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Artificial Intelligence (AI) requires large data centers; these centers are major power consumers, ranging from 20 to 100 MW. In addition to the grid's lack of power generation capacity to meet projected AI power demand, there are policy issues over who funds utility grid expansion and ongoing concerns about the grid meeting AI's critical reliability standards. Data Centers already employ UPS systems and secondary power sources. As such, AI companies are looking at alternative advanced energy systems such as nuclear or geothermal, but to meet their immediate/near-term power requirements outside the Grid, this demand can realistically be met only by engine-driven generator systems, principally diesel, and renewable energy. Also, the load characteristics require Battery Energy Storage Systems (BESS) for UPS and power quality. This information sheet discusses the characteristics of AI Data Center loads and why engine-driven generator systems and BESS are meeting the industry's foreseeable needs for backup power and power quality.

1.0 UNDERSTANDING THE COMPONENTS WITHIN AN AI DATA CENTER:

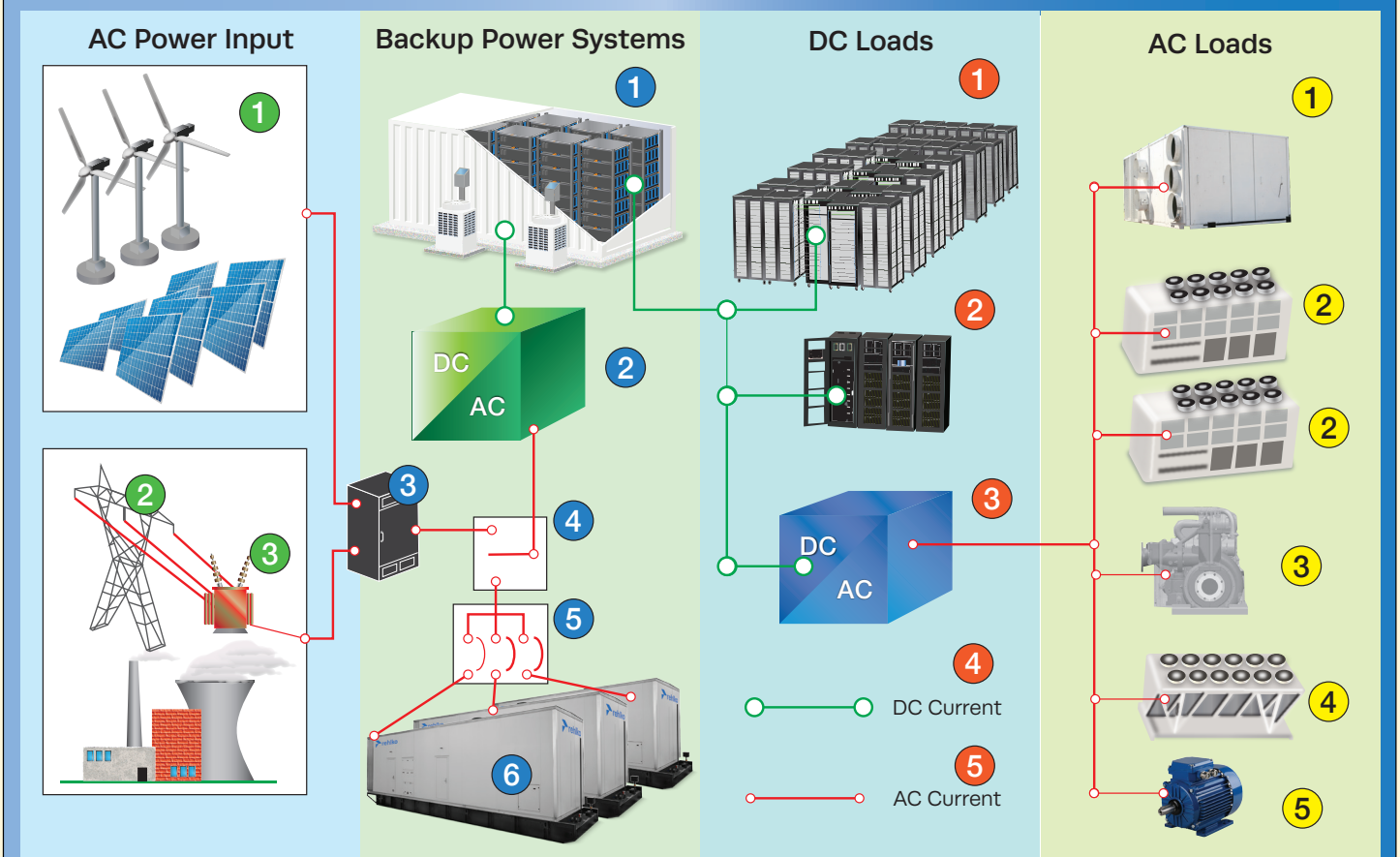
An AI data center, like any major installation, relies on multiple technologies to operate; these include.

1.1 CENTRAL PROCESSING UNITS

At the heart of the data center is the processing units assembled in multiple racks.

While data centers use some Central Processing Units (CPUs), the racks in AI data centers comprise Graphic Processing Units (GPUs). GPUs can perform very fast computations; their parallel processing ability enables them to handle thousands of tasks simultaneously. This is a feature that Large Language Models (LLMs) rely on. LLM refers to a class of AI models trained on copious amounts of data that can understand and produce actual language. *(Continued Over.)*

Figure 1 **Typical AI Data Center Power Supply, UPS System, and DC/AC Connected Loads**



1. Renewable energy sources, wind, and solar
2. Utility grid - fossil, hydro and nuclear
3. Step down transformer

1. BESS - Battery Storage UPS
2. Rectifiers
3. AC power distribution/control
4. Automatic Transfer Switch
5. Paralleling switchgear
6. Standby generators

1. AI LLM chip racks with GPUs
2. CPUs in operating system
3. Inverters converting DC to AC
4. DC current flow
5. AC current flow

1. Air conditioning
2. Chillers
3. Water pumps
4. Dry coolers
5. Other general AC loads

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1.2 RECTIFIERS

The racks containing the GPUs require a 48-volt direct current DC power input. Utility power and most standby power system outputs are alternating current (AC). Rectifiers convert AC to DC. DC power is supplied to the servers, storage systems, and networking equipment. Rectifiers comprise Silicon Controlled Rectifiers (SCRs) and Insulated Gate Bipolar Transistors (IGBTs). Both components produce harmonics (non-linear loads) that can adversely affect engine-driven generator systems.

1.3 BATTERY ENERGY STORAGE SYSTEMS (BESS)

Data Centers are considered critical items; as such, they are subject to various regulations to ensure alternative power is available when the primary power source goes offline. (*See information sheet UL 3223 for data centers*)

In addition to being a standby DC power source, BESS also ensures smooth DC power that GPUs rely upon.

1.3 INVERTERS

While the heart of the AI data center uses DC power, much of the peripheral equipment runs on AC power; inverters convert DC to AC. They are used when the available power comes from BESS or renewable energy sources such as wind, solar, or fuel cells. AC equipment includes building lighting and controls, cooling fans, water pumps, security, etc. (*See information sheet: Inverters in Power Generation Systems*).

1.4 COOLING EQUIPMENT

The processing units generate significant heat. If the GPUs are not adequately cooled, they will stop functioning. Dense chip packing limits airflow and increases heat retention. Consistent cooling is required to prevent hardware damage and reduced life expectancy.

AI data centers can use a considerable amount of water to manage heat from physical computing infrastructure, especially densely packed GPU servers. When an AI data center is proposed, two major factors must be considered: enough power to run the center and enough water to cool the heat generated during chip computation.

2.0 AI DATA CENTER POWER REQUIREMENTS:

As stated, AI data centers need a large amount of power ranging from 20 to 100MW. This level of power is equivalent to powering a small town. Usually, powering the facility from the utility grid is the first option. However, two major issues occur when data centers rely on the utility grid for power:

2.1 THE UTILITY GRID'S CAPACITY TO PROVIDE SUFFICIENT POWER:

In many areas, the utility grid is already struggling to meet existing demand, particularly in summer when air-conditioning loads are high. As the utility grid reaches capacity, it cannot meet the data centers' reliability standards.

3.2 POWER QUALITY:

Data center chips need a very smooth and clean power input. AC power is transformed to DC power via rectifiers. Any distortion in the rectified AC load can cause power spikes outside the chip's tolerance level. (*See information Sheet - The Effect of Nonlinear Loads on Generator Systems*).

3.0 POWER RELIABILITY SOLUTIONS FOR DATA CENTERS:

Data centers that meet UL 3223 reliability requirements use several sources of power for primary and standby power. The industry has increasingly combined engine-driven generator systems with renewable energy solutions, including wind, solar, BESS, and fuel cells.

3.1 PRIMARY POWER:

Primary power is a connection to the utility grid, which is seen as reliable, and/or renewable energy sources. Many installations have adopted a Microgrid system that combines several power sources, particularly renewable ones. This provides independence from the main utility grid. (*See information sheet Micro-grids with Standby Generator Systems).*

3.2 STANDBY POWER USING ENGINE-DRIVEN GENERATOR SYSTEMS:

Engine-driven generator systems, when paralleled, are proving to be the most satisfactory solution for generating MWs of standby capacity when primary power goes offline. Primary reasons for choosing engine-driven systems are:

- **On-site Energy Storage -** On-site fuel storage capacity is calculated to manage the worst-case scenario interruptions.
- **Generation capacity -** Individual 2 to 4MW packages can be easily paralleled to meet MW power requirements.
- **Power On-Demand -** Within a few seconds, total data center power requirements can be brought online.
- **Established Regulations -** Codes for engine-driven standby systems are well established, proven, and documented.

4.0 THE IMPORTANCE OF BESS:

No data center can operate without BESS because it provides the following solutions for power quality and zero power breaks:

- **Uninterruptible Power System (UPS) -** Renewable energy sources, i.e., wind and solar, can fluctuate. UPS ensures no interruption of power and compliance with UL 3223. Engine-driven systems take a few seconds to come online.
- **Power Quality -** Using AC-rectified DC power to float-charge the batteries within the BESS ensures a smooth DC power source to the chips at the heart of a data center. Direct connection to AC generators through rectifiers will not provide the required electrical input power quality. The generator does not have the capacity to absorb non-linear loads.
- **Sized for Total Data Center Load -** BESS provides DC loads directly, but also AC loads through inverters.

To fulfill our commitment to be the leading supplier in the power generation industry, the Buckeye Power Sales team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our Information Sheets are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

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