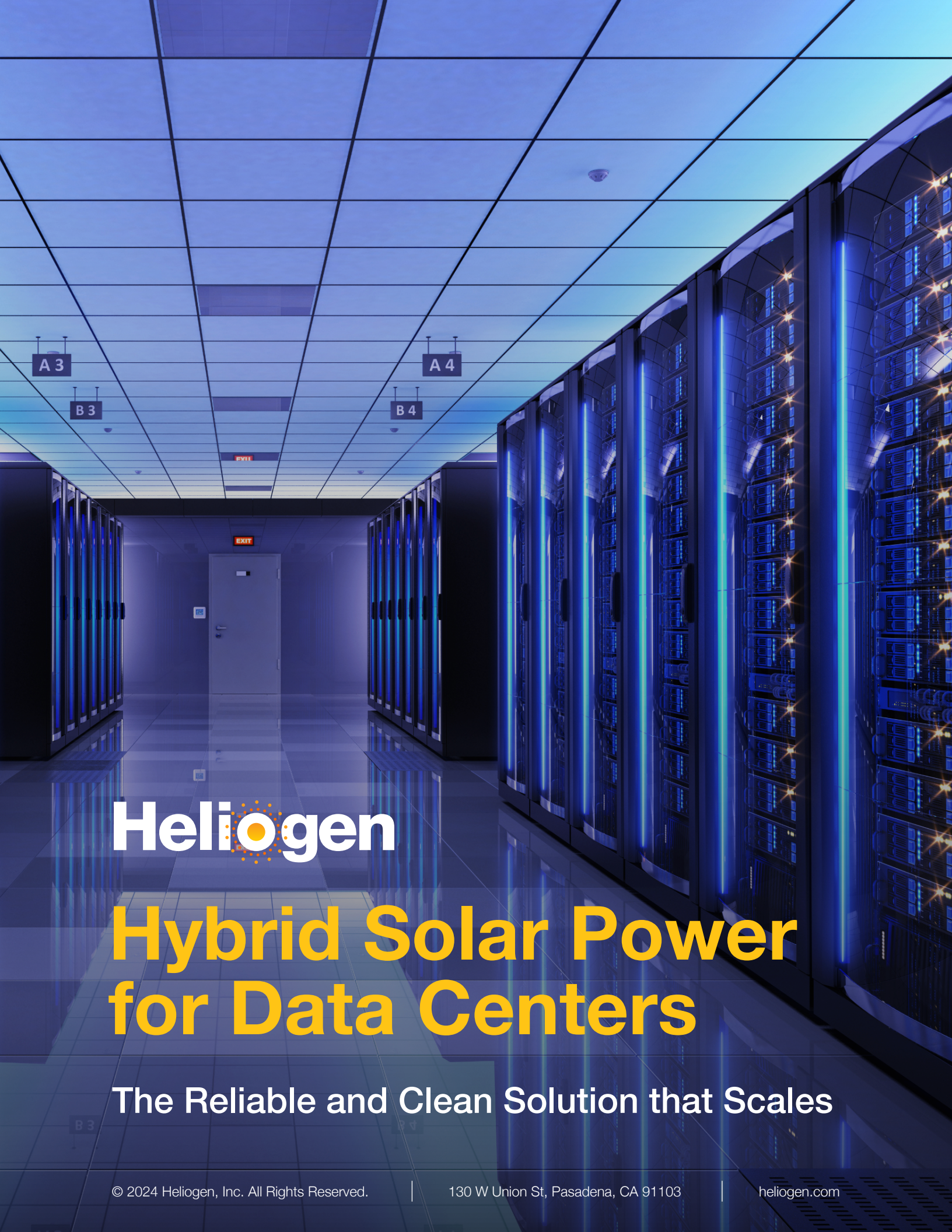

Heliogen

Hybrid Solar Power for Data Centers

The Reliable and Clean Solution that Scales

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Introduction

McKinsey projects that deployment of new servers will more than double power consumption — from 17 gigawatts (GW) in 2022 to 35 gigawatts (GW) in 2030. The United States accounts for 40 percent of this global market.

Providing sufficient energy to meet this soaring need is a growing challenge, compounded by the pressure to make the sector more sustainable, meet regulations, and tap into suitable energy sources. Renewable energy is the answer, but it must be cost-effective, able to meet enormous demand without interruption, and most importantly safe.

This whitepaper looks at the data center industry and its need for a reliable source of carbon-free energy — and why one renewable solution stands out in meeting data center needs.

Data Centers In-Depth

The data center industry is characterized by explosive growth and demand. The emergence of AI, data streaming, cloud computing, and the Internet of Things has amplified the need for data centers. The need for reliable, clean energy solutions compatible with highly specific operational requirements will challenge the sector's escalating growth.

McKinsey's look at the growth of data centers highlights the energy needs of hyperscalers in particular. Amazon, Google, Microsoft, and Meta are a few of the companies that operate hyperscale data centers, and the current power requirements for these facilities start at 200 megawatts (MW). They are projected to grow as high as 1 GW per site in the coming years. The power needed for one hyperscaler's data center can equal that of 80,000 households. As hyperscalers officially commit to carbon-free energy by 2030 and given the influx of new government and regulatory sustainability standards, the widespread need for reliable, carbon-free power to support data centers is clear.

The Nature of Efficiency

Electricity is a data center's biggest operating expense (OpEx) at an average of over 60 percent of the total operating costs. The massive amount of energy needed for data centers isn't just to power the servers, but also from cooling and running the facility itself — which requires a sophisticated infrastructure and a variety of components.

To achieve a satisfactory power usage effectiveness (PUE) and save on energy costs, operators need to incorporate power-saving strategies across lighting and plugs, cooling systems, water pumps, HVAC and IT equipment. While some hyperscalers are tackling the costs of cooling by increasing the internal maximum temperature (to about 80°F), there's a threshold that cannot be crossed to maintain operability of the servers. Strategies to improve efficiency are inherently limited, and the power required to keep all systems running is a significant burden.

Reducing Grid-Dependence to Reduce Risk

As the data center sector continues to expand, the grid is showing clear signs it can't keep up: the phenomenal growth of data centers and their appetite for electricity threatens to exceed the capacity of utilities. Further, electric utilities across the U.S. are doubling their forecasts of how much additional power they'll need by the end of this decade to meet surging demand from a range of pressures, including the current resurgence in manufacturing and the growth in electric vehicle usage. ERCOT (Energy Reliability Council of Texas) recently noted that Texas itself already has the largest power demand in the US, and anticipates that demand will double over the next 20 years. Data centers will have to explore new sources of reliable power.

Reliability is a constant concern: power lapses are untenable for data centers. In the face of potential outages due to a looming storm, weather events, or seasonal strain, data center operators need to be able to shift load to maintain a steady source of sufficient power from the grid.

The energy usage profile of data centers, especially those supporting artificial intelligence operations, often suffers from intermittent spikes. These sudden increases in load present significant challenges to utilities. To balance strain and protect stability, onsite generation is likely necessary.

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All these factors reiterate a key trend: to future-proof their business, data center operators must target regions offering access to dispatchable clean power. As noted by S&P Global, "Power grid pressure and environmental impacts can be alleviated by developing on-site renewable energy generation capabilities."

The Role of Geography

Ample land for large facilities, a favorable regulatory environment, and access to high-capacity factor power are considerations shaping the data center landscape. While Northern Virginia has become the epicenter for the industry, the area may soon reach a tipping point where its grid can't sustain the load. An Avison Young report on the industry for Q4 of 2023 listed other prime markets in the U.S. on the rise, including Nevada, California, Arizona, and Texas.

Access to sufficient power, land and water are deciding factors for the siting and construction of new data centers. For 200 MW and larger, hyperscale operators in the Southwest require access to land to support onsite generation with natural resources, like sunlight. Even in energy markets with a surplus of solar resources, traditional power supply is straining to meet demand, and new clean energy infrastructure will need to be built to support growth in the region.

Solar Access Means Opportunity

With the right technology, the power of the sun can provide a reliable, renewable, and scalable source of clean power for data centers.

Heliogen's hybrid approach combines software-enabled Concentrating Solar Power (CSP) technology with traditional solar Photovoltaics (PV) and long-duration thermal energy storage (LDES). This integrated solution produces high capacity factor, dispatchable, cost-effective energy to support the massive power demand of data centers.

Hybrid Solar: How It Works

Heliogen's unique hybrid system provides a cost-effective, highly reliable, carbon-free power source. Two complimentary technologies — CSP with high-capacity thermal energy storage, and PV — enable data centers to tap into the power of the sun around the clock. The system maximizes and stores energy from the sun over a 24-hour cycle, overcoming intermittency while greatly reducing reliance on unstable grids.

A hybrid system offers distinct advantages for hyperscale data centers to harness renewable energy:

- Modularity
- Energy Capture & Round-the-Clock Storage
- Stabilized Energy Costs & Availability
- AI-powered Heliostat Tracking & Controls

Modularity

Relying on a single system creates a tangible and costly operational risk when it comes to potential maintenance: the entire system may have to shut down to execute a critical fix.

Heliogen's CSP system is designed in scalable modules — a marked departure from the singular, expansive heliostat array fields surrounding a tall receiver tower. Each module includes a smaller grouping of computer vision-driven heliostats around a receiver tower that generates carbon-free heat. This heat is stored in insulated tanks and later dispatched to generate electricity.

The modular system is faster to construct and easier to run, simplifying operations and maintenance, and mitigating the need for overall downtime. If one module needs to be taken offline, the others can continue to generate energy to be stored in a central location.

Energy Capture and Round-the-Clock Storage

Integrating Heliogen's concentrating solar with PV overcomes intermittency challenges by amplifying the strengths of low-cost daytime energy from solar-PV, with the ease of storing thermal energy from concentrating solar for long durations. Deployed in combination with CSP technology, PV and LDES supplement energy output, enabling the system to capture and store sunlight around the clock.

The combination provides a superior supply of long-duration thermal energy storage that is dispatchable, scalable, and reliable. Storing energy as heat is more simple and less expensive than storing energy as electrons in batteries— as other sources of renewable power do.

For customers who require non-stop continuous power, Heliogen offers natural gas integration configurations. Integrating natural gas offers a cost-effective, accessible option to support the near-term transition to renewables.

Stabilized Energy Costs & Availability

For data centers, depending on the grid creates risks in delivery and requires substantial investments in additional sources for a high percentage of backup power. In some states (such as Texas), grid pricing increases in times of high demand, which forces data centers to pay a premium.

Heliogen's hybrid system reduces the need for additional investments to a small percentage. While grid-dependent data centers often invest in standalone solar or solar and battery storage to offset the grid, Heliogen's system reverses the equation: most of the time, data centers can rely on clean, dispatchable, and cost-effective power that greatly reduces grid reliance. Less dependence on the grid also reduces the exposure to paying a premium during times of high demand.

AI-powered Heliostat Tracking and Controls

One of the pressures of harnessing CSP at scale is how to also scale operability. Some systems require manual setup, positioning, and adjustments of heliostats, which can be time-consuming and costly.

Heliogen's control system leverages machine learning to provide autonomous corrections, continually guiding the heliostats into their optimum position. The software reduces the need for human intervention when it comes to calibration and repositioning, greatly reducing operational costs and complexity. Without manually calibrating heliostats to precise degrees during initial setup, construction time is reduced too.

Recent third-party testing at Sandia National Laboratories found that Heliogen's proprietary closed-loop operating system, augmented by computer vision and machine learning, can calibrate and correct the position of each heliostat with 3x more accuracy than traditional methods of heliostat calibration. This translates to superior energy output and plant optimization with reduced operator input, at scale.

Project Spotlight

Brenda Hybrid Power Project

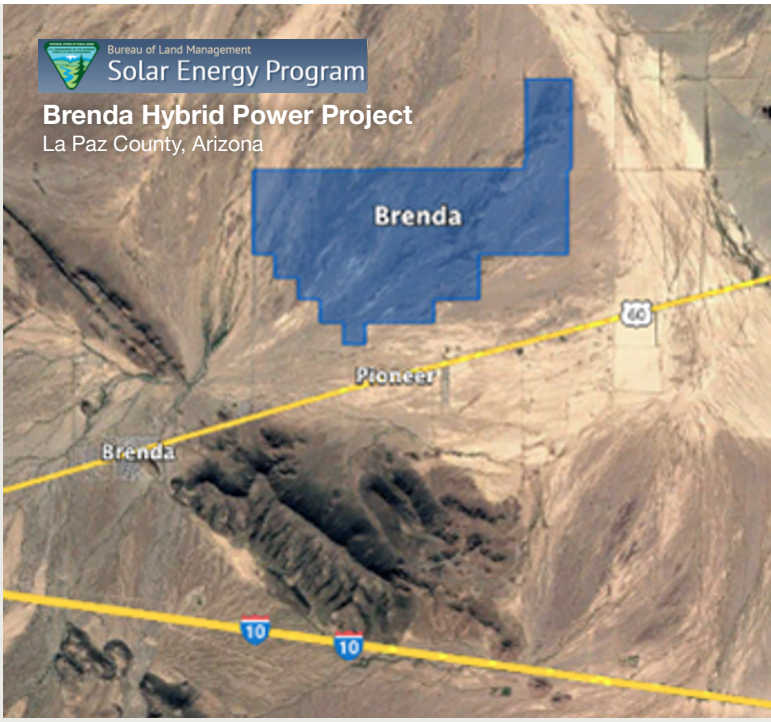
Solar Harnessed for Industrial Use

Heliogen's Brenda Renewable Power Project is an integrated CSP + PV + LDES clean power project in Brenda, La Paz County, Arizona. The hybridized approach positions the project perfectly to harness optimal solar availability in the region.

The firm has secured a 30-year lease for the 3,348-acre site from the Bureau of Land Management (BLM), which has designated the site as a Solar Energy Zone and will prioritize solar energy and associated transmission infrastructure development on the site.

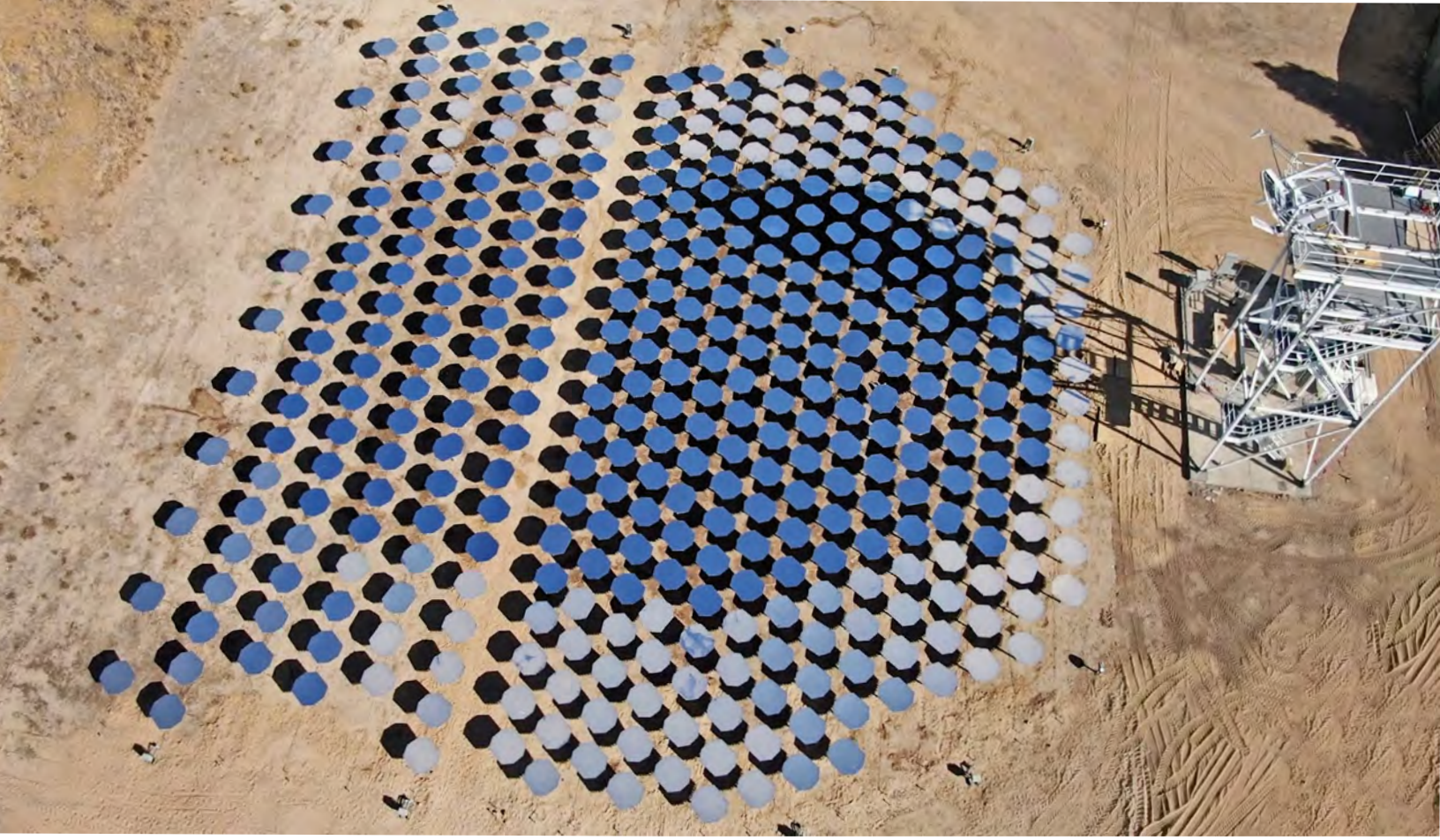
The Brenda site boasts tremendous solar potential (2670 kWh/m^2/year) and has access to water resources to support the facility's power production operations. Brenda is conveniently located near the I-10 Corridor.

Leveraging its unique IP in CSP, Heliogen's Brenda Renewable Power Project is anticipated to produce 190 MW nameplate electricity with a capacity factor of 80%. To satisfy a reliable base load requirement from some industrial consumers — including data centers — the Brenda Project can be customized to provide a base load of up to 30 MW with 97% availability.



Heliogen's Brenda Hybrid Power Project is anticipated to produce up to 190 MW nameplate electricity with a capacity factor of 80%.

- The Brenda Hybrid Power project is still available to produce power for interested off-takers. Reach out to **sales@heliogen.com** for more information.



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An Ideal Solution for Data Centers

Heliogen understands the pressure hyperscalers are under to meet sustainability commitments as they secure sufficient power capacity and handle costs. For projects happening in the near term, Heliogen's hybrid system can be deployed at scale on shorter timelines relative to other solutions.

Hybrid CSP + PV has important advantages over other carbon-free alternatives. For example, nuclear energy has a significantly longer development timeline and a levelized cost of energy 3-5 times higher. Geothermal energy also has a higher levelized cost of energy, uses more water, and is often more geographically constrained.

Hybrid CSP + PV combines proven technologies at a competitive levelized cost. It enables data centers to be more self-sustaining than any other source — with easier-to-maintain technology, longer-lasting energy storage, and the ability to fit the additional needs of exponential growth.

Contact Our Team Today To Decarbonize Your Data Center Operations

Ideal candidates for a Heliogen hybrid system have three factors in common:

- Located in a geographical area with good DNI (direct normal irradiation) for maximum solar potential, with enough acreage to support sufficient modular CSP arrays and PV. The hybrid power system can support off-grid remote operations with efficient, dispatchable power and heat.
- Aiming for a low-carbon or zero-carbon solution to reduce their reliance on fossil fuel for power.
- Committed to making an investment in transforming to clean energy and being at the forefront of innovation in their industry.

To learn more, contact us sales@heliogen.com