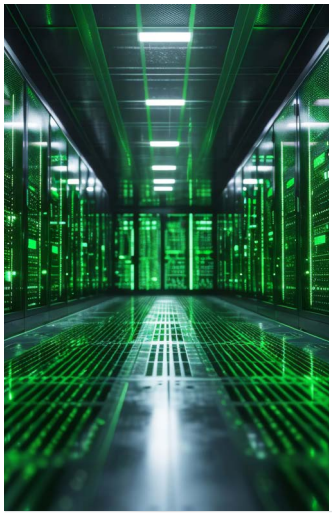
JENBACHER

ENHANCING DATA CENTER EFFICIENCY

Improving Power Usage Effectiveness (PUE) with trigeneration



Industry needs

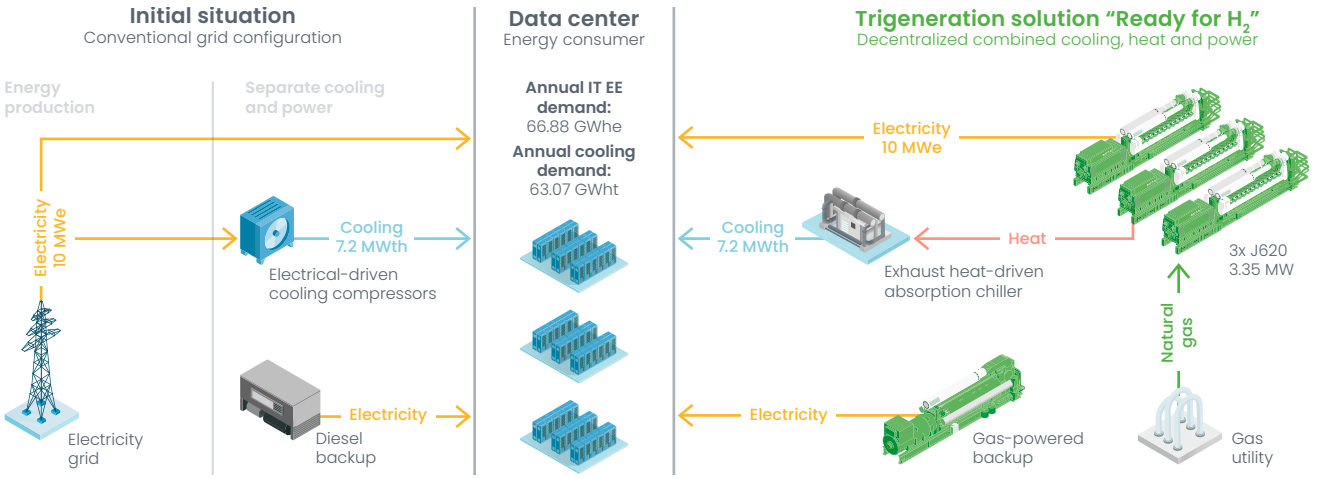
Data centers have unique energy demands, particularly in terms of cooling, which constitutes a significant portion of their overall energy consumption. Implementing a highly reliable trigeneration solution can optimize this energy use by simultaneously producing cooling, heating, and power (CCHP). This integrated approach not only enhances energy efficiency but also contributes to a lower Power Usage Effectiveness (PUE), a critical metric for evaluating data center efficiency. PUE is calculated as the ratio of the total energy used by the data center to the energy consumed by its IT equipment. The following use case provides insights into the technical, financial, and environmental benefits of adopting a trigeneration system for a 10 MW data center.

Business case simulation[1]

The exemplary business case presented is a simulation performed using a dedicated data center simulation software.

This business case is illustrative only and projects need to be evaluated on a case-by-case basis.

INNIO Group is pleased to provide individual business case simulations to explore customer-specific data center projects.



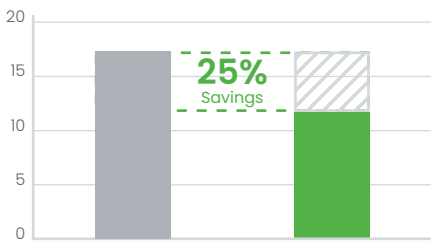
Business case simulation at a glance

Levelized cost of energy (in $/kWh)



Initial situation — With trigeneration

Annual energy costs (in millions of $)



Initial situation — With trigeneration

Amortization time

2–3 Years

CO_2 reduction

-8%

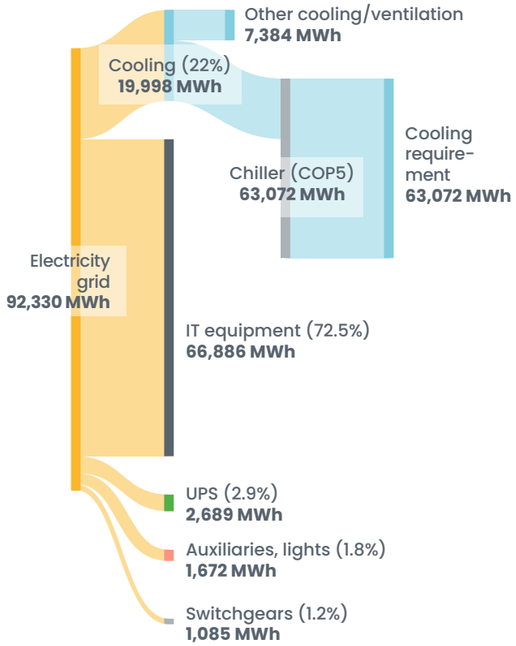
Assumptions: Electrical Energy (EE) grid price: 0.183 USD/kWh. Natural gas price: 0.065 USD/kWh. Backup system not included. European EE grid average CO_2 emission.

Enhancing data center efficiency with Jenbacher trigeneration solutions to achieve improved Power Usage Effectiveness (PUE)

Conventional grid configuration

10 MW grid capacity data center with PUE = 1.38 based on energy consumption. Full year energy consumption, electricity purchase from the grid (energy in MWh).

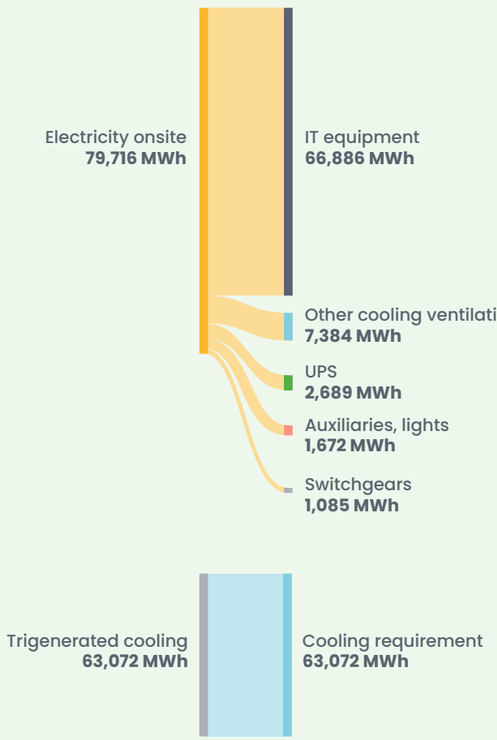
10 MW



Trigeneration configuration

Same data center with PUE = 1.19 based on energy consumption. No grid integration, trigeneration from three Jenbacher J620 engines. Full year energy consumption (energy in MWh).

3 x J620, 10 MW

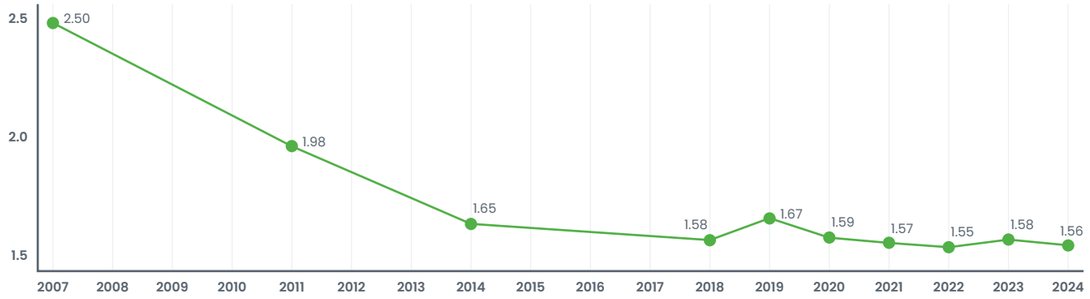




Power Usage Effectiveness (PUE)

The PUE measures the energy efficiency of a data center. The ideal PUE is 1.0, indicating perfect efficiency. The industry average PUE has remained around 1.58 since 2020, although an increase in innovative IT and facility designs has helped reduce average PUE over time.

1.0–1.2	1.2–1.5	1.5–2.0	2.0–2.5
12%	47%	38%	2%



Source: Uptime Institute Global Data Center Survey 2024

Benefits of Jenbacher trigeneration solutions for the data center industry

Cooling efficiency

Cooling typically accounts for 20–40% of power usage in data centers, making it a critical area for efficiency improvements with trigeneration systems, which usually combine a gas engine with heat recovery and an absorption chiller for cooling.

Energy cost savings

Trigeneration helps reduce energy consumption by effectively managing heat dissipation. Jenbacher simulation showed nearly 25% annual energy cost savings with trigeneration compared with the conventional grid configuration.

Emission reductions

Our simulation shows 8% CO_2 reduction when a trigeneration system is installed compared with just using grid electricity.

"Ready for H_2"

Jenbacher power solutions can accept an increasing blend of renewable fuels such as hydrogen, ammonia or biogas, with the aim of eventually running on 100% renewable fuel as supply chains develop. Jenbacher "Ready for H_2" and H2-Engines offer a strategic advantage, aligning with the growing trend of sustainable data center operations.

Trigeneration policy support

European Union

Article 12 of the Energy Efficiency Directive (EED) requires data center operators to monitor and report on their energy performance.

Under delegated regulation (EU) 2024/1364 adopted in March 2024 data center operators are obligated to report key performance indicators (KPIs) to the European database on a yearly basis (energy consumption, power utilization, temperature set points, waste heat utilization, water usage and use of renewable energy).

European Code of Conduct for Data Centers (EU DC CoC) launched in 2008, is a voluntary initiative set to encourage and guide data center operators and owners in cost-effective reductions in energy consumption.

INNIO Group offers a variety of Jenbacher solutions based on individual data center needs. Depending on the data center's operating system, the appropriate configuration is selected—from continuous to hybrid to backup power solutions.

Jenbacher backup power solutions

Fast startup capability

Typically, gas engine technology has been optimized for continuous operation at high efficiency. However, faster response times have become a priority due to recent changes in the energy landscape, such as the expansion of intermittent renewable energy. With technical improvements, including port injection and an advanced control management system, our Jenbacher J620 natural gas generator for data centers can provide full output within less than 45 seconds while supporting a single 100% load step.

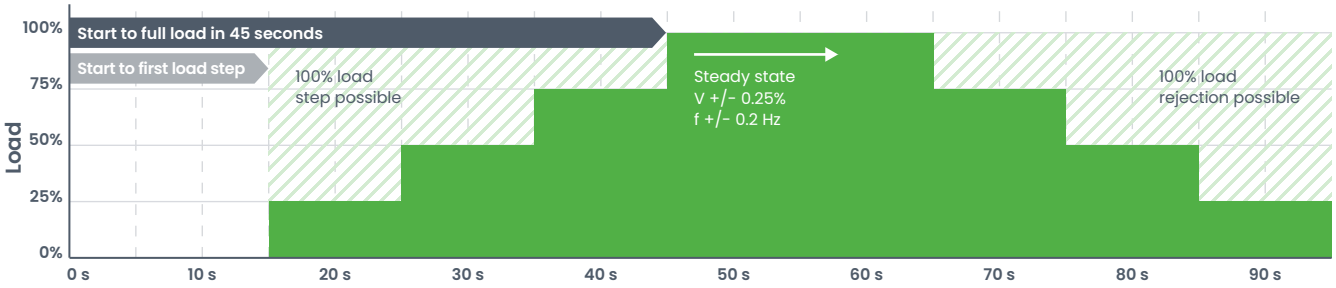
Startup steps	Fast startup with the Jenbacher J620 generator for data centers
Start command, delay and pre-lubrification	5 sec
Firing to nominal speed	10 sec
Nominal speed to full load	30 sec
Start to full power	**45 sec**

Conditions: Pre-heated and pre-lubrificated

Load ramps/steps

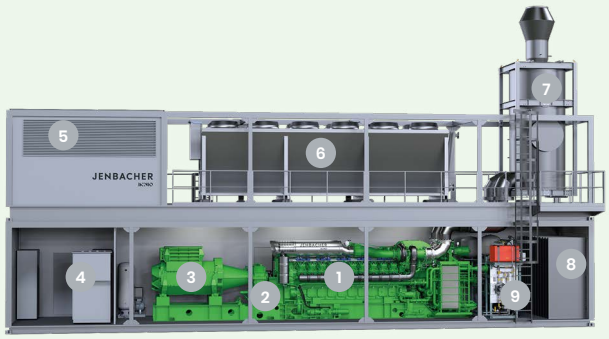
With a pre-heated Jenbacher J620 fast-start, natural gas solution, either load steps or ramps can be applied immediately after reaching the nominal speed. Typical load steps during an engine startup take place at 25% intervals with corresponding limits for voltage, frequency and settling times. The J620 fast-start solution also supports up to 100% load changes without trip and without corresponding limits for voltage frequency and settling time.

Super-fast-start, Black start profile



Example profile for pre-heated/-lubricated; Without synchronization; 480 V configuration; Power quality within +/- 10% voltage, +/-5% frequency

1. **3 MW J620 engine**
2. Gear box (60 Hz only)
3. Brushless 4 pole generator
4. Switchgear room
5. Ventilation system
6. Combined V-shape radiator for HT and LT circuits
7. Exhaust silencer with integrated catalytic converter (optional)
8. Air outlet sound attenuation
9. Pump skid and external lube oil tank



[1] **LEGAL DISCLAIMER: THE INFORMATION PROVIDED HEREIN IS BASED ON ASSUMPTIONS AND MAY VARY ON INDIVIDUAL CIRCUMSTANCES. IT IS INTENDED FOR ILLUSTRATIVE PURPOSES ONLY AND SHALL NOT CONSTITUTE LEGAL OR TAX ADVICE. NO PART OF THIS INFORMATION SHALL BE CONSTRUED OR INTERPRETED AS A REPRESENTATION OR WARRANTY BY INNIO. INNIO EXPRESSLY EXCLUDES ANY LIABILITY ARISING FROM THE USE OR INTERPRETATION OF THE INFORMATION PROVIDED.**

In general, "Ready for H_2" Jenbacher units can be converted to operate on up to 100% hydrogen in the future. Details on the cost and timeline for a future conversion may vary and need to be clarified individually.

For more information, visit INNIO Group's website at **innio.com**

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