WHITE PAPER

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GLOBAL POWER SUPPLY

THE CASE FOR ON-SITE GENERATION IN THE 500 KW – 5 MW INDUSTRIAL SEGMENT

For facilities operating in the 500 kW to 5 MW range - aggregate processing plants, data centers, manufacturing facilities, oil and gas operations, cold storage, cannabis cultivation, and critical industrial infrastructure - the electric grid is no longer a reliable, cost-effective assumption. This paper makes the case for on-site generation as a prime power strategy, not merely a backup measure.

THE GRID IS NOT WHAT IT USED TO BE

The North American electric grid was designed for a different era - centralized generation, predictable load, and decades of spare capacity. That era is over. Today's industrial power buyer faces a convergence of pressures that make utility-only power strategies increasingly untenable:

- Aging transmission and distribution infrastructure producing more frequent unplanned outages
- Extreme weather events - heat domes, polar vortex incursions, hurricane seasons - stressing regional grids to the breaking point
- Load growth from data centers, EV charging, and onshoring of manufacturing outpacing new generation buildout
- Interconnection queues at regional transmission organizations (RTOs) running five to ten years or longer in congested areas
- Rapidly escalating demand charges and time-of-use rates that disproportionately punish high-load industrial users

For a facility with a 1 MW average load, even a single 8-hour unplanned outage can mean tens or hundreds of thousands of dollars in lost production, spoilage, equipment restart costs, and contractual penalties. The question is no longer whether on-site generation makes sense - it is how quickly you can implement it.

THE INTERCONNECTION PROBLEM

In PJM, MISO, CAISO, and SPP, new large-load applicants routinely wait 4-7 years for a studied and approved interconnection agreement. Even 'simple' distribution-level service upgrades for 500 kW-2 MW facilities can involve 18-36 month timelines when feeder capacity is constrained. On-site generation sidesteps this queue entirely - your project timeline is limited by equipment lead times and permitting, not RTO study cycles.

PRIME POWER, NOT A GENERATOR IN THE PARKING LOT

The most important conceptual shift for facilities evaluating on-site generation is this: a well-designed on-site system is a prime power plant, not a backup generator. The distinction is fundamental to both the engineering approach and the economics.

What Prime Power Design Actually Means

A backup generator is sized for emergency loads, run only during outages, and optimized for cold-start reliability. It runs perhaps 50-200 hours per year. A prime power plant is sized for your actual production load, engineered for continuous or near-continuous operation, and optimized for fuel efficiency, maintainability, and heat rate across the dispatch range. It may run 6,000-8,760 hours per year.

Prime power design requires attention to: part-load efficiency curves (most reciprocating engines achieve best heat rates at 75-85% of nameplate); thermal management and cooling system sizing for continuous duty; fuel supply reliability and pressure regulation; controls architecture for load following and parallel operation; and planned maintenance intervals that do not compromise uptime SLAs.

The Microgrid Topology Advantage

A microgrid adds a layer of intelligence and flexibility that a standalone generator cannot provide. By combining on-site generation with a battery energy storage system (BESS) and a controls layer, a microgrid can:

- Dispatch generation assets in merit order to optimize fuel cost and run-hours
- Absorb motor-start transients and short-duration load spikes that would otherwise require oversized generators
- Provide seamless grid import/export switching without production interruption
- Enable planned maintenance on individual generators while maintaining facility power
- Qualify for grid services programs (demand response, frequency regulation) that generate additional revenue

For facilities in the 500 kW - 5 MW range, a common architecture pairs two or more medium-speed reciprocating gensets with a power-dominant BESS - typically configured at a 2:1 power-to-energy ratio (e.g., 500 kW / 250 kWh) - and a microgrid controller that manages both real and reactive power dispatch. This architecture can provide availability equivalent to N+1 redundancy without requiring a dedicated standby unit.

GENERATION TECHNOLOGY: WHAT MAKES SENSE TODAY

1

Reciprocating Engines (NG)

The workhorse of distributed generation. Units in the 500 kW-2 MW range (e.g., Caterpillar G3516, Jenbacher J620, Cummins QSV91G) are well-supported, widely serviceable, and achieve 38-42% simple-cycle efficiency. Excellent part-load performance. Best suited to continuous and prime power applications.

2

Microturbines (NG)

Capstone and Solar turbines in the 250 kW-1 MW range offer low emissions, minimal vibration, and long service intervals. Lower electrical efficiency (~30%) is offset by high-grade waste heat recovery potential. Well-suited to combined heat and power (CHP) configurations.

3

Industrial Gas Turbines

Simple-cycle turbines from 1-5 MW (Solar Centaur, GE LM series) deliver high power density and are proven in oil and gas applications. Higher CapEx per kW than reciprocating engines; economic at the upper end of the target range where fuel cost and emissions are primary drivers.

4

Linear Generators

Emerging technology with reciprocating free-piston architecture. Very high efficiency potential (>50% electrical), minimal moving parts, and fuel-flexible. Companies including Mainspring Energy are deploying 250 kW units. Excellent fit for sites with renewable gas (RNG, biogas) fuel sources.

5

Fuel Cells (SOFC/PAFC)

Bloom Energy, FuelCell Energy, and Doosan offer MW-class systems with grid-quality power and near-zero NOx. High CapEx is offset by exceptional fuel efficiency (>60% LHV), very high uptime, and incentive eligibility. Strong fit for sites with 24/7 base loads and clean energy mandates.

6

Diesel (Backup/Peaking)

Diesel remains the most cost-effective option for true emergency backup due to low CapEx and energy-dense fuel storage. Not recommended as prime power due to fuel cost, emissions constraints, and CARB/EPA Tier 4 compliance complexity for extended run-hour applications. Major exception for remote installations without a natural gas supply, e.g., islands.

A NOTE ON SOLAR AND WIND

Photovoltaic and wind generation are viable contributions to an on-site generation mix, but they are not a standalone prime power solution for industrial loads. Land requirements are substantial - a 1 MW PV array requires 5-7 acres - and intermittency means a full thermal backup capacity must still be maintained. In constrained urban or industrial sites, thermal generation in the 500 kW - 5 MW range typically delivers better $/kW and $/kWh economics without land constraints. Where solar is incorporated, it functions best as a fuel offset layer on top of a thermal prime mover foundation.

RESILIENCE: ENGINEERING BEYOND THE OUTAGE CHECKLIST

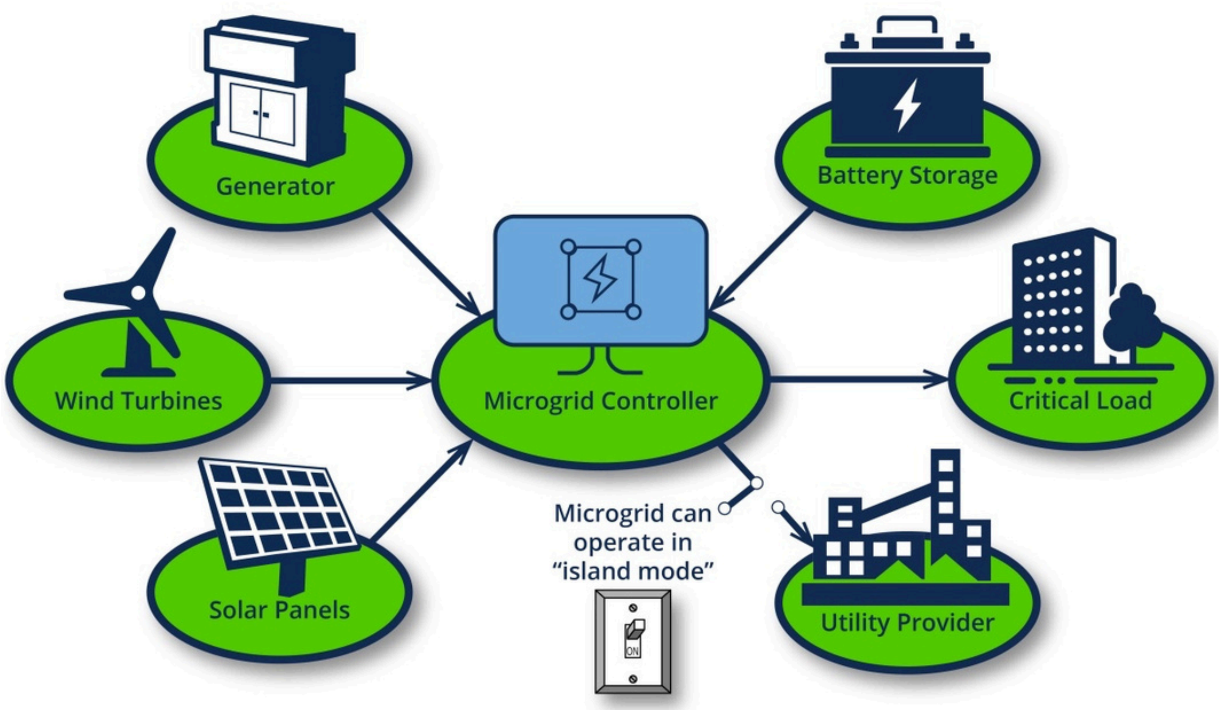
Blackout and Brownout Exposure

Facilities in regions with aging distribution infrastructure - much of the Gulf Coast, parts of the Southeast, the upper Midwest, and rural areas throughout the country - are subject to elevated outage frequency. Utilities are required to file outage data with state commissions, and SAIDI (System Average Interruption Duration Index) figures in excess of 200 minutes per year are common in these regions. For a facility with $500K/hour in production value, a 200-minute annual outage exposure represents $1.67M in unprotected risk, not to mention additional lost production due to start-up times following an uncontrolled shutdown.

Brownouts - sustained voltage depression below 95% nominal - are equally damaging and less visible. They cause motor overheating, reduced torque, shortened insulation life, and nuisance trips on sensitive equipment. A microgrid with on-site generation operates on its own voltage reference, eliminating brownout exposure entirely during islanded operation.

Island Mode and Black Start Capability

A properly engineered microgrid can island from the utility grid and maintain facility power with no interruption during a grid disturbance. This requires grid-forming capable generation - either a generator with fast governor response or a BESS operating in voltage-source mode - and a transfer scheme that detects grid abnormalities and executes controlled islanding within one to two cycles. These are solved engineering problems at the 500 kW - 5 MW scale, and the controls hardware to implement them is mature and commercially available from multiple vendors.



ECONOMICS: THE TOTAL COST OF UTILITY DEPENDENCE

On-site generation projects are often evaluated only on capital cost, which systematically understates their value. A complete economic comparison between utility service and on-site generation must account for the following cost categories:

1

Energy cost ($/kWh)

Industrial tariff rates vary from $0.06 to $0.18/kWh depending on region and rate class. On-site NG generation typically delivers power at $0.07–$0.11/kWh all-in, including fuel, O&M, and capital recovery—and that cost is largely within your control.

2

Demand charges

Many industrial tariffs include demand charges of $10–$25/kW/month on peak demand. A 1 MW facility can incur $120K–$300K annually in demand charges alone. On-site generation with peak shaving eliminates or sharply reduces this exposure.

3

Interconnection & service upgrades

New utility service to a 1–5 MW load can cost $500K–$5M+ depending on distance from substation and distribution infrastructure upgrades required. On-site generation may eliminate or defer this entirely.

4

Outage losses

Lost production, equipment restart costs, spoilage, contractual penalties, and customer attrition. These are facility-specific but typically dominate the economic case in production-critical environments.

5

Rate escalation risk

Utility rates have increased at 3–5% per year historically. On-site generation locks in fuel cost exposure, which can be partially hedged through fixed-price gas supply agreements.

6

Stranded capacity fees

Some utilities assess capacity charges on large customers that are not eliminated even when the customer generates on-site. These vary significantly by jurisdiction and tariff structure and require careful analysis.

OWNING YOUR ENERGY FUTURE

There is a strategic dimension to on-site generation that transcends the spreadsheet. When you own your generation, you control your energy cost structure. You are not subject to utility rate cases, fuel adjustment clauses, infrastructure cost pass-throughs, or the policy decisions of a regulated monopoly. You make the capital allocation decisions, you choose your fuel supply counterparties, and you determine your maintenance philosophy.

Energy as a Competitive Advantage

In energy-intensive industries - aggregate and mining, industrial food processing, cold chain logistics, semiconductor fabrication - energy is a direct input cost. Facilities that control their energy cost structure at $0.07-$0.09/kWh compete differently than facilities paying $0.14-$0.18/kWh on industrial tariffs. In industries with thin margins and commodity pricing, that delta can determine whether a facility is profitable.

Positioning for Future Fuel Flexibility

Natural gas reciprocating engines and fuel cells that operate today on pipeline gas are increasingly capable of accepting renewable natural gas (RNG), biogas, or hydrogen blends. Facilities that invest in on-site generation infrastructure today are building the platform on which they can transition to lower-carbon fuels as those markets develop - without re-engineering their power plant from scratch.

Policy Tailwinds for Thermal Generation

The regulatory and policy environment in 2024-2026 has become meaningfully more favorable to dispatchable thermal generation. FERC Order 2023 reforms and reliability concerns at the regional level have elevated the standing of firm, controllable generation relative to intermittent resources. Permitting reform efforts at both the federal and state level have reduced timelines for natural gas infrastructure. Many states with historically aggressive renewable portfolio standards have introduced reliability carve-outs that effectively preserve the role of dispatchable NG generation in the resource mix. This is a favorable environment in which to make a long-term investment in NG-fired on-site generation.

IS ON-SITE GENERATION RIGHT FOR YOUR FACILITY?

Not every facility is an ideal candidate. The following factors are most predictive of a compelling project economics case:

- Average load above 500 kW with a load factor above 50%
- High cost of unplanned downtime - production-critical processes, cold chain, continuous manufacturing
- Location in a region with elevated outage frequency, long interconnection queue, or constrained distribution infrastructure
- Access to natural gas at the facility or on an adjacent pipeline with available capacity
- Significant demand charge exposure on current utility bill
- Capital budget available for a 4-8 year payback infrastructure investment
- Operational team with capacity to manage or contract for ongoing generator O&M

If your facility meets three or more of these criteria, a preliminary feasibility study is warranted.

Next Steps

Facilities that meet three or more of the qualifying criteria above are strong candidates for a preliminary feasibility study. A well-structured feasibility study for a 500 kW–5 MW project can typically be completed in 4-8 weeks and will deliver enough data to support a go/no-go capital allocation decision with confidence. It should begin with a utility bill analysis and 15-minute interval load data review, followed by technology selection, indicative equipment pricing, and a preliminary pro forma financial model.

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