

LNG-TO- POWER SOLUTIONS

virtual pipelines

JENBACHER
INNIO



EMPOWERING NET ZERO

With flexible, future-proof technology

If you are generating electricity from a carbon-intensive fuel, you probably rely on pipelines, diesel trucks, or large bulk carriers to transport the fuel. Although the electricity you produce is helping to meet global energy demand and encourage local GDP development, COP26 dictates that to meet global climate targets, this type of “carbon shipping” must come to an end.

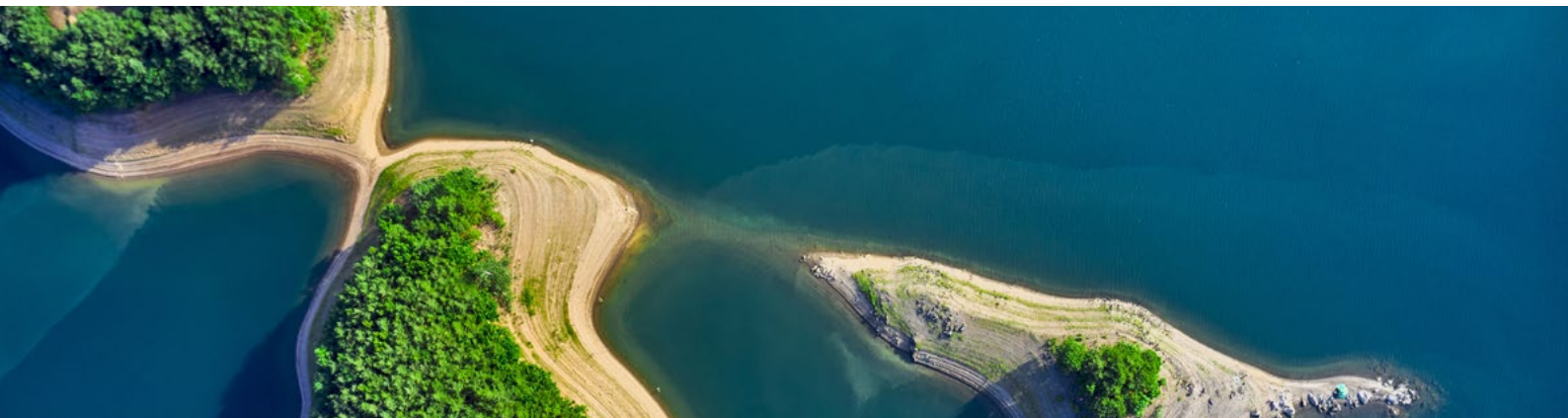
To make that happen, both the energy mix the world relies on and its order of use must change. The electricity mix you adopt will place the flexibility of assets and the lowering of carbon footprints in a leading role.

You will need to deploy green CO₂-free renewables for baseload power, combined with dispatchable power from biogas, biomethane, or clean gas. This dispatchable power can meet your energy needs when volatile renewables are not available.

Operating with liquefied natural gas (LNG) today and transitioning to CO₂-free green H₂ tomorrow is a realizable option. That's because the LNG infrastructure of today can be used for green H₂ when it becomes more readily available. This option can be critical in helping on your path to net zero of your power generation and the industrial production of your local operations.

Today, when considering future investment, you are at a crossroads: You can continue investing in carbon-intensive technologies, such as oil-based CO₂-intensive fuels, or you can invest in a carbon-free multi-fuel strategy, such as natural gas for today and a biogas and H₂ energy mix for a sustainable tomorrow.

LNG is natural gas that has been converted to a liquid form through refrigeration to -260°F (-162°C). A clear, colorless, non-toxic liquid, it occupies 1/600th of its original gas volume, making it economical to safely transport and store.



© Galileo Technologies S.A.

LNG-TO-POWER

Virtual pipeline LNG as a bridge to CO₂-free fuels like H₂

Being the cleanest fossil fuel available globally, natural gas can be used to leverage a fast energy transition and reduce the global carbon footprint. Emitting about 40% less CO₂ than coal, 20% less than oil, and about 30% less than diesel, it is viewed as a perfect dispatchable match to the increasing share of fluctuating non-dispatchable renewables in global power grids.

You can deploy natural gas immediately to serve as a substitute and bridge toward a clean energy future. It emits only 202g of CO₂/kWh instead of the more than 400g of CO₂/kWh that is emitted out of lignite.¹

Natural gas is easy to transport, trade, and store. Especially under liquified conditions, natural gas meets the various supply and demand needs of end-industry customers—whether you are a country, utility, or independent power producer (IPP).

In addition, with LNG you get full access to a global market, with competitive price-building mechanisms providing you with a strong bargaining position and increased political freedom and stability to choose from various sources.

Finally, natural gas can unlock your single-source pipeline supply problem. That is because LNG infrastructure is available globally, especially in countries with long coastal areas and booming economies that maintain a modern and diversified energy supply strategy.

This all started in 1968 in the U.S., when the Methane Pioneer became the first LNG transport ship, importing LNG cargos into the U.S. and the Gulf region. The first shipment of LNG was loaded and delivered to Japan in 1996 and to Spain in 1997 from Ras Laffan Industrial City's port.

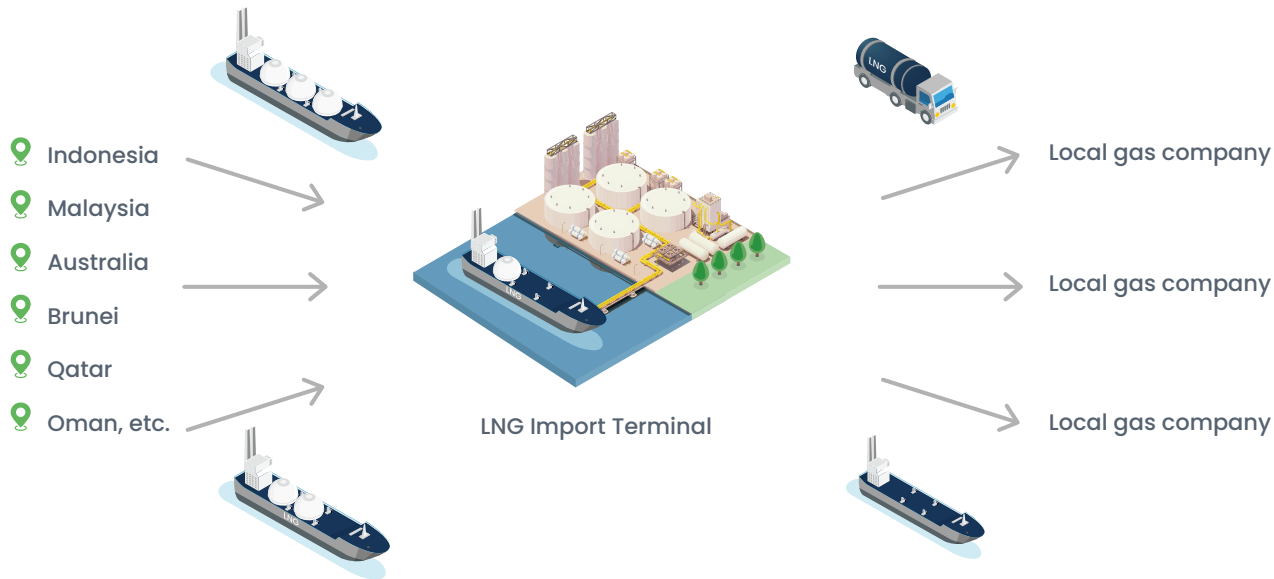
¹ Source: IPCC 2006

The virtual pipeline

To bring LNG and natural gas to your final consumers, a so-called “hub and spoke” business model—also called a virtual pipeline—is needed.

Hub and spoke starts when the LNG leaves the main storage facility—by truck, which can run on LNG as well; smaller feeder ship; rail; or decentralized small pipe that is connected to a power plant or industry complex.

Outline of Hub-and-Spoke System



The LNG advantage



And then on to hydrogen

The reasons for global LNG support are obvious:

- It is cleaner and more cost-effective than oil-based power and heat generation.
- LNG and natural gas can fuel fast starting assets like Jenbacher engines, which can run when the wind does not blow or the sun does not shine, making them the ideal energy source when it comes to supporting renewables in the grid.

Similar to LNG, hydrogen can also be chilled and liquefied for transport on ships, and it can be blended with natural gas to reduce carbon emissions. Both 100% hydrogen and natural gas mixed with H₂ can be liquefied for export. As hydrogen becomes more available, power producers will be able to move closer to net zero electricity generation.

INNIO’s Jenbacher energy systems can use a mixture of natural gas derived from LNG and hydrogen. Additionally, INNIO’s Jenbacher energy systems can operate on 100% hydrogen once H₂ becomes more available. As a key enabler and an integral part of the energy transition, our “Ready for H₂” engines deliver natural gas-fired power today and are ready to deliver up to 100% hydrogen-fired power tomorrow.



SUSTAINABLE

Efficient, flexible, and scalable LNG-to-Power solutions from the experts

With a delivered Jenbacher engine fleet that has the capacity of 35 GW², INNIO is your experienced energy solution and service provider.

A combination of financial and political factors is driving the decision-making process in the power generation industry. Investors want a future-proof and less carbon-intensive investment. You want flexible assets that can serve various market requirements and offer stable revenue over the assets' life cycle. Finally, you want to see attractive economic performance overall regarding returns as well as project profitability.

Small-scale LNG-to-Power solutions

Small-scale LNG-to-Power combines LNG storage, transportation, and regasification with the efficient production of electrical power with an output of up to 50 MW. These small-scale projects are mainly equipped with highly efficient and flexible engines, combining an optimized fit for LNG unloading solutions via ships or trucks, storage mainly in vacuum-insulated tanks, and regasification systems.

Upon the LNG tanker's arrival at its receiving terminal, the LNG is stored in cryogenic tanks. The LNG subsequently is transferred to a regasification plant, where it is heated and allowed to expand back into its original gaseous state. From this point, the gas is pipelined into the power plant where the engines use the gas as fuel. Once the engines are producing electricity, the exhaust gas from the engine can be harvested to generate hot air, which then supplies heat for the LNG vaporizer and speeds up the regasification process.

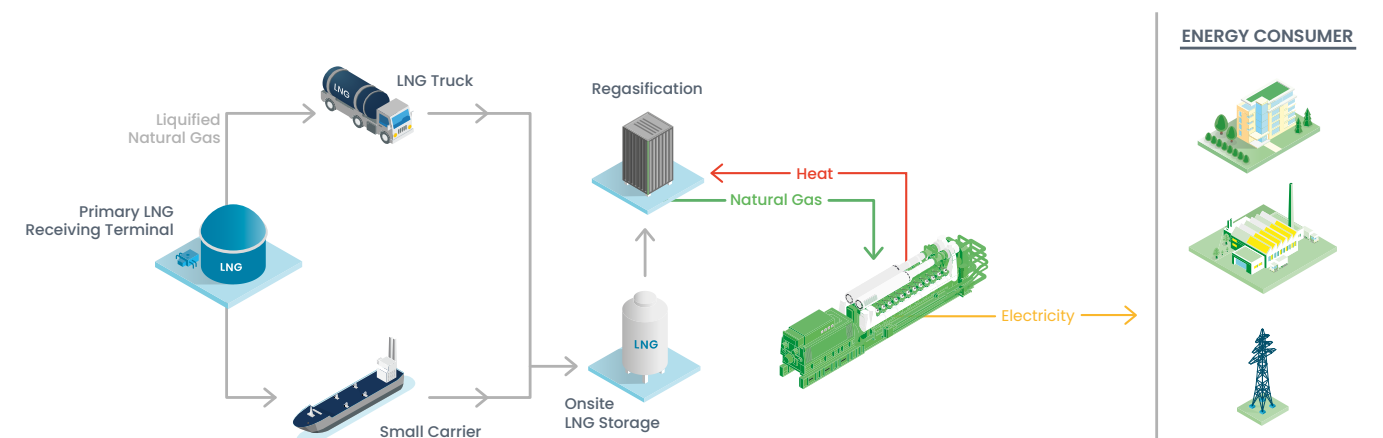
² Based on the number of Jenbacher systems delivered worldwide, assumed 8,000 oph p.a.

LNG storage

LNG storage is available in vacuum-insulated tanks for up to 1,000 cubic meters or in flat bottom tanks, which are preferred for storage requirements larger than 20,000 cubic meters.

Regasification

Regasification closes the loop of LNG by converting the stored LNG into the gas phase, directly suitable for use in our Jenbacher engines in a pressure range below 10 bars. To optimize the overall performance and energy efficiency, the exhaust heat and engine cooling water can be used to drive the regasification process, together with the air vaporizer system. Overall thermal efficiencies of up to 85%, very similar to CHP solutions, will reduce the installation's entire CO₂ footprint.



CONVINCING ADVANTAGES



Accelerating the path to net zero

Reduce your carbon footprint and allow for the reliable integration of renewables with INNIO's solutions for LNG-to-Power installations. Make the switch from heavy fuel oil, diesel, or coal to cleaner gas.

Ready for H₂

With the LNG-to-Power infrastructure, you can use natural gas and biomethane today and be ready to convert to up to 100% carbon-free H₂-based fuels once the hydrogen supply becomes available.

Complementary to renewables

With dispatchable power and the urgently needed flexibility to support the power grids of today and tomorrow, INNIO's LNG-to-Power solutions deliver sustainable power when renewable energy levels are insufficient. Our Jenbacher engines deliver fast-track power and grid and frequency support as well as part-load efficiency when following fluctuating renewables. That can mean additional income and revenue streams on your balance sheet.

INNIO's added value

We know engines. After all, our delivered Jenbacher natural gas engines have a potential installed capacity of 23 GWel and our biogas engines offer more than 5 GWel.³ But we don't stop there. We are involved daily in policymaking and future investments when it comes to a sustainable power generating mix—and we understand that a transformation of the global energy mix starts with a full commitment from all stakeholders and investors.

We believe that LNG can drive decarbonization as a bridging technology toward a CO₂-free H₂ industry. When you invest today in LNG, you can make use of future logistic and infrastructure opportunities for clean and green CO₂-free hydrogen.

With INNIO, you will win in the small-scale LNG-to-Power business while also preparing for a net zero future!

³ Based on the number of Jenbacher systems delivered worldwide, assumed 8,000 oph p.a.

TAILORED

To your specific demands

INNIO is a "one-stop solution provider" for scalable and flexible engine-based LNG-to-Power solutions. You have the gas infrastructure, and we have our highly efficient energy solutions and an advanced service concept for reliable performance.

We work with you to design the power generating concept that meets your needs. For the optimum solution, make use of INNIO's scalable gensets and application packages.



Decentralized power plants typically are in the 10 MW to 50 MW range, which matches our Jenbacher engine product portfolio of 250 kW up to 10.4 MW of single unit electrical power output. Challenges by sea and small island access are easily solved with our engines' compact dimensions and INNIO's containerized solutions, which are quick to install.

The efficient electrical power production of small-scale LNG-to-Power plants can help you with your decarbonization efforts. INNIO collaborates with suppliers, distributors, and other leaders in the LNG value chain to provide tailored and effective solutions to meet your specific needs.

PRODUCT RANGE

The engines that will meet your needs

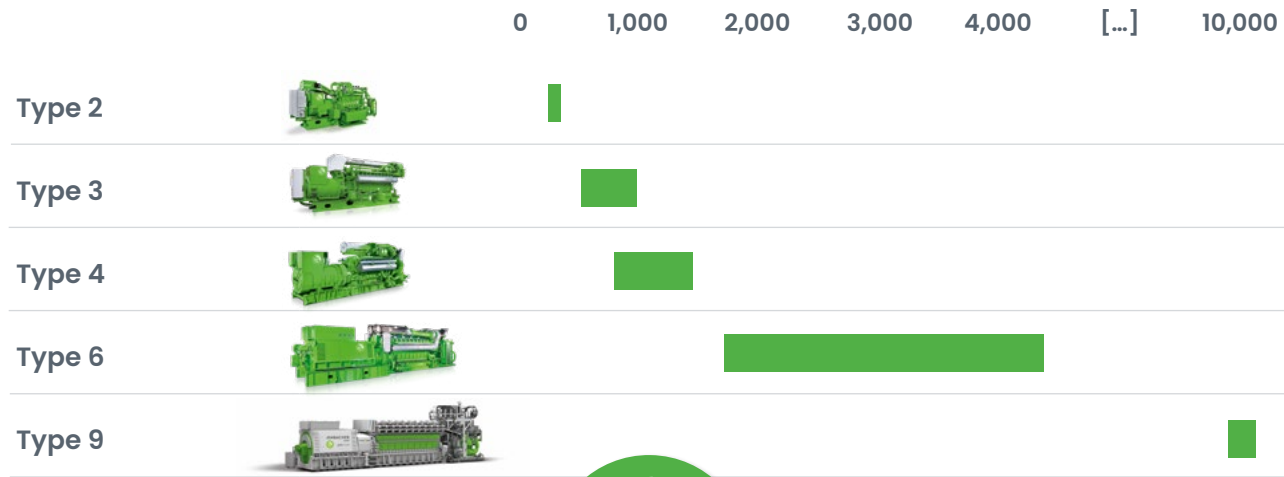
With a wealth of experience, INNIO—and our Jenbacher technology—delivers global technology leadership when it comes to engine-based power generation and waste heat recovery solutions from natural gas, biogas, and H₂.

INNIO offers you a comprehensive portfolio from 250 kW up to 10.4 MW of single unit electrical power output. By using multiple Jenbacher engines in one plant, the power output can be scaled up while part load performance and reliability are significantly increased.

Our portfolio of innovative solutions gives you the ability to generate reliable and efficient power at or near the point of use, anytime—on the grid or off. Transportation and distribution losses also are reduced or eliminated as the decentralized energy supply is aligned where it is needed.

As an energy consultant, INNIO's expertise offers flexible and innovative Jenbacher power plant solutions.

Electrical Power Output (kWel)



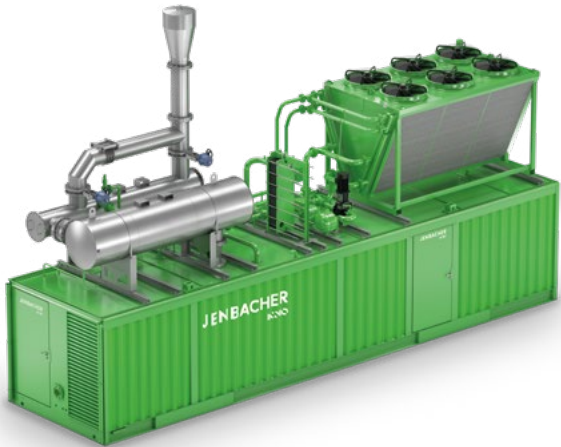
Want to prepare for a greener future?

Visit innio.com/hydrogen to learn more about INNIO's hydrogen solutions.

“Ready for Hydrogen” = optional scope on demand

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



INVESTING

in Jenbacher LNG-to-Power solutions pays off

With INNIO's solutions for LNG-to-Power, you gain economically. Here's why:



Less carbon-intensive fuel. Natural gas and/or biomethane can be used today with a switch to green hydrogen, a 100% CO₂-free fuel, when it becomes more readily available. This flexibility can be a huge opportunity, especially under more—and stronger—CO₂ price emission trading mechanisms. You can use the same infrastructure for LNG as will be used in the future with hydrogen, avoiding stranded assets.



Flexible assets. Available when fluctuating renewables are not, our Jenbacher plants can provide baseload, mid-merit operating, or even grid support through ancillary service and frequency support. These operating benefits offer you multiple revenue streams through Power Purchase Agreements (PPAs), where they serve while operating as well as under a capacity or grid support contract.



Fast construction time. Depending on circumstances, Jenbacher power plants can be mobilized in just a few months to a maximum of 1.2 years for a larger EPC structure. This offers you a fast revenue stream after signing a supply contract and Notice to Proceed.

INNIO'S SOLUTIONS

for LNG-to-Power plants are an excellent investment

As an example, here is the summary of a detailed business case looking into success criteria and indications of financial profitability.

This business case evaluates the economics of a small-scale LNG-to-Power plant for two plant sizes: a 20 MW site with J624 engines and a 50 MW site with J920 engines.

The profitability model is based on the DCF using a project-specific WACC, including a 20% corporate tax rate.

All project cash flows are linked to an energy-market scenario, with sales prices for electricity as well as expenses for fuel and other consumables and services.



Abbreviations

COD	Commercial operating date
DCF	Discounted cash flow
DSCR	Debt-service coverage ratio
FOM	Fixed operation and maintenance costs
IDC	Interest during construction
IRR	Internal rate of return
OP	Operating profit
PPA	Power purchase agreement
SPV	Special purpose vehicle
VOM	Variable operation and maintenance costs
WACC	Weighted average cost of capital

The financial modeling for the LNG-to-Power solution is based on the following inputs:

- **VOM** including periodic maintenance lube oil and start-up costs.
Full O&M management not considered due to the early stage of the project
- **FOM** for running the power plant, including costs for operating staff and local tax rate
- **Financing** parameters covering construction time with the important allocation of the IDC, equity ratio, and costs
- **Capital costs** that reflect the annuities linked to the operating lifetime of the power plant



Input parameters at a glance:

LNG price at COD	€29.5/MWh \$10.2 US/MMBTU
Sales price of electricity under PPA	€120/MWh ⁴
Power plant annual operating hours under 100% load	8,500 annual operating hours under 100% load
Years of commercial operation (project lifetime)	25
WACC	8.4%
Tax rate (corporate tax rate for SPV)	15%

Financial modeling results at a glance:

Parameters	20 MW site with J624	50 MW site with J920
Operating profit, accumulated before tax over lifetime	€160 Mio.	€496 Mio.
DCF over project lifetime before taxload	€43 Mio.	€138 Mio.
OP on average / annum before tax	€6 Mio.	€20 Mio
IRR over the project lifetime	24.3%	26.2%
DSCR on average over 20 years	0.4	1.4
Payback time <small>*First positive cumulative positive cash flow</small>	4 years	3 years

Because of our Jenbacher engines’ high electrical efficiency, the financial model above reveals an overall strong project IRR above WACC (8.4%) for both projects. As you can see, you can gain solid OP and cash flows, especially with the large 50 MW project, as well a good DSCR performance. Your payback time also is very attractive, especially for IPPs and utility business investors. However, gas prices must be linked to a solid PPA to secure stable cash flows over your project’s lifetime.

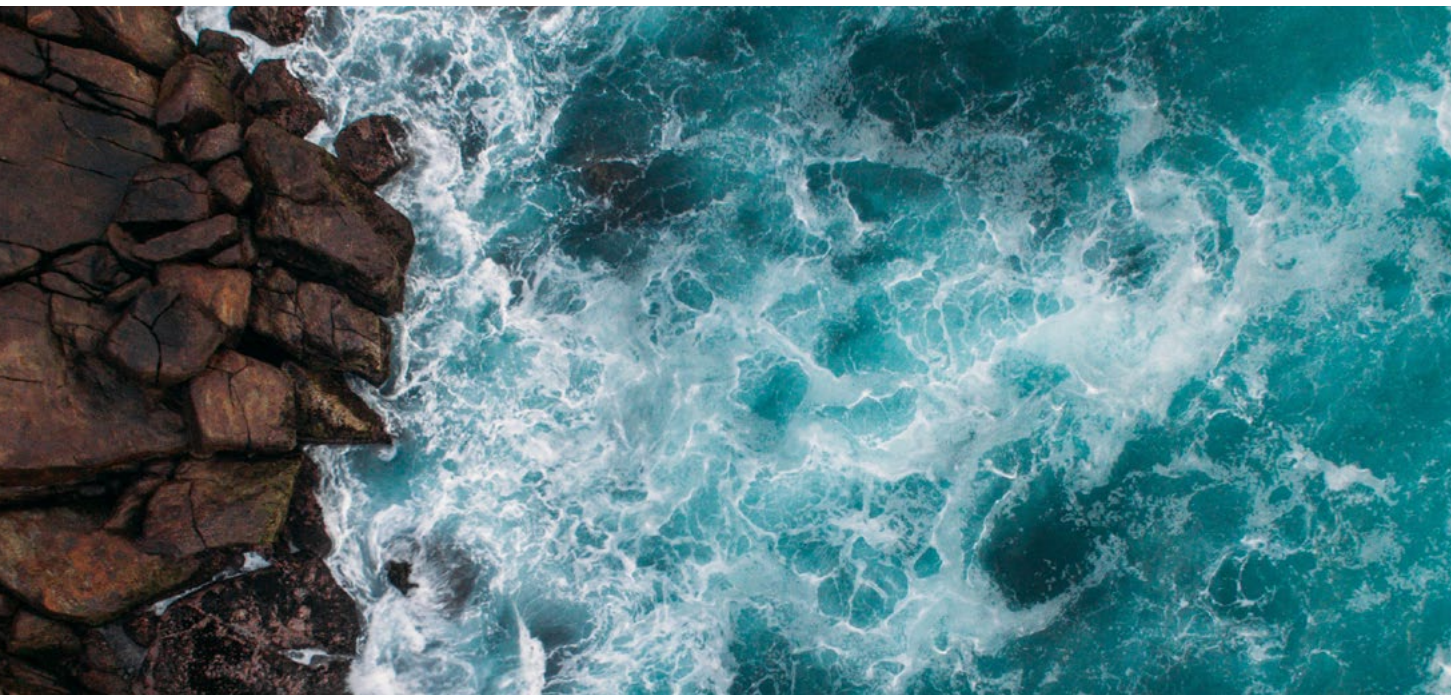
Want to learn more?

The in-depth concept study and financial model for INNIO’s LNG-to- Power solutions examines the economics of additional scenarios linked to a price increase for LNG and natural gas.



Register here to download the study

⁴ Average power price in Japan and Korea in 2021; source: BloombergNEF, JPEX, KEPCO



CASES IN POINT

A proven concept

INNIO is a leading provider of renewable gas and hydrogen-rich solutions and services for power generation and compression at or near the point of use. With our rich history of innovation, we have more than 30 years of experience and expertise in the use of natural gas, biogas, hydrogen, and hydrogen-rich fuels, such as syngas and process gases for power generation. We deliver innovative technology driven by sustainability, decentralization, and digitalization to help leading the transition to net zero.

DEPOSITI ITALIANI GNL S.P.A.

Ravenna small-scale LNG terminal saves big on energy costs



A small-scale power station centered on three Jenbacher J312 generator sets fueled with natural gas derived from LNG is delivering 1,905 kW_{el} of power while reducing energy costs for Depositi Italiani GNL S.p.A., Italy's first coastal LNG storage and handling plant.

Commissioned in 2021 as a turnkey project with the exclusion of civil work, the Depositi Italiani GNL S.p.A. terminal aims to efficiently produce all of the power needed to run the plant.

PLANT FACTS

Engines	3 x J312
Energy Source	LNG
Electrical Output	1.9 MW
Total Efficiency	39.5%
Year of Commissioning	2021

»Our Ravenna plant is Italy's first small-scale LNG plant aimed at promoting and developing our domestic LNG market to help guarantee a practical supply within the country. To meet this goal, we turned to INNIO for an efficient and cost-effective power production solution. INNIO has proven to be an ideal partner, providing its reliable Jenbacher energy production technology and skillful technicians.«

Dr. Alessandro Gentile, CEO,
Depositi Italiani GNL S.p.A.



GNT RESOURCES PTY LTD.

Delivering high efficiency, low emission gas power at Australian gold mine



A power station centered on four Jenbacher J620 gensets fueled with natural gas derived from LNG is delivering 13.4 MWel while reducing energy costs and emissions at the GNT Resources Pty Ltd's Dalgara Gold Mine.

It has achieved power cost savings of more than A\$2 million over just 10 months of operation compared to equivalent diesel power. It also is expected to cut an estimated 57,270 metric tons of CO₂—a 28.8% emission reduction*—over the six-year initial life of the mine compared to diesel.

*according to the customer

PLANT FACTS

Engines	4 x J620
Energy Source	LNG
Electrical Output	13.4 MW
Year of Commissioning	2018



MAMUDA FOODS NIGERIA LTD.

Power plant provides key to success for Nigerian manufacturing group



Three Jenbacher J612 and five Jenbacher J620 engines fueled with natural gas derived from LNG meet the power needs at the Mamuda Foods plant in Kano, Nigeria.

This infrastructure project includes a long-time agreement with one of the largest LNG companies in Nigeria, which trucks LNG to the site. Mamuda Foods is part of the diversified business conglomerate Mamuda Group, which is able to ramp up production and diversify its product lines on the strength of their ability to generate their own power.

PLANT FACTS

Engines	3 x J612, 5 x J620
Energy Source	LNG
Electrical Output	22.8 MW
Year of Commissioning	2020, 2021



»More than 40% of the cost of business goes to power, so generating our own power at cost-effective rates gives us a competitive edge while helping to reduce the load on the grid so others can benefit. Our company is saving on costs, guaranteeing uninterrupted power, and—most importantly—reducing our carbon emissions. Sustainability is at the heart of what the company does.«

Nemr Hammoud, Vice Chairman & COO,
Mamuda Group



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 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 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 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 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% 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 50%* 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 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.**

* The number refers to connected Jenbacher engines.

** Rating took place in February 2022

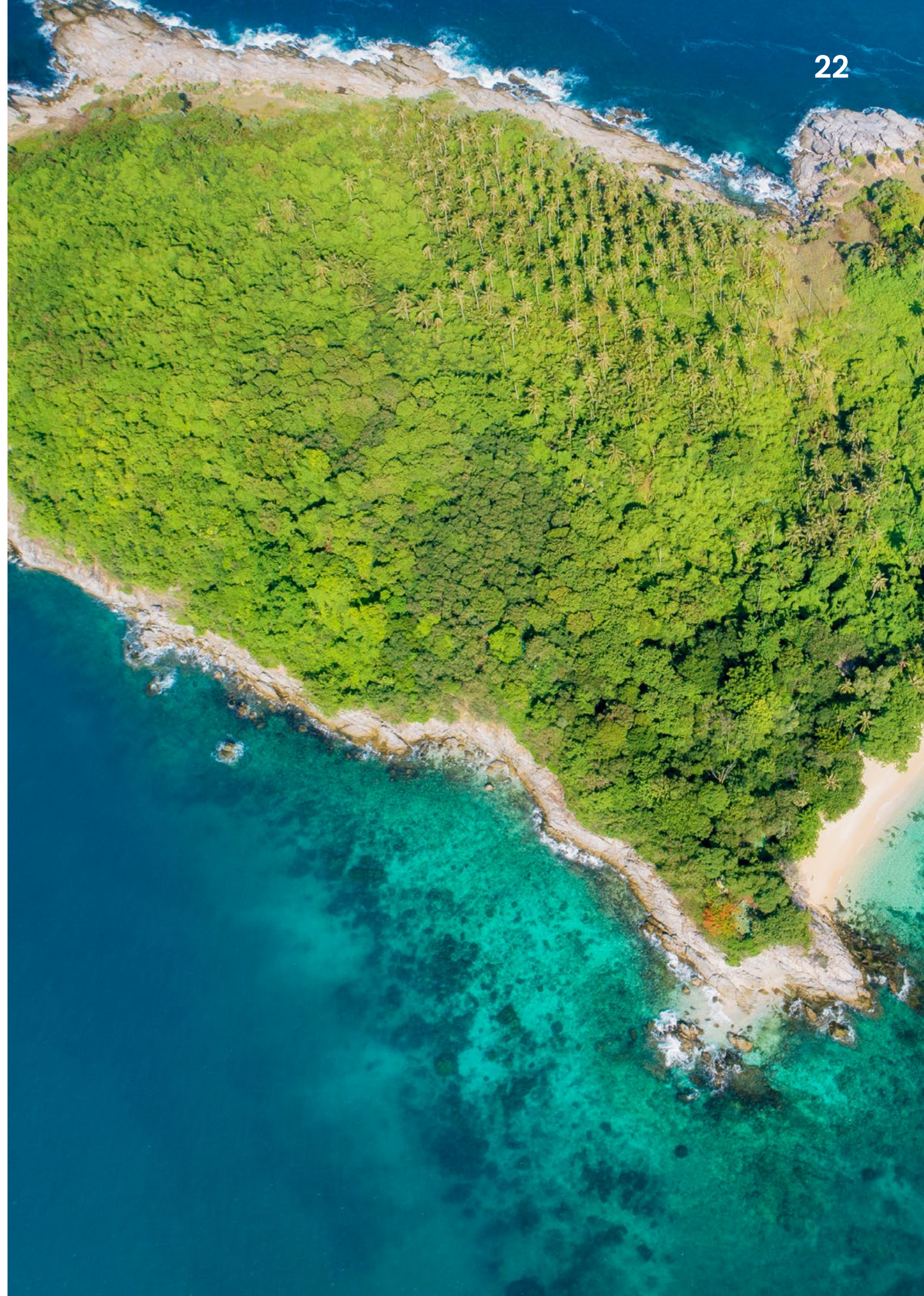
INTERESTED?

INNIO is among the world's technological leaders in LNG-to-Power!

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, 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 3,500 experts provides life-cycle support to the more than 54,000 delivered engines globally through a service network in more than 80 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

Follow INNIO on  



ENERGY SOLUTIONS.
EVERYWHERE, EVERY TIME.



Online version
available

© Copyright 2022 INNIO.

Information provided is subject to change without notice.

INNIO, **INNIO**, Jenbacher, , myPlant, Waukesha are trademarks in the European Union or elsewhere owned by INNIO Jenbacher GmbH & Co OG or one of its affiliates. All other trademarks and company names are property of their respective owners.

