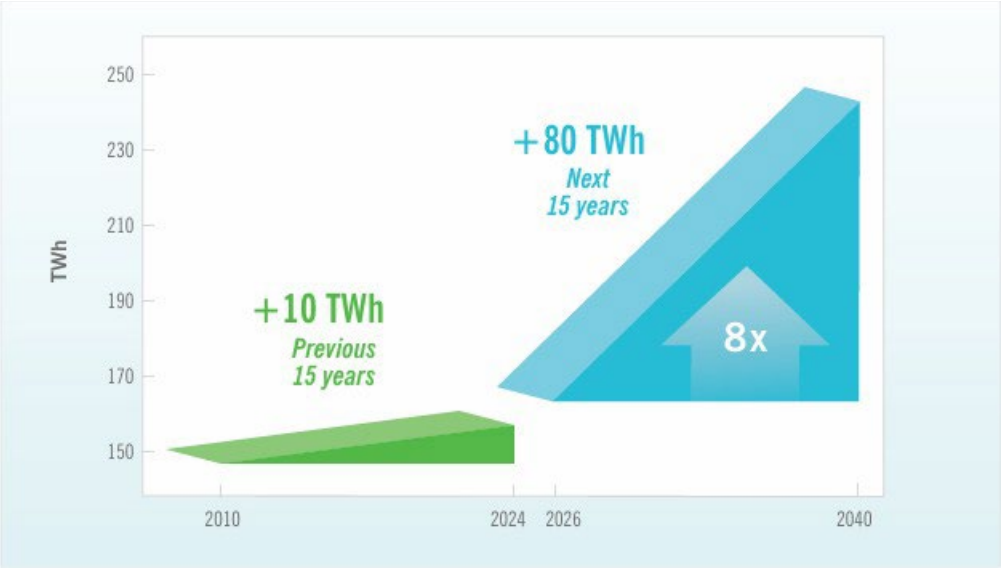

Figure 7: Projected increase in energy demands across the Carolinas through 2040. Source: 2025 Carolinas Resource Plan

The latest data from the Energy Information Administration (EIA) on electricity prices and sales contradict the narrative that data centers are already driving up electricity prices, as further analysis of these data indicate that there is no statistically significant correlation between the number of data centers in a state and its current electricity prices. **Additionally, analysis from LBNL shows negative correlations between average retail prices and changes in electricity sales.** From 2015 to 2024, data centers modestly lowered average retail rates in the United States.

It is important to distinguish what has been seen to-date with projected future impacts. New modeling from the Open Energy Outlook Initiative shows that data center and cryptocurrency mining growth through 2030 *could* increase average U.S. electricity generation costs by 8%. Additionally, another study found that existing data centers have already increased wholesale electricity prices (not retail prices, as considered by LBNL) by an average of 3–5% nationwide, with significantly larger impacts in regions that host major data center corridors. Extending the analysis through 2028, the authors show that, if proposed data center construction proceeds under high-utilization scenarios, wholesale prices *could* increase by as much as 50%. Under more moderate build-out scenarios, price increases are projected to be smaller, at around 20%, but still *could* represent a meaningful impact on power markets.

Alongside potential cost impacts, increased demand for energy and investments in energy generation and infrastructure could result in increased GHG emissions. Some of these emissions may be generated on-site through fossil fuel generators either for back-up energy generation or routine power delivery. Other emissions impacts will come from the

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system-level, as utilities invest in fossil fuel infrastructure to serve new data center load growth. According to one study, emissions in the power sector could increase by up to 30% when compared to scenarios without data center-driven load growth. This increase translates to 275 million metric tons (MMT) of CO_2 annually, which is approximately France's entire carbon output. The rise in emissions is not fully attributable to new generation needed; the study also concludes that a significant amount (25 GW) of coal capacity may stay online to serve data center-driven load growth. Without the significant need for increased energy, that coal capacity may have retired in favor of less expensive and lower emitting forms of energy generation.

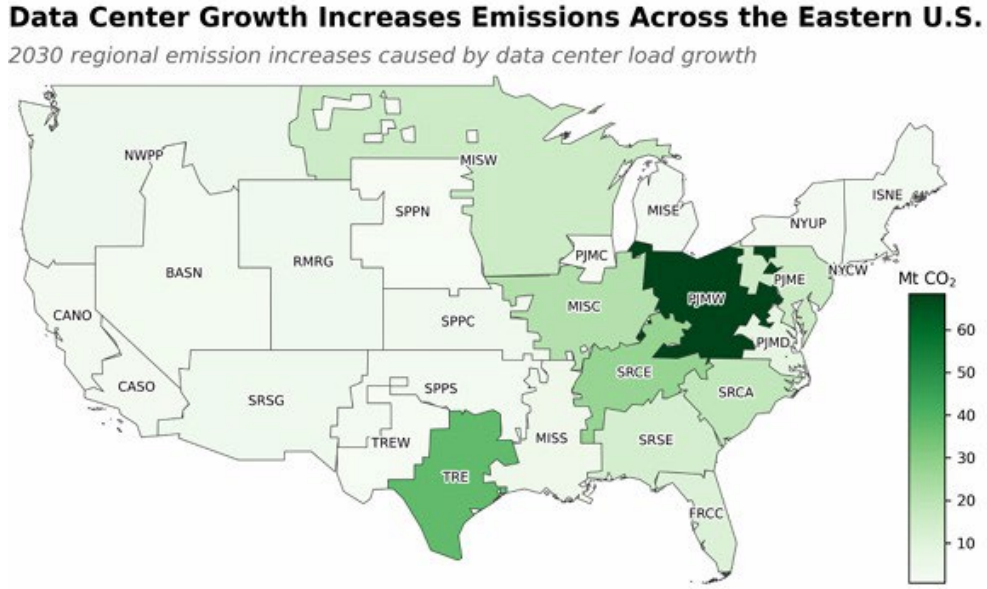

Figure 8: Projected regional greenhouse gas (GHG) emission increases by 2030. Source: Electricity Grid Impacts of Rising Demand from Data Centers and Cryptocurrency Mining Operations

A 2024 white paper from EPRI projects electricity consumption with increased data center activity and studies how these new loads could impact CO_2 emissions with various future policy scenarios. In all modeled scenarios, CO_2 emissions decline with time due to retirement of aging fossil fuel infrastructure and investments in no- or low-emitting energy resources. **However, EPRI finds that data center-driven load growth could result in increased near-term CO_2 emissions due to delays in retirement or increased utilization of exiting fossil infrastructure, including coal and natural gas, to provide needed capacity to data center loads.** Data centers get a significant portion of their electricity generation from natural gas today (IEA estimates 40% globally) and are expected to continue to run largely on natural gas in a business-as-usual scenario.

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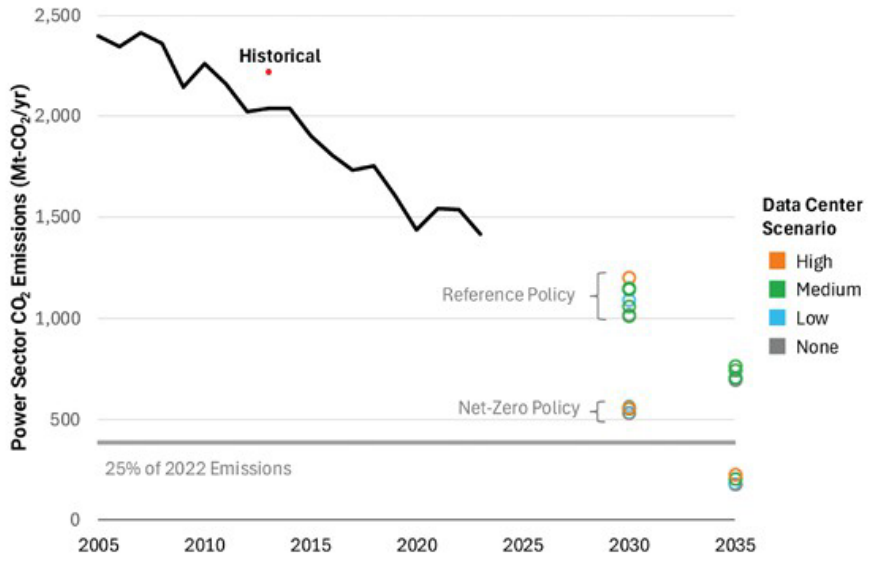

Figure ES-4. *Power sector CO_2 emissions over time by scenario. Projected values show scenarios across data center load assumptions. Historical emissions are based on U.S. EPA's "Inventory of U.S. Greenhouse Gas Emissions and Sinks." The 25% of 2022 emissions line is the threshold where power sector Inflation Reduction Act tax credits begin to expire.*

Figure 9: Projected power sector CO_2 emissions over time by a high, medium, and low data center scenario. Source: Powering Data Centers: U.S. Energy System and Emissions Impacts of Growing Loads

Energy Demand: Local Considerations

In May 2025, the Charlotte City Council voted to formally adopt the Strategic Energy Action Plan Plus, building on its previous Strategic Energy Action Plan framework. Under this plan, Charlotte seeks to reduce community-wide GHG emissions by 72% by 2035 and ultimately achieve net-zero emissions by 2050. **The construction of data centers within city limits, however, may make achieving this goal significantly more difficult.**

In general, local governments served by investor-owned utilities, such as Charlotte, have a limited ability to influence system level and customer bill impacts from data center development. Resource planning and ratemaking processes are regulated at the state level through legislation and regulatory agencies like the North Carolina Utilities Commission. Transmission infrastructure and planning, meanwhile, is regulated at the federal level by the Federal Energy Regulatory Commission. **To influence wider decisions around energy generation, transmission, distribution, Charlotte would need to continue to engage with these entities through bilateral conversations or formal engagement and intervention.** Proceedings that have impacts on energy costs and decarbonization efforts include Integrated Resource Planning (IRP), rate cases, and large load tariff dockets.

However, local governments have oversight over local projects through zoning and permitting authorities. This is particularly relevant for on-site generation: almost all data centers have back-up generators, most often powered by diesel fuel, which run during emergencies and for regular testing and maintenance. Additionally, some data center projects plan for part or all of their

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primary generation needs to be met by on-site natural gas generation. Some local governments have placed restrictions or limits on these kinds of facilities, regulating their construction or operation. Other local governments have also considered promoting on-site or closely sited clean energy generation to make progress towards clean energy goals, such as the Strategic Energy Action Plan, which has a goal of installing 600 MW of distributed renewable energy generation in Charlotte by 2035.

Energy Demand: Example Local Government Actions

Example actions a local government could take to manage energy use impacts largely focus on the operation of specific proposed data centers within Charlotte's jurisdiction. For Charlotte, remembering the targets set forth in the Strategic Energy Action Plan may support decisions about actions to prioritize. *Note that this list is not exhaustive of all potential actions a local government could take. The examples of local government actions provided herein are intended for illustrative purposes only. The authority of a local government to undertake any particular action varies by state and may be limited by state constitutions, statutes, regulations, or judicial decisions. As a result, some examples may not be applicable or permissible in all jurisdictions. Local governments may consult applicable state law and legal counsel to determine the extent of their authority before pursuing any action.*

Jurisdiction	Local Approach	Energy Management Objective
Virginia (proposed statewide framework) (2025)	Require data centers to disclose annual or monthly energy consumption data to regulators and/or the public. Virginia's JLARC review specifically recommended energy- and water-use reporting for data centers to improve transparency and planning.	Increase transparency about energy demand, support grid planning, and enable communities to evaluate the cumulative environmental and climate impacts of data center development.
Aurora, Illinois (2026)	Require annual public reporting of data center energy consumption and submission of energy consumption modeling reports during project review. New data centers must also prepare an energy plan and comply with energy consumption limits.	Increase transparency regarding energy demand, improve utility planning, and help communities evaluate the cumulative environmental impacts of data center growth.
Aurora, Illinois (2026)	Require new or expanded data centers to provide either on-site renewable energy generation equal to 25% of peak load or on-site battery storage capable of supporting 50% of peak load for 15 minutes (or approved alternative compliance).	Reduce dependence on grid-supplied electricity, support renewable energy deployment, improve resilience, and lower emissions associated with data center power consumption.
Chester County and Montgomery	Includes restricting or prohibiting on-site fossil-fuel generation, including natural-gas turbines, through zoning, conditional-use review, or energy-	Reduce local emissions and avoid long-term dependence on on-site fossil-fuel infrastructure.

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County, Pennsylvania (2026)	source requirements for data centers as part of the Pennsylvania planning guide.	
Birmingham, Alabama (2026)	Prohibit routine on-site power generation using natural-gas turbines and continuous diesel generation while allowing solar, fuel cells, and battery storage under specified conditions. Backup generators are restricted to emergencies and testing.	Reduce fossil-fuel emissions, discourage long-term reliance on on-site combustion generation, and encourage cleaner energy technologies and energy resilience solutions.
Birmingham, Alabama (2026)	Require applicants to disclose generator type, fuel source, capacity, operating schedule, and proposed mitigation measures for backup power systems.	Improve accountability for backup generation systems and help limit local air-quality and community impacts associated with emergency power operations.
Lancaster, Pennsylvania (2025)	Require data centers to use 100% clean-energy electricity and annually demonstrate compliance with the city's clean-energy commitments under the Community Benefits Agreement.	Align data center development with municipal climate and sustainability goals and reduce emissions from electricity consumption.
Frederick County, Maryland (2025)	Establish a Critical Digital Infrastructure Overlay Zone (CDI-OZ) that limits data center development to a defined area near existing industrial uses, fiber infrastructure, and high-voltage transmission facilities. The county's Data Centers Workgroup recommended siting data centers near existing or planned critical infrastructure, and subsequent legislation requires facilities within the overlay to be located near transmission infrastructure.	Concentrate high-energy-demand facilities in locations where grid infrastructure already exists, reducing the need for widespread new transmission development, minimizing land-use conflicts, and improving efficiency of utility investments.

Table 4: Energy demand examples from other jurisdictions.

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Air Quality

The energy demands of data centers pose potential concerns for air quality impacts primarily depending on how a data center meets its energy needs. **Ultimately, the type and amount of fossil fuels used to generate a data center's electricity are key factors for how data centers impact air quality, including more local impacts from on-site generation or more regional impacts from grid power.**

Air Quality: Impacts

Historically, most of the energy demand for data centers has been supplied by the grid, and data centers often employ backup fossil-fuel electricity generators for emergency use. **On-site fossil fuel generators release air pollutants directly into their communities including nitrogen oxides (NOx), particulate matter (PM 2.5 & 10), sulfur dioxide (SO2), ozone (O3), mercury, and other particulate emissions which have adverse effects on human health, contributing to conditions such as asthma, heart disease, stroke, and more.** Recent studies show air quality-related health impacts from data centers, with one study estimating over $6 billion in public health damages nationally from data center electricity generation in 2023, where grid-supplied electricity drove over 90% of the modeled costs.

As data center development intensifies and expands to include hyperscalers, developers are aiming to procure more on-site generation capacity. Diesel generators can produce 200 to 600 times more NOx than natural gas plants per unit of electricity. **Back-up diesel generators, even when used sparingly for emergencies and maintenance, have been found to have significant air quality and associated health impacts.** A pre-print study found that Virginia's data centers could be responsible for 14,000 asthma symptom cases and 13-19 deaths annually from backup generators alone. To further complicate this, in May 2025 the EPA loosened regulations to allow certain back-up generators to operate in non-emergency conditions for up to 50 hours per year.

Air Quality: Local Considerations

For Charlotte, the Mecklenburg County Air Pollution Control Ordinance (MCAPCO) establishes rules and regulations around the county's air resources such as permitting and enforcement. The MCAPCO generally defers to existing state and federal policies like the Clean Air Act. **It is important to note that any amount of exposure to air pollutants poses risks to human health, so minimizing pollutants even beyond the thresholds set by standards is best to minimize health impacts.**

Mecklenburg County Air Quality (MCAQ) runs a community monitoring program that serves to collect air quality data and educate and engage communities on their local air quality. Thirteen existing monitoring stations monitor air quality 24 hours a day, 365 days a year and provide information about peak air pollution levels, typical ambient levels in populated areas, and air

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pollution levels near specific sources. This program supports an understanding of localized air-quality impacts and regulatory compliance monitoring. The monitoring program is not specific to or focused on data centers.

As of 2024, Mecklenburg County is compliant with federal health-based air quality standards. However, following significant efforts between 2005 and 2015 to bring ozone and PM2.5 levels into compliance, these levels remain within concerning proximity to federal standards. The American Lung Association gave Mecklenburg County a failing score for its ozone and particle pollutant levels for the 2022-2024 period, which was the worst score in the state for counties with available data. According to 2023 data from Greenlink Equity Map (GEM) and the CDC's National Health Interview Survey, there are parts of Charlotte where neighborhoods experience nearly double the national average asthma rate of 8.4%, which aligns with the moderate air quality in Charlotte driven by relatively high ground level ozone and PM2.5. The following table compiles Mecklenburg census tracts with an existing data center (built in 2023 or earlier). Each of these census tracts had 2023 asthma rates that exceeded the national average according to GEM data. However, this does not show causality between data center development and asthma rates and does not include a comparison to census tracts without data centers.

Census tract	# of Existing data center parcels as of 2026	2023 Asthma rate (%)
38.05	3	9.30%
38.09	1	11.40%
51	1	13.80%
52	1	12.50%
55.33	4	10.50%
59.15	1	10.70%
59.28	1	9.90%
6	4	11.10%
64.03	1	10.20%

Table 5: Asthma rates by census tract, including the number of existing data center parcels as of 2026.

Air Quality: Example Local Government Actions

Minimizing the fossil fuel dependency of data center operations is central to limiting their air quality impacts. Example actions a local government could take to manage air quality impacts from data centers largely align with those laid out to address energy demand impacts discussed in this document. *Note that this list is not exhaustive of all potential actions a local government could take. The examples of local government actions provided herein are intended for illustrative purposes only. The authority of a local government to undertake any particular action varies by state and may be limited by state constitutions, statutes, regulations, or judicial decisions. As a result, some examples may not be applicable or permissible in all jurisdictions.*

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Local governments may consult applicable state law and legal counsel to determine the extent of their authority before pursuing any action.

Jurisdiction	Local Approach	Air Quality Management Objective
Chandler, Arizona (2022)	Require the data center operator to host a public website announcing the times when on-site power generators will be in operation, with at least twenty-four hours of notice including for testing purposes. Require the data center operator to notify the city's communications and public affairs office ahead of on-site power generator testing. Limit backup generation to working hours except during power outages.	Provide transparency, accountability, and predictability for air quality and noise impacts of on-site power generator use.
Loudoun County, Virginia **Prince William County, Virginia (2026)**	Conduct ongoing air-quality monitoring around concentrations of data centers, including monitoring for pollutants such as NO_2, CO, and PM2.5 associated with backup generators.	Track community exposure to data center-related emissions, identify pollution hotspots, and inform future permitting and mitigation requirements.
Birmingham, Alabama (2026)	Prohibit routine on-site power generation using natural-gas turbines and continuous diesel generation while allowing solar, fuel cells, and battery storage under specified conditions. Backup generators are restricted to emergencies and testing.	Reduce fossil-fuel emissions, discourage long-term reliance on on-site combustion generation, and encourage cleaner energy technologies and energy resilience solutions.
Fairfax County, Virginia **James City County, Virginia**	Require mandatory setbacks from residential areas. • Fairfax County: At least 200 feet • James City County: At least 1,000 feet	Minimize impacts on neighboring communities and create greater separation between industrial facilities and residential areas.
Washington State (2012)	Require health risk assessments (HRA) as part of the air permitting process for data centers that use diesel generators, evaluating potential health impacts on nearby residents before construction approval	Identify and manage public health risks associated with emissions from data centers and backup generation equipment before facilities are developed or expanded.

Table 6: Air quality examples from other jurisdictions.

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Noise

Noise is one of the primary operational considerations associated with data center development. Data centers generate sound from mechanical equipment used to cool servers, distribute electricity, and provide emergency backup power**. Noise levels vary considerably depending on facility design, equipment selection, site layout, topography, surrounding land uses, and operational characteristics.** Although many facilities are designed to comply with local noise ordinances, public attention has increasingly focused on continuous mechanical noise and periodic generator testing as data center development has expanded.

Noise: Impacts

Data centers generate sound from several types of mechanical and electrical equipment, including heating, ventilation, and air conditioning (HVAC) systems, cooling towers and chillers, air handling units, transformers, and emergency backup generators. Most cooling equipment operates continuously to maintain appropriate operating temperatures for information technology equipment, while backup generators are typically operated only during power outages and periodic testing.

Noise levels vary considerably depending on facility design, equipment selection, cooling technology, site layout, topography, surrounding land uses, and the use of engineering controls such as acoustic enclosures, barriers, or building placement. Manufacturers publish sound ratings for HVAC equipment, cooling towers, and generators under standardized testing conditions, but measured sound levels at nearby properties depend on equipment configuration, distance, shielding, terrain, and other site-specific conditions.

The character of the sound can be as important as the overall sound level. Cooling fans, chillers, and transformers may produce continuous low-frequency or tonal sounds that differ from intermittent or short-duration noise sources. Consequently, facilities with similar measured sound levels may produce different community responses depending on background ambient conditions, operating schedules, weather conditions, and the acoustic characteristics of the surrounding environment.

Published research indicates that community concerns have most frequently been documented where large data centers are located near residential neighborhoods. Acoustic studies conducted in Northern Virginia measured sound levels of approximately 40 to 59 dB at nearby residential properties associated with facilities that generated community complaints. Although these measured levels generally complied with applicable local noise ordinances, they illustrate that compliance with regulatory thresholds does not necessarily eliminate community concerns related to continuous mechanical noise.

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Environmental noise is evaluated for different purposes using different standards. Municipal noise ordinances generally establish enforceable sound limits for determining regulatory compliance, while organizations such as the World Health Organization (WHO) have developed public health guidelines intended to reduce the long-term effects of environmental noise exposure. The WHO's Environmental Noise Guidelines for the European Region, for example, recommend lower nighttime outdoor noise levels than are commonly established in local noise ordinances because the guidelines are based on population-level health research rather than regulatory enforcement.

Measuring and evaluating industrial noise can present technical challenges. There are a few common filters for measuring sound response: A-weighted decibel [dB(A)], B-weighted decibel [dB(B)], and C-weighted decibel [dB(C)]. The most widely used is dB(A), which filters roughly to the human ear; most municipal ordinances, including Charlotte's, rely on dB(A) measurements because they provide a standardized basis for enforcement. Acoustical literature notes, however, that additional engineering analyses, including octave-band analysis or frequency-specific modeling, may be used to evaluate low-frequency or tonal sound where those characteristics are of particular interest. This includes a dB(C) filter, which captures low-frequency sounds that dB(A) may underrepresent such as from machinery, engines, or subwoofers.

There is growing community concern about the impacts of vibration, or humming, from mechanical equipment used at data centers as a nuisance to surrounding areas. These frequencies are measured by dB(C) rather than dB(A). While there is limited available research to understand the impacts of dB(C) noise from data centers, some local governments – including Loudoun County, VA – are including consideration of dB(C) noise as a part of their best practices for communities considering data centers.

Noise: Local Considerations

The City of Charlotte regulates noise through both the Unified Development Ordinance (UDO) and the City Code of Ordinances. The UDO establishes separation requirements for mechanical equipment near certain sensitive land uses, while the City's Noise Ordinance establishes enforceable sound limits for mechanical equipment measured at the complainant's property line. Mechanical noise, excluding certain exempt activities such as construction, lawn maintenance, refuse collection, and parking garage operations, is generally limited to 70 dB(A). Enforcement is complaint-driven and is administered through the Charlotte-Mecklenburg Police Department (CMPD) and Code Enforcement, with violations subject to civil penalties.

Charlotte's current framework is consistent with the approach used by many local governments, relying on standardized A-weighted decibel [dB(A)] measurements to provide an objective basis for evaluating compliance. A-weighted measurements are widely used because they

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approximate the range of sound most readily perceived by human hearing and provide a practical standard for field enforcement.[4]

Acoustical literature notes that certain industrial sound sources, including large fan arrays, cooling equipment, and transformers, may also produce low-frequency or tonal sound characteristics that are not fully described by a single A-weighted sound measurement. **For that reason, detailed acoustical studies prepared for complex industrial facilities sometimes incorporate additional analytical methods, such as octave-band analysis or predictive sound modeling, to evaluate facility performance under a range of operating conditions.**[5]

City planning staff also evaluated operational conditions at existing facilities during the development of the temporary data center moratorium. During Council discussions, staff reported that a field visit to a nearby hyperscale data center did not identify significant noise concerns at that location. At the same time, noise was identified as a topic of interest during the City's public engagement process, including testimony received during the public hearing on the proposed moratorium. **These observations illustrate that noise conditions may vary among facilities depending on site design, surrounding land uses, operational characteristics, and local conditions rather than representing a uniform characteristic of all data centers.**[6]

Because municipal noise ordinances are generally enforced after a complaint is received, compliance is typically evaluated after a facility becomes operational. As a result, some local governments supplement operational noise standards with predictive acoustical studies during the development review process to evaluate anticipated sound levels before construction. Examples of these approaches are discussed in the following examples from other jurisdictions.

Noise: Example Local Government Actions

Local governments are addressing noise impacts through a variety of mechanisms including amending zoning ordinances, requiring noise or acoustic studies during project proposal, instituting a Special Use Permit process, or updating development standards. *Note that this list is not exhaustive of all potential actions a local government could take. The examples of local government actions provided herein are intended for illustrative purposes only. The authority of a local government to undertake any particular action varies by state and may be limited by state constitutions, statutes, regulations, or judicial decisions. As a result, some examples may*

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[4] International Organization for Standardization. ISO 1996-1:2016, Acoustics—Description, Measurement and Assessment of Environmental Noise—Part 1.

[5] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). *HVAC Applications Handbook* (chapter on sound and vibration control), or the *ASHRAE Handbook—HVAC Applications*.

[6] Charlotte City Council agenda materials and staff presentation for the temporary data center moratorium (including the reported site visit and public hearing summary).

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not be applicable or permissible in all jurisdictions. Local governments may consult applicable state law and legal counsel to determine the extent of their authority before pursuing any action.

Jurisdiction	Local Approach	Noise Management Objective
Fairfax County, Virginia (2024)	Amended the Zoning Ordinance to require applicants for new data centers to submit a predictive acoustical study before site plan approval. Studies must be prepared by a qualified acoustical engineer using ISO 9613 modeling at full build-out, account for all noise-generating equipment and noise attenuation measures, and evaluate routine generator testing. A post-construction acoustical verification study is required before issuance of a Nonresidential Use Permit, and subsequent equipment additions require updated modeling using measured field data. Routine generator testing is generally limited to daytime hours unless otherwise evaluated through the approved acoustical study.	Evaluate anticipated operational noise before construction, verify compliance after facilities become operational, and integrate acoustical performance into the land development review process.
James City County, Virginia (2025)	Amended the County Code to regulate data centers through the Special Use Permit process. Applicants must submit acoustical studies before and after construction prepared by a licensed acoustical engineer using ISO 9613 standards. The ordinance establishes a 55 dB maximum sound level at nearby residences for generators and associated mechanical equipment and authorizes mitigation measures such as acoustic barriers or equipment enclosures where studies project exceedances. The County also increased recommended residential setbacks from approximately 400 feet to 1,000 feet for occupied dwellings.	Coordinate land use review, noise mitigation, and site design to reduce operational noise near residential neighborhoods before facilities become operational.

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Loudoun County, Virginia (2024)	Following increased community concern regarding operational noise from existing hyperscale data centers, the County updated its Data Center Zoning Ordinance and design standards to strengthen buffering, landscaping, and compatibility requirements adjacent to residential areas while continuing to evaluate acoustical performance through the development review process. The County has also commissioned technical studies to better understand cumulative impacts associated with clustered data center development.	Improve compatibility between expanding data center campuses and nearby residential development through land use planning, buffering, and continued technical evaluation.
Henrico County, Virginia (2025)	Adopted Data Center Design Guidelines as part of the County's Comprehensive Plan to guide future data center development. The guidelines encourage site design that minimizes impacts on surrounding properties through building orientation, setbacks, landscaping, screening, and operational design. For individual projects, the County may also require additional conditions through the rezoning process, including noise attenuation measures and operational sound limits where appropriate.	Incorporate compatibility with surrounding land uses into the planning and development review process while allowing project-specific conditions to address operational impacts, including noise, where warranted.
Prince William County, Virginia (2023–2024)	During review of multiple large-scale data center proposals, the County incorporated detailed acoustical analyses into rezoning and Special Use Permit applications. Staff and decision-makers considered predictive noise modeling, equipment placement, landscape buffers, and generator testing schedules as part of project-specific conditions negotiated during the entitlement process.	Incorporate project-specific acoustical analysis into discretionary land use approvals to evaluate potential operational impacts before construction.
Douglas County, Georgia (2024)	Updated development standards for data centers to address compatibility with surrounding land uses, including buffering, setbacks, and operational considerations reviewed through the zoning process. Noise impacts are evaluated as part of the County's broader compatibility review rather than through a standalone data center noise ordinance.	Integrate operational impacts, including noise, into compatibility reviews for rapidly developing suburban areas near major metropolitan regions.

Table 7: Noise examples from other jurisdiction

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Urban Heat Island

Data center developments may involve a significant amount of hard infrastructure and generate heat through the cooling required for the IT hardware. **This type of land use could exacerbate urban heat island effect, depending on how the data center is constructed and the type and level of cooling required for the facility.**

Urban Heat Island: Impacts

While there is limited research available on how data centers contribute to urban heat island effect, emerging evidence is beginning to show that data centers can have measurable impacts on ambient temperatures in their surroundings. A study of a 12 MW data center complex in Pando, Uruguay found that temperatures around the data center were 3.8 degrees Fahrenheit warmer than surrounding areas. An Arizona State University study found that temperatures downwind of four data centers in the Phoenix metro area averaged 1.3-1.6 degrees Fahrenheit higher than upwind locations, reaching as high as 4 degrees at maximum. These effects were found to be detectable up to 500 meters away or five city blocks away. At this point, however, there is no research on whether differences in data center energy use, size, or workload contribute to differences in heat island impacts.

Urban Heat Island: Local Considerations

Charlotte's existing warm-humid climate, rapidly developing urban landscape, and exposure to climate change make extreme heat a critical concern. Without proper mitigation efforts, large industrial developments like data centers may serve to exacerbate or intensify heat impacts in surrounding areas.

It is important to consider where heat impacts from data centers may originate from. **Data centers may raise external temperatures by exhausting waste heat produced as a result of cooling; additionally, the construction of the data center and its surrounding campus (i.e. concrete roofs, pavement in parking lots, etc.) may trap heat and raise local temperatures as well.** Mitigation of these impacts will require addressing both of these issues, as well as strategies addressing other sources of heat island impacts in neighborhoods containing data centers.

Urban Heat Island: Example Local Government Actions

Example actions for local governments to address heat impacts from data center development can be divided between addressing source waste heat and wider building/construction impacts. *Note that this list is not exhaustive of all potential actions a local government could take. The examples of local government actions provided herein are intended for illustrative purposes*

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Jurisdiction	Local Approach	Urban Heat Management Objective
Lancaster, Pennsylvania (2025)	Require a Thermal Impact Mitigation Plan as part of zoning applications, including evaluation of waste heat reuse or dissipation strategies and site design measures to offset urban heat island impacts. *This ordinance has been introduced but not passed.*	Ensure data centers assess and implement measures to manage waste heat and minimize heat island effects before development approval.
Montgomery County, Pennsylvania (2026)	Includes a Thermal Impact Mitigation Plan as part of a guide to support local governments prepare for data center development.	Ensure data centers assess and implement measures to manage waste heat and minimize heat island effects before development approval.
Ontario, Canada and several European examples	Promote or require waste heat recovery and reuse technologies for district heating, thermal energy networks (TENs), industrial and agricultural processes, or supplemental electricity generation.	Capture and beneficially reuse excess heat, reducing waste heat released into the surrounding environment and improving energy efficiency.
Louisville, Kentucky (2017)	Provide incentives for cool roofs and green roofs that reduce roof surface temperatures or add vegetative cover.	Lower building and surface temperatures, reduce heat absorption, and manage urban heat island effects.
Philadelphia, Pennsylvania (2023)	Upgrade building and development codes to promote or require heat-mitigating design strategies and construction materials. This may include cool roof or similar heat-mitigating provisions.	Reduce heat retention and heat generation from buildings and infrastructure over the long term.

Table 8: Urban heat examples from other jurisdictions.

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