Bloomenergy

BROCHURE

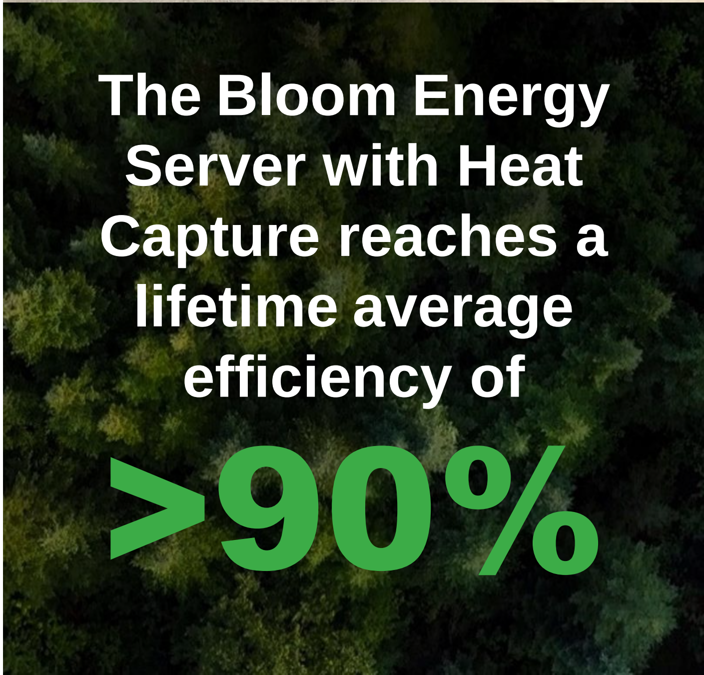
Energy Server® with Heat Capture

Resilient. Predictable. Sustainable.

Bloom Energy is a world leader in fuel cell-based power generation. With a platform based on solid oxide fuel cell (SOFC) technology, the Bloom Energy Server uses an electrochemical reaction to convert fuel to energy. The Energy Server is hydrogen ready and fuel flexible, able to operate on Natural Gas, Biogas, Hydrogen, or a blend of fuels. The Energy Server can be configured as a primary power solution – operating in parallel with the grid, as a microgrid to increase the power system's resiliency, or as an off-grid load following system.

The Energy Server produces clean energy at one of the highest efficiencies in the market today. Its internal operating temperature is above 800 °C, and the resulting exhaust is available at above 350 °C. The exhaust of the Energy Server can be channeled and integrated with Combined Heat and Power (CHP) systems, increasing overall system efficiency and improving economics. By adding Heat Capture, the total system efficiency can reach a lifetime average of >90%.

The Energy Server is available in block sizes of 325 kW and is scalable to hundreds of MW. The installation can be on the ground level or stacked in a power tower. While operating on carbon-based fuels, the power generated by the Energy Server has a low CO_2 footprint, negligible NOx, Sox, and no particulate emissions.



Bloom Energy's Heat Capture Offering

The Bloom Energy Server has a modular design consisting of modules that look alike but have unique functions. A key component is the Power Module, which houses the high-temperature SOFCs that generate power. The Bloom Energy Server with Heat Capture offering consists of mechanical exhaust adapters installed on the back of the Power Modules (see *Figure 1*) that harness the high-temperature exhaust at two connection points for easy integration to heat capture systems. The heat from Power Modules can be aggregated for installations with multiple Energy Server systems before supplying it to the heat recovery equipment.

Bloom Energy offers an installation guide for heat recovery process experts to make necessary connections, share reference architectures, and provide best practices for the design of the full CHP system. Bloom Energy can also provide full turnkey solutions for CHP applications for customer convenience.

Figure 1:
Power Module Options

Power Module without Heat Capture

Power Module with Heat Capture enabled

Typical Applications for the Bloom Energy Server with Heat Capture

The Bloom Energy Server produces waste heat at an average temperature of >350 ℃. The three most common Energy Server exhaust heat applications are hot water production, steam generation, and chilled water generation. Without a CHP system, the facility would have used additional natural gas or electricity to meet heating and cooling needs. Applications utilizing CHP realize benefits in terms of sustainability, increased overall efficiency, and a significant reduction in operational costs. Below is a brief description of some of the CHP applications.

Hot water generation: Industrial processes use hot water in applications such as food processing, space heating, and miscellaneous facility hot water needs. The energy required to generate this hot water is usually derived from burning fossil fuels such as natural gas or electricity needed to power boilers. With a CHP solution to facilitate hot water generation, waste heat from the Energy Server can be passed through a heat exchanger to generate the hot water required by the facility. Using a CHP system results in significant overall efficiency improvements and reduces carbon emissions per MWh of energy generated and savings in the facility's natural gas/electricity consumption.

Steam generation: Steam is used in industrial processes and applications across industries from healthcare and pharmaceuticals to electronics and petrochemicals. The energy required to generate steam comes from burning fossil fuels such as natural gas or electricity to power steam boilers. With an Energy Server based CHP solution, the exhaust from the Energy Server can power a steam boiler to generate the steam required by the facility. Furthermore, economizers may heat the incoming water and extract more heat from the flue gas. Using a condensing economizer, in turn, increases the CHP system's overall efficiency by capturing the exhaust's latent heat. Depending on the yield of steam needed, this solution could be the sole source of process steam generation in many applications. In the standard offering, steam can be dry-saturated or superheated, ranging in operating pressure from 5 barg to 15 barg.

Chilled water generation: Industrial applications such as data centers have extensive cooling needs that can be greatly reduced by leveraging waste heat. Using the exhaust heat from an Energy Server, the thermal energy in the exhaust can generate chilled water via an absorption chiller or a Vapor Absorption Machine (VAM). If not for a VAM, the facility would have to resort to conventional cooling systems such as an electric chiller, increasing energy consumption. In addition to increasing the overall efficiency of energy conversion, VAMs do not use CFC refrigerants that are part of conventional electric chillers providing benefits beyond carbon savings and adding to the sustainability benefits. *Figure 2* below shows a typical application of a Bloom Energy Server working with an absorption chiller to generate chilled water

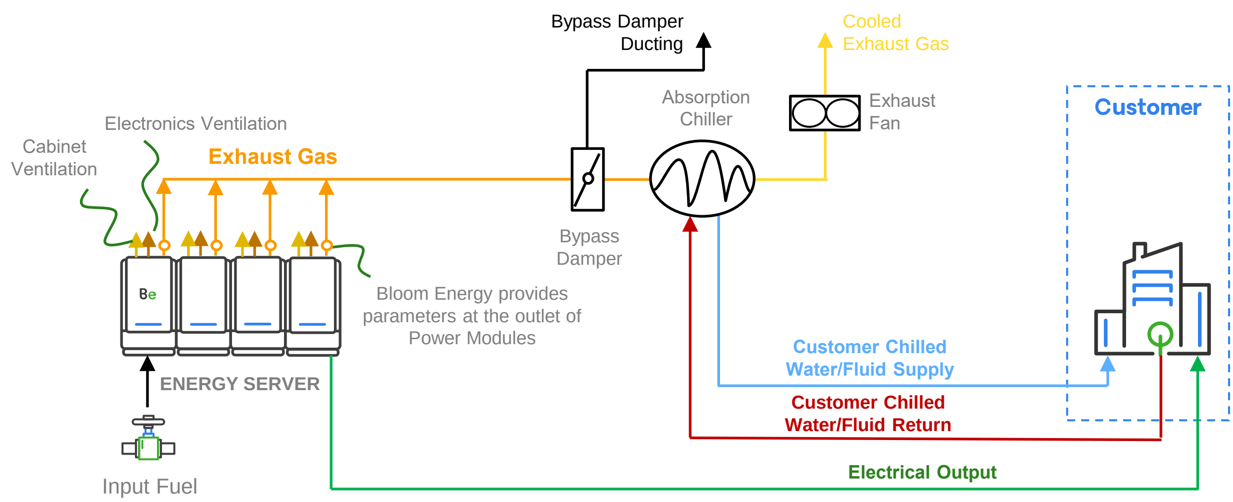


Figure 2: Bloom Energy Server Delivering High Temperature Heat for a Cooling Application

Benefits of the Bloom Energy Server with Heat Capture

By harnessing heat and repurposing it, the system's overall efficiency increases, and more energy is utilized per unit of fuel. With the Bloom Energy Server with Heat Capture, the system can reach a lifetime average efficiency of >90%. This efficiency advantage equates to considerable savings compared to less efficient systems, especially if fuel prices are high. Depending on the application, the efficiency advantage also reduces scope 1 and/or 2 emissions. Table 1 illustrates the yield and sustainability benefits of using a 1 MW Energy Server with Heat Capture to produce hot water, steam, and chilled water.

Table 1: Yield and sustainability benefits using a 1 MW Energy Server

	Hot Water	Steam	Chilled water (VAM)
Yield	13,000 – 16,500 kg/h[1] @ 80 ˚C	540 – 675 kg/h[2] @ 10 barg	175 – 200 tons[3]
System-wide Emission Reductions	500 – 650 MT CO_2e/year[4]	580 – 740 MT CO_2e/year[5]	665 – 830 MT CO_2e/year + HFCs[6]

Notes:
Yield calculations are based on the following parameters:
1. Hot water: Outlet hot water temp.: 80 ℃, feed water temp.: 50 ℃, CHP equipment efficiency: 93.5%, temperature at exhaust of stack: 100 ℃;
2. Steam: Steam parameters 10 barg (dry saturated), feed water temp.: 90 ℃, CHP equipment efficiency: 93.5%, temperature at exhaust of stack: 155 ℃;
3. Chilled water: Water supply temp.: 7 ℃, return water supply temp.: 12 ℃, temperature at exhaust of stack: 120 ℃.

Emission reduction calculations are based on the following parameters:
4,5. Calculated in MT CO_2e/year by avoiding using 90% efficient natural gas-powered boilers for hot water and steam generation.
6. An electric chiller with a COP of 4

The lower end of the yield range indicates operation under ISO conditions (15 °C) and the upper end at an ambient temperature of 40 °C. Additional thermal energy can be extracted from the exhaust by using a condensing economizer in series to pre-heat or generate additional hot water. This will provide a minimum efficiency boost of 5% and is applicable for all utility generation, i.e., steam, hot water, and cooling.

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Table 2 illustrates the operational and performance parameters for a 1 MW Energy Server installation. The exhaust air values scale linearly for larger installations. *Figure 3* below shows field installations of the Energy Server with heat capture.

Table 2: Expected Operating Parameters and Performance Highlights - 1 MW Energy Server Installation

	Lifetime Average			
Electrical Efficiency	54%			
Heat Recovery Efficiency	>36%			
Total CHP Efficiency	>90%			
Minimum Allowed Static Pressure at Power Module Outlet	-5.0 mbar			
Maximum Allowed Static Pressure at Power Module Outlet	7.5 mbar			
Maximum Allowed Pressure Drop across Heat Recovery Unit(s)	60 mbar			
	Units	**Min**	**Avg**	**Max**
Exhaust Air (Thermal Recovery Condition) – Mass	kg/h	4,595	5,968	6,850
Exhaust Air (Thermal Recovery Condition) – Flow rate	SLPM - 0 ˚C	60,445	78,255	89,782
Exhaust Air (Thermal Recovery Condition) – Volume	m^3/h	8,303	12,924	10,969
Exhaust Air (Thermal Recovery Condition) – Temperature	˚C	356	367	384

Notes:

1. Values are for reference only; system performance depends on site and system specifics. All values in the table are +/- 5% accurate estimations compared to actual field data.
2. Data assumes pipeline natural gas as fuel and ISO conditions with an ambient air temperature of 15 ˚C.
3. Temperature and flow rate measurements are made at the exhaust adapter of the Energy Server.
4. Exhaust parameters are linearly scalable for larger installations.
5. Values calculated at 95% Total Maximum Output (TMO).
6. Maximum exhaust temperature and flow rate predicted to occur approximately 2 years after commissioning of the Energy Server.

Figure 3: Bloom Energy's heat capture installations

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Flexible. Future Proof.

Accelerate your path to a zero-carbon future.