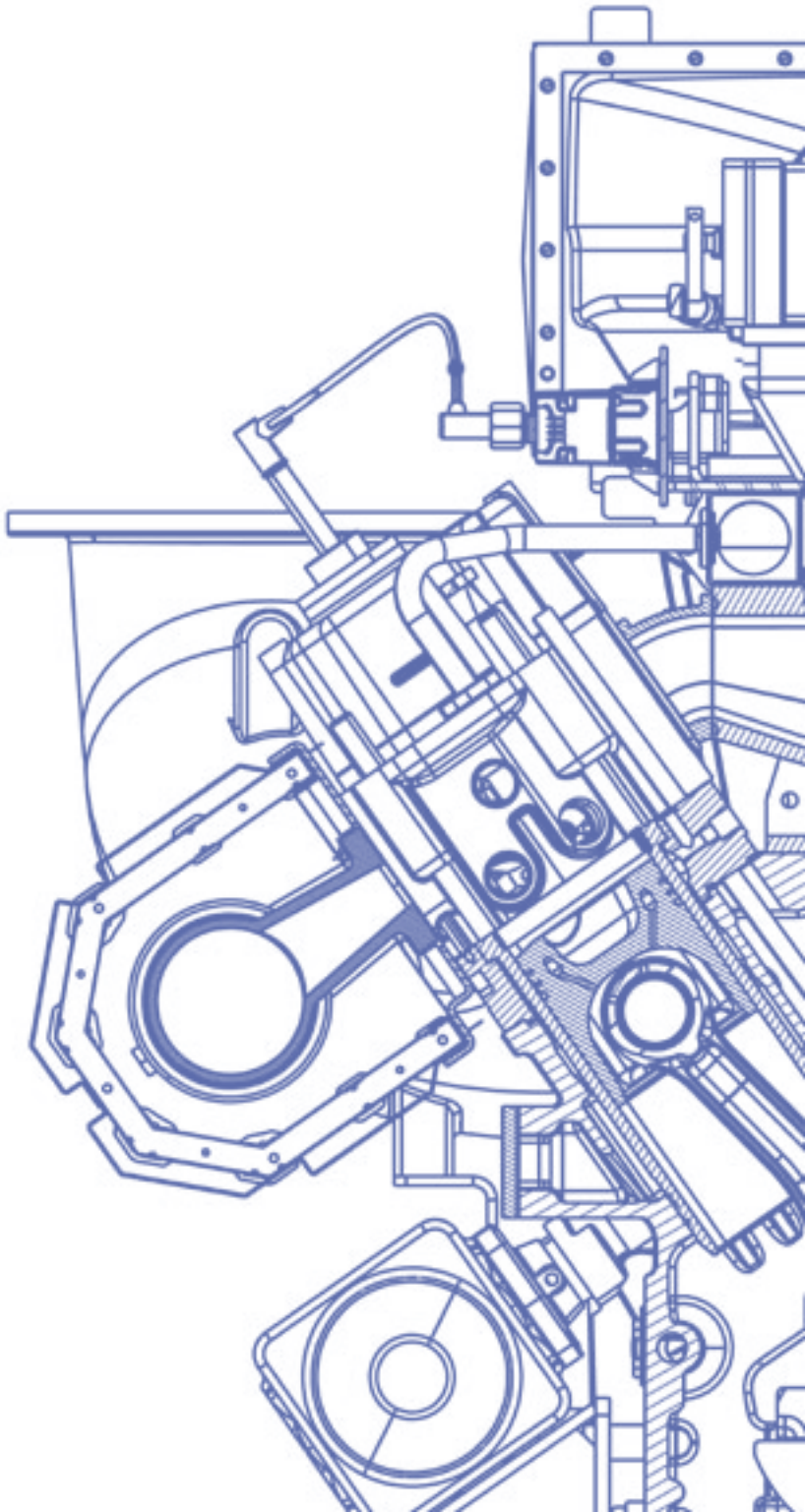
GE
Energy

# driven by ideas

## power solutions with Jenbacher gas engines



GE imagination at work

# overview



GE imagination at work

# striving for excellence

## GE's gas engine business: technology, quality and service

GE's gas engine business is one of the world's leading manufacturers of gas-fueled reciprocating engines, packaged generator sets and cogeneration units for power generation. It is one of the only companies in the world focusing exclusively on gas engine technology.

Jenbacher engines range in power from 0.25 to 3 MW and run on either natural gas or a variety of other gases (e.g., biogas, landfill gas, coal mine gas, sewage gas, combustible industrial waste gases). A broad range of commercial, industrial, and municipal customers use Jenbacher products for on-site generation of power, heat, and cooling. Patented combustion systems, engine controls, and monitoring enable our power generation plants to meet all relevant international emission standards, while offering high levels of efficiency, durability, and reliability.

The Jenbacher product team has its headquarters, production facilities, and 1,200 of its more than 1,400 worldwide employees in Jenbach, Austria.

This brochure provides an overview of the Jenbacher product range, including the variety of possible fuels, their significance as a valuable source of energy, and the advantages of a decentralized energy supply using Jenbacher equipment.

# seeing the potential of nature and chemistry

# numerous advantages

## natural gas

### Energy source of the future

The natural gas segment of GE's gas engine business includes the production and delivery of plants for decentralized energy supply based on natural gas as fuel.

### Natural gas utilization in gas engines offering numerous advantages

**Lowest emissions of all fossil fuels**
The utilization of natural gas in gas engines is characterized by the lowest $CO_2$ emission levels among fossil fuels, and particularly low emissions of $SO_2$, $NO_x$ and particulate matter.

**Most important fossil energy source**
Natural gas plays a major role in energy supply today and will become the most significant fossil energy medium in the next 50 years.

**Well developed natural gas supply system**
The natural gas supply system is well developed and reliable. Gas engines are therefore an optimal technology for decentralized energy supply.

### Flare gas

In addition to classic natural gas, flare gas also forms part of this fuel segment. Flare gas is an associated gas obtained during crude oil exploration, largely consisting of methane and higher hydrocarbons. This composition results in a gas with low knocking resistance, which requires specially designed engines. The use of flare gas, which is generally available free of charge as a waste product, ensures a fuel source for on-site power generation and, if required, the engines can also provide a heat supply for surrounding facilities. Consequently this problem gas, instead of flaring it off while causing ecological exposure, can be used economically and practically.

## biogas and special gases

### Alternative energy sources

The biogas and special gases segment is comprised of plants fueled by gases from landfills, agriculture, coal mining, chemical plants, and other industries. The environmentally-appropriate disposal of problem gases is the primary concern in this segment. The simultaneous energetic utilization of these gases for generating power ensures the economic viability of the power plants. The continuous development of its gas engines and the focus on special gas applications have made Jenbacher engines one of the world leaders in this segment today.

Due to their cost-effectiveness, high output and measurable benefits to the environment, Jenbacher biogas, landfill gas, and coal mine gas-fueled engines have been certified as GE "ecomagination" product by an independent agency. Ecomagination is a GE commitment (www.ge.com/ecomagination) to use and develop new technologies to help customers around the world meet escalating environmental challenges.

### Biogas and special gas utilization in gas engines offering numerous advantages

- Highly efficient for cogeneration of power and heat
- Substitute for conventional fuels
- Alternative disposal of problem gases
- Avoids venting methane ($CH_4$) into the atmosphere
- High potential for reduction of greenhouse effects

**Overview of the most important applications**
- Biogas
- Sewage gas
- Coke gas
- Landfill gas
- Coal mine gas
- Pyrolysis gas/wood gas

Farm Wolfring, Germany

Landfill site Nent, China

## Biogas

For a wide range of organic substances from agriculture, foodstuff, and feed industries, anaerobic fermentation is a superior alternative to composting. Biogas – a mixture of methane and carbon dioxide – is formed in the fermentation process and serves as a high-energy fuel with a calorific value of 5 to 6 kWh/$m^3_N$ that can substitute fossil fuel energy. Thereby an increased utilization of fossil fuels is avoided and fossil $CO_2$ emissions reduced. Due to the organic nature of the components of biogas, burning it in a gas engine for power generation emits the same amount of $CO_2$ into the atmosphere as was originally absorbed during the process of photosynthesis in the natural $CO_2$ cycle. Using biogas in gas engines promotes proper waste disposal, and allows the use of the end products from the fermentation process as fertilizer.

## Landfill gas

Landfill gas is created similar to biogas during the decomposition of organic substances in the waste and consists of methane ($CH_4$), carbon dioxide ($CO_2$), nitrogen ($N_2$), and to a minor part of oxygen ($O_2$). If this gas escapes uncontrolled, it hampers the recultivation of the landfill site. To prevent this and to avoid offensive smells, smouldering fires, or the migration of landfill gas into the water ways, the gas must be continuously extracted under controlled conditions. With a calorific value of about 4 to 5 kWh/$m^3_N$, landfill gas constitutes a high-value fuel for gas engines and can therefore be economically utilized for power generation.

# gas as energy source

Sewage treatment plant Annacis Island, Canada

Colliery Tahmoor, Australia

## Sewage gas

Sewage sludge is created as a waste product in the mechanical/biological process stages of sewage treatment plants. The sludge is dried, then transferred to a digester where an anaerobic fermentation process takes place. The fermentation produces biogas – also called sewage gas – consisting of 60 to 70% methane and 30 to 40% carbon dioxide. This composition makes sewage gas highly suitable for combustion in gas engines. The electrical energy produced by the gas engine can be utilized for the treatment plant as well as for feeding into the public power grid. The thermal energy can be used for heating the sewage sludge or to offset the treatment plant's other heat requirements.

## Coal mine gas

Coal mine gas (firedamp) is a problematic phenomenon associated with pit coal mining, as the gas can form explosive mixtures together with air. The main component of the primary coal seam gas is methane in a concentration of 90 to 95%. The gas develops during the geochemical conversion of organic substances to coal (carbonization). Coal seam gas is present both as liberated gas in fissures, faults and pores and as adsorbed gas on the inner surface of the coal and neighboring rock. For safety reasons, the methane gas released during coal mining, must be ventilated, generating a mixture of air and methane. In many countries, coal mine gas is still emitted into the atmosphere, causing high levels of greenhouse gas emissions and thereby contributing widely to the global warming process. Combustion of coal mine gas in gas engines is practical as an environmental problem is effectively resolved, while an otherwise lost source of energy is economically utilized.

Coke production Profusa, Spain

Biomass power station Guessing, Austria

## Coke gas

Coke gas is a by-product of coke production from hard coal. Coke gas consists mainly of hydrogen (50 to 60%), methane (15 to 30%) and carbon monoxide. Due to the extremely high hydrogen content of coke gas, specially modified Jenbacher engines are used to generate power from this fuel source.

## Pyrolysis gas/wood gas
## gases from gasification processes

The production of special gases through various gasification processes is becoming increasingly important for the utilization of alternative energy sources. Various base materials (e.g., domestic and commercial waste, light shredder fractions, bulk waste, wood, meat and bone meal, old tires) are subjected to high-temperature gasification processes, such as fixed bed, fluidized bed, or pyrolytic gasification. The efficient combustion of the resultant gases requires a highly sophisticated gas engine, since composition and partly problematic trace elements in these gases set a new challenge on the engine design. Depending on the gasification process, the combustible components mainly consist of hydrogen, carbon monoxide and methane, having a calorific value in the range from 1.5 to 3.5 kWh/$m^3_N$. Sophisticated gas treatment, rapid reaction to changing calorific values, accurate monitoring of the combustion process in the engine, and effective system coordination between the engine and gasifier, are only some of the complex requirements for gas engines using such fuels.

# finding the right solutions

# outstanding technology

## gas engines

### Core competence

For about 50 years, GE's Austrian-based gas engine business has been recognized as a world leader in the development and production of gas engines for the efficient generation of power and heat. Jenbacher products are highly-developed and tested, and well matched to each customer's specific requirements. Jenbacher engines are designed for stationary, continuous duty operation, and are characterized by particularly high efficiencies, low emissions, and high durability as well as reliability.

The Jenbacher product engineering team, with its 100+ employees, is focused exclusively on gas engines, and is committed to the continuous evolution and improvement of gas engines, associated equipment, and services.

### Four success factors

**Jenbacher gas engine concept**
Jenbacher engines are characterized by the uncooled exhaust manifold located outside the V-space and the resulting cross-flow cylinder heads. This revolutionary engine design allows optimal combustion and thereby ensures highest possible efficiencies and long life of the cylinder heads and spark plugs.

**LEANOX® lean mixture combustion**
The worldwide, patented Jenbacher LEANOX® lean mixture combustion control ensures the correct air/gas ratio under all operating conditions to minimize exhaust gas emissions while maintaining stable engine operation.

**Optimized combustion**
With our focus on highest efficiencies and lowest emissions we continuously enhance the combustion behavior of our gas engines. Optimization of cylinder head flow, continuous spark plug development and steadily increased specific output lead to top efficiency values while maintaining a high level of reliability.

**Development of engine components**
Essential components necessary for reliable engine operation (e.g., spark plugs, gas mixer, engine controls) are developed directly in Jenbach. This allows GE to control the development and construction, system integration, and testing of the complete units.

## Wide performance range in four engine types

To optimally cover the requirements of various customer power needs and applications, GE offers a gas engine product range divided into four types, and ten different engine sizes from 0.25 to 3 MW electrical output.

**Type 2**
- Electrical output from 250 to 330 kW
- Available as in-line 8 cylinder engine
- With 1,500 rpm (50 Hz) and 1,800 rpm (60 Hz)
- Packaged in a 20-foot or 40-foot ISO-container available
- Main applications: biogas, sewage gas, cogeneration, small power-generation

**Type 3**
- Electrical output from 500 to 1,100 kW
- Available as V12, V16 and V20 cylinder engine
- With 1,500 rpm (50 Hz) and 1,200 rpm or 1,800 rpm (60 Hz)
- Packaged in a 40-foot ISO-container available
- Main applications: biogas, flare gas, landfill gas, sewage gas, cogeneration, on-site power-generation

**Type 4**
- Electrical output from 800 to 1,500 kW
- Available as V12, V16 and V20 cylinder engine
- With 1,500 rpm (50 Hz) and 1.200 rpm or 1.800 rpm (60 Hz)
- Packaged in a 3m-wide 40-foot ISO-container available
- Main applications: biogas, coal mine gas, landfill gas, cogeneration, $CO_2$ fertilization

**Type 6**
- Electrical output from 1.5 to 3 MW
- Available as V12, V16 and V20 cylinder engine
- With 1,500 rpm (50 Hz, 60 Hz with gear-box)
- Main applications: coal mine gas, flare gas, landfill gas, cogeneration, $CO_2$ fertilization

## Three key competencies across all four engine types

**Efficient**
- Top efficiencies
- High performance density
- Long service intervals
- Low life-cycle costs

**Durable**
- Established, field-tested designs
- Optimized, robust engine components
- Stationary engine concept

**Reliable**
- Maximum operational safety and availability through optimized individual components
- High degree of maturity
- Proven control and monitoring concept
- Continuous and focused further development of the products

## Flexible application

All Jenbacher gas engines are suitable for use with
- Natural gas,
- Biogas, or
- Special gases

and ensure minimum emissions over the entire running period. In addition, on costumer's request GE offers gas engines running on a fuel mixture of different gases, ensuring highest operational flexibility.

## Product ranges at a glance

GE is committed to providing its customers with the "best fit" products, and full range of product configurations. Our scope of delivery includes:
- Generator sets
- Cogeneration systems
- Container solutions

GE's gas engine business has designed the following innovative systems to further enhance the performance of its engines:
- DIA.NE® XT – Dialog Network, the user-friendly man-machine interface
- Activated carbon adsorber, for fuel gas cleaning of sewage gas and landfill gas to provide gas quality almost equal to natural gas
- CL.AIR® – Clean Air, the robust and reliable exhaust gas treatment system also for contaminated gases

# advanced solutions

## generator sets

### Maximum efficiency in power generation

Generator sets provide on-site power generation on demand. Jenbacher generator sets are characterized by a compact design and high power density, and therefore require a comparatively small footprint. The engine and generator are mounted on a frame that is vibration-dampened by means of durable elastomer elements. In the same manner, the frame is also insulated from the foundation, preventing any vibration from affecting the building.

## cogeneration systems

### Combined generation of power and heat

Cogeneration systems generate power and heat where required, providing maximum efficiency in the conversion of energy with minimum emissions. Their basic structure corresponds to that of the generator sets – with the addition of heat exchangers for utilizing the waste heat. A wide range of engine heat sources – from engine cooling water, oil and air/fuel gas mixture to exhaust gas – is configured to maximize the benefit to each individual customer.

The highly compact design and the efficient elastic mounting of Jenbacher cogeneration systems require little in terms of space and foundation design so that the peripheral installation costs are minimal.

## container solutions

### Maximum flexibility

The scope of delivery for Jenbacher engines includes fully containerized plants, requiring only gas and power connections on location for operation. All plant components required for operating the set are integrated in the container and on the container roof. The electrical control and switching system is located in a separated compartment of the container, providing for comfortable operation of the plant. The overall compact design ensures a space-saving installation with service oriented accessibility.

With this flexible container design our customers' requirements can easily be met.

# DIA.NE® XT – Dialog Network

## Optimum control

DIA.NE® XT is the latest Jenbacher engine management system, and is designed for use with all Jenbacher engines. The system comprises powerful central industrial controls that handle master control and feedback control for the engine-plant, as well as visualization. A link, via standardized industry buses or using direct signal lines, with central process control is provided to meet the specific requirements of each customer.

The focus of the DIA.NE® XT design lies in combining powerful and flexible open- and closed-loop control electronics with a user-friendly operating concept. The novel hardware design employs the most modern components and sets new standards for performance, functionality and operating safety. The visual display uses a color graphics display screen, providing a clear and comprehensible presentation of information and measured values while offering the greatest possible ease of use.

With additional components it is possible to adapt DIA.NE® XT individually to meet various customer requirements:

**MONIC**
Monitoring Ignition Control: On-line monitoring system of the ignition voltage that allows preventive maintenance of spark plugs and ignition coils.

**HERMES**
Data remote transmission: HERMES offers the operator remote diagnostics and solutions at any time via internet, modem or LAN connection.

HERMES provides the following two applications, which can be used separately or together:

**DIA.NE® WIN**
Dialog Network for Windows Systems: Delivers full remote operation of Jenbacher engines as well as comprehensive functions for analysis and trend identification in the familiar Windows environment.

**DIA.NE® RMC**
Dialog Network for Remote Message Control: Automated data and message transmission to a remote data transmission center and auto-alarm by way of fax, SMS and/or e-mail. All incoming messages and data are archived for maximum traceability of operations.

# fresh air

## activated carbon adsorber

### Longer service life through fuel gas cleaning

Sewage gas and landfill gas frequently contain gaseous silicon compounds. For cleaning the fuel gas from these substances, we have developed an activated carbon adsorber system.

The system prevents the formation of silica in the engine, increasing component service lives and reducing engine wear. Gas cleaning also extends oil life and enables – under certain conditions – the use of conventional oxidizing catalytic converters for the reduction of CO and formaldehyde emissions. As a result, the Jenbacher activated carbon adsorber allows reliable, durable, highly efficient, and low emission operation with sewage gas and landfill gas.

Especially for landfill gas applications and plants with larger output range in remote areas, we have developed the TSA (Temperature Swing Adsorber), which is a regenerative system. The advantage of this new technology is that the activated carbon regenerates itself, which ensures continuous operation over longer periods of time without the need to change the activated carbon.

## In detail:

Fuel gas is passed through a vessel filled with activated carbon where certain gaseous compounds (mainly silicon and halogen) are adsorbed by the activated carbon. The degree of saturation of the activated carbon is regularly checked and replaced when the prescribed maximum limit has been reached. For landfill gas plants, GE provides the automatic self-regenerating TSA system where the replacement of the activated carbon is only necessary at very long intervals.

## CL.AIR® – Clean Air

### Exhaust gas treatment for cleaner air

If fuel gases such as landfill gas or sewage gas are used, the harmful contaminants in the gas may inhibit quickly the performance of the oxidizing catalytic converters. With the CL.AIR® system, we utilize thermal re-combustion to maintain minimum CO, HC and formaldehyde limit values. In so doing, the engine can be operated with both maximum specific power and maximum efficiency.

## In detail:

The exhaust gas flows over a hot ceramic storage mass where the gas is heated to approximately 800°C. Uncombusted components of the exhaust gas (e.g., CO, or HC) are recombusted at this high temperature. The exhaust gases then flow over a second, cooler storage mass, which is heated in the process. Through a change-over mechanism, alternately passing the exhaust gas over the two storage masses, the energy requirement is minimized so that system-related thermal losses can be largely compensated.

# expanding boundaries

# energy supply

Valley Medical Center, USA

## decentralized energy supply

### Numerous advantages with Jenbacher systems

Jenbacher generator sets and cogeneration systems are well designed to fulfill any decentralized energy supply needs. Some of the key features of our products are:

- High electrical efficiencies of up to 43%
- Overall efficiencies (electrical and thermal) of over 90%
- Minimum $NO_x$-emissions through the patented LEANOX® lean mixture combustion
- Specially designed engines for utilization of alternative, renewable energy sources (e.g., biogas or landfill gas) and special gases (e.g., coal mine gas or coke gas)
- Maximum operational safety and availability
- High power density

Through supply of energy directly at the load source, it is also possible to reduce or avoid altogether transport and distribution losses.

## cogeneration

### Maximum overall efficiencies

With combined power and heat generation (cogeneration) the waste heat incurred during engine operation is deliberately and economically utilized, resulting in overall efficiencies of more than 90%. This efficient form of energy conversion is able to achieve primary energy savings of about 40% using gas engine cogeneration systems, compared with conventional separate power and heat generation. In addition, investment costs for gas engines, relative to competing technologies, are low.

### Power and heat utilization

The power generated is utilized to cover the consumption of the individual facilities (e.g., hospitals) and/or fed into the public power grid. The thermal energy can be used for both generating heating water and steam production, as well as for various types of process heat. Gas engine cogeneration systems are also used for $CO_2$ fertilization in greenhouses and trigeneration systems (combined generation of power, heat, and cooling).

Processing of cocoa beans Altinmarka, Turkey

Greenhouse Van der Arend Roses, The Netherlands

## generation of heating water

Cogeneration systems capture excess heat from the engine. The heat can be used to generate heating water, which can then be utilized by local or district heating systems to cover their basic heat requirements. Peak heat demand can be covered through the combined use of a buffer and a peak boiler. Due to varying heat demands during the year, multi-engine-installations are the preferred solution for district heating systems.

## steam production and drying processes

Roughly 50% of the thermal energy generated in a gas engine consists of exhaust gas heat with a temperature of approximately 400 to 500°C and can be utilized for the production of steam. The remaining waste heat contained in the engine cooling water, oil, or air/fuel gas mixture, can be utilized for feeding water preheating. Applications include processed steam for industrial operations, hospitals to meet their requirement for sterilization steam, and foodstuff processing operations. The exhaust gas from the gas engines can also be utilized directly or indirectly for drying processes (e.g., in brick works, the ceramic industry, animal feed drying). Overall efficiencies of more than 98% can be achieved through the recovery of the heat discharged from the cogeneration plant by way of heat exchangers and the exhaust and radiation heat.

## $CO_2$ fertilization in greenhouses

Heat, light and $CO_2$ promote the growth of plants in greenhouses. With artificial lighting, plants absorb even more $CO_2$. If the greenhouse atmosphere is enriched with $CO_2$, plant growth and consequently the harvest yield can be increased by up to 40%. This process – also called $CO_2$ fertilization – is able to make use of the $CO_2$ contained in the exhaust gas of a gas engine through catalytic converter purification. As a result, greenhouses utilizing gas engine cogeneration systems can cover the power and heat requirement for the artificial lighting and heating in an economical manner, while effectively utilizing $CO_2$ of the engine exhaust gas.

## trigeneration

The combination of gas engines with absorption chillers is an optimal solution for generating air conditioning and/or refrigeration. The waste heat from the mixture intercooler, the engine oil, the engine cooling water, and the exhaust gas serves as drive energy for the chillers. Combining a cogeneration plant unit with an absorption refrigeration system allows utilization of seasonal excess heat for cooling. Using trigeneration, it is possible to achieve overall efficiencies (power and air conditioning and/or refrigeration) of up to 75%, increasing both annual capacity and overall plant efficiency.

# for your reliability

On the way to the top you better have a strong partner.

Gas engine manufacturing building at the Austrian headquarters

## on-site in more than 30 countries

The Jenbacher product team's commitment to the customer goes beyond designing the best available technology. Our success is measured by our customers' long term satisfaction with the performance of our equipment. The main concern in this regard is to offer customers the full range of services needed to ensure a reliable and efficient energy supply and special gas disposal from one source.

### Service agreements

With customized service agreements GE ensures the best possible fulfillment of individual customer requirements.

### Worldwide service organization

Jenbacher service technicians and authorized external service providers are located in more than 30 countries. This service network secures the optimum care and support of our customers.

### Remote diagnosis and remote servicing

The in-house Jenbacher competence center makes use of remote diagnosis and remote servicing by means of HERMES, the data remote transfer system developed in-house, and networked worldwide by satellite. The competence center is run by a team of experienced and highly-qualified commissioning service engineers in Jenbach and ensures timely and accurate technical support.

### Training center

The Jenbacher training center, located in Jenbach, offers specific participant-oriented training courses for customers, operators, and sales and service providers. Hands-on training programs are offered either at the customer site or at the training center.

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GE imagination at work



GEA-14068A-R1