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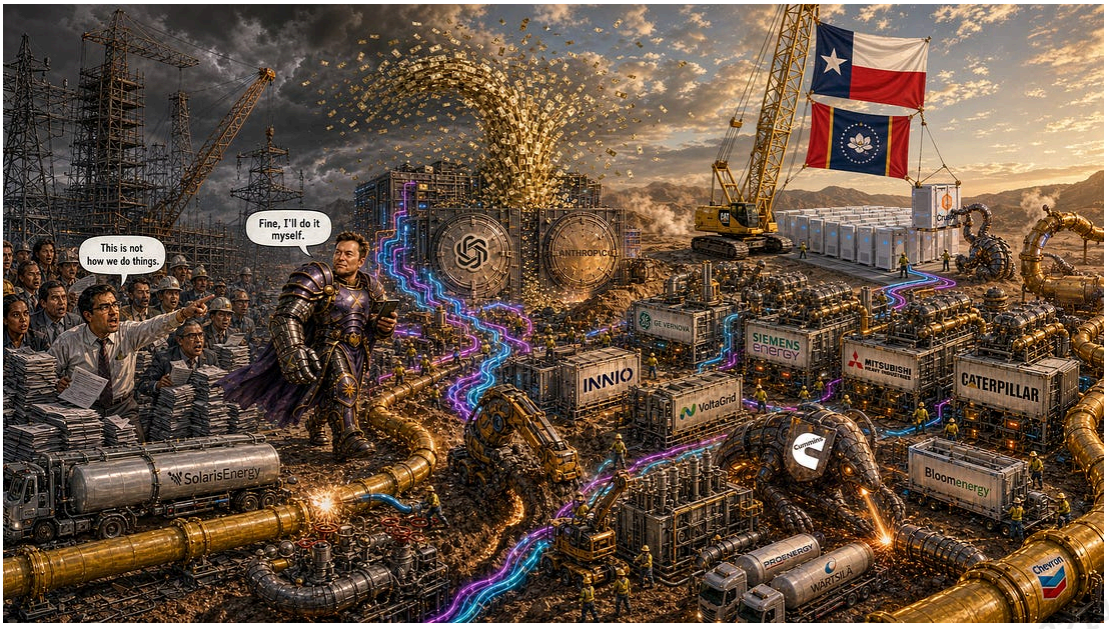
What is So Hard About Behind-The-Meter Power For Datacenters? Part 1

Dumb Science Experiments vs. Money Printing Machines

ELLIE HOLBROOK, ROBERT BOSWALL, JEREMIE ELIAHOU ONTIVEROS, NICOLAS BONTIGUI, AND DYLAN PATEL

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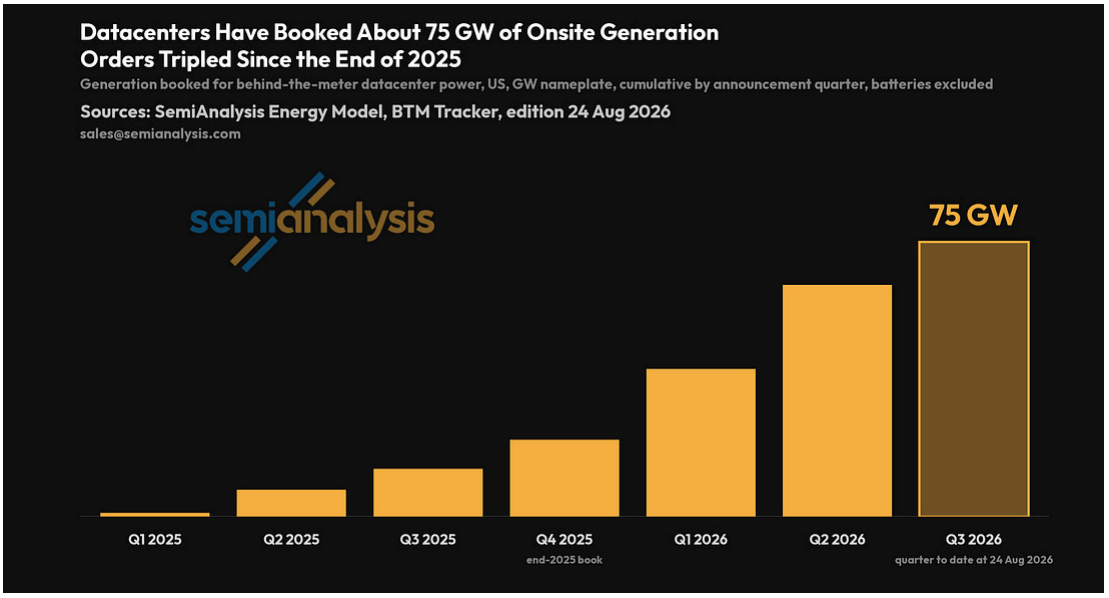


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Last year we were the first to call out Onsite Gas Generation as the primary method adopted by AI Labs and Hyperscalers to solve power constraints. Our positive view

was far from being consensus: behind-the-meter primary power solutions have been called all sorts of names, such as “science experiments”, “Dark Gigawatts”, and “literally the dumbest thing that human beings have ever attempted to do”!

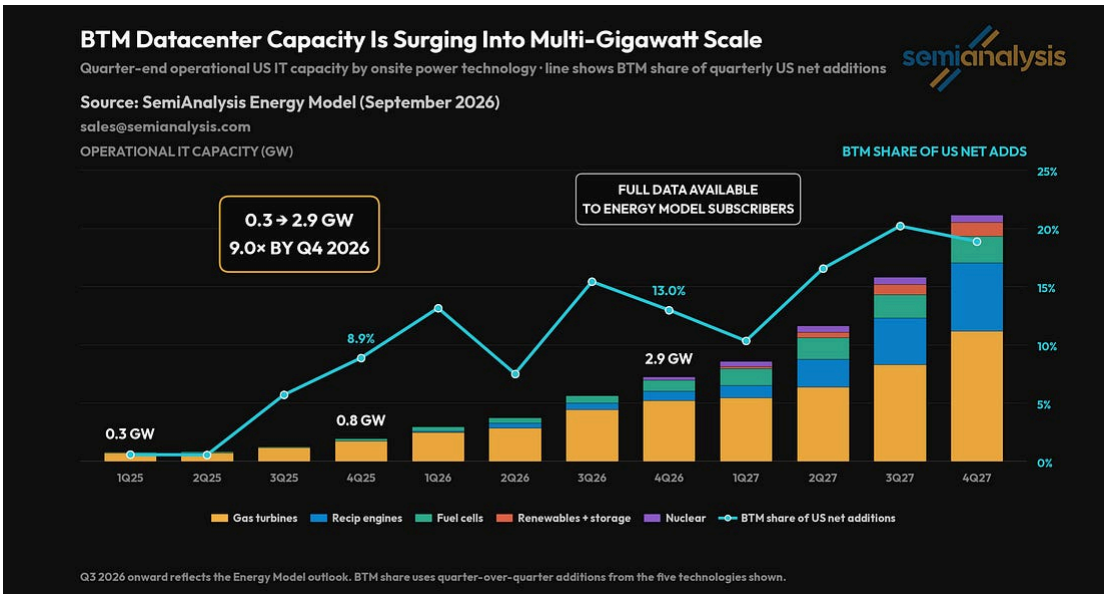
But since then, that supply chain has witnessed a massive acceleration. Our Energy Model now tracks 75GW of firm, binding orders in the supply chain **only for for behind-the-meter AI compute** - of which ~20GW alone ordered in Q2 2026. What started as an Elon Musk experiment is now mainstream for every single AI Lab and hyperscaler. To be clear, this data does not include the hundreds of GWs of speculative, baseless announcements that many other analysts track in their numbers - we only focus on binding orders received by OEMs specifically serving BTM AI compute, tracked at the project-level.



Sources: SemiAnalysis Energy Model; sales@semianalysis.com

The path from firm equipment order to delivered project is still long and challenging. There is substantial execution risk and that’s what we’ll focus on in this report. But the industry is more experienced than you’d think: by the end of the year, ~3GW of operational US datacenter IT capacity will be powered behind-the-meter, and that number will experience multiple straight years of triple-digit growth. Our Energy and Datacenter models account for all potential delays, as we’ve explained in depth in our piece Stop Saying Half of 2026 US Datacenter Capacity is Canceled.

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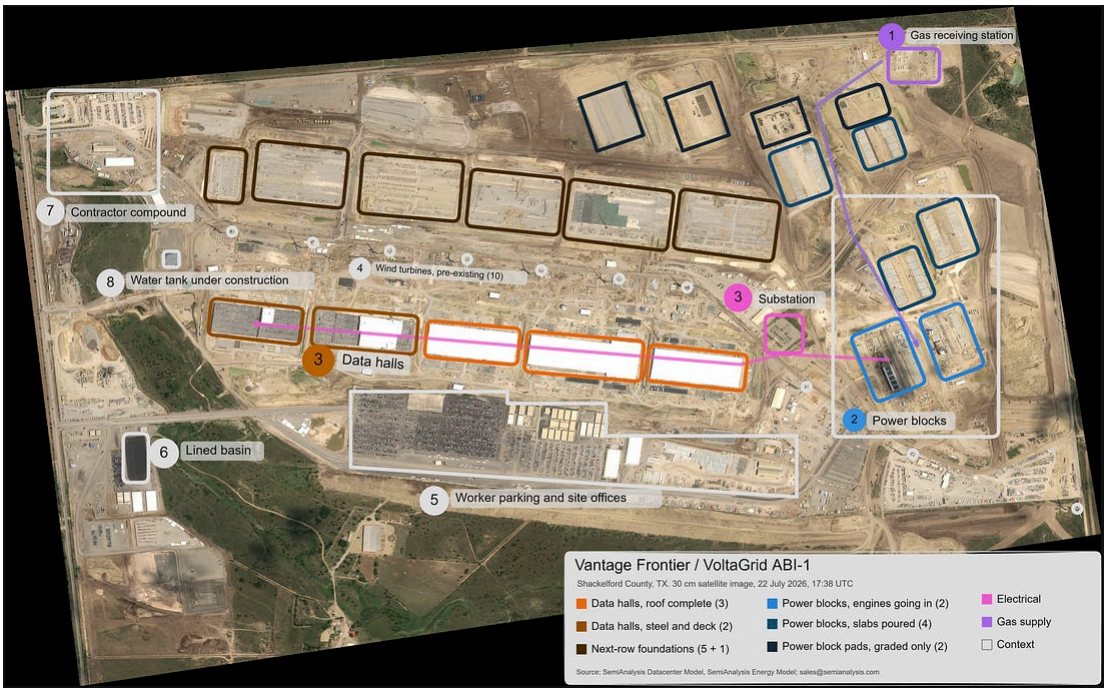


Source: SemiAnalysis Energy Model, sales@semianalysis.com

Some of the most strategic projects developed by leading AI labs and hyperscalers are relying on behind-the-meter, supporting hundreds of billions of future revenue. Adoption has never been more broad-based. A few examples:

- In 2026 year-to-date, Microsoft has signed over 5GW of behind-the-meter nameplate capacity, of which 2.7GW with Chevron, and well over 2GW through turnkey datacenter leases with companies like Crusoe. That 5GW encompasses a broad range of different types of power equipment; full breakdown available to our Energy Model subscribers.
- Google, historically the most reluctant to onsite gas, is deploying 930MW of off-grid aeroderivative turbines in a flagship campus in Armstrong County. In addition, the Search Giant will deploy 900MW of Bloom Energy Fuel Cells in Wyoming - as we called out back in February 2026 as a huge positive for Bloom Energy. They'll be paired with >1GW of Mitsubishi J-class turbines.
- Both Anthropic and Meta have signed 300-500MW deals with Enchanted Rock, a supplier of 0.5MW gensets built around a 21.9-liter V12 gas engine. Separately, Anthropic's flagship campus in Texas, backstopped by Google, will also deploy over 1.5GW of off-grid generation; full breakdown of Anthropic's exact datacenter facilities available to our Datacenter Model subscribers.
- OpenAI will imminently start operations in its flagship off-grid 1.4GW (IT capacity) campus in Shackelford County, TX, using over **five hundred 4.25MW Jenbacher J624 engines**. We show below a portion of the campus. Combined with their 1.3GW IT site in New Mexico, that represents over $150B of contracted spending that OpenAI signed with Oracle relying on behind-the-meter power.

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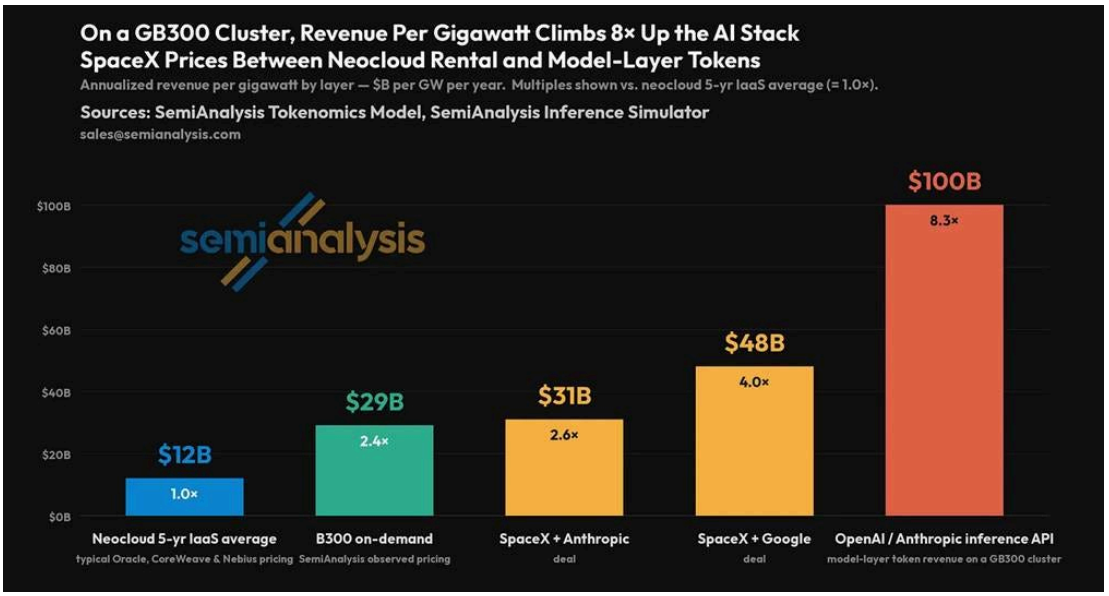


Sources: SemiAnalysis Datacenter Model; SemiAnalysis Energy Model; Sales@semianalysis.com

Why is this happening, and why have many energy experts been so wrong? It comes down to understanding AI economics. We've discussed this at length in many other articles and in our Tokenomics Model. As a quick reminder, the value of megawatts for end-users is skyrocketing. A power plant supporting an islanded 1GW IT datacenter typically costs ~$5B. In today's environment, **inference API revenue can yield $100B per GW per year, at 90%+ gross margins.** Paying 2x more money or accepting 30% lower efficiency for faster speed of deployment becomes a no-brainer**.** Said differently, **Anthropic and its peers can pay back the value of a power plant in 20 days of inference revenue**. As we discussed six months ago, most of the value in the AI infrastructure stack is shifting to frontier model developers.

The grid simply cannot keep up with demand. Building new generation can easily take over five years, and on the demand-side, interconnecting a datacenter takes years. Read more in our article on US Grid Constraints.

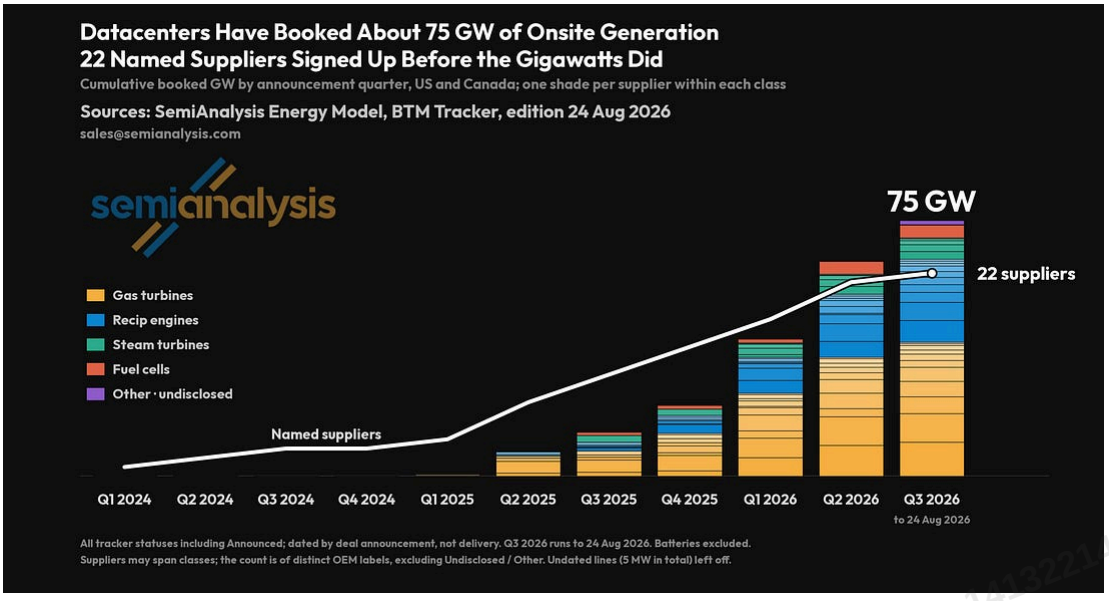
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Sources: SemiAnalysis Tokenomics Model; SemiAnalysis Inference Simulator; sales@semianalysis.com

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That market context is overwhelmingly positive for behind-the-meter power to overcome such constraints. But these datacenter onsite power solutions are increasingly divergent from their grid-connected peers. As predicted a year ago, winners have not only been the incumbents like GEV and Siemens Energy. The biggest beneficiaries have been the dozens of suppliers of reciprocating engines, of various shapes and forms, with solutions from 0.5MW per unit to 20MW per unit being adopted at scale. A year ago, we counted 12 distinct manufacturers that had secured multi-hundred-MW datacenter off-grid orders; but today that count is 22 and will continue to grow. Our Energy Model tracks quarter-by-quarter manufacturing capacity, orders, deliveries, and availability for over 30 OEMs.



Sources: SemiAnalysis Energy Model; sales@semianalysis.com

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While the bright side of this is innovation, the flip side is the looming execution challenges facing the industry. Many of these things have never been done at this scale or speed. Cracks are starting to emerge. Permitting delays have caused high-profile sites, like Oracle Project Jupiter and Nebius New Jersey, to perform emergency pivots to less polluting alternatives (Bloom fuel cells). Pipeline delays have also impacted Oracle's 1.3GW IT Project Jupiter (as our Energy Model called out in May 2026, well before the headlines). Market chatter of reliability issues is increasingly frequent. Labor shortages are surging. Design and up-time considerations are challenging and slowing down some FIDs. A secondary market for turbines is starting to emerge as a result of firm orders tied to failed projects.

In today's report, we dive into the world of "datacenter microgrids". We consider the challenges and doubts regarding the BTM buildout and look at how it is being done.

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1. **What** even is 'Behind-the-Meter'. Detailing the ways a datacenter can relate to the grid, between primary and back-up power; including when something is a phony microgrid. How does one define behind-the-meter?
2. **How** projects succeed or fail. We lay out the six key stages & challenges of BTM projects: contracts & bankability, permitting, fuel supply, equipment procurement, workforce, and the physics of operating without a grid-connection. We start with the financing wall, with chicken-and-egg situations being increasingly common for developers, and the rise of the new "BTM utilities".
3. **Where** we go from here. 'To grid or not to grid'; what happens to these plants when grid power finally arrives; export-to-grid, stay primary power, become backup, or move elsewhere. At the same time what happens with these order books and the manufacturing capacity that has scaled so hard to meet the moment. We'll also give our view on the implications for BTM in Texas.

Over recent months we have published significant research for our Energy Model clients, laying out winners & losers in the equipment landscape (turbine, recips, fuel cells), contractors like AGX, BoP equipment like MV UPS systems and how new LVRT regulations could have negative impact to certain huge industrial companies. Behind the paywall of this report, we have included some of this work for Substack subscribers now to enjoy.

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> Conferences: in September members of SemiAnalysis' Energy Model team will be at Gastech in Bangkok 14-17th; Data Center World Power in Dallas 21-23rd;

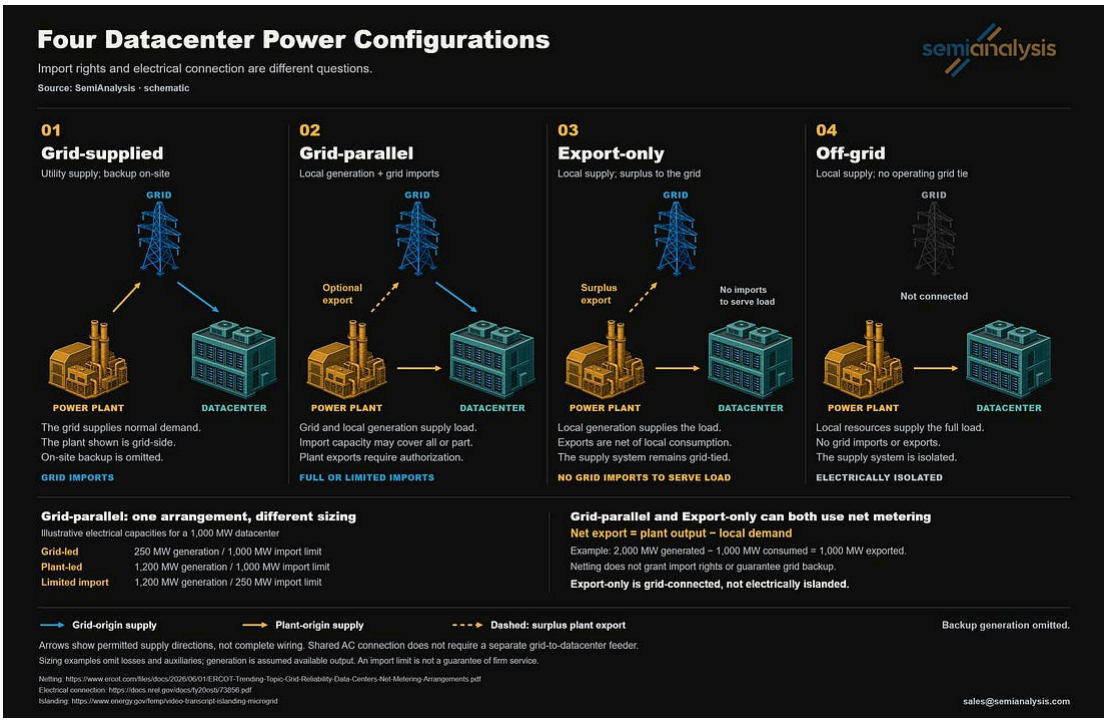
> Yotta in Las Vegas, and Gulf Coast Power Association in Austin, both 28-30th. Email energy@semianalysis.com and lets talk power!

What even is “BTM”?

A meter is a device that counts electricity; it is stationed at the point where the project’s wires meet the grid’s wires. Everything on the grid side of that point, the substations, the pylons, the power plants, is “front of the meter”; everything on the project’s side, the switch-gear, the batteries, and onsite generators, is “behind the meter”.

There are then specific terms but in practice they get used interchangeably: “behind-the-meter”, “off-grid”, “islanded”, “co-located”, and “micro-grid”. This is frustrating and leads to common disagreements over the definitions, but one way to think about them is by connection configuration:

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Source: SemiAnalysis

1. **Grid-supplied:** The grid supplies the datacenter; on-site generation is backup only. Power plants supply the public network, which supplies the datacenter.
2. **Grid-parallel:** Local generation and grid imports can both supply the datacenter. Exports are optional depending on the rights and connections.
    a. The relative sizes of the datacenter, its local generation, and its permitted grid imports can vary substantially. ERCOT’s Withdrawal-Limited Private

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Use Network, or WLPUN, framework expressly accommodates on-site generation reducing the transmission capacity a large load requires.

b. Consider three illustrative configurations, each serving a **1,000 MW datacenter**:

   i. **Grid-led:** 250 MW of local generation and a 1,000 MW import limit. Local generation offsets part of grid consumption; when producing 250 MW at full datacenter load, it leaves 750 MW to import.

   ii. **Plant-led, full-sized import connection:** 1,200 MW of local generation and a 1,000 MW import limit. The plant can cover normal demand, while the import limit is large enough to accommodate the entire datacenter load.

   iii. **Plant-led, limited import connection:** 1,200 MW of local generation and a 250 MW import limit. At full load, at least 750 MW must come from local resources. Losing all local generation would require replacement supply or at least 750 MW of load reduction.

3. **Export-only:** Local generation supplies the datacenter; the grid connection permits exports but not imports to serve the load.
4. **Off-grid:** Local generation supplies the datacenter without an operating grid connection.

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Net metering

In this context, net metering means netting the datacenter's consumption against associated generation at the relevant grid-facing metering or settlement boundary. ERCOT describes it as reducing the customer's metered consumption from the grid; it is not necessarily the retail rooftop-solar arrangement that credits exports against consumption over a billing cycle.

Freestone is an example: ERCOT reports PUCT approval in May 2026 of an arrangement between a 1,099 MW gas plant and a 760 MW datacenter in Freestone County.

Why Export-only is not Off-grid

The datacenter does not need a separate grid feeder to remain electrically connected. If its supply circuit connects into the plant's grid-connected AC system, it is connected to the grid through the plant; the site participates in the interconnection's frequency dynamics and shared inertial response even while exporting net power. Depending on how well run the grid is this arrangement can be beneficial to the datacenter with improved electrical reliability and quality.

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Existing generation adds a regulatory distinction

Regulators can also distinguish new generation from a plant that previously supplied the grid. Texas Utilities Code §39.169, “Co-location of Large Load Customer With Existing Generation Resource,” covers certain net-metering arrangements involving an operating facility registered as a stand-alone generation resource **as of September 1, 2025**; it requires ERCOT notification and PUCT review, subject to exemptions and a deemed-approval provision.

Diverting existing output to a new load can reduce supply available to the wider grid. ERCOT says the two netting arrangements approved by May 2026 required the datacenters to reduce consumption or switch to backup, and the plants to return their full output to the grid within 30 minutes of an ERCOT instruction.

Operating states and deployment: island, bridge power, grid as backup

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“Islanded” is an operating state: a grid-connected datacenter opens the breaker and runs on its own generation. Then related but separate, the Department of Energy defines a “Microgrid” as “a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid,” and its Grid Deployment Office adds that a microgrid “can operate in either grid-connected or in island mode, including entirely off-grid applications”. In this piece, “islandable microgrid” means a grid-connected site that can separate; “off-grid microgrid” means a site with no connection at all. Many BTM projects use the term loosely, perhaps because it avoids saying “gas”.

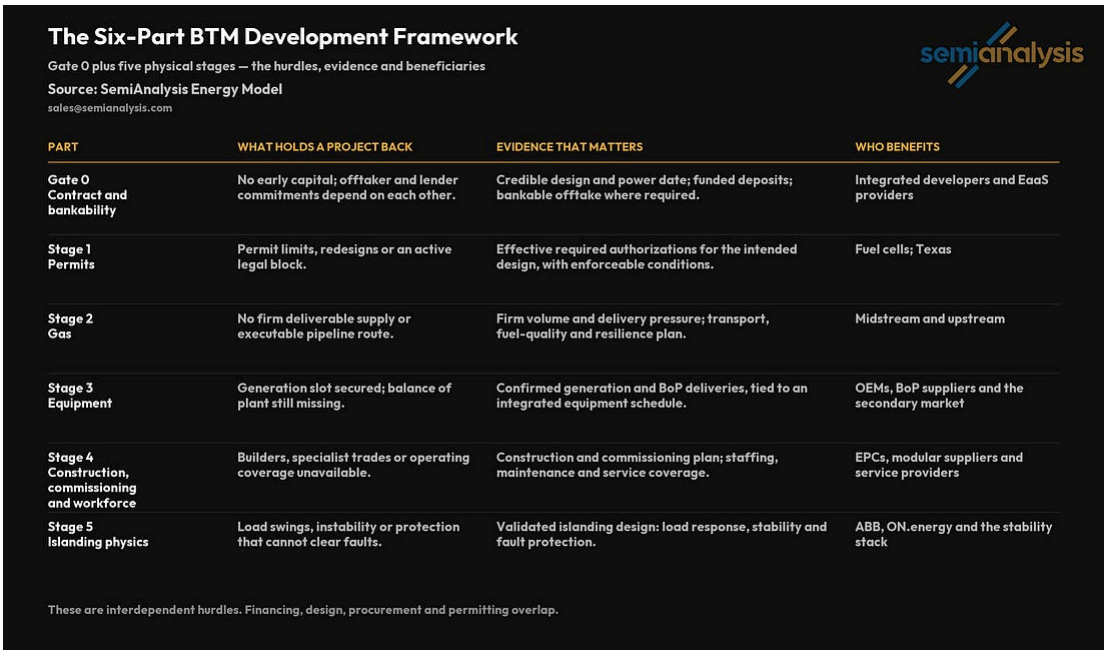
In practice, this may change a lot over time. Many BTM projects plan for a grid connection and use BTM as a “bridge” - once the utility delivers the connection, the generators can shift into a backup role. We described this in depth the Onsite Gas Deep Dive as the most popular approach because electricity systems benefit from substantial economies of scale in both cost and reliability. xAI’s Colossus 1 in Memphis has taken this route.

Other projects plan for a grid connection that will serve as “backup”, i.e. as a new energy resource that will help increase the expected uptime. We’ve seen projects planning for 2 or 3 “nines” of expected uptime while in full island mode, and adding an additional “nine” once grid-connected. We’ll provide more thoughts behind paywall on how many BTM plants will become grid-connected in coming years.

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Why is Building BTM So Hard?

A turbine order and a nearby pipeline do not make a project. Between the press release and first power stand six key hurdles: contract & bankability, permits, fuel, equipment, workforce, and electrical physics. Our permit-level tracking shows booked capacity facing difficulties at nearly every one of them.



The Six-Part BTM Development Framework

Gate 0 plus five physical stages — the hurdles, evidence and beneficiaries

Source: SemiAnalysis Energy Model

sales@semianalysis.com

PART	WHAT HOLDS A PROJECT BACK	EVIDENCE THAT MATTERS	WHO BENEFITS
Gate 0 Contract and bankability	No early capital; offtaker and lender commitments depend on each other.	Credible design and power date; funded deposits; bankable offtake where required.	Integrated developers and EaaS providers
Stage 1 Permits	Permit limits, redesigns or an active legal block.	Effective required authorizations for the intended design, with enforceable conditions.	Fuel cells; Texas
Stage 2 Gas	No firm deliverable supply or executable pipeline route.	Firm volume and delivery pressure; transport, fuel-quality and resilience plan.	Midstream and upstream
Stage 3 Equipment	Generation slot secured; balance of plant still missing.	Confirmed generation and BoP deliveries, tied to an integrated equipment schedule.	OEMs, BoP suppliers and the secondary market
Stage 4 Construction, commissioning and workforce	Builders, specialist trades or operating coverage unavailable.	Construction and commissioning plan; staffing, maintenance and service coverage.	EPCs, modular suppliers and service providers
Stage 5 Islanding physics	Load swings, instability or protection that cannot clear faults.	Validated islanding design: load response, stability and fault protection.	ABB, ON.energy and the stability stack

These are interdependent hurdles. Financing, design, procurement and permitting overlap.

Source: SemiAnalysis Energy Model; sales@semianalysis.com

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Gate 0: Contract and Bankability

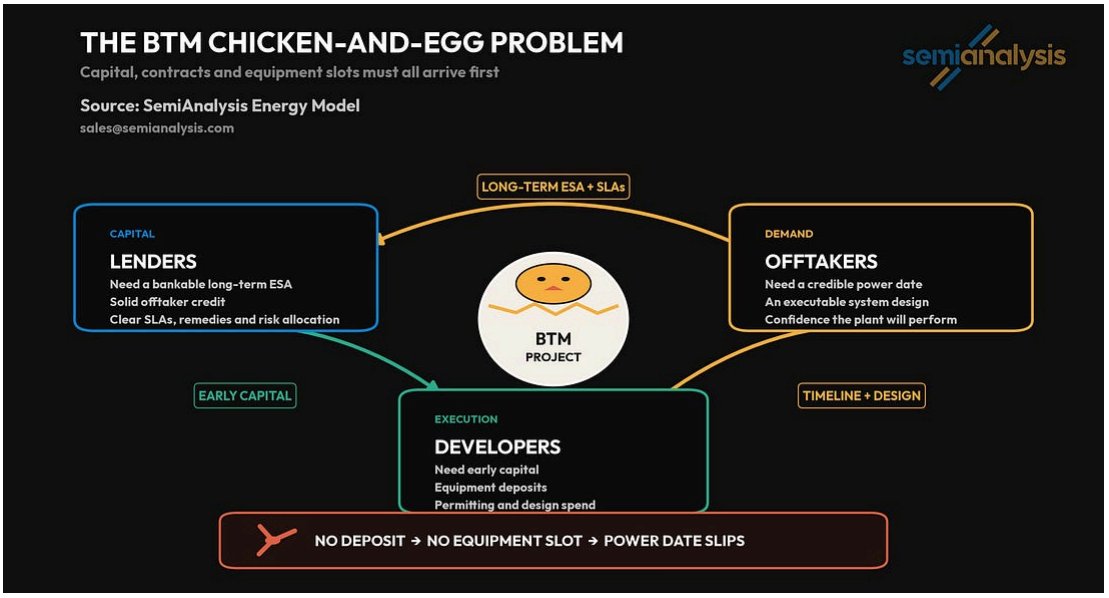
Below, we'll discuss all the physical challenges in bringing online GW-scale islanded datacenters. But before getting there, there's perhaps an even bigger challenge: the financial one. Traditionally, one can connect to the grid very cheaply, with both interconnection requests and letter of credits being very modest. This was enough to develop credible sites, even at GW-scale, and led to a frantic search for power in the US and worldwide. It was easy to turn a quick profit with limited capital, i.e. a few million at most. We discussed this at length in our Onsite Gas Deep Dive, and our US Grid Constraints articles.

Islanded datacenters are fundamentally different because there is no existing infrastructure to connect to. With power plants typically at ~5B per GW of IT capacity, and equipment deposits increasingly expensive, the upfront capital expenditure blocks many projects.

This leads to the classic BTM chicken-and-egg problem: lenders want a long-term ESA with a solid offtaker, and clear SLAs and other contractual terms. Offtakers want a credible timeline and project system design. Developers need early capital to pay for equipment deposits to provide that credible timeline and design. And with the

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insatiable demand for gas generation equipment, not having that capital means that timelines keep slipping.



Source: SemiAnalysis

Early successes have come in three forms:

1. Full vertical integration, the Musk playbook: as discussed at length in our Colossus 2 article, xAI built its own power plant for self use, seeing it as the fastest way to build compute. This was most likely equity-funded.
2. Full-scope datacenter developers: certain developers have both construction and energy in their core capabilities, and take responsibility for the BTM power plant when selling to hyperscalers. In a Yield on Cost model, they typically include the onsite power in the cost envelope - which then commonly crosses the $20M/MW mark. Full site-level details in our Datacenter Industry Model.
3. Datacenter + power partnership: datacenter developers go-to-market together with power developers to sell a site to a hyperscaler. But the hyperscaler signs two separate contracts: one for the datacenter, one for power. Certain Oracle Stargate sites are built on such arrangements. The joint go-to-market means that the offtaker is offered a full-stack solution. But the main drawback is dealing with more parties, and facing a risk of paying stranded expenses if either the power or the datacenter are late - given the contracts are independent of each other.

For BTM power, all of that complexity has led to the development of a new type of service providers: Energy-as-a-Service (EaaS) vendors. These are the new “BTM utilities”. Companies such as VoltaGrid deliver power, not just equipment, under long-term contracts with guaranteed capacity and up-time commitments. EaaS can do

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everything from leasing gensets to trucking compressed natural gas to site as ‘virtual pipelines’ while permanent power plants and actual pipelines are permitted, built, and commissioned.

VoltaGrid has proved to be one of the winners of that trend, landing multiple gigawatts of orders with top tier developers like Vantage Datacenters. Others like Williams, Solaris are also on the rise and have scored massive contracts. Separately, some manufacturers are increasingly doing that themselves, such as Bloom Energy and Enchanted Rock. We track all of the supply chain, EPCs, BESS/SynCon and such for hundreds of projects in our Energy Model.



Source: VoltaGrid

Does this capital wall mean that BTM is structurally disadvantaged versus the grid? ***It used to, but it’s not anymore***. US Grid constraints are playing out in real-time, in two ways:

1. With firm US grid headroom being exhausted, serving a new GW-scale datacenter requires GW-scale generation paired with it. Capital requirements are commonly in the multi-billion-dollar-per-GW range today. Cheap GW-scale interconnections do not exist anymore.
2. Most utilities are notoriously slow and unreliable, and grid ESAs typically aren’t as binding and don’t have as many penalties as a BTM contracts in case of late delivery or uptime issues. It makes sense, they’re very different contracts in nature. As such, for GW-scale projects where speed and credibility of execution matters, BTM is an increasingly competitive play.

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Therefore, we view the financing environment increasingly favorable towards BTM. In addition, datacenter developers are getting more sophisticated on energy and building their own world-class teams, and increasingly offering a full turnkey scope to offtakers, including the BTM plant.

Stage 1: Permits

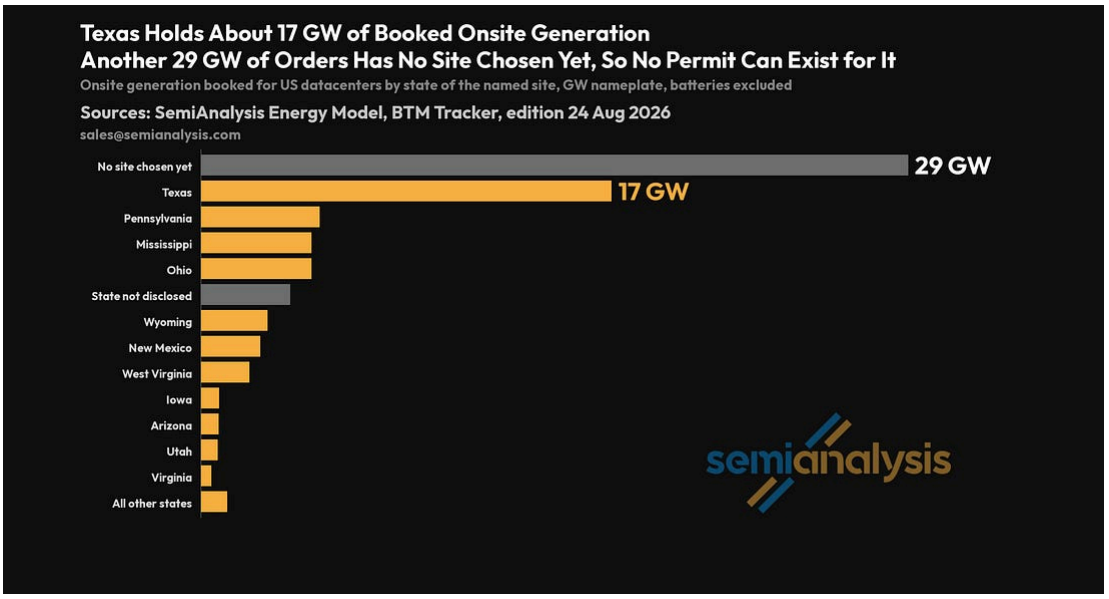
The State Decides

With that said, let's now tackle the physical challenges, starting with permits. We warned in the Onsite Gas Deep Dive that getting an air permit for onsite generation can take a year or more even in the fastest states, and that permits were already delaying some projects. In this section, we outline the varying permitting intensity by state, and how some developers have come up with creative solutions to circumvent permitting blockers.

The first decision is therefore where to file. Finding favorable regions is paramount, and if you are not sure then you can hedge your bets by locating on a border. Colossus 2 sits on Tulane Road in Memphis, Tennessee, a few hundred meters north of the Mississippi border. Its power plant sits on the other side, on a former Duke Energy site in Southaven that an xAI affiliate bought in July 2025. That moved the air permit out of Shelby County, which had permitted the Colossus 1 turbines, and into Mississippi. Mississippi let the turbines run for up to 12 months as "temporary" units with no air permit, and in March 2026 its Permit Board unanimously approved a 41-turbine, 1.2 GW plant to make them permanent.

The wider lesson is that developers now choose jurisdictions almost as carefully as they choose equipment. The same plant can face a standardized registration in one state, a case-by-case air permit in another, and separate air, siting and generation approvals in a third.

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Sources: SemiAnalysis Energy Model; Sales@semianalysis.com

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That asymmetry between states, as much as cheap gas, explains why Texas is set to host more of the BTM fleet than any other state. The state determines how the process plays out but federal rules set most of the parameters. The Environmental Protection Agency (EPA) sets the core air-quality standards, emissions definitions and major-source framework; state and local authorities usually administer those rules, issue the permits and add their own authorization routes.

How the Air Permit Thresholds Work

Potential to emit (PTE) is the tonnage a plant would emit running flat out all year, counted per pollutant. Every US air permit tests PTE. For a gas generator the two pollutants that matter are nitrogen oxides (NOx) and carbon monoxide (CO). Two federal lines apply. A plant with PTE above 250 tons a year of any pollutant goes through a full major-source review: modeling, a public process, and potentially years added to the timeline. A plant with PTE above 100 tons also needs a Title V operating permit, a second layer of federal oversight. States set their own lines below the federal ones.

Tiers:

1. Exempt as a nonroad engine: A portable engine that stays on site under 12 months

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    a. Sits outside stationary-source permitting. Works for reciprocating engines only: any turbine of 10 million Btu an hour or more falls under a federal emission standard, confirmed by EPA's January 2026 turbine rule. Mississippi exempted xAI's trailer-mounted Southaven turbines under a state rule; that decision is being challenged in federal court; 40 CFR 1068.30.

2. Minor New Source Review (NSR): PTE below every major threshold
    a. A construction permit from the state or county, which sets the exemption cutoffs and how much modeling is needed. Public comment of at least 30 days. A plant that accepts an enforceable cap on hours or fuel to stay under the lines is a "synthetic minor"; changing that cap later triggers a full major-source review as if the plant were new; 40 CFR 51.160 to 51.161; 40 CFR 52.21(r)(4).

3. Prevention of Significant Deterioration (PSD), the major-source review: PTE of 250 tons a year of any pollutant. 100 tons for 28 listed industries; EPA reads "steam electric plant" to cover combined-cycle plants, while simple-cycle plants are treated as unlisted and so face the 250-ton limit.
    a. Usually issued by the state. Once major for one pollutant, the plant applies Best Available Control Technology to every pollutant above the significance rates (40 tons of NOx, 100 of CO), models its air-quality impact, usually supplies a year of monitoring data, and takes at least 30 days of public comment. The Clean Air Act requires a decision within a year of a complete application (section 165(c)); no national data on actual times exists; 40 CFR 52.21.

4. Nonattainment NSR: The area fails a federal air standard for the pollutant. It replaces PSD for that pollutant; PSD still applies to the rest.
    a. The limit falls to 100 tons a year, then to 50, 25 or 10 tons of NOx and VOC as an ozone area is rated serious, severe or extreme (Clean Air Act 182). The plant must meet the Lowest Achievable Emission Rate and buy offsetting cuts from other sources in the same area, at 1.1 to 1.5 tons per ton. Location sets the line: Dallas and Houston sit at 25 tons, Chicago, Salt Lake City and Las Vegas at 50, Northern Virginia and Phoenix at 100 (EPA Green Book); 40 CFR 51.165.

5. Title V operating permit: PTE of 100 tons a year or more, on top of whichever construction permit applies.
    a. Applied for within 12 months of commissioning. Gathers every requirement into one enforceable document with a five-year term. EPA

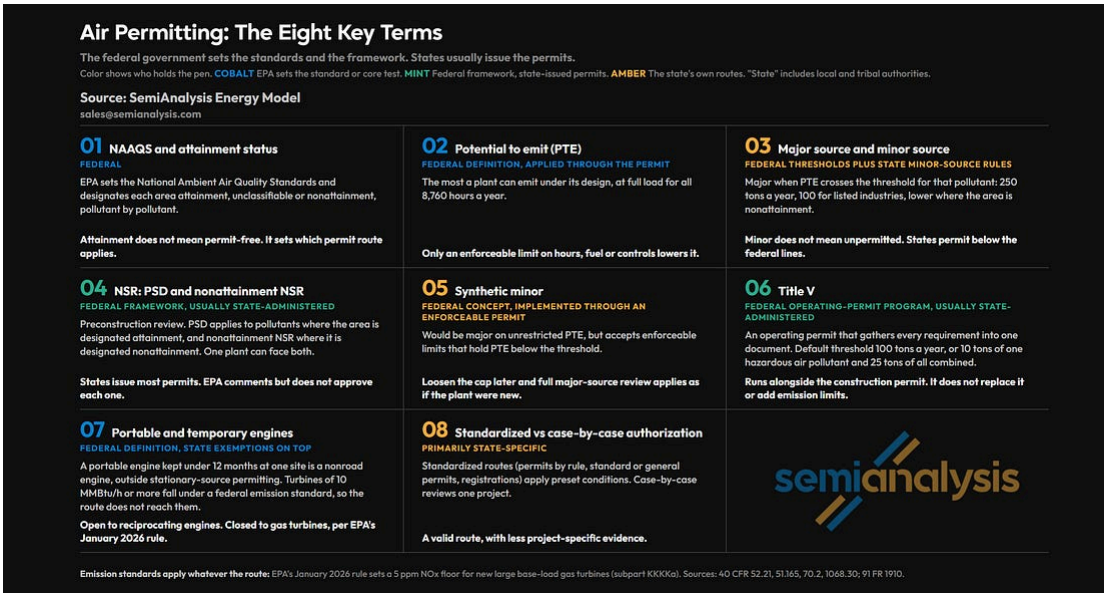
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gets 45 days to object and the public 60 days to petition. Adds monitoring, reporting and fees, and sets no new emission limits of its own; 40 CFR 70.2.

Three caveats.

1. The 250-ton line for simple-cycle plants rests on consistent agency practice, including Mississippi's own xAI permit, not on a written EPA ruling.
2. States differ below the federal lines. Texas requires control technology for every new facility. Virginia permits anything above 40 tons of NOx. California districts trigger controls at 10 pounds a day.
3. Federal emission standards apply whatever the permit tier. The January 2026 rule sets a 5 ppm NOx floor for new large turbines running base load. That means selective catalytic reduction from day one.

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Sources: SemiAnalysis Energy Model; Sales@semianalysis.com

Small emissions rates become big annual totals at campus scale. At an illustrative controlled NOx rate of 0.10g/kWh, 250MW × 8,760 hours produces about 241 US short tons a year; the same calculation reaches 250 tons at roughly 259MW. The actual answer depends on the equipment's controlled emissions, the applicable threshold and which units the regulator counts together as one source.

That leaves developers working on both plant size and the operating plan. A phased authorization can, where the project and rules allow it, bring an initial tranche online while approval for the larger build progresses. But the hours and emissions limits must survive contact with the intended operating schedule and be enforceable. The regulator needs a credible plan for how the whole campus will run.

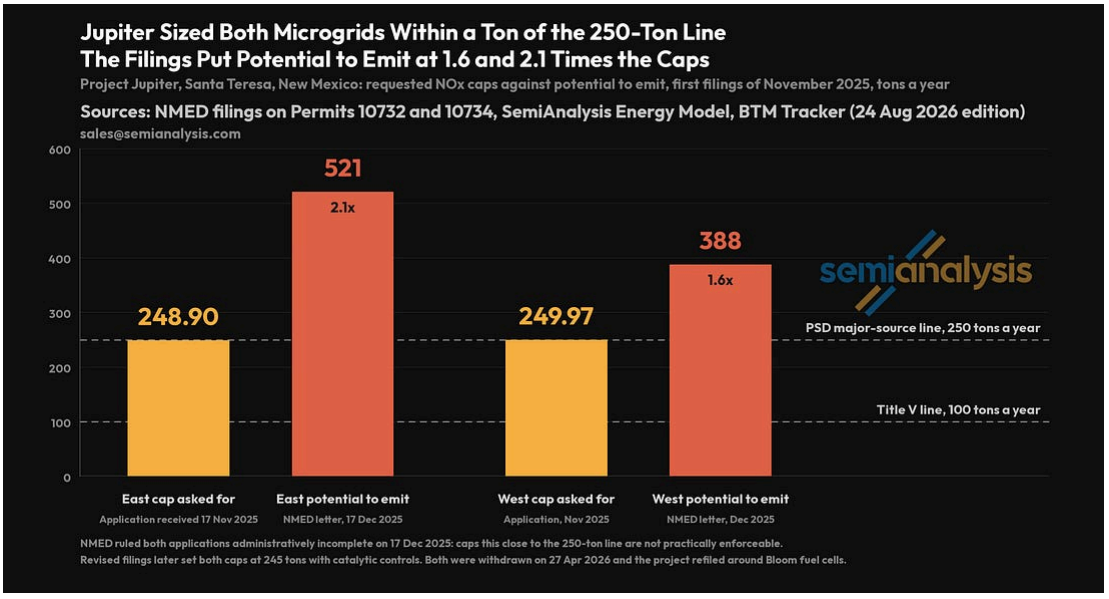
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Project Jupiter: Grand Designs

UK television legend and architecture critic Kevin McCloud would be raising his eyebrow at Oracle's Project Jupiter because it shows how permitting can force the redesign of an entire facility at breakneck speed.

The original applications were filed on 17 November 2025 for two separate microgrids, East and West, each sized to sit just under the federal 250-ton major-source line. The West application proposed 34 GE TM2500 and 20 Mitsubishi FT8 units (54 turbines, roughly 1,677 MW) with the East microgrid at a higher scale. The strategy was to operate as a synthetic minor: install equipment capable of emitting well above the major-source threshold, then accept operating limits that keep permitted emissions just beneath it. The East microgrid reported the potential to emit of 521 tons of NOx a year and requested a cap of 248.90, 1.1 tons under the line.

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Sources: SemiAnalysis Energy Model; sales@semianalysis.com

New Mexico's Environment Department determined that limits set so close to the threshold were not practically enforceable. The applicant resolved that by dropping both caps to 245 tons, and the department ruled both applications complete and published its intent to issue - but some 7,155 public comments came in, the Secretary concurred in holding a hearing, and the applicant withdrew both on 27 April 2026, the day it announced the fuel-cell redesign.

The project then abandoned the turbine design and refiled around Bloom Energy solid-oxide fuel cells in April. The revised proposal targets roughly 37 tons per year of NOx, around 92% below the original turbine configuration.

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The technology change did not make the permit issues disappear. On August 23, 2026, the New Mexico Supreme Court stayed the administrative air-permitting

proceeding until further order. The stay paused the process rather than deciding the merits of the application, and on September 1 the justices unanimously refused the developer’s request to lift it even temporarily. The regulator’s decision deadline is November 23, 2026.

The Fuel-Cell Escape Hatch

Fuel cells offer an escape hatch from the trickiest part of permitting but not from the permit process itself.

The technology generates electricity electrochemically rather than through flame combustion, generally producing far less NOx and other conventional pollutants than a comparable fleet of turbines or reciprocating engines. Depending on the site and configuration, fuel cells can keep a project below PSD major-source thresholds and allow it to follow a standardized or minor-source route instead. They still require permits and still produce CO_2 and smaller quantities of other pollutants, but the advantage here is a lighter regulatory profile, not zero emissions.

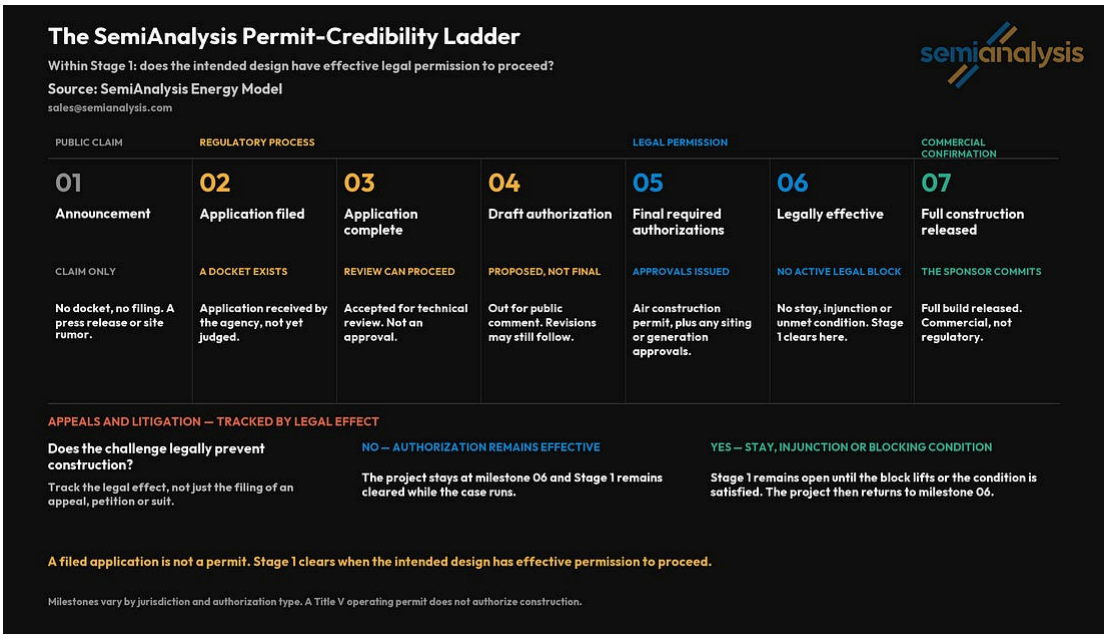
AEP Ohio’s 72.9MW Bloom installation at AWS’s Hilliard site in Ohio shows the wrinkles in permitting fuel cells, remaining below the thresholds that would have triggered the major-source route. The project still required an Ohio EPA air permit and separate state siting approval, while the air permit was appealed by the City of Hilliard in November 2025.

Nebius also made the technology trade in its first BTM US deployment, replacing the previously planned combustion-based generation with 328MW of Bloom fuel cells under a 10-year power agreement, with the company pointing to faster deployment and the lighter permitting burden as advantages of the switch.

Fuel cells can accelerate projects through the permitting matrix but can also make speculative projects easier to decorate. In one Texas filing we found, a proposed 560MW Bloom fuel-cell plant paid a $900 standard-permit fee and moved from application receipt on December 19, 2025, to authorization on January 14, 2026, TCEQ concluding that the installation was not a major source under either PSD or Title V.

A standard permit confirms that a proposed equipment configuration fits a pre-written emissions envelope. It does **not** prove that the datacenter has a committed tenant, financing, purchased equipment, firm gas supply or a construction notice to proceed. That is why we do not treat “permitted” as a greenlight for a new BTM project.

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Source: [SemiAnalysis Energy Model]

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Note that another often overlooked constraint for permitting is water. For radiator-cooled recips, process-water demand can be very low: the radiators dump engine heat into the air. But for certain single cycle turbines, water or steam injection for NOx control creates a continuing water requirement, while dry low-emissions (DLE) combustion avoids that injection. The turbine package matters as much as the technology label. For example, the Pratts FT8 MOBILEPAC use water injection.

Combined cycle adds another decision. Wet recirculating cooling loses water through evaporation and blowdown, the discharge used to keep dissolved material from building up. Dry cooling rejects that heat to the air.

Stage 2: Gas

Now, while permits are a core site selection constraint, fuel adds a second one. The US is awash with natural gas: high oil prices maintain the incentive to drill baby drill, and the gas that comes out as a by-product needs to find a home somewhere, while Appalachia and the Haynesville add ample supply of dry gas (not associated with oil extraction).

However, the hard part is transportation of that gas. Building pipelines can be simultaneously the hardest and easiest aspect of the BTM datacenter construction process, but like permitting, it depends quite significantly on geography. In addition, one pipeline typically isn’t enough. A firm contract is tied to a maximum daily quantity, specific receipt and delivery points and, where agreed, minimum delivery pressure; interruptible service can be curtailed when the pipe tightens. A line on the map is therefore weak, what matters is how much firm gas can physically reach the

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plant’s meter. The physical fuel system also has to survive a failure. Depending on the site, that can mean independent feeds, redundant internal distribution, stored LNG or dual-fuel capability, plus redundant boost compression where inlet pressure requires it. Gas quality matters too: changes in methane number, heating value and Wobbe index can force control changes or derating if they move outside the machine’s fuel envelope.

A couple of examples of large projects:

- To build a pipeline in Texas, you only have to answer the Texas Railroad Commission, meaning datacenter developers in the state are increasingly just building the pipeline themselves. Federal water-crossing permits and easements still apply, and a purely private lateral gets no condemnation power, so a single holdout forces a reroute. Crusoe filed by itself for the 16-inch line to Duroc power plant at Abilene, and Trailblazer Infrastructure - the Sweetwater developer, unrelated to Tallgrass’s Trailblazer system - budgets $120M for a 31-mile extension in its tax-increment finance plan. Add this to ERCOT’s connection rules and some of the cheapest gas in the country, and you have another explanation for why so much of this build-out is planned in Texas.
- In Louisiana, Energy Transfer subsidiary ETC Tiger Pipeline is building the Franklin Farms lateral - 13.2 miles of 36-inch pipe at a billion cubic feet a day, plus a shorter branch - to feed Entergy Louisiana’s new combined-cycle plants, which in turn power Meta’s Hyperion campus over the grid. Entergy, not Meta, is the shipper, so this is the utility-served route rather than a behind-the-meter one. Even with no compression, it still runs 19 months from the federal filing in July 2026 to a February 2028 in-service date.
- New Mexico. Again we arrive at Oracle’s Project Jupiter. The campus is set to received pipeline gas from the Transwestern-built Green Chile pipeline. That pipeline was contractually due in service on 15 August this year, but the date passed without even an approved route, let alone a start to pipe laying. On 14 August Transwestern filed a new in-service date of 1 February 2027, with the federal apparatus moving unusually fast. This speed will need to continue if that start date of February next year is to be met, with a FERC order required in the next two months. No comparable certificate on record has been issued that fast, and none of the 33 comparable projects we have tracked was approved before the public comment period closed. Our estimation is first gas in April or May 2027, with full ramping up to the 2.45 GW in mid-2028, however, there are several hurdles to overcome before that.

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The fuel contracts and pipeline filings can also help separate wheat from the chaff. A nearby pipeline doesn't prove much, but a firm transportation contract, signed gas supply agreement, or a pipeline application filed at the regulator can help understand which sites may be on the way to receiving gas for their site.

Some interesting observations:

- Energy Transfer contracted 150 MMcf/d to the Nexus Hubbard campus, enough to run about 750 MW of the reciprocating engines actually ordered. But the campus's pending air permit covers a 5,230MW fleet, meaning it needs about seven times the contracted gas supply , so either there are more gas contracts are coming, or permitting was a hedge ahead of contracting gas supply.
- Liberty Energy's joint venture with PowerBridge covers a planned 2 GW campus in West Texas, with more than 300 MW of generation in a first phase targeted for the fourth quarter of 2027. Liberty told investors on July 22, 2026 that the site would start behind the meter, likely inside ERCOT's Batch Zero, and could take a grid connection of undetermined size in 2028. Most of the campus would then sit behind a private use network, the ERCOT structure that nets a site's generation against its load at a single connection, which we explain in US Grid Constraints.

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Stage 3: Equipment

The market for turbines, reciprocating engines and other types of generation equipment has grown significantly so far this year, with new manufacturers coming into the fold and existing OEMs increasing manufacturing capacity to keep pace with the growing demand for onsite power generation.

In our Onsite Gas Deep Dive we went through the new types of technology and incumbent manufacturers, so you can go through the different types of equipment available to datacenter operators in that article.

Since writing in December 30, 2025 article, the three broad categories have remained unchanged:

1. Gas turbines (GTs):
    a. industrial gas turbines (IGTs), smaller, heavier machines in the tens of megawatts;
    b. aeroderivatives (aeros), jet engines repackaged for power in the 30 to 115 MW range and able to ramp in 5 to 8 minutes; and

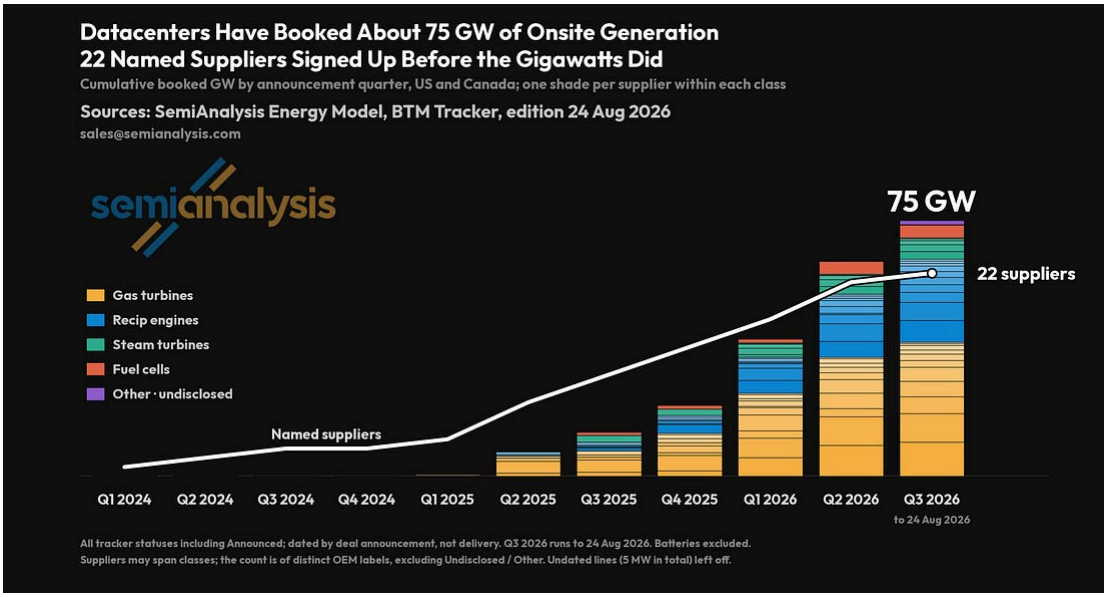
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c. heavy-duty frame turbines of roughly 400 MW, with increased fuel efficiency when put into a combined cycle with steam turbines.

2. Reciprocating internal combustion engines (RICEs), or “recips”:
   a. high-speed engines (1,500 to 1,800 rpm) of roughly 0.5 to 4.5 MW per unit, such as INNIO’s Jenbacher Type 6 and Caterpillar’s G3520; and
   b. medium-speed engines (500 to 1,000 rpm) of roughly 5 to 20 MW, such as Wärtsilä’s 34SG, 31SG and 50SG, INNIO’s J920 and Everllence’s 51/60G.
3. Fuel cells: solid-oxide units from Bloom Energy carry nearly all the orders (3.8 GW of the tracker’s fuel-cell bookings against 0.03 GW for FuelCell Energy).

While turbines captured most of the initial orders, they very quickly ended up being sold out, with first slots now past 2030. This is because BTM developers compete with utilities for these turbine slots. However, recips are much less popular among utilities and they are increasingly aking to AI compute pure-plays. That’s why our quarter-by-quarter tracker of firm orders for BTM AI compute has seen sign a drastic shift towards recips.

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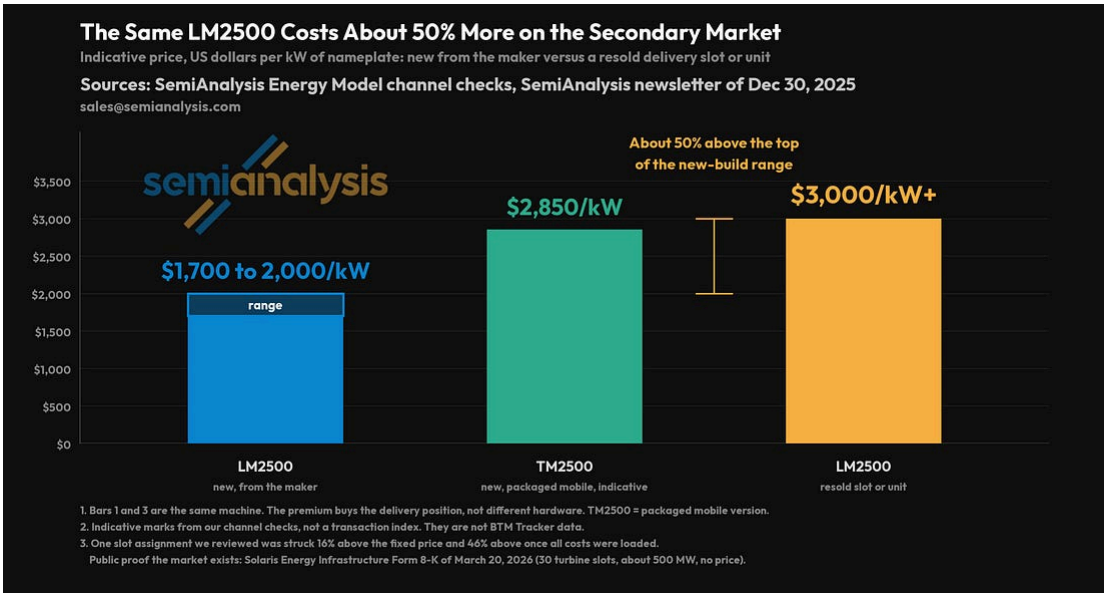


Sources: SemiAnalysis Energy Model; sales@semianalysis.com

And we expect the trend to continue. Folks like EROCK, FTAI Power and Dynamis, alongside INNIO, Wartsila, Caterpillar and Cummins, and Bloom Energy, are expanding capacity more aggressively than incumbents like GEV, and directing more supply to the datacenter market. Caterpillar is lifting its large reciprocating-engine output to nearly 3x 2024 levels, while INNIO expects to roughly triple total capacity from 3.5 GW a year in 2025 to around 10 GW a year by 2030.

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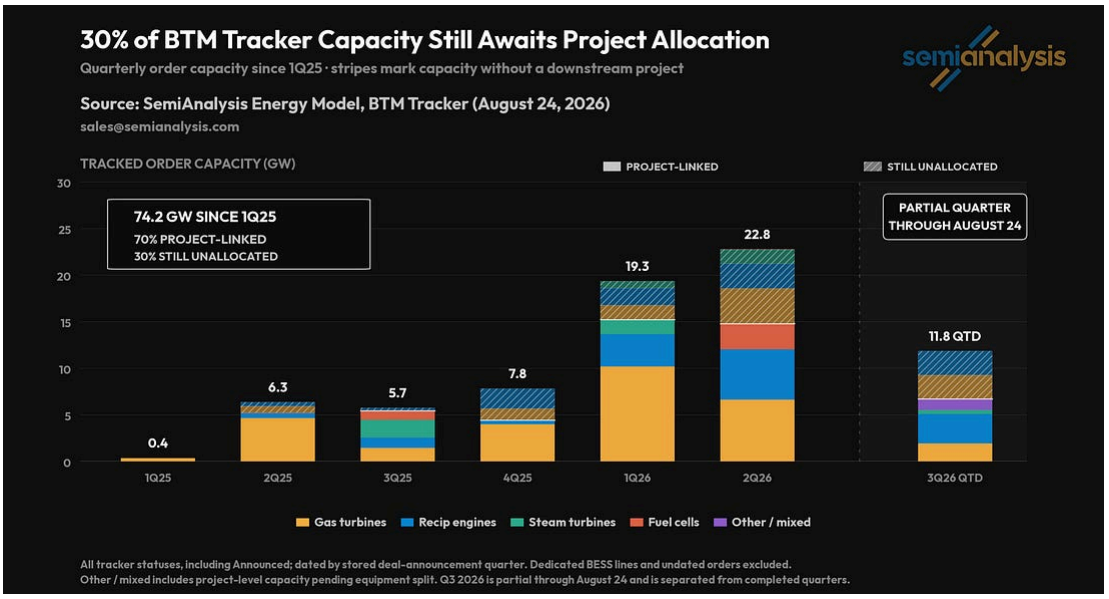
We have also seen the emergence of a secondary turbine market. They don’t come cheap, though! The scarcity across the main OEMs has built a secondary market where the premium buys time. A released delivery slot trades at a real premium to a factory order - the clearest public mark is a slot assignment struck 16% above the fixed price, and 46% above once all costs are loaded - and what the premium buys is a slot delivery in the next couple of years (or sooner) rather than in the next five years, and quicker energization.



Sources: SemiAnalysis Energy Model; sales@semianalysis.com

Key to chat secondary market is the presence of speculative orders in the supply chain. Folks commit to buying turbines or sign minimum purchase agreements, and pay deposits, yet don’t have actual datacenter sites to deploy them. We’re seeing that behavior primarily impacting the gas turbine market, notably incumbents GEV and Siemens. That equipment remains premium today and in high demand, and some “speculators” have been nicely rewarded given the secondary market prices discussed above.

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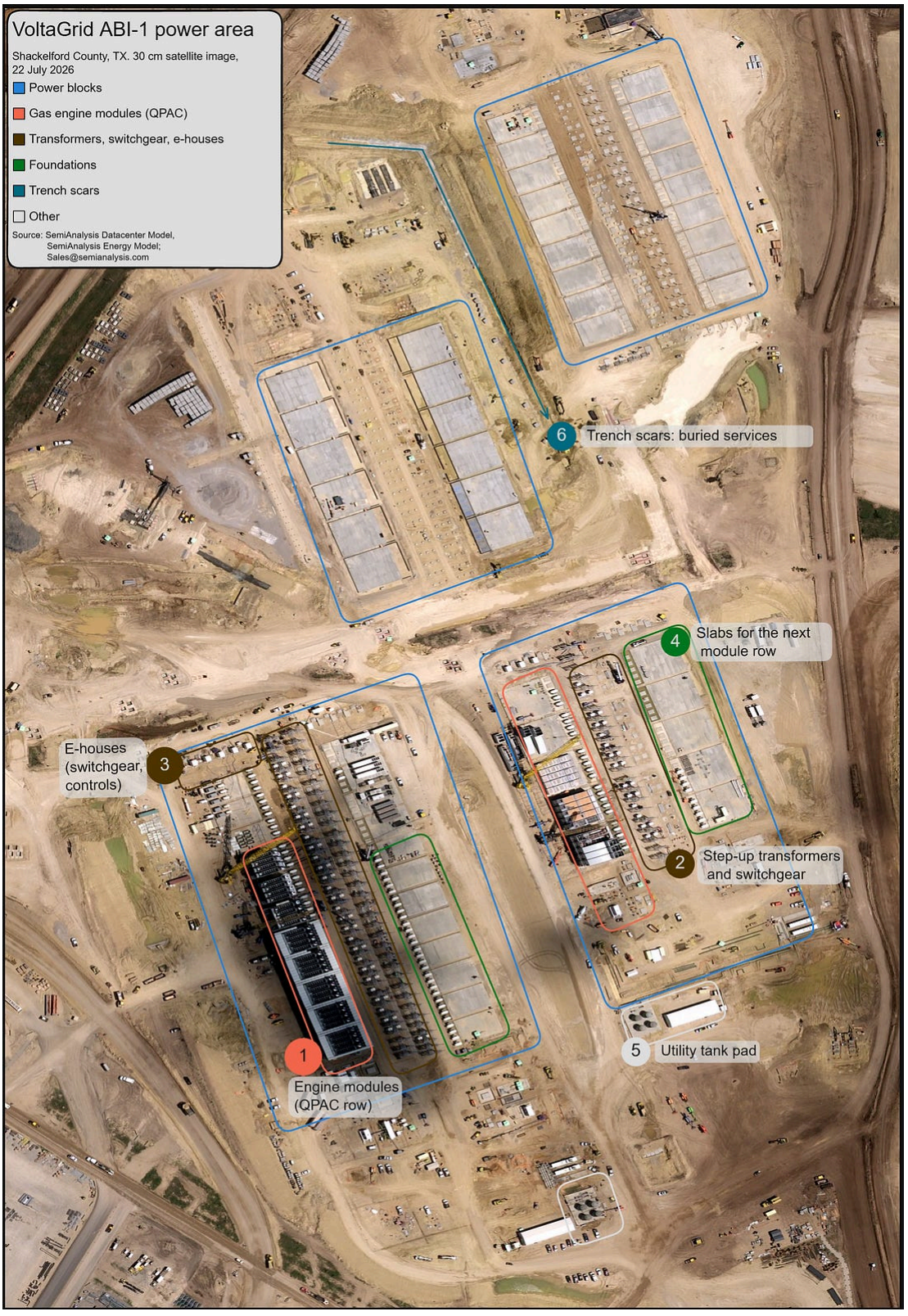


Source: SemiAnalysis Energy Model, sales@semianalysis.com

No BTM Plant Without Balance of Plant

While generation equipment is typically the center of the conversation when discussing BTM constraints, we think that's increasingly shifting to BoP. Generation equipment will be useless if the campus waits for transformers, medium-voltage switchgear or the e-houses that hold the electrical equipment. The collection system and controls also have to bring the fleet's output together into a working plant. And this electrical equipment, often at medium voltage and sometimes high voltage (depending on plant size and system design), is in very high demand due to being standardized and often used by datacenters themselves, as part of their electrical systems (see our deep dive on the topic here).

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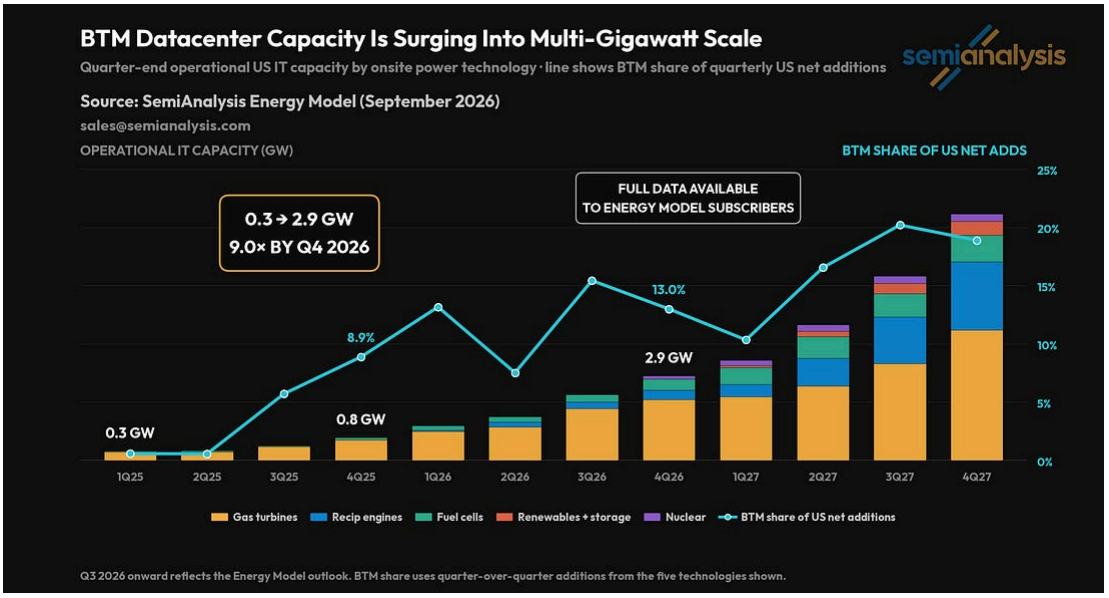


Sources: SemiAnalysis Datacenter Model; SemiAnalysis Energy Model; Sales@semianalysis.com

Stage 4: Construction, Commissioning and Workforce

Once capital, permits, gas and equipment are solved, a whole other challenge arises. Building the power plant, and operating it at the contractually defined SLA standards needs highly qualified labor, contractors and EPCs. To be clear, folks calling this a “science experiment” are entirely missing that 3GW of Datacenter IT capacity is

already running with behind-the-meter power plants. Our Datacenter Model and Energy Models track every single project and exact timelines and supply chain.



Source: SemiAnalysis Energy Model, sales@semianalysis.com

But as the scale dramatically increases, there will be issues, particularly in the context of surging labor scarcity driven by the datacenter buildout.

Our labor market modeling in The Wild Wild West of LEGO Datacenters sized the 2027 gap at 288,000 workers, based on our Labor Model included in our Industrials Model. Electricians are the largest trade at about 30% of site hours, drifting toward 40% by 2030 as liquid cooling adds mechanical work.

Moving the mechanical and electrical work into a factory cuts on-site labor by about 63% and on-site licensed-electrician hours by about 85%, which is why prefabricated eHouses, skidded plants, and full modular offerings are spreading through the vendor list: they are labor arbitrage as much as an opportunity to shoot ahead of schedule.

But plenty of labor is still needed onsite. When it comes to power plants, the US has been building them for decades, meaning a healthy labor supply pool and lower costs than the datacenter build. Large combined cycle gas plants peak at about half a construction worker per megawatt:

- Palomar, 546MW in California, peaked at 283 craft
- Guernsey, 1,875MW in Ohio and fifteen years later, at close to 1,000

So, on a gigawatt campus the power plant build can be a fifth to a quarter of the peak headcount.

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However, ***it is not the same labor.*** A CCGT plant is a mechanical pressure project, meaning boilermakers setting HRSG pressure parts, pipe welders whose welds have to pass radiography, and millwrights aligning a turbine to thousandths. **There are 10,200 boilermakers in the United States, the occupation turns over about 800 people a year, and the Bureau of Labor Statistics projects it to shrink.**

That said, the BTM buildout is set to use a variety of solutions and each generation type draws on different trades, and each have their pros and cons regarding labor.

- Reciprocating engines need no boilermakers, but they lean on electricians and millwrights, so the power plant competes with its own datacenter for the same people.
- Fuel cells need none of the scarce trades: no pressure parts, so in a labor-constrained buildout, that is a strong argument. But at mutli-gigawatt scale, hundreds of fuel cell banks and the required supercapacitors, BESS and so on, make for a different kind of configuration which has never been done at scale.

This is why “labor-light” power solutions are increasingly attractive to end-customers. As the US grid runs out of power & headroom in 2028, these solutions will be the primary way to solve datacenter power constraints.

Of course, commissioning is not the finish line. A permanent island needs daily operating coverage, remote monitoring, local response, scheduled maintenance, spare parts and service coverage for unplanned work. The cadence is measured in operating hours. Caterpillar illustrates a 20,000-hour top-end and an 80,000-hour major overhaul; Jenbacher packages can require major work at 60,000 or 80,000 hours. At 8,000 running hours a year, that is roughly 2.5 years to the Caterpillar top-end and 7.5–10 years to a major. The exact answer varies by engine and duty cycle.

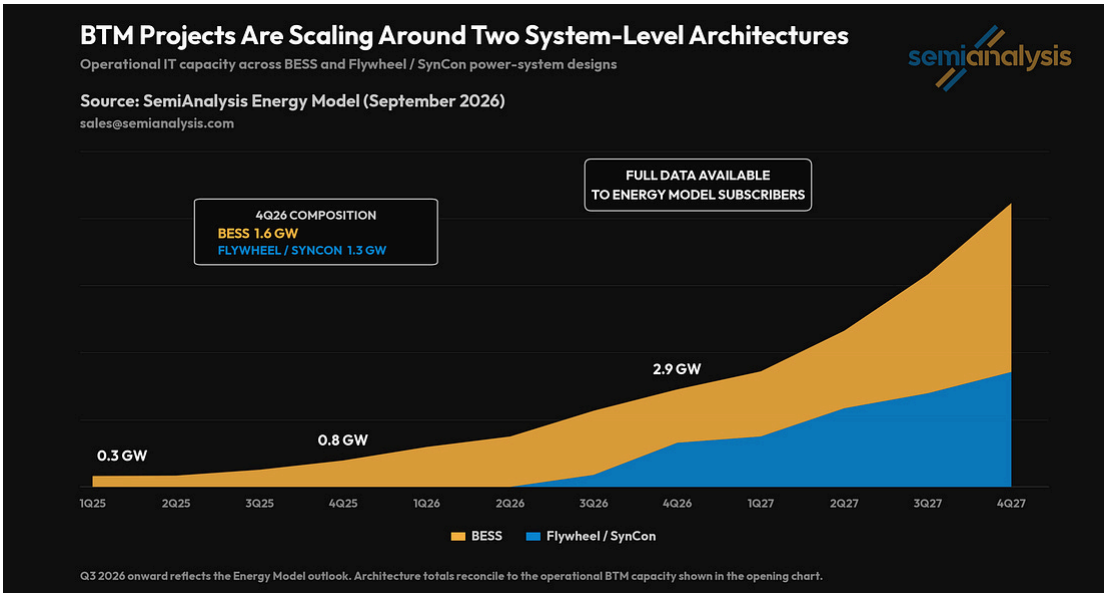
To counter both issues, some OEMs are increasingly going vertical. Bloom Energy is the main example, as their solution is of course not as broadly established than turbines and engines. Bloom takes care of most installation and O&M work for its deployment, and hires and trains staff to do that. Others are following, and both issues are increasingly a deciding factor for equipment orders. EROCK has also relied on this, and their use of smaller truck-derivative engines means that both installation and O&M are much simpler than for a traditional turbine-based power plant. PROENERGY also discloses a large in-house staff that can act as EPC and O&M if need be.

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Stage 5: Islanding Physics

The last stage is the least visible and the least forgiving. At xAI's Colossus 1, matching gas turbines to GPU load proved harder than expected, with jitters of 10 to 20MW several times a second and oscillations like these exciting torsional modes and eating up turbine-generator shaft life. This issue led to xAI deploying the first phase of 150MW Tesla Megapacks. We've discussed at length here the issues with AI Training load fluctuations. This has led to the rise of a new battle: BESS vs Flywheels / SynCons to be paired with generation equipment at BTM sites.



Source: SemiAnalysis Energy Model, sales@semianalysis.com

The combustor technology that makes modern gas turbines permittable holds its emissions performance only above roughly half of rated load, or about 35% with turndown upgrades. AI training loads, which swing hard and fast, can push turbines below that floor, where controls add pilot fuel or revert to diffusion mode and NOx, CO and unburned hydrocarbons all jump. A permit is written based on potential emissions, so that floor is integrated into the application.

A grid-connected plant borrows two services from the system: inertia, the spinning mass that resists frequency change, and fault current, the surge that lets a breaker recognize a short circuit and trip. An islanded plant must make both itself. Engines and turbines deliver five to ten times rated current into a fault; batteries, solar and fuel cells are clamped by their electronics to roughly 1.2-2x, thin enough that conventional overcurrent protection loses its margin. An island built only on inverters can fail to clear its own short circuits.

Fuel cells answer the same question with supercapacitors, which dump into a step load and recharge as the stack ramps. Channel checks for Bloom's sizing ratio put it near 3:2 on a power basis, which would make Project Jupiter's 2.45GW imply about 1.6GW of supercapacitors, far above the existing precedent of 58MW.

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Can You Do This Without Gas?

Plenty are trying, and after six stages of difficulty you may well think renewables could dodge the permitting, fuel, and supply chain bottlenecks. Some are already trying, notably Crusoe with Redwood. Others like Google are deploying renewables & BESS at very large scale, but these sites remain grid connected.

Renewables clear air permitting far more easily, since there is no combustion source to permit, the fuel costs nothing, and there is no pipeline to route. The catch is electrical physics. In an off-grid context everything connects through inverters. Inverter-based sources push only a thin multiple of rated current into a short circuit, a fraction of what an engine or turbine delivers, too little margin for conventional overcurrent protection to trip reliably. So a clean renewable island has to buy grid-forming inverters plus synchronous condensers.

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Our December 2025 onsite-gas piece measured average US grid availability at about 99.93%, roughly three nines, and showed that onsite supply has to be overbuilt to match it.

Crusoe and Redwood Materials' operating datacenter microgrid in Sparks, Nevada has run since June 2025 on 12 MW of solar and 63 MWh of second-life electric vehicle batteries, with the grid as backup. In a March 24, 2026 release Crusoe reported 99.2% availability over seven months of continuous operation and announced an expansion to 20 MW. Scaling a solar-and-battery design to a gigawatt campus requires substantial generation capacity, storage and land; the amounts depend on the load profile, weather, reliability target and availability of grid backup. Batteries earn their place inside gas projects: ride-through, load smoothing and backup energy. Liberty Energy's chief financial officer said on July 23, 2026 that battery power capacity averages 50% of gas capacity across its datacenter clients.

Buyers are becoming more tolerant of interruption. Microsoft says its Fairwater Atlanta site was selected for resilient utility power and is "capable of achieving 4x9 availability at 3x9 cost," four nines of availability (99.99%) at the cost of three nines (99.9%), which lets it forgo onsite generation, uninterruptible power supply (UPS) systems and dual-corded distribution for the GPU fleet (Scott Guthrie, Microsoft, November 12, 2025). In our Industrials Model, we track the expected uptime for 30+ different datacenter designs, based on our deep bottoms up equipment-by-equipment BoM. We track desings of Anthropic, OpenAI, Meta and all other hyperscalers and we are seeing a clear trends towards lower redundancy.

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Currently, no pathway clears all six gates: gas is exposed on permits and on the pressure trades (the boilermakers and pipe welders), fuel cells on stability spend and

unproven scale, solar and batteries on the island itself.

Where do we go from here?

Let’s now discuss the longer-term outlook and winners&losers. We’ll discuss our outlook for BTM plants and whether they are all destined to be grid-connected or not, and how solar and batteries fit into that outlook.

We’ll also discuss winners and losers in the OEM market, and in the BoP market. Some big industry changes are negative for certain large industrial companies, but there are balancing factors within their portfolio.

First of all, we see the Texas moratorium as a strong positive for BTM. Projects getting large-scale hyperscale leases are increasingly behind-the-meter, as they can provide much more certainty on timelines.

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Backup, Peaker, or Rate Base?

Every datacenter which uses onsite prime power eventually faces the same question: what happens when the grid becomes available? Most sites are not planned to be permanently off-grid, they are bridges to energize quickly while the connection queue clears.

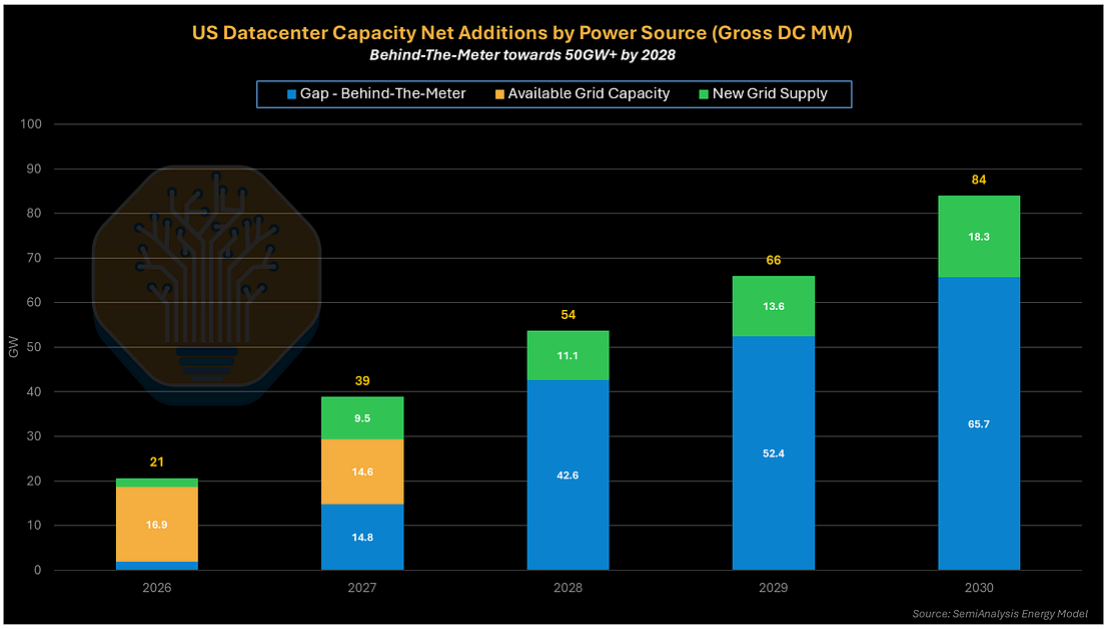
We have seen the migration of turbines as prime power to back-up power at Colossus 1. But this cannot be the only solution for the tens of gigawatts of BTM power generation equipment set to come online in the coming year.

There are a few more options: moving to the equipment to peakers and reserve, selling into the utilities rate base, redeployment to the next site or staying on as an additional flexibility layer, letting the site offer demand flexibility without interacting with the compute.

Overall, we continue to stand by our behind-the-meter and long-term power forecast. The grid will expand, but will be materially slower than AI’s infrastructure requirements. As such, we do not expect every single BTM plant to end up being grid-connected.

Rather, we think BTM campuses will become larger and larger, and start integrating a broader mix of energy resources. They’ll become true microgrids (or macrogrids?). Ultimately, this will be a strong positive for solar and batteries, in our view. Stay tuned for much deeper content.

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Source: SemiAnalysis Energy Model

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Winners and losers:

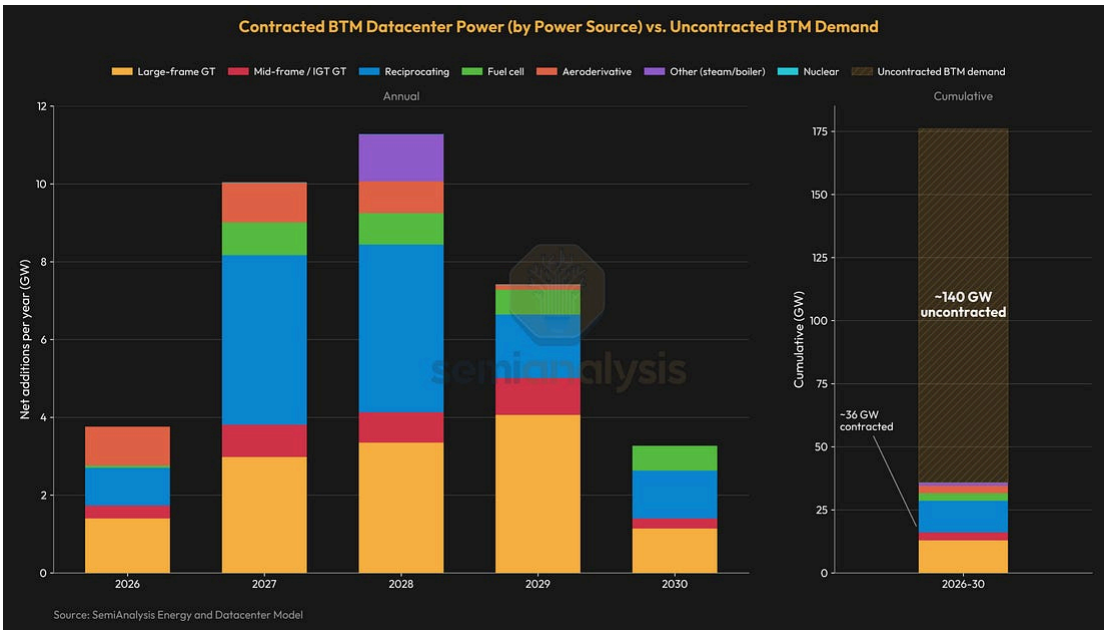
This is a taste of what Energy Model and Industrials Model clients read this summer.

Pistons at the Gate (2 July 2026)

In the recip market we like Caterpillar (CAT), INNIO (INIO), Rolls Royce (RR.LN), and Cummins (CMI). We see Caterpillar and INNIO continuing to win orders off the back of aggressive capacity expansion plans and strong bench of PaaS partnerships. We prefer Caterpillar on relative value, and INNIO's customer concentration risk bears watching with Voltagrid accounting for >40% of orders. Rolls-Royce is seeing strong growth in orders, and we think they have yet to see material orders from their just-launched gas-prime product and we see upside to orders. However, screens more expensive on relative value, and dependent on Liberty Energy (PaaS) to win deals. We expect Cummins and Generac will remain predominantly backup power stories. Cummins' purpose-built gas-prime engine launches only in 2028, and the bulk of its prime-power opportunity will land after 2031. However, it screens well on relative value to Generac, which unlike Cummins lacks datacenter prime power optionality.

Overall, we see substantial growth coming and see recips as best positioned to serve it.

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Source: SemiAnalysis Energy Model

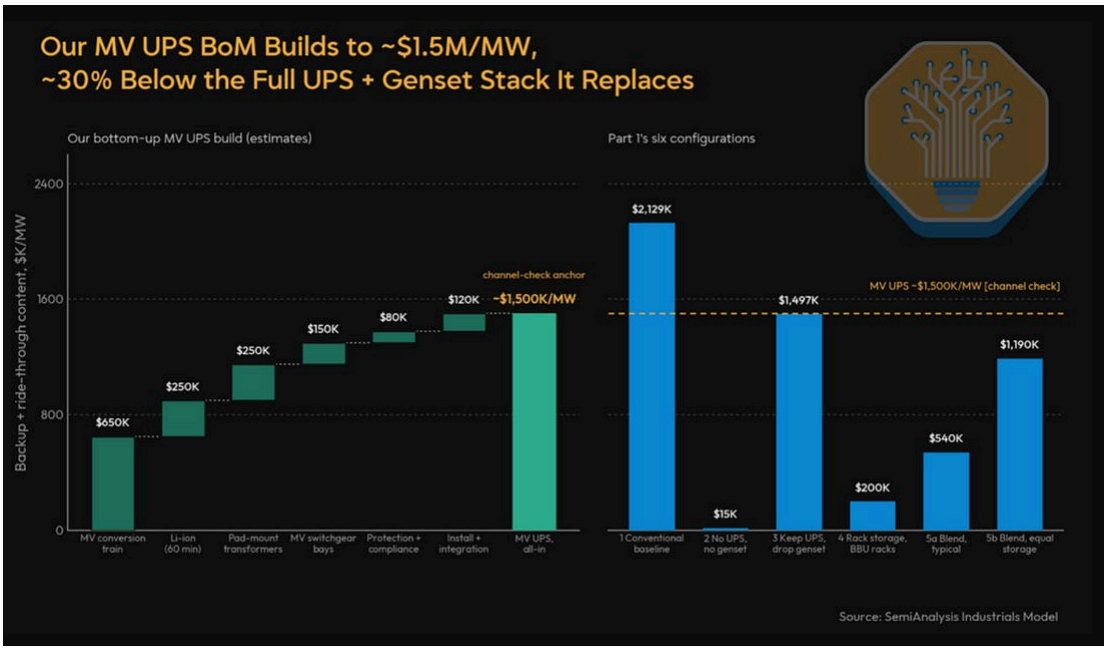
While lead times are now also extending, an order put in for recips today will be operational in ~20 months compared to 60+ months for a CCGT.

The UPS-less Era (Part 2): MV UPS and ERCOT Ride-Through Regulation (7 August 2026)

Every large site, grid-connected or BTM, now has to hold its load through voltage and frequency swings instead of dropping it. That has created a new piece of kit: the medium-voltage UPS, or MV UPS, one big unit at the point where the campus meets the grid, in place of the dozens of small ones inside the building.

Riding through a fault the way Texas and other grids now require costs about a quarter more per MW than the kit it replaces, roughly $300K per MW. Our bottom-up BoM build puts all-in MV UPS content around $1.5M/MW, against the ~$1.2M/MW LV UPS line per our Industrials Model. It is not quite apples to apples: the MV box carries 60 minutes of storage against the old line’s five, and absorbs the dedicated transformer and grid interface.

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Source: SemiAnalysis Industrials Model

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Main beneficiaries are ABB and ON.energy first, then: Prolec GE on transformers, EPC Power on inverters, and ~$250K/MW of Li-ion demand. At our numbers, Crusoe's 5GW commitment alone implies roughly $7.5B of all-in content. Genset OEMs and the LV UPS lines sit on the other side, though the incumbents are moving too, as Vertiv's early MV BESS UPS line shows. However we still see traditional UPS winners, like Vertiv, as key losers of this trend. They've been slow and late. But Vertiv has many other parts of its portfolio that are more exciting and make them a good pure-play on datacenters, as opposed to a share loser. We notably like their modular exposure, which dramatically increases their content per MW. We've discussed at length in our modular datacenter primer.

The Incoming Construction Supercycle (10 March 2026)

The labor and power shortage has resulted in highly attractive economics facing the few EPCs equipped to construct and install gas power plants. The capital cost of a combined cycle gas power plant has risen from ~$750/kW for turbines that came online in 2018 to ~$2,000/kW. In dollar terms, nearly half of the increase accrues to the EPCs, more than the OEMs (~40%).

We like Primoris, given the size of the opportunity relative to revenues and the severity of the EPC constraint, which suggests a high likelihood of pipeline conversion.

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