

COAL MINE GAS SOLUTIONS

Harnessing
the power of
coal mine gas

JENBACHER
INNIO



DESPITE CHALLENGES, COAL REMAINS A SIGNIFICANT PART OF THE ENERGY MIX

But operators are mindful of greenhouse gas emissions

Although the world increasingly relies on renewable power sources, fossil fuels such as coal are still an active part of the energy mix today. In fact, in 2021 global coal consumption was just under the previous record from 2014. Most of that consumption—81.5% of it—took place in countries that are not part of the Organization for Economic Cooperation and Development (OECD), with six of the world's 10 largest consumers found in the Asia Pacific region.

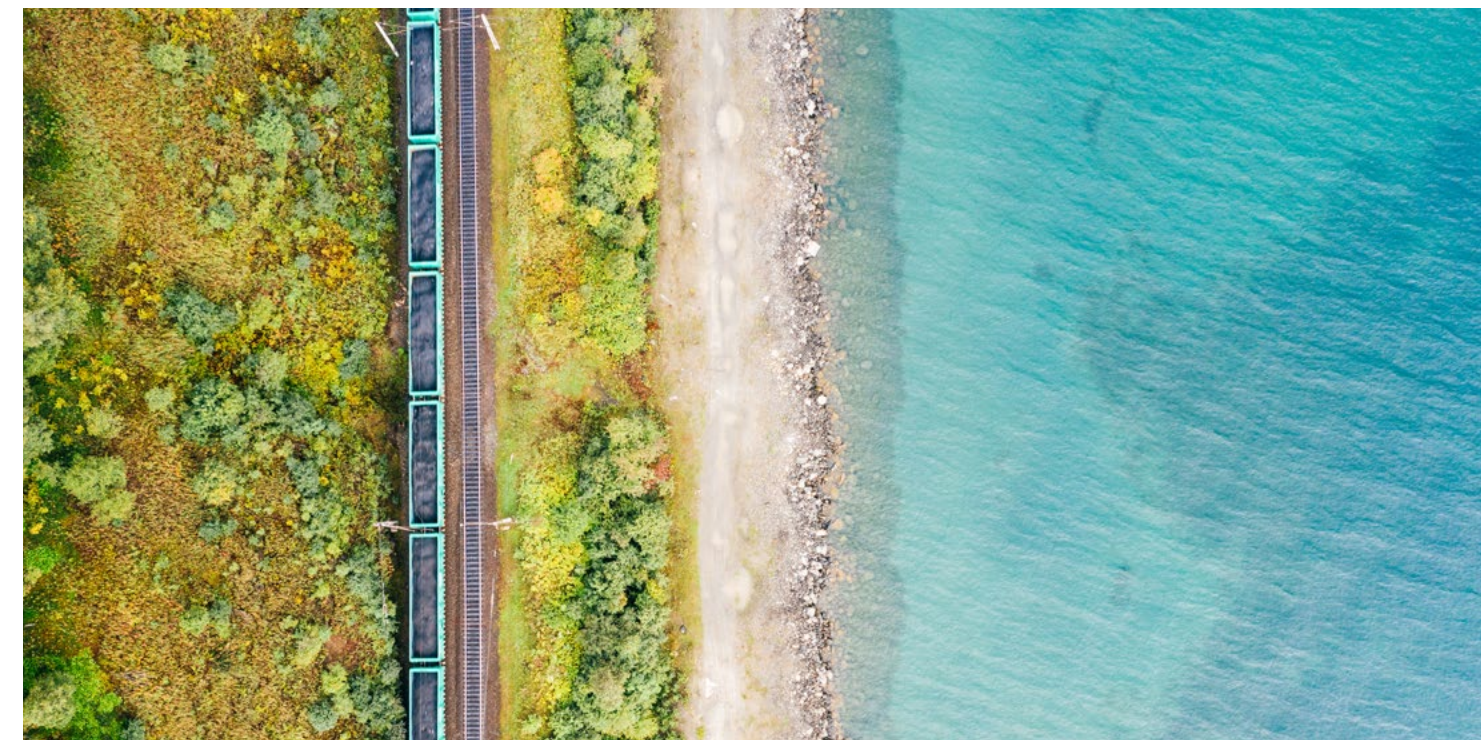
However, coal operators worldwide are well aware of a growing tide of public opinion against the use of coal. For instance, because of its high CO₂ emissions, the coal mining industry is seen as a barrier to many nations' "carbon-free" strategic goals. While a key concern relates to the emissions associated with the burning of coal as a power source, other concerns relate to the coal mining process itself. Coal mining can be dangerous to miners because of the high risk of explosions from coal mine gas, which develops during the geochemical conversion of organic substances to coal (carbonization).

Coal mine gas—which is present in fissures, faults, and pores of coal seams and as adsorbed gas on the inner surface of coal and neighboring rock—is problematic for another reason, too. McKinsey estimates that the mining industry as a whole emits 1.9 to 5.1 gigatons of CO₂ equivalent of greenhouse gas emissions each year, and most of those emissions come from coalbed methane released as part of the coal mining process. Worldwide, many underground mines with a certain rank, permeability, and location of coal strata can be considered gassy.

Mine degasification

In pit coal mining, coal mine gas and air can combine to form ignitable mixtures. For worker safety, mines must be degasified if the ventilation system cannot prevent such risk. This can be achieved by installing various types of gas suction systems.

In addition to increasing safety standards, capturing coal mine gas provides an energy source and also helps mitigate greenhouse gas emissions, especially in countries with large coal production.



COAL MINE GAS AS AN ENERGY SOURCE

Putting coal mine gas to work while cutting greenhouse gas emissions

Combined heat and power (CHP) plants can effectively generate power and heat using coal mine methane (CMM)—found in most large underground hard coal mines—as well as abandoned mine methane (AMM). The generated energy can meet the coal mine’s electricity requirements or supply the public power grid. Thermal energy can deliver onsite heating or feed into a district heating system.

The gas mining conditions are challenging, with lower pressure, high humidity, and dust, and—with the passage of time—a decreased concentration of available methane. INNIO’s advanced Jenbacher technology meets these challenges with reliability and efficiency.

The types of coal mine gas

Coal mine methane (CMM)

For safety reasons, coal mines must vent and capture CMM, a methane/air mixture released during active coal mining. CMM typically has an oxygen content from 5% to 15%, and the methane content ranges from 25% to 60%. However, the methane/air proportion can change suddenly, thus complicating its use in gas engines.

Coalbed methane (CBM)

Also called coal seam gas (CSG), coalbed methane from unmined coal beds consists of more than 90% methane and can be harvested independently of coal mining in some locations. Because of its stable gas composition, CSG can be fed either directly into the pipeline gas network or an engine.

Abandoned mine methane (AMM)

Even after coal mines are shut down, they continue to release coal mine gas. Coal mine gas from abandoned mines typically contains no oxygen but a considerable amount of carbon dioxide (3%–20%), and its composition changes slowly compared to CMM. The methane content ranges from 40% to 80%.

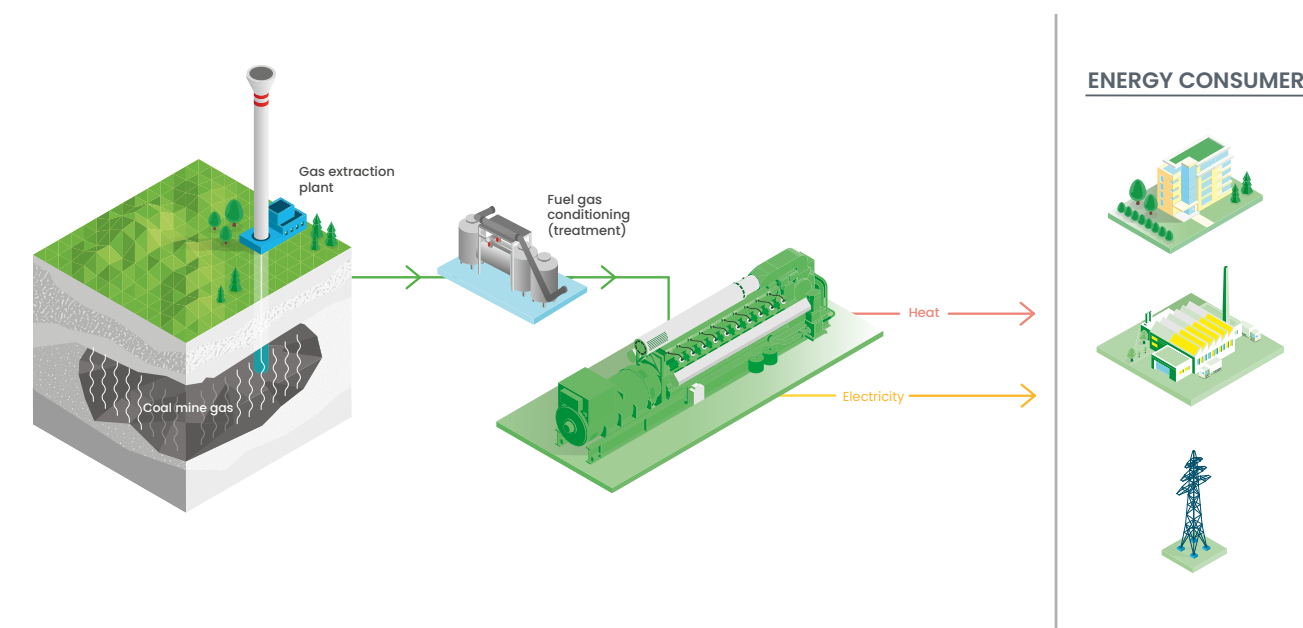
COAL MINE GAS-FUELED CHP PLANTS

Turning coal mine gas into power and heat

An efficient power solution, Jenbacher gensets offer large output with a small footprint, high efficiency and availability, and low NOx emissions.

Instead of venting methane-laden gas into the atmosphere, we convert this gas into energy for use in a Jenbacher combined heat and power plant, reducing greenhouse gas emissions and creating financial value. When the methane is combusted in engines, it converts to CO₂, which is approximately 25 times (GWP 100¹) less harmful to the climate than methane.

Up to 90% of the energy found in methane can be converted into power and heat through CHP solutions that use coal mine gas. Even low concentration mine methane (LCMM) can be used in Jenbacher solutions—efficiently and reliably—to generate electricity and heat, including warm water for district heating in the winter.



Support for gas conditioning

Coal mine gas must be treated to obtain the necessary gas quality. Therefore, investments in the gas suction system or gas supply to reach the required coal mine gas quality and gas flow stability do pay off. In combination with a highly efficient and specialized Jenbacher CHP unit, this setup optimizes the profitability of coal mine gas power generation projects.

¹www.ecometrica.com/assets/Understanding-the-Changes-to-GWPs.pdf

THE ADVANTAGES OF USING COAL MINE GAS FOR ENERGY

Boosting sustainability... and your bottom line



Enhance worker safety

with an installed or refurbished gas suction system



Mitigate greenhouse gases

by avoiding the venting of coal mine gas into the atmosphere



Monetize carbon credits

with additional revenues from feed-in tariffs or through carbon credit projects, as applicable



Increase revenue from power and heat

by feeding any surplus into the public grid and even supplying warm water or steam to the consumer



Achieve excellent overall efficiency

with up to 90% in combined heat and power applications and more than 43% in power generation alone



Get fast load capability

from demand to 100% load in 5 minutes



Install quickly, even in tight spaces

with a compact and modular design that meets low footprint and dynamic weight-per-kW requirements



Meet sustainability goals

with LEANOX technologies for low NOx emissions



Get advanced service support

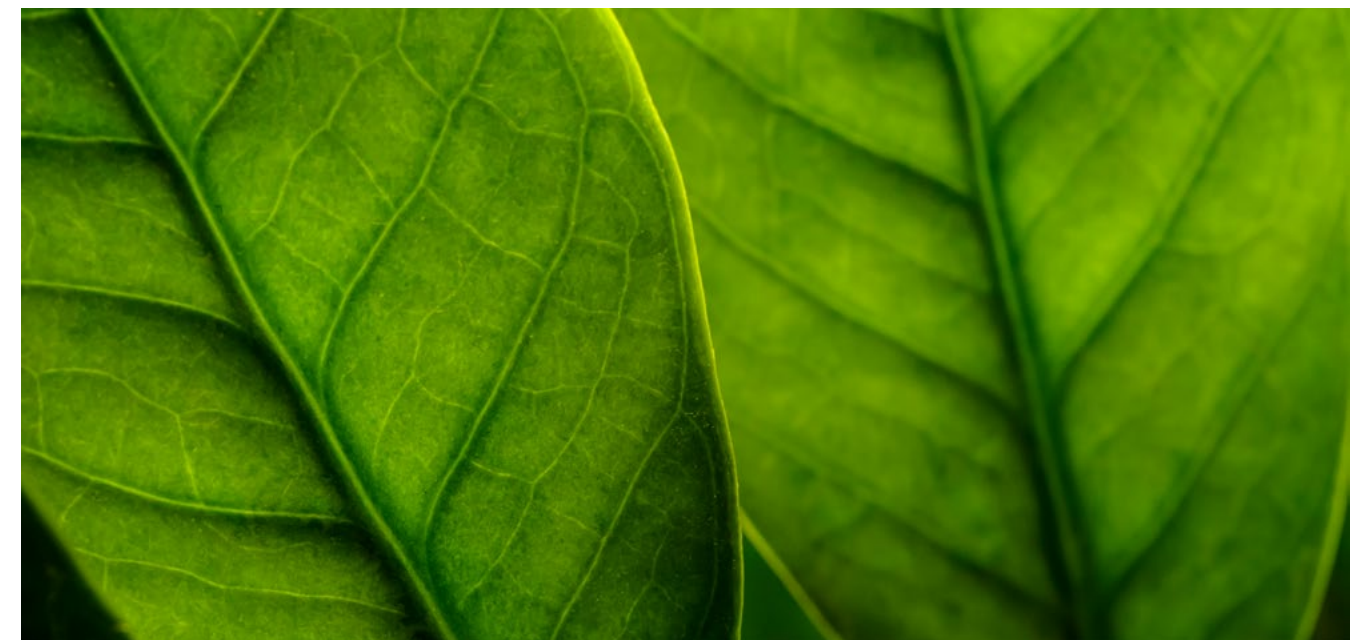
through our extensive service network and Contractual Service Agreements

PROVEN JENBACHER TECHNOLOGY

For coal mine gas power and heat generation

Jenbacher solutions are proven to meet the challenges of the coal mine industry. For instance, sudden changes in the composition of coal mine gas from active mining put greater demands on the engine design, but the Jenbacher team has developed a special gas mixing and engine control system that allows the efficient use of this challenging gas. In special cases with dedicated safety regulations, coal mine gas with a methane content down to 10% (vol) can be used.

Additionally, Jenbacher engines can operate on full load despite a variety of obstacles such as low gas pressure; fluctuations in pressure and methane content; or high humidity, dust load, and altitude. Moreover, our Jenbacher solutions feature an integrated methane measuring unit so you can achieve compliance with UNFCCC specifications.



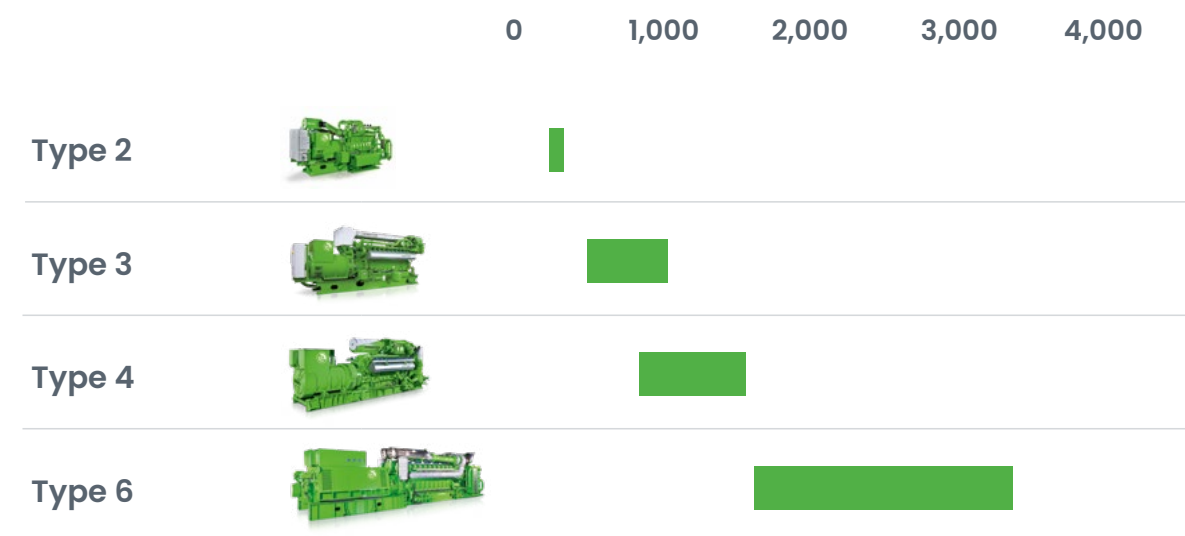
A POWERFUL PORTFOLIO

For a variety of coal mine gas-fueled CHP applications

INNIO offers you a comprehensive portfolio for coal mine gas applications, from 330 kW up to 3,360 kW of single unit electrical power output. By using multiple gensets in one power plant you can scale up your power output while significantly enhancing part load performance and reliability.

We offer a wide range of available generator voltage levels and flexible hydraulic integration variants for excellent integration into your existing electrical and thermal systems. Depending on your needs and capabilities, INNIO can provide you with the basic module, including its control system, or with an extended supply scope that includes balance-of-plant equipment.

Electrical output (kWel)



PROVEN JENBACHER TECHNOLOGY

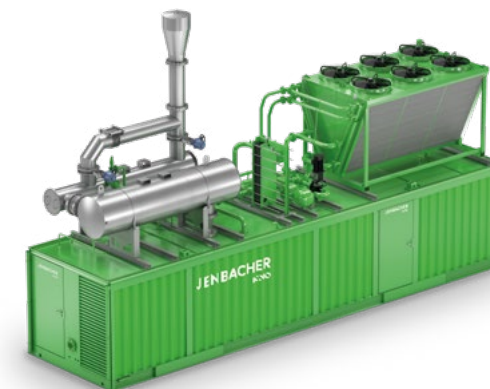
For coal mine gas applications

INNIO recognizes that you need a reliable and available energy source. With our quick and simple installation, our Jenbacher container solutions are an ideal fit for your site.

Containers are available for Jenbacher Type 2, 3, 4 and 6 engines with a broad range of options to meet your specific project requirements, such as sound attenuation, heat recovery, exhaust treatment, non-standard ambient temperatures, or earthquake safety.

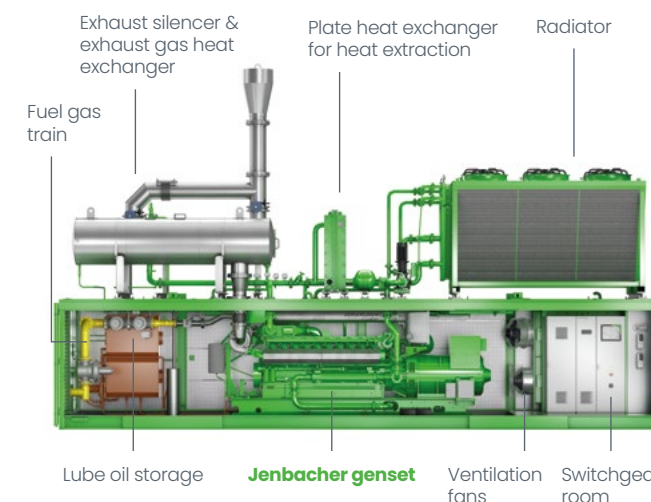
The main benefits of our container solutions are:

- Quick and easy site installation due to pre-installed package with all necessary auxiliaries
- Less space consumed on site due to compact footprint
- Enhanced genset performance because all components are perfectly matched to the specific site requirements by Jenbacher engineering experts



Our containers incorporate the following main systems and features:

- Jenbacher genset
- VFD-controlled, positive-pressure ventilation system including weather grids, air filtration, and sound attenuation baffles
- Cooling systems with roof-mounted dump radiator and optional heat recovery equipment
- Fuel gas train
- Roof-mounted exhaust silencer and optional exhaust gas heat exchanger
- Lube oil storage and refill system
- Separate control room (air conditioning optional) for module control panel, generator circuit breaker, and VFDs
- Bunded floor for reliable fluid retainment in the unlikely event of spills
- Multiple access doors to facilitate maintenance



JENBACHER COAL MINE GAS-FUELED CHP TECHNOLOGY

An investment that pays off

With INNIO's coal mine gas-fueled CHP solutions, you gain economically—and the environment benefits.

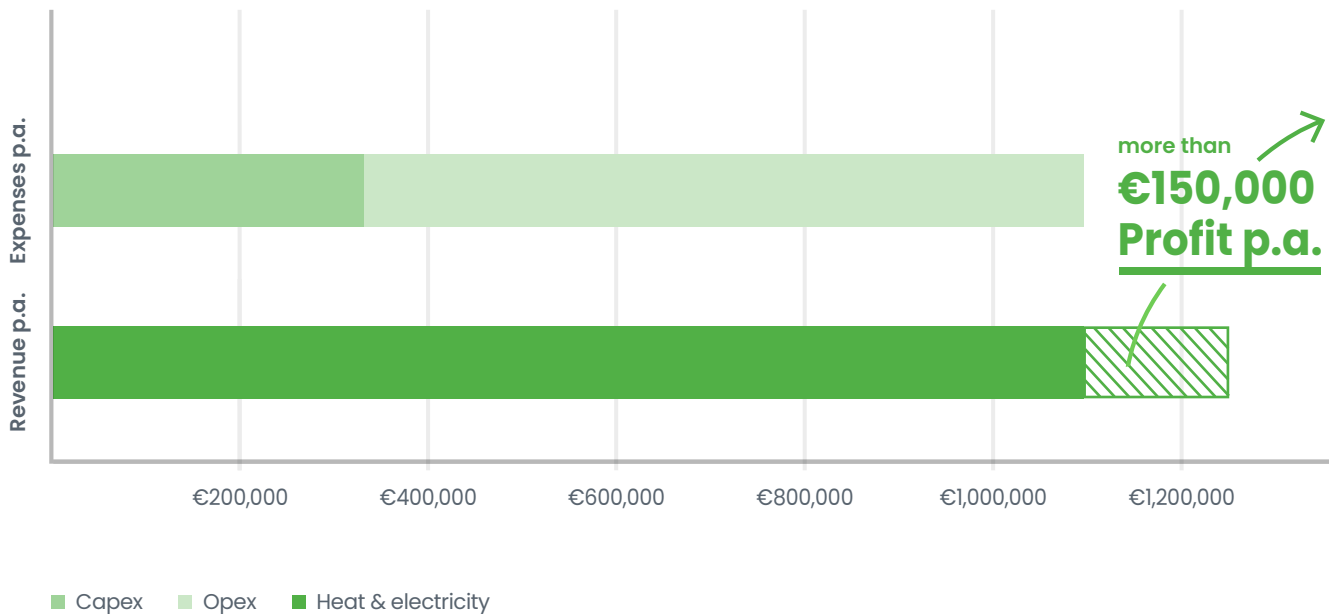
The following example from China details how it pays off to use coal mine gas in a Jenbacher CHP plant. In addition to delivering economic advantages, this application also significantly reduces coal mine gas emissions into the atmosphere.

CHP PLANT KEY TECHNICAL DATA

Engine	1 x J620
Electrical output	3,352 kWel
Thermal output	3,556 kWth
Energy input	7,827 kW
Power generation	26,414 MWh/a
Heat generation	28,448 MWh/a



All values rounded. Currency conversion rate 1 RMB = 0.13 EUR.



Return on investment: less than 7 Years

- Assumptions:**
- Coal Mine Gas: €0.0039/kWh
 - Electricity Price: €0.043/kWh
 - Value of Heat: €0.004/kWh
 - Annual operating hours: 8,000
 - Based on a review period of 20 years, 8% interest rate p.a.



MORE THAN 30 YEARS OF EXPERIENCE

with coal mine gas applications

We installed our first Jenbacher systems using coal mine in Germany and Great Britain in the early 1990s. Today, more than 500 units, with the potential to generate a total electrical output of about 1,200 MW, run on coal mine gas worldwide. In remote areas with critical frame conditions, our Jenbacher engines achieve maximum availability of 8,000+ operating hours per year.

These plants potentially can generate about 9 million MW-hours² of electricity annually—enough to cover the demand of about 2.5 million EU homes³. Generating this amount of electrical power with coal mine gas could save over 2,100 million cubic meters of pipeline gas a year. In addition, Jenbacher engines using coal mine gas can reduce the release of methane into the atmosphere by about 85% compared to releasing the gas into the atmosphere, which corresponds to 24,000 tons⁴ of CO₂ emissions savings per year.



² Based on the number of Jenbacher systems delivered worldwide and assuming 8,000 operating hours p.a.

³ Based on average electricity consumption per EU household in 2018. www.odyssee-mure.eu/publications/efficiency-by-sector/households/electricity-consumption-dwelling.html

⁴ Based on the carbon intensity of power generation in 2021, IEA www.iea.org/reports/tracking-power-2021

CHENGZHUANG CMG POWER GENERATION PROJECT

Delivering efficient, greener power with coal mine gas

At one of INNIO's biggest coal mine gas (CMG) power generation projects in China, 12 Jenbacher J620 gensets are efficiently delivering a total capacity of 40.5 MW of electrical output and 36 MW of thermal output.

Delivering total efficiencies of around 80% running on energy-rich methane gas from coal mines, the J620 units work in conjunction with two 3 MW condensing steam turbine gensets in combined cycle operation. What's more, the plant helps reduce greenhouse gases in the region by producing significantly lower emissions than similar capacity coal plants.



PLANT FACTS

Engines	12 x J620
Energy source	Coalbed methane
Electrical output	40.5 MW
Thermal output	36 MW
Total efficiency	80%
Year of commissioning	2017



Winner of 2 Industry POWER Awards:

In 2020, the site's Jenbacher gensets ranked No. 1 in contests for both "Yearly Max OPH" of individual gensets and "Yearly Max Avg. OPH" of genset fleets among various CBM power plants. The Industry POWER Award was established by the Shanxi Gas Power Generation Association—the first gas power generation association in China—to commend companies that have made outstanding contributions toward the development of the gas power generation industry.*

*www.sgpga.com/news/show/310

SHANXI JINJU HUDI COAL MINE GAS POWER GENERATION PROJECT

Supporting China's energy transition with distributed power from low concentration mine methane

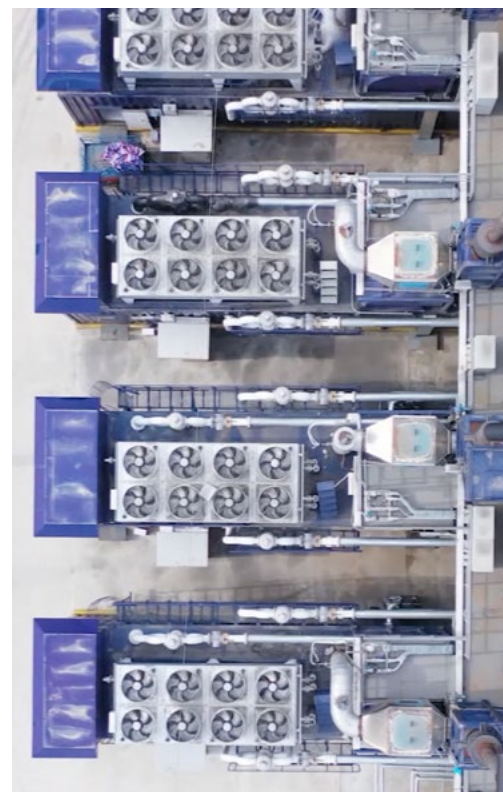
In China, the Hudi gas power station is putting low methane gas produced as part of the Shanxi Jinju Coal-Power-Chemical Company's mining operation to work in support of the country's energy transition goals.

The project is the first in China to put both coal mine gas (CMG) and low concentration mine methane (LCMM) to use separately for power generation at the same site. Because power generation with LCMM requires high reliability and efficiency, the company decided to center its Hudi station on eight of INNIO's Jenbacher J420 gensets. With an installed capacity of 10 MWel of power and total heat recovery of 10.5 MWth, the plant is one of INNIO's largest LCMM power generation projects to date, delivering approximately 70 GW of power annually while also reducing the area's greenhouse gas emissions.



PLANT FACTS

Engines	8 x J420
Energy source	LCMM gas
Electrical output	10 MW
Thermal output	10.5 MW
Total efficiency	80%
Year of commissioning	2019



OUR COMMITMENT

to you

Flexibility and experience you can count on

For the last 65-plus years, Jenbacher has been an innovator of power generation technology. Today's highly efficient Jenbacher systems deliver energy independence through an efficient, low emission, secure and cost-effective energy solution.

Thinking long-term. Thinking circular

With our flexible, scalable, and resilient energy solutions and services, INNIO is embracing the circular economy—recycling, reusing, and upgrading our engines to meet the latest environmental requirements. For example, upgrading to hydrogen operations for a renewed life or using heat that normally would be wasted during power generation are sustainable solutions that can keep entire communities or businesses warm and electrified.

Through our service network in more than 100 countries and our digital capabilities, we provide life-cycle support for our globally installed units, helping to ensure a greater runtime for longer equipment life.

Zero-carbon H₂ operation tomorrow

In addition, the same proven and economically viable INNIO equipment can be moved from conventional fuels today to full CO₂-free H₂ operation tomorrow, once H₂ becomes more readily available.



BENEFIT

from a powerful digital platform



Through our myPlant Performance digital solution, INNIO provides digital remote support for our connected customer-operated systems across the globe. Today, more than 12,000 engines are managed remotely, with more than 1.2 trillion data points evaluated annually—a powerful proof-point of INNIO's knowledge and experience.

Fulfill emission requirements

Our engine and fleet emission monitoring solutions help you more easily comply with emissions requirements—until you can operate your plant with 100% H₂ and become carbon-free.

Improve business planning

Increase your power system's lifespan by taking advantage of self-learning algorithms that analyze component condition and calculate parts lifetime.

Optimize engine management

Real-time engine monitoring and operations provide you with remote access to your assets via desktop or app, whenever you need it, by aligning operational practice with maintenance requirements.

Achieve greater availability

With the ability to solve more than 60% of logged cases remotely, you can reduce the need for travel to your site—saving time and money.

Rely on INNIO's engagement to sustainability

For INNIO, ethics and compliance, along with a sustainable way of conducting business, are front and center of everything we do. By selecting INNIO as your supplier, you enter a long-term relationship with a dependable collaborator. Our fundamental mission to accelerate the world's transition to net zero was recognized with the prestigious EcoVadis ratings. Also in 2021, INNIO joined the "Race to Zero" campaign, initiated by the United Nations, to bring together global leadership for a healthy transition to a net-zero future. Thanks to our efforts in 2021, INNIO's ESG Risk Rating places us number one out of more than 500 worldwide companies in the machinery industry assessed by Sustainalytics.*

*Rating took place in February 2022

INTERESTED?

INNIO is among the world's technological leaders in energy solutions and services for coal mine applications.

Let us develop a powerful energy concept for your company.

Reach out today by completing the contact form online:
innio.com/contact

Our Sales team will get back to you.



INNIO is a leading energy solution and service provider that empowers industries and communities to make sustainable energy work today. With our product brands Jenbacher and Waukesha and our digital platform myPlant, INNIO offers innovative solutions for the power generation and compression segments that help industries and communities generate and manage energy sustainably while navigating the fast-changing landscape of traditional and green energy sources. We are individual in scope, but global in scale. With our flexible, scalable, and resilient energy solutions and services, we are enabling our customers to manage the energy transition along the energy value chain wherever they are in their transition journey.

INNIO is headquartered in Jenbach (Austria), with other primary operations in Waukesha (Wisconsin, U.S.) and Welland (Ontario, Canada). A team of more than 4,000 experts provides life-cycle support to the more than 55,000 delivered engines globally through a service network in more than 100 countries.

INNIO's ESG Risk Rating places it number one of more than 500 worldwide companies in the machinery industry assessed by Sustainalytics.

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

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ENERGY SOLUTIONS.
EVERYWHERE, EVERY TIME.

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