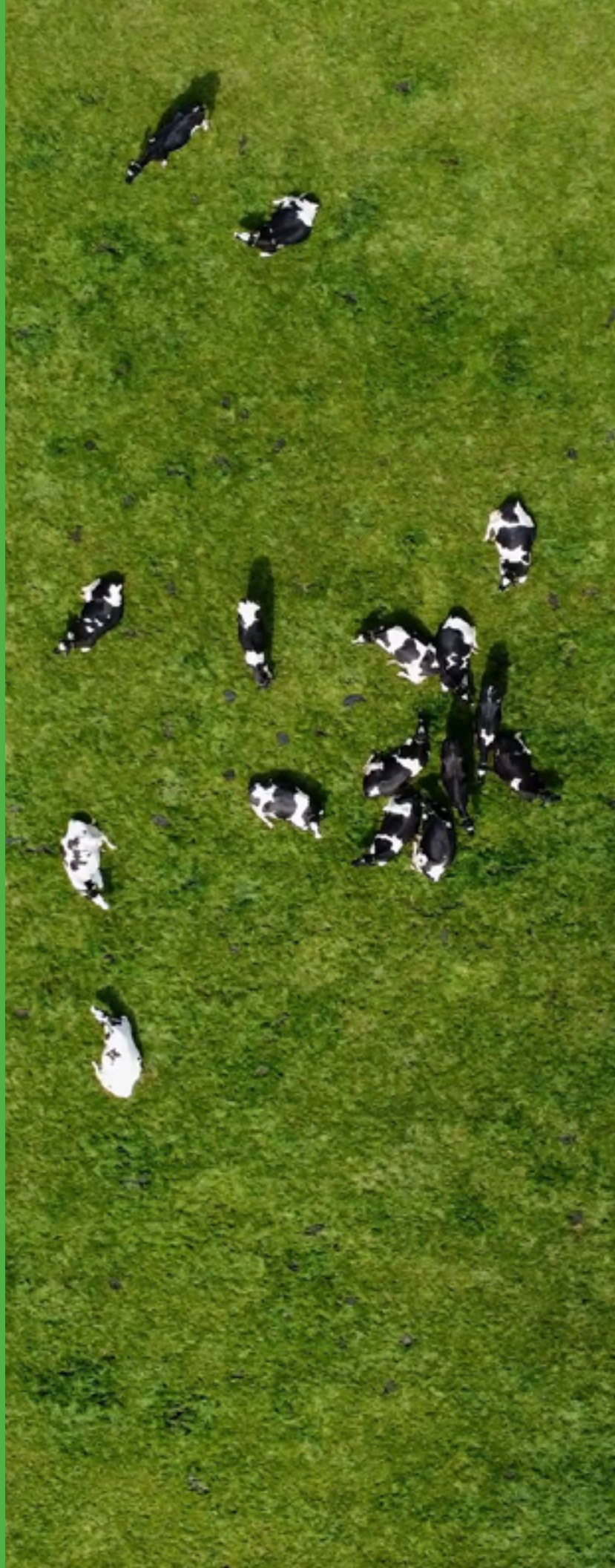
WASTE TO POWER

Turning biogas into heat and power



JENBACHER

GENERATING AND MANAGING ENERGY sustainably

As the energy transition progresses with a push to net zero, the demands on power generation are increasing. With the phase-out of coal and nuclear power, centralized electricity producers often are replacing larger plants with a number of smaller, decentralized wind energy and photo-voltaic plants that provide power and heat where it is needed.

There's a downside, though: fluctuations in electricity production due to volatility of renewable energy sources. To avoid blackouts, the missing electricity must be generated through other available sources, quickly. That's where another renewable energy source, biogas, comes into play—as a complement to these volatile, weather-dependent energy sources.

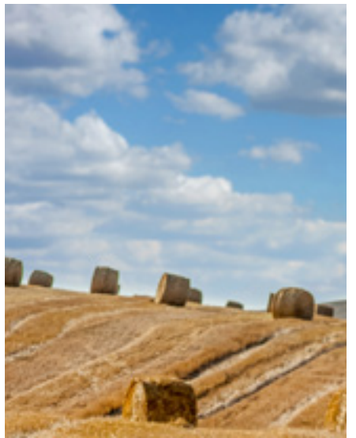
With global electricity use continuing to rise, electrification is yet another challenge to power generators. The switch to electric vehicles and heat pumps in certain regions, as well as advancing digitalization, not only increases energy demand, but also makes it more difficult to calculate. Energy producers require intelligent digital tools to successfully navigate the energy market—and make a profit.

THE BIOGAS SOLUTION

Instead of producing waste that creates emissions, organic waste—also called biomass—can be used as a valuable energy source when turned into biogas. And the use of biogas to fuel engines as a substitute for fossil fuels is on the rise across the energy market. That's because this renewable energy source complements other renewable energy sources such as wind and solar–with one big difference. It's not dependent on the weather!

A mixture of methane and carbon dioxide, biogas is created during anaerobic fermentation. Its sources include dung, liquid manure, biodegradable waste, and the growth from nature conservation and flowering areas—most of which would need to be disposed of otherwise. The digested material can even be turned into fertilizer.

Biogas-fueled engines improve waste management while maximizing the use of an economical energy supply. This locally produced renewable energy source can enable your journey toward net zero as you face the challenges of the energy transition.



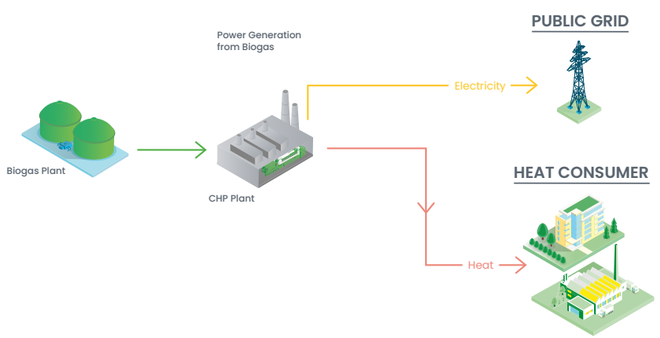
BIOGAS-FUELED CHP PLANTS

turn biomass into power and heat

INNIO offers flexible, innovative, and proven Jenbacher combined heat and power (CHP) solutions that turn biomass into power and heat. With a wealth of experience in biogas applications, INNIO Jenbacher also is a global technology leader when it comes to engine-based power generation and waste heat recovery solutions including CHP (also called cogeneration).

In fact, our Jenbacher biogas-fueled engines are already a green technology—improving waste management while maximizing the use of an economical energy supply.

In addition to providing power for your local site, INNIO's CHP technology also can be used to export generated electricity to the public grid, creating additional value streams for you while supporting the local grid as needed. Similarly, you can use the generated thermal energy to satisfy your onsite thermal loads by creating hot water, hot air, steam, or process heat.



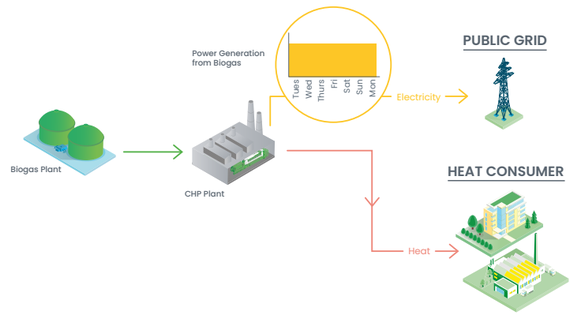
Thermal energy also can be stored for later or used for trigeneration to meet your air conditioning demands. By integrating large buffer storage tanks and gas storage capacities, CHP biogas plants function as renewable storage power plants.

FLEXIBILITY IS KEY

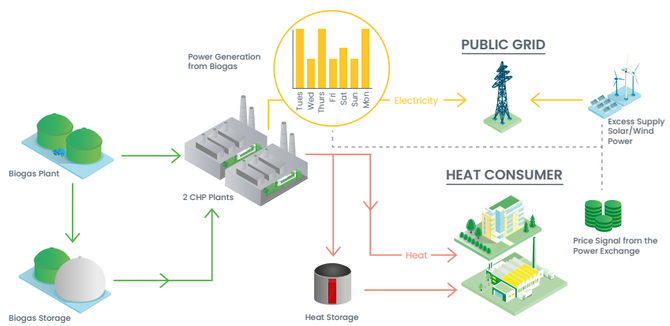
Biogas-fueled CHP plants now operating in balancing mode

Wind and solar energy sources are non-dispatchable—they can't be controlled, in other words. And, as more of these renewable sources are used around the globe, fluctuations in energy production are the norm. When there is a shortfall of renewable energy sources such as solar and wind, power can't be produced. Sufficient power is needed that can be called up quickly to generate the missing quantities of electricity. CHP offers the flexibility to run when those sources aren't available, effectively balancing the load rather than running continuously. In Europe, for instance, a number of biogas-fueled CHP plants are operating in balancing mode, covering the residual load instead of providing baseload power to the public grid. Existing biogas plants can be converted to allow flexible production so that they, too, can contribute to the future power supply.

Generating heat and power with biogas-fueled CHP plants can help close future gaps within a system that relies on renewables. In recognition of the strategic importance and value of biogas-fueled CHP plants, governments have launched various monetary incentive programs encouraging the operation of biogas plants in a demand-driven mode.



Before:
A combined heat and power plant generates electricity from biogas produced in the digester around-the-clock at a constant maximum level.



After:
Multiple combined heat and power plants adjust their power generation to the fluctuating feed-in of solar and wind power or to price signals from the electricity exchange. Biogas is not immediately converted into electricity, but—like the generated heat—it can be stored temporarily when necessary.

CONVINCING ADVANTAGES

An investment in INNIO's Jenbacher cogeneration technology lets you realize impressive economic and ecological benefits when using biogas for power generation:

Sustainable

Green waste-to-power applications are an important contributor to the energy transition. Using resources that otherwise would be wasted and/or removed at great cost, a Jenbacher CHP biogas plant is much more economical than traditional power production while also reducing harmful emissions.

Economical

Biogas-CHP plants provide a maximum overall fuel efficiency and the combination with a sufficient gas and heat storage allows you to operate your assets flexibly and to optimize your earnings. You can run the plant when electricity prices are high and buffer heat to balance differences in thermal energy production and demand.

Ready for tomorrow

Many governments have incentivized CHP plants to shift from base-load to balancing operations. Depending on the dynamics of local provisions, INNIO's experts can help you identify the right Jenbacher technology—digitally enabled with myPlant solutions for your peace of mind and adapted to the provisions in your region.

Increased resilience

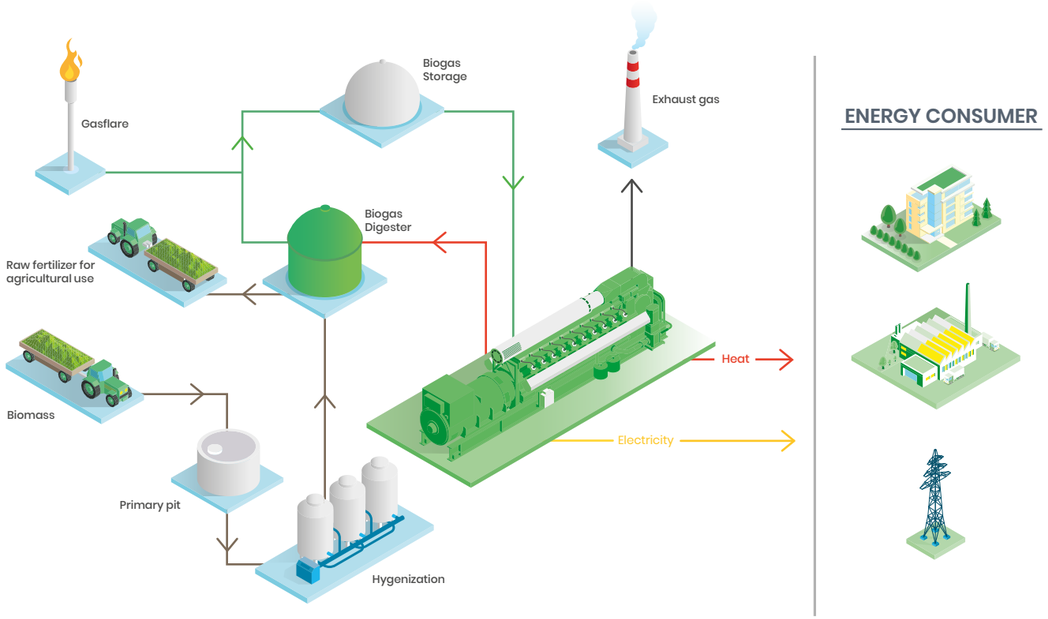
During natural or manmade disasters, CHP systems can support your critical facility operations or stem potential losses when the local or regional electric grid fails. Cogeneration plants equipped with decoupling devices to monitor voltage, frequency, and short interruptions provide an extra level of security and energy continuity. On demand biogas-fueled CHP plants can do blackout starts and be operated in island mode.

Less waste

After the biogas is formed, the remaining substrate can be used as high-quality agricultural fertilizer, characterized by its neutralized acid, higher pH value, retained nutrients, and lack of odor.

PROVEN JENBACHER TECHNOLOGY

for biogas power and heat generation



Here's a look at some of the Jenbacher technology needed at the biogas plant:

Customized hydraulic integration

Through special hydraulic integration variants, INNIO allows for flexible sequencing of the different heat sources of the cogeneration unit. This provides thermal energy at temperature levels specifically tailored to your needs.

Boiler systems for heat storage

Combining the cogeneration plant with a boiler system can help you meet peak heating requirements, leading to added plant flexibility and efficiency with decoupled heat production and consumption.

Support for drying and pre-heating processes

The cogeneration plant's different heat sources can be used to support your onsite production processes such as drying or pre-heating of hay, wood, and other agricultural products. Depending on the temperature levels required in your processes, the CHP unit can work independently or be co-fired with other energy sources for even higher temperature levels.

Trigeneration for cooling

Trigeneration—or combined cooling, heat, and power (CCHP)—provides a substantial advantage over traditional cooling methods. An excellent solution for sites with fluctuating heating and cooling requirements, trigeneration offers you an efficient year-round source for both thermal and cooling power needs. With an absorption chiller linked to the Jenbacher CHP system, excess energy can be used to generate chilled water for air conditioning.

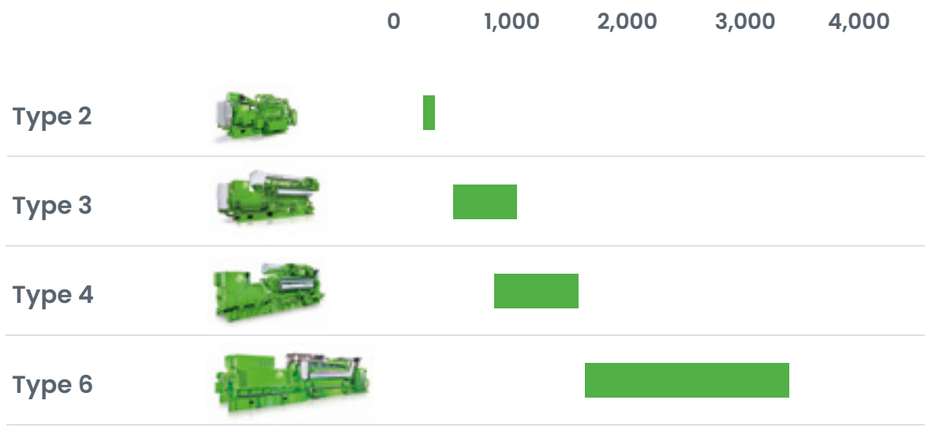
A POWERFUL PORTFOLIO

the INNIO biogas-fueled CHP range

INNIO offers a comprehensive portfolio of single-unit electrical power output from 250 kW up to 3,360 kW for biogas application. By using multiple CHP systems in one plant, your power output can be scaled up while part load performance and reliability are significantly increased.

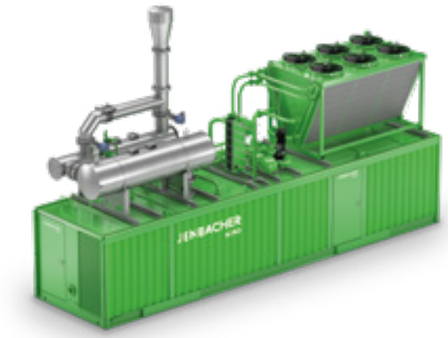
A wide range of available generator voltage levels and flexible hydraulic integration variants is available to allow for excellent integration into your existing electrical and thermal systems. Depending on your needs and capabilities, INNIO can provide you with the basic module, including its control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

Electrical Power Output (kWel)



Jenbacher Container Solutions

Containers are available for Jenbacher Type 2, 3, 4 and 6 with a broad range of options to meet the project requirements.



Benefits

- Pre-installed package completed with auxiliary systems ensures a quick and easy site installation
- Compact footprint consumes minimum amount of space on site
- All components perfectly matched and tuned to the specific site requirements by INNIO Engineering to ensure optimal performance

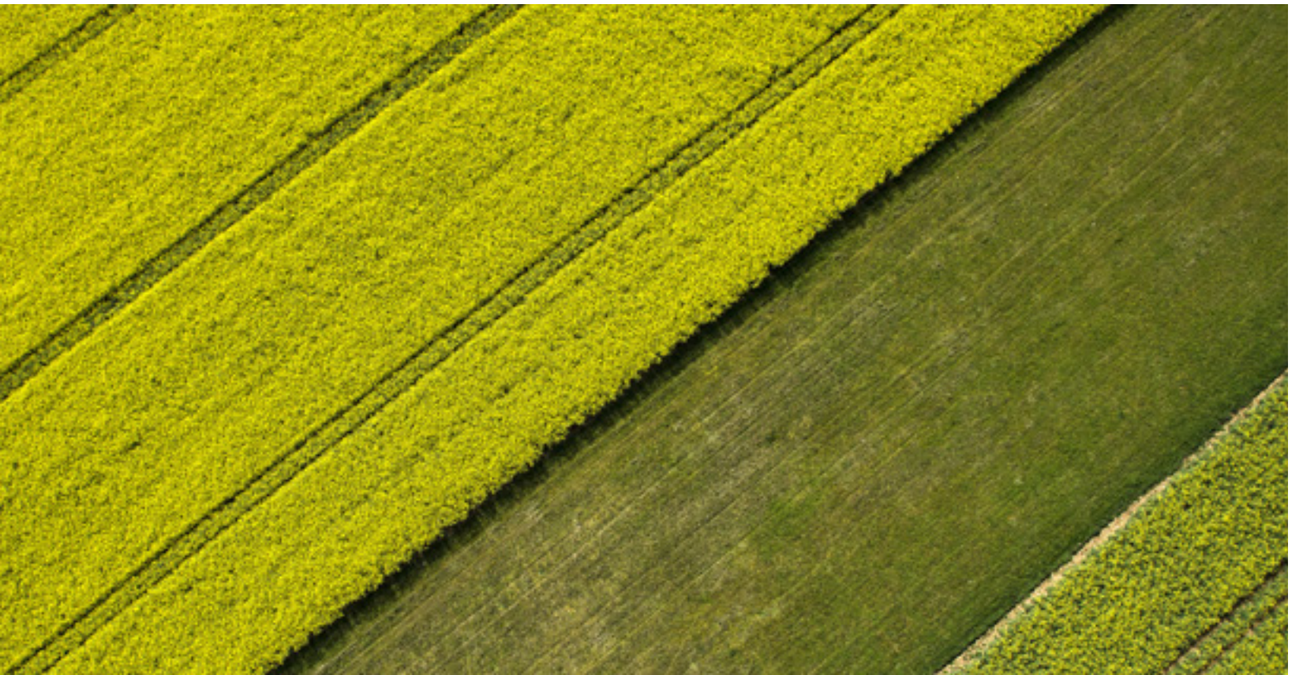
JENBACHER BIOGAS-FUELED CHP TECHNOLOGY

an investment that pays off

With INNIO's biogas-fueled CHP solutions, you gain economically—and so does the environment.

Some countries are discontinuing their subsidies for biogas plants that run continuously because wind, solar, and hydropower are less expensive renewable energy baseload systems. However, governments are recognizing that in times of low renewable energy supply, biogas-fueled CHP plants can step in to produce dispatchable power and heat to stabilize the grid.

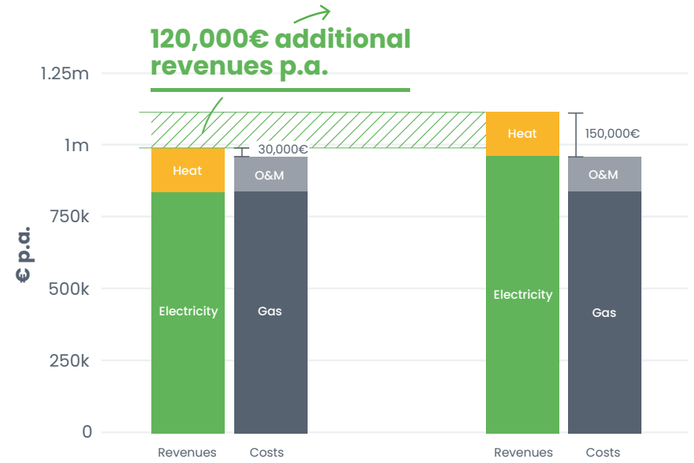
That's why some governmental incentive programs now subsidize biogas plants that provide extra capacities while operating in a new balancing mode sometimes referred to as "flex-operation."



An attractive use case

The following generic use case compares a 500 kW CHP plant running in baseload 24/7 operation to a 1 MW CHP plant running in flexible operation mode with only half the annual operating hours based on demand.

The calculations are based on a volatile electricity market, which enables higher feed-in tariffs (FIT) for a limited time.



Baseload Operation

Plant Key Technical Data:

Engines	1 x J312
Energy Source	Biogas
Electrical Output	500 kWel
Thermal Output	360 kWth

Flexible Operation

Plant Key Technical Data:

Engine	2 x J312
Energy Source	Biogas
Electrical Output	2 X 500 kWel
Thermal Output	2 X 360 kWth

Assumptions

- Simplified, generic flex-operation without incentives
- Gas storage and heat storage available for flex-operation
- Average electricity price baseload 20ct/kWhel
- Average electricity price flex-operation 23ct/kWhel

This sample simplified use case shows that the baseload operation case generates revenue from electricity and heat amounting to approximately 980,000€ per year. In comparison, in flexible operation the biogas plant generates revenue amounting to approximately 1.1 million €—an additional 120,000€—annually, excluding CAPEX or any specific subsidies for flexibilization.
In fact, the one-time investment to enable flexible operation can pay off within the first two or three years of operation, depending on the specific site layout.

6,000 BIOGAS SYSTEMS

around the globe

INNIO has delivered more than 6,000 biogas engines that can generate a total electrical output of green energy of approximately 5.5 GW.

Our delivered biogas-fueled fleet has the potential of an annual production of 44 TWh of electricity[1]. This amount of energy can deliver annual average electricity for around 11.7 million EU homes[2].

Our biogas-fueled fleet can reduce CO_2 emissions by more than 28 million tons[3]. That's powerful proof of INNIO's leading position with our highly efficient biogas-fueled systems.

Chicken farm biogas project in Penglai City—Shandong Province, China

[1] based on assumed 8,000 oph p.a.

[2] Based on average electricity consumption of households in EU, 2018 www.odyssee-mure.eu/publications/efficiency-by-sector/households/electricity-consumption-dwelling.html

[3] Based on EU natural gas emission factor, 2017, EU Open Data Portal www.data.europa.eu/euodp/en/data/dataset/jrc-com-ef-comw.-ef-2017 and carbon intensity of power generation, 2021, IEA www.iea.org/reports/tracking-power-2021

HESLERHOF

Future-proofing a German biogas plant

Isny
Germany

With the installation of a Jenbacher J420 engine and investments into a large buffer storage tank and a gas storage tank, the biogas plant at the Heslerhof Farm in Germany was converted into a renewable storage power plant with flexible, power market-driven operation.

The farm generates its own power, which is used to supply all the electricity it requires, and surplus power is fed into the grid at attractive feed-in tariffs at market rates. Through environmentally sustainable energy production from regionally available energy sources and flexible operation, the plant is making essential contributions to grid stability in support of the energy transition.

PLANT FACTS

Engines	1 x J420
Energy Source	Biogas
Electrical Output	1.6 MW
Thermal Output	1.8 MW
Total Efficiency	90.1%
Year of Commissioning	2021

»A flexible, power-market-driven approach is both the present and the future of every biogas plant. We decided to gradually flexibilize our biogas plant, transforming it into a renewable storage power plant based on Jenbacher CHP technology. This enables us to optimize our revenue potential while also making optimal use of raw materials.«

Clemens Maier, Shareholder of Clemens and Gregor Maier GbR, Heslerhof

Heslerhof video:
Town, country, flexibility—Heslerhof

HEFEI XIAOMIAO ORGANIC WASTE TREATMENT CENTER PROJECT

Converting waste into renewable energy

Hefei City
Anhui Province, China

The first kitchen waste-to-biogas power project in China's Anhui Province is turning 800 tons per day of catering and kitchen waste into renewable power, resolving Hefei City's kitchen waste disposal challenge while emitting 7,900 fewer tons of CO_2.*

At the Hefei Xiaomiao Organic Waste Treatment Center Project, organic waste is pretreated and turned into biogas through anaerobic digestion at a nearly 67,000-square-meter facility. Two Jenbacher J420 biogas-fueled gensets power the facility and also supply power to the local grid.

PLANT FACTS

Engines	2 x J420
Energy Source	Biogas
Electrical Output	3 MW
Total Efficiency	85%
Year of Commissioning	2021

»This has been an ambitious renewable energy project, and we are very pleased with the results. It is the first project of its kind in the Anhui Province to turn kitchen waste into biogas, using the biogas to fuel the whole process. Not only are two Jenbacher gensets powering the project, they also are supplying additional power to the local grid. And they generate a great deal fewer greenhouse gas emissions than a similarly sized coal plant would.«

Xianhai Zhang, Deputy GM, Anhui Haoyue Renewable Resources Utilization Co. LTD

*according to the customer

CHOK YUEN YONG INDUSTRY CO., LTD

Delivering innovative cogeneration solution at Thai tapioca starch production facility

Kham Thale So District, Nakhon Ratchasima
Thailand

Five Jenbacher J420 biogas-fueled engines produce more than enough electric power to supply Chok Yuen Yong Industry Co., LTD's tapioca starch factory. The excess electricity produced by the engines—about 1,000 kW—is supplied to the public grid to further reduce the facility's power costs.

And, an efficient heat recovery system converts exhaust gas from the engines into steam that is used in the starch production process. In 2016, Chok Yuen Yong reported a 2-million-euro (2.27+ million USD) reduction in energy costs, with the project delivering an exceptional 43.33% return on investment.

»We are very pleased with the project results. The Jenbacher engines provide high reliability and performance while operating in challenging conditions with difficult fuel gases.«

Thanthit Yuenyongtechahiran, Managing Owner, Chok Yuen Yong Industry Co., LTD

PLANT FACTS

Engines	5 x J420
Energy Source	Biogas
Electrical Output	7.1 MW
Thermal Output	5.2 MW
Year of Commissioning	2012, 2017

SHANDONG MINHE BIOLOGICAL TECHNOLOGY CO., LTD

Lowering emissions with chicken farm biogas project

Penglai City
Shandong Province, China

A biogas power generation system in China's Penglai City is saving 33,000 tons of CO_2 emissions each year. The farm's biogas power generation project uses chicken manure and sewage fermentation to produce biogas.

The project includes both biogas power generation and biogas purification to produce biological methane. Commissioned in 2009, the facility is powered by three Jenbacher J320 biogas-fueled engines, with the addition of a J620 biogas-fueled engine in 2018.

PLANT FACTS

Engines	3 x J320, 1 x J620
Energy Source	Biogas
Electrical Output	6.2 MW
Thermal Output	6.4 MW
Total Efficiency	86%
Year of Commissioning	2009, 2018

»As a leader in the biogas and biofertilizer utilization industry, we have developed China's first Clean Development Mechanism (CDM) project using biogas from manure. We are very satisfied with the excellent performance of the Jenbacher gensets. The combination of gensets with different output allows us to keep power generation efficiency and flexibility in varying biogas production volumes in balance. Plus, this entire project flexibly responds to the actual needs of the market and maximizes the value of our resources.«

Tianfeng Yao, Manager of production department, Shandong Minhe Biological Technology Co., LTD

OUR COMMITMENT

to you

Flexibility and experience you can count on

For the last 65-plus years, INNIO has been an innovator of power generation technology. Today's highly flexible Jenbacher CHP systems deliver energy independence through an efficient, low emission, secure and cost-effective energy solution. We have already delivered more than 13,000 CHP systems globally.

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 80 countries and our digital capabilities, we provide life-cycle support for over 40,000 installed units globally, helping to ensure a greater runtime for longer equipment life.

Zero-carbon H_2 operation tomorrow

In addition, the same proven and economically viable INNIO equipment can be moved from conventional fuels today to full CO_2-free H_2 operation tomorrow, once H_2 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 10,000 engines are managed remotely, evaluating more than 900 billion data points 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% H_2 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 about 65% 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 Silver Medal Rating for 2021 and Gold Medal plus Platinum Medal Rating for 2022. 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 it number one 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 CHP using biogas.

Let us develop a powerful energy concept for your company.

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

Our Sales contact will follow up with 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, we offer 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. INNIO is individual in scope, but global in scale. With our flexible, scalable, and resilient energy solutions and services, we enable 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 improved ESG Risk Rating again secures the number one position across more than 500 companies globally in the machinery industry assessed by Sustainalytics.

For more information, visit the INNIO website at **www.innio.com**

Follow INNIO on

ready for H_2

ENERGY SOLUTIONS.
EVERYWHERE, EVERY TIME.

Jenbacher is part of the INNIO Group

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