

SOLUTIONS FOR INDEPENDENT POWER PRODUCERS

Enabling the
transition to
green energy

JENBACHER





TRANSITIONING TO GREEN ENERGY

As the world advances its net zero efforts, the electricity grid increasingly relies on renewable energy sources. The result is reduced grid stability, increased congestion, and greater volatility in the electricity markets.

These challenges are compounded by the growing demand for energy. The U.S. Energy Information Administration (EIA) projects that world energy consumption will grow by nearly 50% between 2018 and 2050.¹ Along with increased digitalization comes an increase in the number of devices and smart sensors that are connected to the grid. That's in addition to increased electricity use by consumers—particularly in high-density areas—who are switching to e-mobility and heat pumps.

However, net zero and increased electrification aren't the only challenges faced by plant operators. Climate change has led to an increase in storms, droughts, and other natural disasters—a major cause of power generation disruptions.

Adding distributed energy resources such as renewables, storage, and combined heat & power has increased complexity, while decentralization has brought more participants into the power generation industry.

These global challenges make the effort of balancing supply and demand on the electric grid more complex than ever before.

¹ www.eia.gov/todayinenergy/detail.php?id=41433

A SLOWER JOURNEY

While there is a growing realization that net zero is necessary, the transition to green energy is still underway.

In the U.S., for instance, the interconnection permit process can be long and tedious. Recent supply chain issues for the delivery of solar and wind technologies as well as batteries have added to the slowdown.²

The delay in the build-out of renewable energy generation comes as coal plants in the U.S. have been shuttered and nuclear plants—another low-carbon energy source—increasingly are being decommissioned. That decline has offset many of the gains made by the progress in renewables. Diverse regions in the U.S. face their own unique challenges. California is undergoing a three-year drought, meaning less water availability for hydropower.³

The margins are not looking healthy for the Midcontinent Independent System Operator (MISO), which delivers power across 15 U.S. states and the Canadian province of Manitoba. With just 119 GW available and predictions of peak demand at 124 GW in summer 2022, MISO was predicting a shortfall.⁴

One area that could help these system operators meet their growing commitments is dispatchable gas-fired generation. However, investment funds have become more difficult to obtain for non-renewable power generation projects, so these projects are stymied by lack of investment.

² <https://ourworldindata.org/decarbonizing-energy-progress>

³ EIA Short Term Forecast Drought Impact, May 2022; www.utilitydive.com/news/california-5-gw-reliability-reserve-shortfall-caiso-puc/6238664/; www.utilitydive.com/news/california-drought-could-halve-summer-hydropower-share-leading-to-more-nat/

⁴ www.eia.gov/todayinenergy/detail.php?id=52618



ENABLING THE TRANSITION WITH DISTRIBUTED TECHNOLOGIES

Net zero efforts can move forward at a much faster pace with accelerated wind and solar development. At the same time, gas power generation from Independent Power Producers can act as a bridge, providing fast, reliable power to the grid in times of shortfall from renewable energy sources. Plus, the opportunity to mix gas with H₂ can reduce carbon footprints and further enable the energy transition. Finally, to further accelerate the transition to net zero, storage systems such as batteries must be put in place.

As climate change issues continue to disrupt generation capacity while spiking demand, distributed dispatchable generation can provide the reliable power needed to withstand difficult weather challenges. In addition, behind-the-meter backup power and peaking power for commercial and industrial users can be part of the solution in support of the grid.

With the predicted extended shortfall in reliable dispatchable generation in the U.S. and elsewhere, distributed dispatchable generation should be increased. To lower costs and improve resiliency, smaller utilities and cooperatives should look to self-generate rather than relying on the wholesale market.

Finally, a move toward distributed generation and microgrids will increase energy resilience. The trend today is away from large-scale combined cycle gas turbine power plants. Smaller power plant projects offer lower CAPEX and good efficiency, and smaller, modular systems offer increased reliability, often as multi-unit plants. In addition, capacity remuneration market (CRM) auctions help grid operators achieve required capacity in the electrical grid.



HELPING YOU ON YOUR JOURNEY TO NET ZERO

Industries and communities need future-proof solutions that are ready today. As a leading energy solutions and services provider, INNIO is empowering the transition to clean energy and enabling the path to net zero.

INNIO is helping to bridge power generation gaps through our dispatchable, modular, distributed power generation facilities that offer short start times and high electrical efficiencies.

INNIO's Jenbacher engines run on a variety of fuels. Our technologies include hydrogen and other gases that are vital to the transformation of the energy sector such as biogas, biomethane, landfill gas, sewage gas, and special gases like syngas. As of today, more than 8,500 Jenbacher systems have been delivered worldwide to generate power with renewable energy sources.

CONVINCING ADVANTAGES



Reliable and resilient energy supply

The increased reliability and availability that comes with multiple engines, makes your entire plant more resilient and able to provide power when needed. And, because our solutions are dispatchable and complimentary to renewable energy sources, they increase the reliability of the overall energy supply—providing flexible power when non-dispatchable renewable sources are not available.



Competitive installation costs and delivery

INNIO's solutions are more rapidly deployed and economical when compared to larger power plants. Our modular systems are known for their fast delivery, installation, and commissioning.



Smooth transition to green energy

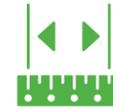
Our proven Jenbacher engines are setting a benchmark on the path toward a net-zero future. INNIO offers the Jenbacher product portfolio with a "Ready for H₂" option.* These models can operate with up to 20% (25%) (vol) H₂ in the pipeline gas and can be retrofitted to 100% H₂ operation as soon as sufficient green hydrogen is available. All Type 4 engines can be offered for 100% H₂ operations, and as of 2025+, INNIO's entire Jenbacher product line is expected to be rolled out for 100% hydrogen operation.



Electric efficiency for higher revenues

Electrical efficiency has become increasingly important in peaking applications as it reduces the cost of generation for the plant, thereby reducing the strike price for participation in the spot market and allowing for longer operating hours and increased revenues. The revenue stream provided by spot market participation has become a bigger share of the total revenues of peaking plants as demand response and frequency response services already are partially served by Battery Energy Storage Systems (BESS). INNIO's engines boast greater than 45% electric efficiency with fuel flexibility and optimization for high ambient temperature and elevation.

* "Ready for Hydrogen" = optional scope on demand



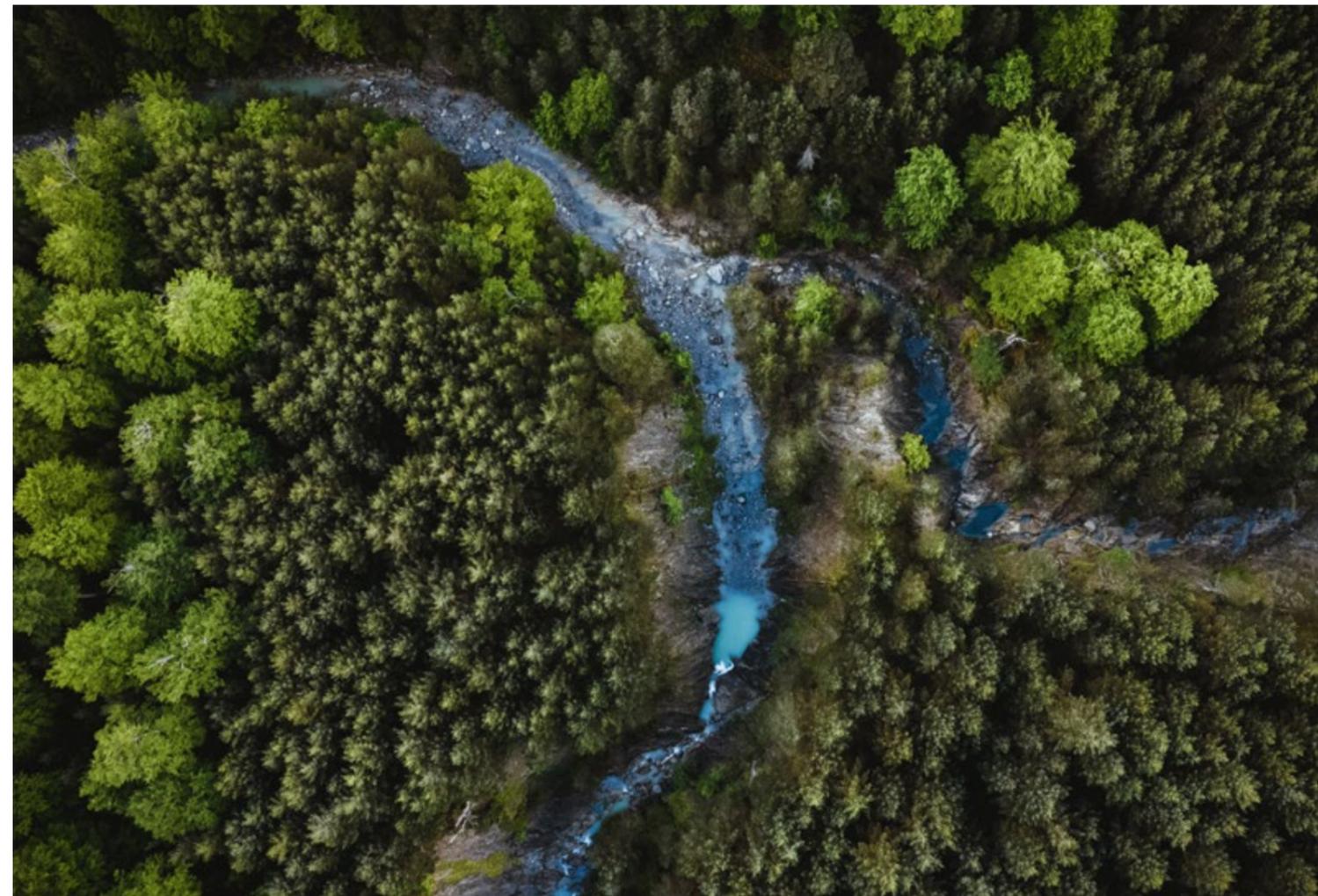
Scalability

The size of a power plant can be increased by adding engines in incremental steps, providing greater flexibility for future expansion. In addition, during part load operation, a reduced number of engines can be operated, enhancing overall plant efficiency.



Dependable operations & service

INNIO's services network is backed by our own staff and distributors in more than 80 countries, allowing us to connect with you locally and provide a rapid response to your service needs. Monitored remotely, our digital solution myPlant Performance anticipates an unexpected event of your engines and determines if assistance is required. With remote support, 65% of these events can be checked and rectified immediately.



DELIVERING POWER PLANTS THAT MEET YOUR NEEDS

INNIO's global sales and service network delivers modular and powerhouse solutions with a flexible scope. We're there when and where you need us, whether you simply want core equipment delivery or a semi-turnkey approach.

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. For instance, we can help develop the project and provide design support, equipment delivery, and commissioning. Our offerings also include digital solutions as well as maintenance through the project's life-cycle.

Jenbacher Container Solutions

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



3-Container layout for the J624

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 Jenbacher engineering experts to help ensure optimal performance

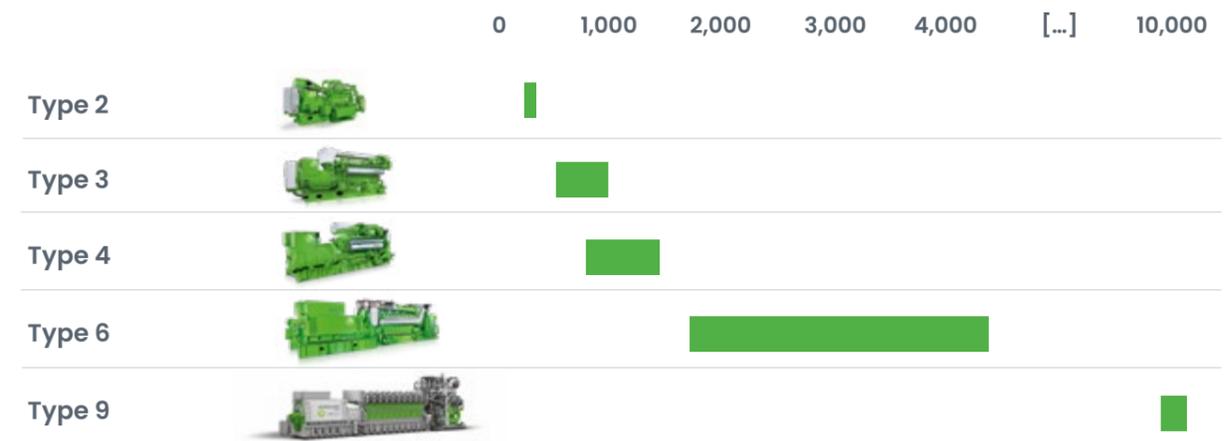
A POWERFUL portfolio

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

Jenbacher solutions offer fuel flexibility with engine versions that can handle different gas qualities. Moreover, they are suitable for high ambient temperatures and elevations.

There is potential for an even more sustainable solution: INNIO's Jenbacher energy systems can use a mixture of pipeline gas and CO₂-free hydrogen as an energy source today and be converted to 100% hydrogen (H₂) operation once H₂ becomes more available.

Electrical Power Output (kWel)



Jenbacher Type 2, 3, 4 and 6 engines are available as stationary and containerized solutions. Type 9 is offered as a stationary and modular powerhouse solution.

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

REVENUE STREAMS OF PEAKING PLANTS

The revenue streams of peaking plants can contain guaranteed payments over defined time periods. These can be in the form of capacity payments such as CRM auctions or fixed fees that are determined by the IPP and the grid operator.

Other ancillary service payments may include demand response and/or frequency response as well as non-spinning reserves. Because these streams by themselves typically do not provide an adequate return on investment for the power plant, an additional energy trading revenue stream often is necessary.

Annual revenue distribution

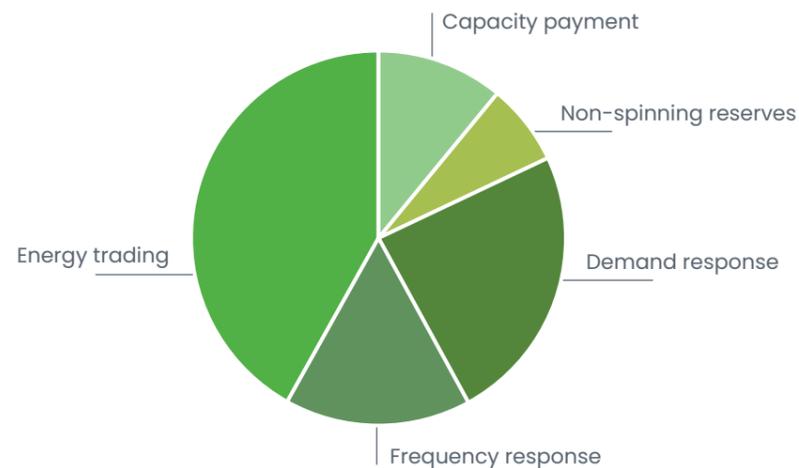


Figure 1: revenue streams for a peaking plant

To boost the energy trading revenue stream's contribution to overall revenue, electrical efficiency is paramount.

For a 20 MW Jenbacher Type 6 power plant with an electrical efficiency of 45.6% and gas cost of €0.02/kWh and service cost at €0.014/kWh, the marginal power production cost is €57.7/MWh. An alternative solution with an electrical efficiency of 40.6% and similar service cost achieves only €62.9/MWh.

That means that the 5% efficiency boost of the Jenbacher Type 6 plant delivers marginal power production costs that are approximately 8% lower than the alternative, low efficiency solution. These reduced costs allow the equipment to be dispatched at lower day ahead prices, delivering increased run time as shown in the following figure.

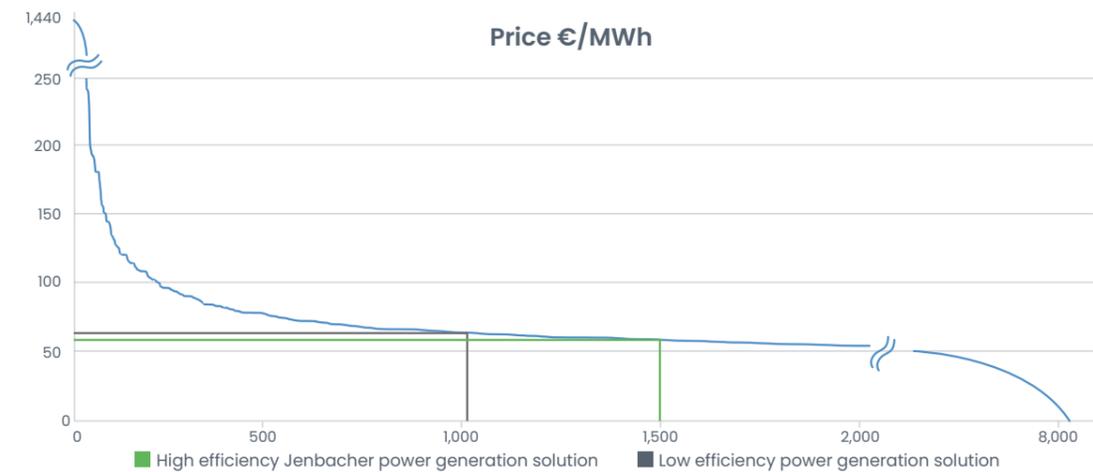


Figure 2: Possible run time of 20 MW Jenbacher Type 6 plant compared to 5% less efficient variant (NE2X day ahead prices of year 2016)

The Jenbacher Type 6 plant potentially can run for 1,485 hours, while the less efficient alternative can only achieve 997 hours above marginal cost.

From the above numbers, the following annual revenue, gas cost, and margins of the two variants can be derived:

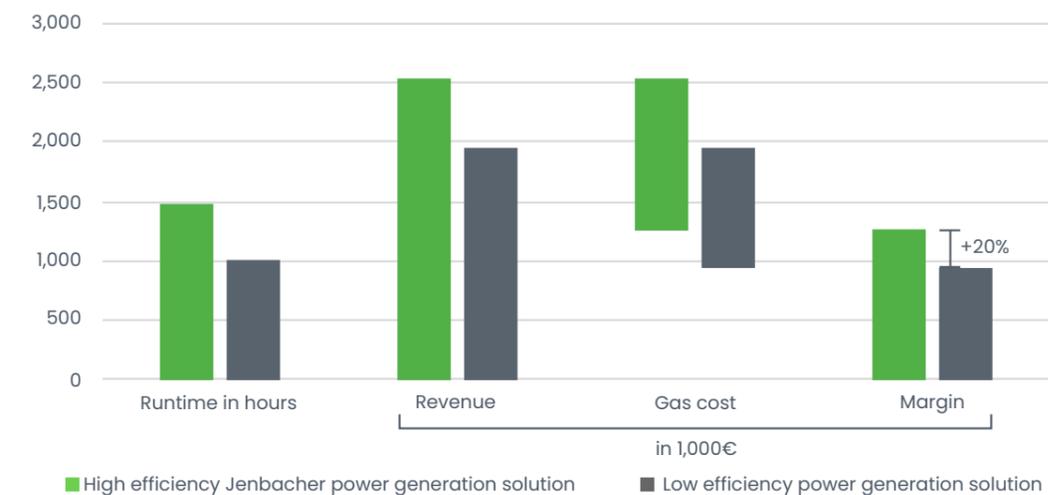


Figure 3: Annual run time, revenue, gas cost, and margin comparison of a 20 MW Jenbacher Type 6 plant compared to a 5% less efficient alternative

The Jenbacher Type 6 plant can run 500 more hours, allowing it to generate a €1.2 million margin, €200,000 (20%) more than the alternative solution and adding to the margins from the other revenue streams.

Once a power plant reaches the flattening part of the energy price curve, higher efficiency can increase potential run time significantly. While a major portion of the revenue can be earned at very high price hours, it is not always possible to accurately predict these times. That's where higher efficiency comes in. The resulting reduced strike price allows operation duration to increase, helping to ensure profitable investments even when the highest price hours are missed. With an expected rise in carbon price, efficiency will become even more important.

OFFERING PROVEN IPP EXPERTISE

Over 65 years of innovation, INNIO's Jenbacher technologies continually have offered efficient onsite power, heat, and cooling approaches. With more than 1,300 Jenbacher engines delivered worldwide into Independent Power Producer applications, INNIO's delivered Jenbacher engines since 2000 have the capacity of 2,750 MWe.⁵ Our engines range in power from 250 kW to 10.4 MW and run on a broad range of energy sources to meet your specific needs.

⁵ Based on the number of Jenbacher systems delivered worldwide into the respective application, 8,000 oph p.a.

FORSA ENERGY

Delivering grid stability

Forsa Energy delivers peaking power in minutes via Jenbacher engines. The engines were designed to fit within a limited footprint and are mounted inside a purpose-built precast concrete enclosure for reduced noise.

Grid stability is assured with the engines' fast startup, and electricity is quickly provided to the National Grid at times of peak demand



PLANT FACTS

Engines	1 x J616, 4 x J624
Energy Source	Pipeline gas
Electrical Output	20.7 MW
Thermal Output	13.3 MW
Electrical Efficiency	up to 45.1%
Year of Commissioning	2020



SKY GLOBAL PARTNERS, LLC

Providing peaking power with largest North American J920 FleXtra project

Six of INNIO’s pipeline gas-fueled Jenbacher J920 FleXtra generator sets provide peaking power at the 51 MW Sky Global Power One power plant—the largest J920 FleXtra project in North America. The Jenbacher units designed for continuous operation supply electricity to members of the San Bernard Electric Cooperative in a seven-county region in south-central Texas.



»The Jenbacher technology allowed us to quick-start the power plant in less than 5 minutes to support grid stability and supply 51 MW to San Bernard’s members. This helped to provide secure and reliable power to approximately 20,000 homes in the San Bernard region. As a consequence, the power plant also helped to heat the homes via electrical baseboard or heat pumps.«

Frank Rotondi, Chairman, CEO & President, Sky Global Partners, LLC

PLANT FACTS

Engines	6 x J920 FleXtra
Energy Source	Pipeline gas
Electrical Output	51.4 MW
Electrical Efficiency	47%
Year of Commissioning	2016



IMG ENERGY SOLUTIONS

Meeting independent power producer’s peak power needs



IMG Energy Solutions’ Wolf Run project in Bradford County, PA, provides power generation during peak electricity demand hours, operating approximately 5,000 hours per year.

Five Jenbacher containerized 4.2 MW J624 engines deliver a total of 21 MW of power that can be sold into the wholesale market. The highly flexible Jenbacher engines can start and stop whenever needed and reach full power output in several minutes.

PLANT FACTS

Engines	5 x J624
Energy Source	Pipeline gas
Electrical Output	21 MW
Electrical Efficiency	44.7%
Year of Commissioning	2019



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.

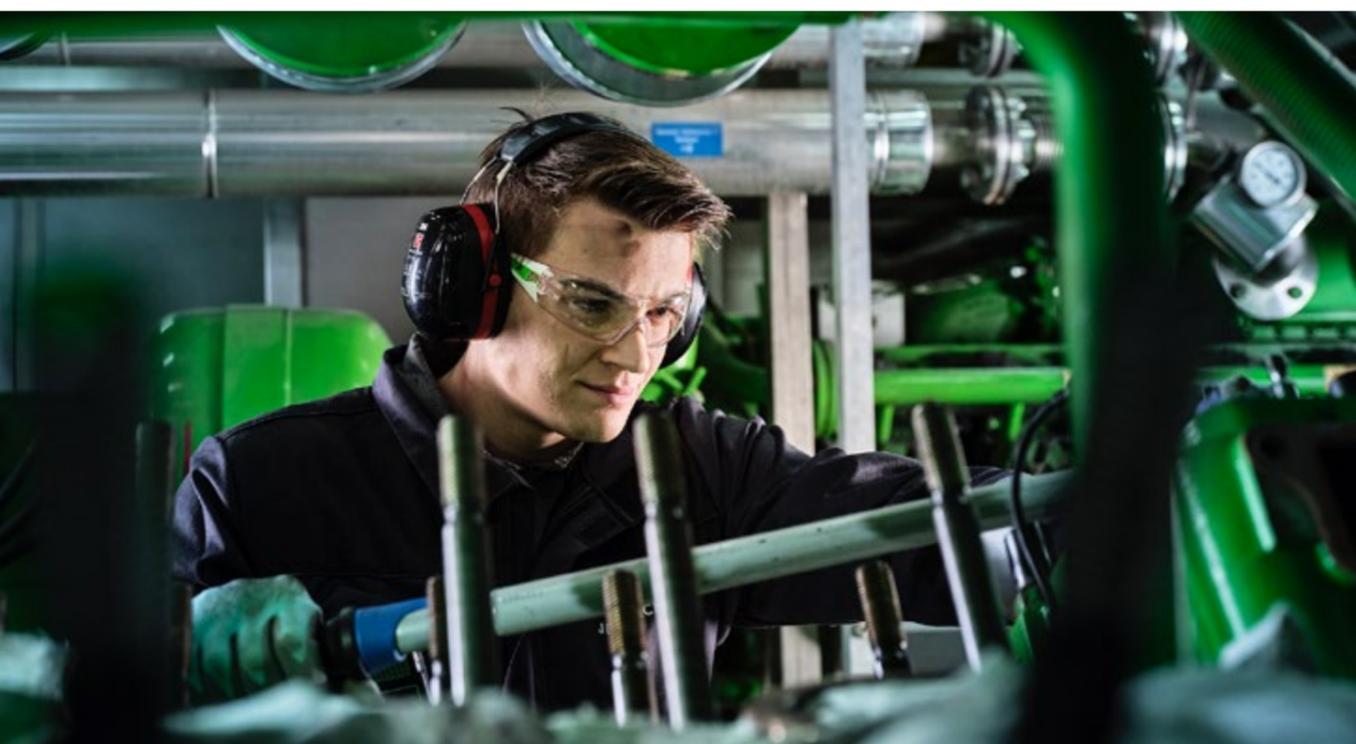
Thinking long-term. Thinking Circular.

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 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

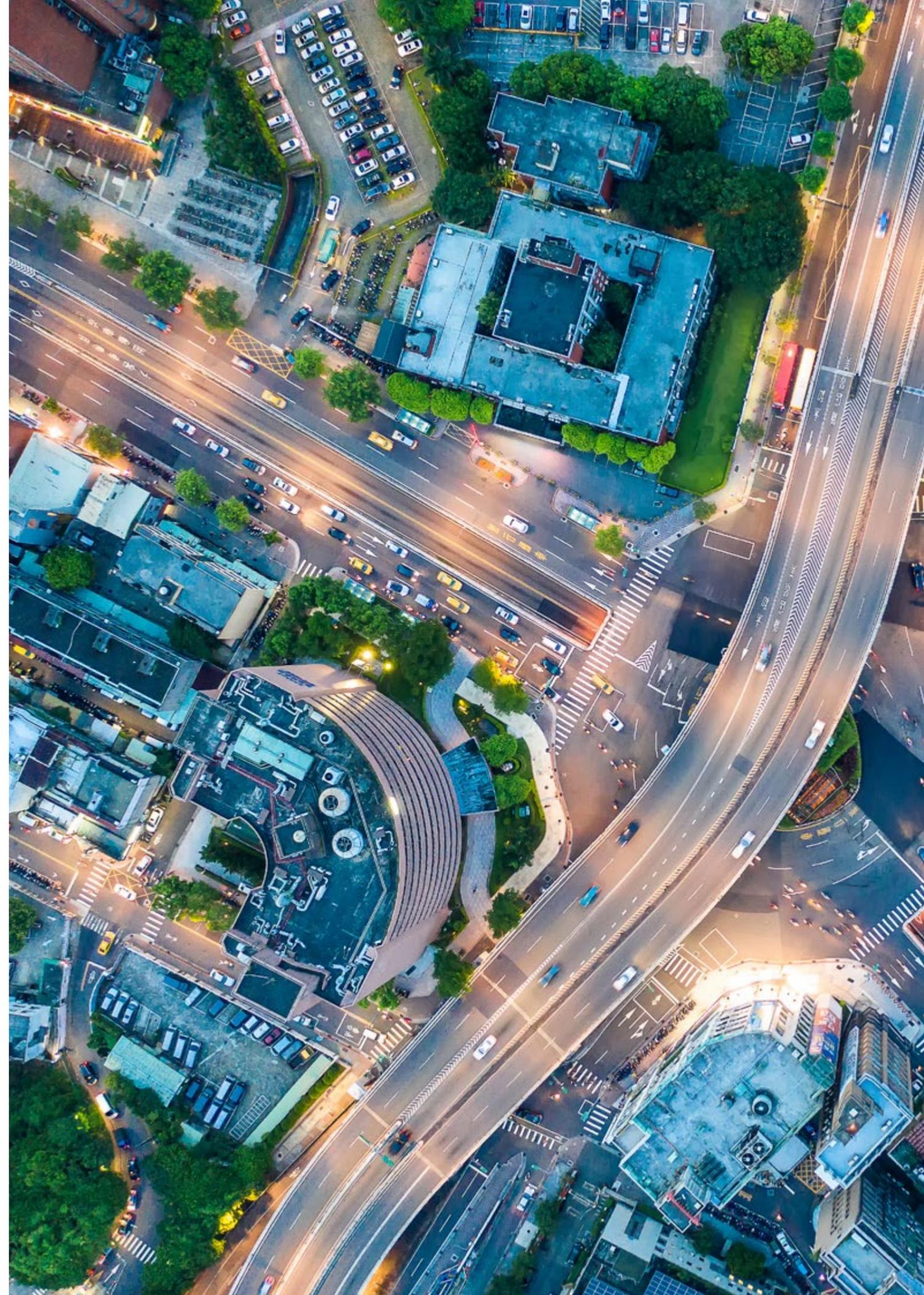
INTERESTED?

INNIO is among the world's technological leaders in engine solutions for independent power providers.

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.

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

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ENERGY SOLUTIONS.
EVERYWHERE, EVERY TIME.



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