

Winning the Race to Revenue - Bridge Power Solutions for Data Centers

Abstract/Introduction

The data center industry is experiencing substantial growth, placing increasing pressure on the power grid to meet the rising demand. These facilities require continuous power with zero interruptions and highly reliable backup to minimize downtime. This expansion creates a gap between power demand and grid capacity, lasting months to years. Developers are exploring alternative solutions, known as bridge power, to mitigate these challenges. Reliable bridge power solutions are critical for expediting revenue and enhancing the resilience of mission-critical developments. While this paper focuses on the U.S. region, many trends and applications have global relevance.

This paper will discuss why bridge power solutions are becoming increasingly viable, considerations for developing a bridge power solution, selecting a provider and how to best mitigate risks.

WHAT'S CAUSING THIS INCREASE?

Several important factors drive the increasing power demand of data centers. Firstly, more data centers are being commissioned worldwide, reflecting a growing demand for data processing and storage. These data centers are not only becoming more numerous but also larger in size, with many now measured in terms of megawatts (MW).

The rapid advancement of technologies such as artificial intelligence (AI) and cloud computing further contributes to this surge in power consumption. According to a recent report published by the International Energy Agency (IEA), data centers consumed approximately 460 terawatt-hours (TWh) of electricity in 2022. This figure is projected to exceed 1,000 TWh by 2026, indicating a dramatic rise in energy usage as the demand for data processing continues to grow.

THE PROJECTED GROWTH OF US DATA CENTER DEMAND

As demonstrated in the graph above, U.S. data center energy consumption is expected to keep growing, meaning the capacity problem isn't going away. To keep pace with the widespread adoption of AI technologies and the ongoing digitization of various sectors, data center power consumption could potentially triple by the end of the decade.

THE BOTTLENECK

The supply chain for utility infrastructure development often faces multiple bottlenecks, with permitting being the most significant challenge. This lengthy process involves various government levels and regulatory agencies, taking anywhere from four years to a decade.

Areas that were previously targeted for data center development are rapidly reaching their power capacity limits. In a sector where availability, stability, and reliability are crucial, data centers face numerous power-related challenges. Assisting developers and operators in resolving these issues is essential for continued growth and expansion.

WINNING THE RACE TO REVENUE WITH BRIDGE POWER

Given the challenging position data centers face with utility delays and rising power demand, bridge to grid solutions are an excellent option. Essentially, bridge power fills the gap between when utility-supplied electricity becomes available, and the actual power needs of the business.

So, what is a bridge to grid solution? These solutions can vary greatly in complexity and installation time, consisting of turbines, natural gas generator sets, diesel generator sets, and Battery Energy Storage Systems (BESS). They can be set up in weeks and remain in place for days, weeks, months, or even years. This is ideal given some utilities' 3-7 years' wait times for connection.

Here are some factors to consider when considering a bridge power solution:

1. DURATION

One of the first factors to examine is the length of time from power need to utility availability. The key question is: when can we expect utility power to be available? Accurately assessing the duration for which the bridge solution is needed is vital in determining other components of the power system. For short-term power requirements, reciprocating diesel or natural gas generator sets are typically the most effective option, as they can be quickly mobilized and efficiently provide the necessary energy.

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For longer bridge-to-grid projects spanning multiple months or even years, several alternatives become viable. Solutions may include gas turbines that offer higher efficiency and output, battery energy storage systems that can store and dispatch power as needed, or a combination of reciprocating generator sets. Additionally, a microgrid can provide a versatile approach, incorporating multiple energy sources and enhancing reliability.

2. FUELING THE PRIME MOVER

The next critical consideration is fuel, as it represents one of the most significant ongoing expenses for projects that operate 24/7. The total fuel cost over the lifecycle of a project can quickly escalate, making it essential to choose the right fuel type. For shorter-duration projects (a few days to months), reciprocating engine generators are commonly used, operating on gas or diesel. Diesel is generally favored due to its quick availability and ease of mobilization.

Conversely, natural-gas-fueled reciprocating engine generators have been proven to be highly effective in distributed generation applications. They offer reliable power supply, easy maintenance, and low life-cycle costs. Natural gas is widely available and often has low market prices, making these generators cost-effective.

For longer projects, incorporating gas turbines becomes relevant. They are well-suited for long-term use and can be combined with reciprocating engines to optimize capacity and ensure uninterrupted power supply. This combination leverages the strengths of both technologies for efficient and reliable energy production.

No Pipeline Gas

In situations where natural gas is inaccessible, but the project's duration justifies its use, a virtual pipeline system can be deployed. This system uses a modular approach with Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG), transported via highway, railway, and waterways. Virtual pipelines bridge the gap in areas lacking direct natural gas infrastructure, enabling efficient fuel delivery to remote sites well before a conventional pipeline is built, addressing immediate energy needs while awaiting permanent solutions.

3. EMISSION REQUIREMENTS

Another vital consideration when selecting fuel is the emissions produced during operation. Emission standards can vary based on local regulations, classifying areas as either "attainment" or "non-attainment" under U.S. EPA guidelines. Diesel generators must comply with local and federal regulations, dictating permissible operating hours and emissions limits. Some localities may impose stringent NOx emissions limits for gas engines, as low as 0.5 grams per brake horsepower-hour (bhp-hr).

Project developers must thoroughly research local emissions requirements and engage with permitting authorities early in the planning process. In jurisdictions with rigorous air quality standards, an integrated fuel solution may be necessary to ensure compliance. In these instances, it is highly desirable to pursue technologies that produce lower emissions, aligning with emissions regulations/ requirements.

4. AVAILABLE TECHNOLOGIES

Every site presents a unique opportunity, and navigating local conditions can inspire a fusion of technologies to deliver powerful solutions. Data center owners, operators, and users should stay alert to available and future supplemental energy sources to bridge any power gaps.

See overview of the equipment options you can leverage below.

Diesel Generators: Diesel-powered reciprocating engines deliver prompt and dependable power solutions for data centers, making them an essential component for maintaining uptime during critical operations. These engines benefit from well-established supply chains that ensure consistent availability of parts and service, reinforcing their reputation as a reliable choice for emergency power demands. One of the key advantages of diesel generators is their ability to be mobilized swiftly, allowing for rapid deployment in times of need. Additionally, with a robust network of fueling stations and logistics in place, fuel availability remains strong, ensuring that these generators can operate efficiently when it matters most.

Lean-Burn Gas Generators: Lean burn engines are particularly beneficial for operations that maintain a steady base load, offering a cost-effective solution for continuous energy generation. Their efficiency truly shines in environments with flat base-loading scenarios, where they can effectively mitigate the drawbacks associated with longer startup times. One of the key advantages of lean burn engines is their ability to produce significantly lower nitrogen oxide (NOx) emissions compared to traditional diesel power generation, all while achieving superior fuel efficiency.

Additionally, these engines are equipped with an advanced air-gas management system that not only optimizes combustion conditions but also plays a crucial role in controlling emission levels. This innovation reduces the dependency on costly aftertreatment systems, thus lowering overall operational expenses. Moreover, the higher power density of lean burn engines is a direct result of this optimized air-gas management and combustion process, allowing them to deliver enhanced performance in energy production.

Rich-Burn Gas Generators: Rich burn gas generators are known for their ability to operate at elevated exhaust temperatures and achieve a high level of combustion efficiency. This leads to exceptional load acceptance, which is particularly vital in environments such as data centers, where reliability and performance are paramount.

The innovative design of these generators allows for precise sizing to meet specific operational needs, thereby enhancing system redundancy and overall reliability. When combined with an oxidation catalyst, rich burn gas generators significantly lower emissions, contributing to a more environmentally friendly operation.

Moreover, rich burn gas engines excel in their responsiveness to fluctuating demands. They offer outstanding load acceptance, quick transient response, and the capability to adeptly handle variations in load due to their unique combustion characteristics. This makes them an ideal choice for applications that require consistent and efficient power delivery.

Natural Gas Turbines: Natural gas turbines serve as a prominent choice for bridge power solutions in data center applications, attributable to their reliability, environmental advantages, cost efficiency, and versatility, as well as the relative ease of permitting and compliance.

The consistent supply of natural gas ensures uninterrupted power, which is critical for the operational integrity of data centers. Moreover, the diminished emissions profile associated with natural gas turbines streamlines the process of acquiring air permits and fulfilling environmental regulatory requirements. Additionally, where applicable, natural gas can be integrated into combined heat and power (CHP) systems, which enhance overall energy efficiency by repurposing waste heat for heating and cooling applications. This integration not

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only reduces the demand for supplementary energy sources but also diminishes operational costs.

Collectively, these considerations establish natural gas turbines as a compelling solution for data centers pursuing reliable, cost-effective, and environmentally responsible bridge power alternatives.

Fuel Cells: Fuel cells deliver a highly efficient and environmentally friendly power source, producing significantly lower emissions than many alternative technologies. Their silent operation is a perfect match for those who prioritize sustainability and are focused on reducing their carbon footprint through self-generation. While the installation of fuel cells does demand a certain amount of physical space and an upfront financial investment, their true potential becomes evident, especially in regions characterized by soaring energy costs and progressive regulatory frameworks that favor clean energy solutions.

Battery Energy Storage: Battery energy storage systems (BESS) offer a cutting-edge solution for managing peak power demands in a dynamic energy landscape. By intelligently charging during hours of low electricity consumption and discharging during peak usage times, these systems play a critical role in energy management. They bolster the stability and reliability of data centers and the electrical grid by delivering uninterrupted power to accommodate short-term fluctuations and unpredictable energy demands.

Moreover, BESS can be seamlessly integrated with renewable energy sources, such as wind and solar power, enabling the efficient storage of surplus energy generated during optimal conditions. This stored energy can then be utilized during periods of high demand, thereby reducing dependency on traditional power sources. Additionally, when combined with conventional fossil fuel energy systems, BESS contribute to the creation of a dependable on-site energy supply, ensuring consistent and robust power availability for grid operations.

Balance of Plant: When implementing a bridge power solution for a data center, several balance of plant (BOP) considerations are crucial to ensure efficient and reliable operation. Ensuring a stable and sufficient fuel supply, such as natural gas or diesel, is essential, including adequate storage facilities and reliable delivery logistics to prevent interruptions. Effective cooling systems are necessary to maintain optimal operating temperatures, integrating chillers, cooling towers, and air handling units with the power generation system. Proper electrical distribution infrastructure, including transformers, switchgear, and distribution panels, is needed to manage the power generated. Advanced control systems are required to monitor and manage power generation and distribution processes, optimizing performance and detecting faults. Compliance with environmental regulations involves implementing emissions control technologies to minimize environmental impact. Redundancy in critical components like generators, fuel supply lines, and cooling systems ensures continuous operation even in case of component failures. The bridge power solution must be compatible with existing data center infrastructure, ensuring seamless integration without disruptions. Additionally, the power solution should be scalable to accommodate future growth and increased power demands, with modular systems that can be easily expanded. These considerations help create a robust and efficient bridge power solution that ensures the data center remains operational and meets its performance and sustainability goals.

Metering and Monitoring: Metering and monitoring are critical considerations for a bridge power solution in a data center to ensure efficient and reliable operation. Accurate metering is essential

for tracking energy consumption, fuel usage, and overall system performance. This involves installing high-precision meters at key points in the power generation and distribution network. Monitoring systems are necessary to provide real-time data on various parameters such as power output, fuel levels, temperature, and emissions. Advanced monitoring solutions often include remote access capabilities, allowing operators to oversee the system from anywhere and respond quickly to any issues. Additionally, integrating these systems with data analytics tools can help in predictive maintenance, identifying potential problems before they lead to failures. Effective metering and monitoring also support compliance with regulatory requirements by providing detailed records of operational data. Overall, these considerations help in optimizing the performance, reliability, and sustainability of the bridge power solution, ensuring the data center remains operational and efficient.

UNDERSTANDING THE RISKS

A bridge power solution represents a substantial investment, and like any significant financial commitment, it comes with various inherent risks throughout different phases of the project. These risks can be categorized into several areas:

1. Technology Risks: This includes evaluating the track record of the equipment, its operational efficiency, and its overall reliability. It is crucial to choose proven technologies that can be trusted to perform adequately over the long term.

To effectively mitigate technology risks, it is crucial to assess multiple solutions and thoroughly understand the risks associated with each. Engaging site operators and relevant utility providers in the risk assessment process is essential to determining their risk tolerance. This collaboration ensures that all parties are actively involved and fully comprehend the technologies being deployed, as well as how different technologies across various operational areas can impact one another. Choosing technologies that precisely meet your requirements while minimizing risks is imperative; it will significantly reduce the potential for operational disruptions.

2. Environmental Permitting Risks: Securing the necessary environmental permits can be a complex and time-consuming process. Compliance with regulations is essential to avoid potential legal and financial repercussions.

To prevent delays associated with the permitting process, it is essential to thoroughly understand the regulations that impact the site. As these regulations may differ significantly, it is imperative to comply with the requirements set forth by federal, state, and local authorities. Given the complexity of these regulations, it is recommended to engage with regulatory agencies, local community stakeholders, and environmental organizations. Additionally, utilizing the expertise of a permitting consultant can greatly enhance the overall efficiency and success of the permitting process.

3. Construction Risks: These encompass several factors including the quality of construction, budget adherence, and project timelines. Delays or overages in construction can significantly impact overall project viability.

Developing a well-structured and actionable construction plan is vital for mitigating risks effectively. It is essential to identify and address potential hazards associated with the construction site proactively. Furthermore,

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implementing a comprehensive strategy to manage unforeseen delays and events will help ensure that construction continues without interruption in the face of unexpected circumstances. A robust financial analysis, along with effective change management strategies, is critical for closely monitoring and managing costs associated with the construction process. Lastly, establishing a comprehensive safety plan for all on-site workers is imperative to ensure a safe working environment.

4. Financial Risks: This involves considerations related to debt service and cash flow. Understanding the financial landscape is vital to maintaining fiscal health throughout the project lifecycle.

Before moving forward with any financing options, it is crucial to develop detailed and accurate cost estimates that reflect the true financial requirements of the project. Establishing robust processes for monitoring project scope and costs is essential to ensure that everything stays on track. This includes regularly reviewing economic forecasts to anticipate any changes that could impact the project and keeping a close eye on cash flow to maintain financial stability. Partnering with a supplier who offers a variety of financing tools and strategies can significantly help manage potential risks and provide flexibility in funding options.

5. Property Risks: These are risks associated with physical damage to property and liability concerns that could arise during operation.

Conducting regular site inspections and thoroughly reviewing safety guidelines is crucial for minimizing risk. By consistently adhering to these safety protocols, we create a safer work environment for everyone involved. Additionally, routine maintenance of equipment and testing of safety devices is vital—not only to ensure that your machinery operates efficiently but also to confirm that safety systems will function when needed. By prioritizing these practices, we can protect both personnel and property from unforeseen events as much as possible.

Regardless of whether the project is financed internally or externally, addressing risks upfront is crucial. This can be achieved through contracts that assign each risk to the party best equipped to manage it. The reliability of any power solution depends on rigorous, planned maintenance, which must be included in the financial model from the start to ensure operational success.

Condition monitoring and trending allow for informed, advance repairs, preventing unexpected downtime. Engaging with the local dealer or distributor of the engine or turbine manufacturer ensures routine maintenance and service tasks are performed as needed, often within a fixed, predictable monthly cost program. This maximizes equipment availability and minimizes inactivity.

CHOOSING THE PROVIDERS

To streamline the project, collaborating with an experienced organization specializing in bridge power solutions is advisable. One ideal option is an engine-generator manufacturer, which not only provides a full spectrum of technology choices but also possesses the expertise to deploy these

solutions effectively in critical applications like data centers, where uptime is paramount.

The ideal provider should have a strong track record of installing and servicing comprehensive power solutions, supported by a network of local service technicians. These experts offer a range of services from basic maintenance to detailed long-term service agreements, ensuring sustained performance.

They should also manage the entire project lifecycle, including engineering, procurement, and construction (EPC), while supplying all necessary components such as engines, generators, transformers, switchgear, UPS, fuel treatment systems, and other essential ancillary equipment.

Another crucial aspect is the provider's diverse financing capability. They should understand the specific financial requirements of data center power projects and be able to finance the entire infrastructure, not just the generation equipment. Offering flexible financing programs tailored to unique project needs is invaluable for managing cash flow and ensuring project success.

SUMMARY

As businesses encounter significant delays in securing grid power, they face critical challenges that are intensified by issues like crowded interconnection queues and the phased retirement of traditional power plants. The prolonged wait for grid power could mean businesses incur substantial costs if relocation is necessary.

To meet the surging power demand, companies are exploring alternative solutions like permanent self-generation, bridge power, and enhanced load flexibility. This underscores the need for technology-agnostic strategies and highlights the effectiveness of a holistic solutions approach. In an industry striving to expand data center capacity, adopting these innovative solutions could be crucial for long-term success and competitive advantage.

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