Data Center Energy & Infrastructure Glossary

A reference guide for local governments and planners

Metropolitan Washington Council of Governments

ICF

Grid Governance, Regulators, and Public Agencies

Local governments control land use and permitting, but grid rules, reliability standards, and many cost drivers are set through federal and state processes, which shape when and where infrastructure is needed.

Federal Regulators and Reliability Organizations

FERC (Federal Energy Regulatory Commission): The federal agency that regulates interstate electricity transmission and wholesale power markets and approves the rules used by regional grid operators such as PJM. FERC oversees the framework for interconnection, transmission planning, and wholesale pricing, but does not regulate local land use or retail electricity rates.

NERC (North American Electric Reliability Corporation): The organization authorized to develop and enforce reliability standards for the bulk electric system, shaping how high-voltage infrastructure is designed, operated, and protected across regions including PJM.

BES / BPS (Bulk Electric System / Bulk Power System): The high-voltage transmission network and major generation resources (generally ≥100 kV) that maintain regional reliability, distinct from the lower-voltage distribution systems managed by local utilities.

State Utility Regulators

SCC (Virginia State Corporation Commission): Virginia's regulatory body that oversees investor-owned utility rates, service, and certain infrastructure approvals, including how costs associated with data center growth may be recovered from customers.

PSC (Public Service Commission): Maryland's regulatory body that oversees electric, gas, and other utilities, including rate cases and approvals for some generation and transmission facilities.

PUC (Public Utility Commission): A general term for a state utility regulator that governs retail electric service, utility rates, and certain infrastructure investments, distinct from PJM's role in wholesale markets.

Environmental Agencies

DEQ (Virginia Department of Environmental Quality) / MDE (Maryland Department of the Environment) / DOEE (District Department of Energy & Environment): State or district agencies that issue environmental permits affecting data centers, including air permits for generators and water permits for cooling systems, which can influence project design and timelines.

EPA (U.S. Environmental Protection Agency): The federal agency that sets and enforces environmental standards and operates programs such as ENERGY STAR that are often used in benchmarking and policy discussions.

DOE (U.S. Department of Energy): The federal agency that supports energy research and publishes technical guidance frequently used in planning, benchmarking, and policy development.

Other Organizations

NRECA (National Rural Electric Cooperative Association): A national trade association that represents electric cooperatives and provides policy advocacy, technical assistance, and research support, particularly in rural and suburban service territories.

Local and Regional Governments

Local Governments (counties, cities, towns): Local jurisdictions that control zoning, comprehensive plans, site plan approvals, and building permits for data centers and related infrastructure, including substations and some transmission facilities.

Councils of Governments (COGs) / Regional Planning Bodies: Regional entities that coordinate across jurisdictions and often evaluate cumulative impacts such as land use, water use, and greenhouse gas emissions that may cross local boundaries.

Grid Operators, Utilities, and "Who Does What"

Data center projects involve multiple entities, with regional operators managing the grid, utilities building infrastructure, and regulators overseeing costs and approvals.

Regional Grid Operator

PJM (PJM Interconnection, L.L.C.): The Regional Transmission Organization (RTO) that operates the high-voltage electric grid and wholesale electricity markets across a 13-state region, including Maryland, Virginia, and DC. PJM is responsible for coordinating grid reliability, operating markets, and planning transmission upgrades, and plays a central role in how large loads like data centers are connected and served.

ISO / RTO (Independent System Operator / Regional Transmission Organization): Organizations that operate transmission systems and wholesale markets without owning generation; in the Mid-Atlantic, PJM serves this role.

Planning Processes

RTEP (Regional Transmission Expansion Plan): PJM's regional planning process that identifies and approves transmission upgrades needed to maintain reliability and meet future demand growth. Projects in the RTEP can include new transmission lines, substation expansions, or equipment upgrades, some of which may require local approvals and can have visible community impacts.

EIT (Expedited Implementation Track): A PJM process designed to accelerate certain grid upgrades that address near-term reliability needs, often moving faster than traditional planning processes. In regions with rapid load growth, such as Northern Virginia, EIT projects can reach local governments with shorter lead times.

IRP (Integrated Resource Plan): A long-term planning document filed by vertically integrated electric utilities in some states (such as Virginia) that forecasts future demand and identifies a portfolio of resources to meet that demand. In restructured states like Maryland, where utilities primarily operate distribution systems and generation is supplied through competitive markets, utilities generally do not file IRPs; instead, resource adequacy is addressed through PJM markets and state-level policy and planning processes.

Utilities and Service Providers

Electric Utility: A company, cooperative, or public entity that delivers electricity to customers and owns distribution infrastructure, and sometimes transmission facilities, and is responsible for physically connecting and serving data centers.

IOU (Investor-Owned Utility): A for-profit utility owned by shareholders and regulated by a state commission, which is the dominant model serving most large data center clusters in the Mid-Atlantic, including Northern Virginia.

Electric Cooperative (Co-op): A member-owned utility that typically serves rural or suburban areas and may have different governance and rate structures than investor-owned utilities.

Municipal Utility (Muni): A utility owned and operated by a city or town, with local control over rates and service decisions.

TO (Transmission Owner): The entity that owns transmission lines and substations, while PJM coordinates their operation and regional planning.

EDC (Electric Distribution Company): The utility responsible for delivering electricity to customers over the local distribution system; in states like Maryland, customers may purchase electricity from a competitive supplier, but the EDC still owns and operates the local wires.

LSE (Load Serving Entity): The entity responsible for securing electricity supply (energy and capacity) to meet customer demand, which may be a utility or a competitive supplier depending on the state structure.

Electricity Markets and Cost Drivers

Electricity markets influence costs, infrastructure needs, and development patterns, even though they are not directly regulated at the local level.

Core Markets

Wholesale Electricity Market: The system through which electricity is bought and sold between generators and utilities, operated by PJM, with prices varying across locations and time based on system conditions.

Capacity Market (Reliability Pricing Model – RPM): A forward market operated by PJM that pays power plants and other resources to be available to meet future peak demand, ensuring long-term grid reliability. Capacity costs can be a significant component of electricity costs in high-growth regions.

Ancillary Services: Grid services, such as frequency regulation and reserves, that maintain system stability and reliability and are procured through PJM markets.

Pricing and System Constraints

LMP (Locational Marginal Price): The cost of delivering electricity to a specific location, reflecting energy costs, transmission congestion, and losses. In high-demand areas such as Northern Virginia, LMPs may be higher due to transmission constraints.

Congestion: A condition in which transmission constraints limit the ability to deliver lower-cost electricity to a specific area, resulting in higher local prices and potentially driving the need for new transmission infrastructure.

Power and Energy Units

kW / MW / GW (kilowatt / megawatt / gigawatt): Units of power that represent the instantaneous rate at which electricity is used or generated, with 1 MW equal to 1,000 kW and 1 GW equal to 1,000 MW. Large electricity users such as data centers are typically measured in megawatts, while gigawatts are used to describe very large systems such as regional grid capacity or multi-site development pipelines. For context, a 100 MW resource operating continuously (such as a nuclear or natural gas plant) can supply electricity for roughly 70,000–80,000 homes, while a 100 MW solar facility, which produces electricity only part of the time, may generate enough annual energy to serve closer to 10,000–20,000 homes. Individual hyperscale data center campuses are often planned in the range of 100–500 MW, and in high-growth regions such as Northern Virginia, total data center demand is increasingly discussed at the gigawatt scale across multiple sites. Because data centers require continuous, 24/7 power, they depend on grid resources that can reliably supply electricity at all hours.

kWh / MWh / GWh (kilowatt-hour / megawatt-hour / gigawatt-hour): Units of energy that represent electricity use over time, with power (kW/MW/GW) driving infrastructure needs and energy (kWh/MWh/GWh) driving total consumption.

Demand and Billing Concepts

Demand Charge: A component of an electricity bill based on the highest level of power (kW or MW) used during a billing period, meaning a brief spike in demand can significantly increase costs.

PLC (Peak Load Contribution): A measure of a customer's contribution to system peak demand, used in PJM to allocate capacity-related costs; because it is based on a limited number of peak hours, short periods of high demand can affect costs for an entire year.

Flexibility and Grid Interaction

Demand Response (DR): Programs that reduce or shift electricity use in response to grid needs or price signals, often coordinated through PJM markets.

Curtailment: The reduction of electricity consumption or generation output to maintain system reliability or manage costs.

Dispatchable Power: Power sources that can be turned on or adjusted as needed, such as natural gas plants or batteries, and are important for maintaining reliability.

Baseload Power: Generation that operates continuously to meet steady demand, such as nuclear plants, which can help support round-the-clock electricity needs.

Grid Infrastructure, Interconnection, and Cost Allocation

New data centers often require substations, transmission upgrades, and distribution expansions, and the costs of these upgrades are governed by tariffs and regulatory rules.

Core Infrastructure

Transmission System: High-voltage lines and substations that move electricity across regions, coordinated by PJM and often spanning multiple states.
Distribution System: Lower-voltage lines and equipment that deliver electricity to individual buildings, owned and operated by local utilities.
Substation: A facility that transforms voltage and routes electricity between transmission and distribution systems, and is often the most visible piece of infrastructure associated with data center growth.
Transformer: Equipment that changes voltage levels between transmission and distribution systems or within the distribution system.
Feeder: A distribution circuit that delivers electricity from a substation to customers.

Interconnection and Planning

Interconnection (PJM Process): The technical and contractual process, governed by PJM's interconnection procedures, through which a new load or generator is evaluated and connected to the electric grid. This process involves coordinated studies by PJM and the local utility to assess reliability impacts and determine required upgrades to both transmission and distribution systems. For large data centers, interconnection is often the critical path and can trigger infrastructure upgrades both locally and across the regional grid.
Queue / Study Process (PJM Interconnection Queue): The structured process used by PJM to evaluate interconnection requests, in which projects are entered into a regional queue and studied in groups through a defined sequence of analyses. Because projects are evaluated together, changes or delays in one project can affect the cost, timing, and required upgrades for others.
POI (Point of Interconnection): The physical location where a facility connects to the grid, such as a substation or feeder; in constrained areas like Northern Virginia, available capacity at a POI can significantly affect development feasibility and timing.
OATT (Open Access Transmission Tariff): The FERC-approved tariff that governs how transmission service and interconnection are provided within PJM, including rules for connecting new loads, allocating the costs of transmission upgrades, and reserving transmission capacity. These rules determine how costs are shared between individual customers and the broader system.

Cost and Rate Design

Tariff: The utility's official rulebook, approved by regulators, that defines how customers are served, how rates are calculated, and how infrastructure costs are recovered, including both retail tariffs (utility) and wholesale tariffs (PJM).

CIAC (Contribution in Aid of Construction): An upfront payment required from a customer to fund certain utility infrastructure upgrades needed to serve their load, typically for site-specific distribution facilities, while broader transmission upgrades may be shared across ratepayers.
Standby Service: A rate structure for customers with on-site generation that still rely on the grid for backup or supplemental power.

Reliability and Engineering

N-1 Standard: A planning criterion requiring the system to continue operating without interruption after the failure of a single major component, commonly used by utilities and grid operators.
Short Circuit / Fault Duty: The maximum electrical current that equipment must safely withstand during a fault condition.
Power Factor (PF): A measure of how efficiently electricity is used, with lower power factor increasing system losses and equipment loading.

Data Center Types and Siting Drivers

Different types of data centers have different sizes, infrastructure needs, and land use impacts, but all depend on reliable power and network connectivity.

Colocation (Multi-Tenant) Data Center: A facility that provides space, power, cooling, and connectivity for multiple customers; this model is common in Northern Virginia's "Data Center Alley."
Hyperscale Data Center: A very large facility built for a single major cloud or technology company, often driving the largest individual infrastructure requirements.
Enterprise Data Center: A facility owned or operated by a single organization for its internal use.
Edge Data Center: A smaller facility located closer to end users to reduce latency and improve performance.
Embedded Data Center: A data center integrated within a larger building rather than a standalone facility.
MAE-East (Metropolitan Area Exchange – East): A historic internet exchange point that helped establish Northern Virginia as a major data center hub due to its dense network connectivity, which continues to attract data center development.

Data Center Electrical Systems and Resiliency

Data centers are designed for extremely high reliability, which drives electrical infrastructure scale, generator deployment, and site design.

Reliability Concepts

Uptime: The percentage of time a data center remains operational, often expressed as very high reliability targets such as 99.999%.
Redundancy (N, N+1, 2N): Design approaches that provide backup capacity to ensure continuous operation, with higher levels of redundancy increasing both reliability and infrastructure requirements.
A/B Power: Dual independent power paths to equipment, allowing maintenance or failure without interruption.

Electrical Equipment

UPS (Uninterruptible Power Supply): Battery-based systems that provide immediate, short-duration power during grid disturbances, allowing time for backup generators to start; large UPS systems may also participate in grid programs without affecting operations.

Backup Generator: On-site generation installed to provide power during grid outages or instability, enabling data centers to maintain continuous operations. Because data centers are expected to achieve very high reliability (often referred to as "uptime"), most facilities include multiple backup generators that can operate for extended periods. These generators are typically fueled by diesel or natural gas and can affect air quality, noise levels, and fuel storage requirements. Backup generators are usually tested regularly (for example, monthly), which can generate intermittent emissions and noise even when the grid is functioning normally.

ATS (Automatic Transfer Switch): Equipment that automatically switches the electrical load from utility power to backup generation.

Switchgear: Equipment used to control, protect, and isolate electrical systems.

MSB (Main Switchboard): The primary distribution point where incoming power is received and distributed within the facility.

PDU (Power Distribution Unit): Equipment that distributes power to IT racks and equipment.

Emissions and Controls

Tier 4 Final: The most stringent U.S. EPA emissions standard for many diesel engines, requiring advanced controls to reduce nitrogen oxides (NOx) and particulate matter. While many emergency generators are required to meet Tier 2 standards, some jurisdictions with stricter air quality requirements require Tier 4 Final engines for new installations.

DEF (Diesel Exhaust Fluid): A fluid used in Tier 4 Final diesel engines to reduce emissions by converting nitrogen oxides into nitrogen and water.

Cooling, Water, and Thermal Management

Cooling systems are a major driver of energy consumption, water use, and site design, making them a key focus of local review. Data centers generally use one or a combination of three cooling approaches: air-cooled systems (low water use), evaporative systems with cooling towers (higher water use), and liquid cooling for high-density computing.

HVAC (Heating, Ventilation, and Air Conditioning): Systems that manage temperature, humidity, and airflow within buildings.

Air-Cooled Systems: Cooling systems that rely primarily on ambient air and mechanical refrigeration to remove heat, typically using air-cooled chillers or direct expansion systems without evaporative cooling. These systems generally use little or no water but require more electricity and larger heat rejection equipment, such as outdoor condenser units or dry coolers. Air-cooled designs are common in smaller data centers (such as enterprise or embedded facilities) and are increasingly considered in areas with water constraints.

Chiller: Equipment that produces chilled water used to remove heat from the data center, often serving as the central component of a cooling system. Chillers may be paired with either air-cooled or water-cooled heat rejection systems.

Cooling Tower: Equipment that removes heat by evaporating water, allowing systems to operate more efficiently than air-cooled alternatives but requiring a continuous water supply. Cooling towers are commonly used in large data centers and can be a significant driver of water use and permitting considerations.

Economizer: A system that uses favorable outdoor conditions (air or water temperature) to reduce or eliminate the need for mechanical cooling, improving energy efficiency. In the Mid-Atlantic climate, economizers can reduce energy use during cooler months.

Liquid Cooling: Technologies that directly remove heat from servers or chips using a liquid medium (such as cold plates or immersion cooling), which is more efficient at high power densities. Liquid cooling is becoming more common with AI and high-performance computing and can change both energy and water use profiles.

Efficiency Metrics and Resource Use

Efficiency metrics help compare facilities, but do not always reflect total energy or water consumption.

PUE (Power Usage Effectiveness): The ratio of total facility energy use to IT equipment energy use, with lower values indicating higher efficiency.

WUE (Water Usage Effectiveness): A metric that measures water use relative to IT energy consumption.

IT Workloads and Load Characteristics

The type of computing affects power demand, cooling needs, and infrastructure requirements.

CPU (Central Processing Unit): A general-purpose processor used for a wide range of computing tasks.

GPU (Graphics Processing Unit): A processor designed for parallel computation, commonly used for artificial intelligence workloads, often increasing power density.

Training vs. Inference: Training involves building machine learning models with sustained, high energy use, while inference involves running models with more variable demand.

Latency: The delay in data transmission, which influences where data centers are located relative to users and network hubs, contributing to clustering in regions like Northern Virginia.

Rack Density (kW per rack): The amount of power used per server rack, with higher densities increasing cooling and electrical requirements.

On-site Energy, Storage, and Microgrids

On-site energy systems affect resilience, emissions, and permitting, and may change how facilities interact with the grid.

DER (Distributed Energy Resource): Small-scale generation, storage, or controllable load located near where electricity is used, often behind the meter.

BTM (Behind-the-Meter): Resources located on the customer side of the utility meter, such as on-site generators or batteries, which are typically subject to local permitting.

Microgrid: A coordinated system of loads and distributed energy resources that can operate connected to the main grid or independently ("islanded") during outages. Microgrids can improve resilience for data centers by enabling continued operation during grid disruptions, but most still rely on the broader grid for normal operations and may include generators, batteries, or other on-site resources.

Islanding: The ability to operate independently from the grid during outages.

VPP (Virtual Power Plant): A system that uses software, communications, and controls to coordinate many distributed energy resources—such as batteries, backup generators, or flexible loads—so they can operate together as a single, dispatchable resource for the electric grid or electricity markets. VPPs can provide services such as reducing demand during peak periods, supplying reserve power, or helping stabilize the grid, often without requiring new large power plants. For example, a data center campus with large UPS battery systems or on-site storage could participate in a VPP by briefly reducing grid consumption or discharging stored energy during peak demand events, then returning to normal operations without affecting uptime.

District Energy: A centralized system that produces and distributes heating or cooling (such as chilled water) to multiple buildings through a network of pipes. In data center contexts, district energy systems may be used to supply cooling or to capture and reuse waste heat for nearby buildings, though these systems require nearby compatible uses and coordinated development.

CHP (Combined Heat and Power): A system that generates electricity and captures the waste heat from that process for useful purposes such as heating, hot water, or cooling, allowing the same fuel to produce both power and thermal energy more efficiently than separate systems. CHP systems are typically fueled by natural gas and can achieve higher overall efficiency by using heat that would otherwise be wasted. In data center applications, CHP can support on-site power and cooling, but its effectiveness depends on having a consistent use for the recovered heat, such as in campus or mixed-use developments.

Fuel Cell: A technology that generates electricity through a chemical reaction, often with lower emissions than combustion-based generation.

HVDC (High-Voltage Direct Current): A transmission technology that efficiently moves large amounts of power over long distances and is sometimes proposed to deliver power into constrained regions.

SMR (Small Modular Reactor): A smaller-scale nuclear reactor design intended to be factory-built and deployed in modular units, offering the potential for reliable, carbon-free electricity generation. SMRs are often discussed as a long-term solution for providing continuous power to large loads like data centers, but most designs are still in development and are not yet commercially available. SMRs may be deployed on-site, but may also be used as centralized grid-connected resources.

Energy Procurement and Sustainability

Many sustainability claims relate to financial instruments rather than physical electricity supply, which can create confusion in planning discussions.

PPA (Power Purchase Agreement): A contract to purchase electricity from a generator, which may involve physical delivery or financial settlement.

VPPA (Virtual Power Purchase Agreement): A financial contract in which a company agrees to pay a fixed price for electricity from a renewable energy project while the power is sold into the wholesale market, with the difference settled financially. Because the electricity is not physically delivered to the buyer's facility, a data center may claim renewable energy use through a VPPA while still being served by the local grid mix.

REC (Renewable Energy Certificate): A tradable certificate representing the renewable attributes of one megawatt-hour of electricity generation, used to support renewable energy claims. Purchasing RECs does not change how electricity is generated or delivered locally, but instead affects accounting for emissions and sustainability reporting.

24/7 Carbon-Free Energy (CFE): An approach that seeks to match electricity consumption with carbon-free generation on an hourly basis, which can be more challenging in regions with transmission constraints or limited local clean generation.

Scope 1 / 2 / 3 Emissions: Categories of emissions including direct emissions (Scope 1), purchased electricity emissions (Scope 2), and value chain emissions (Scope 3).

Building Standards and Management Systems

Standards and certifications are often referenced in development approvals, sustainability requirements, or corporate commitments.

ENERGY STAR® (Data Centers): A federal program that benchmarks and certifies energy performance.

LEED® (Leadership in Energy and Environmental Design): A widely used green building certification system.

ISO 50001: An international standard for energy management systems focused on continuous improvement.

EnMS (Energy Management System): The processes and systems used to monitor and improve energy performance.

BMS (Building Management System): A control system used to monitor and manage building equipment such as HVAC and electrical systems.

This glossary was compiled from multiple authoritative sources, including the PJM Interconnection, the Federal Energy Regulatory Commission, the North American Electric Reliability Corporation, U.S. Environmental Protection Agency, U.S. Department of Energy and the national labs, state utility and environmental agencies in Maryland and Virginia, electric utilities, industry associations, and data center industry publications. Definitions have been adapted and simplified to support use by local governments and planning professionals.