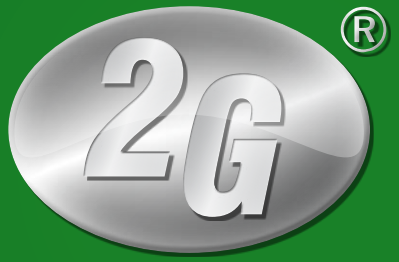
# 2G. Additional equipment.

Standard components for special applications of combined heat and power generation.
For special environments. For flexible energy requirements.

**2G. Cogeneration.**


2G
R

# 2G. Periphery and accessories. CHP taken to the next level.

2G has installed combined heat and power plants in more than 40 countries around the world. Their common attribute is the highly efficient, reliable production of power and heat by means of cogeneration. The core of every plant is an innovative, high-quality gas engine. It is part of a complex supply concept that must fulfill entirely different requirements. In addition to the production of power and heat, the plants can convert heat into steam or chilled water, adapt to flexible energy requirements and operate in extremely cold or extremely hot regions.

2G Energy AG offers additional equipment parts that have been proven in practice for nearly every application, as well as experience. The most important from the standard 2G program are found in this brochure.

**CHP taken to the next level. And installed thousands of times over.**

# Contents

## Container/Noise protection



## Regional options



## Exhaust gas post-treatment



## Maintenance and operation



## Example of use

## Fermenter

Biogas is generated

Biogas: T = approx. 35 °C
Sulfur: 100 ppm

## Gas cooling

- Cold water replacement
- Tube bundle heat exchanger
- Pipework

The temperature is reduced to extract the moisture from the gas

Biogas: T = approx. 7 °C
Sulfur: 100 ppm

## Reheating

- Tube bundle heat exchanger
- Pump
- Mixer

The temperature is raised in order to reduce the relative humidity of the gas to the required level

Biogas: T = approx. 25 °C
Sulfur: 100 ppm

## Active carbon filter

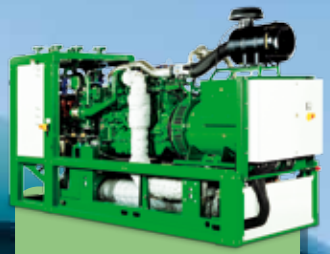
Active carbon removes the sulfur content from the gas

Biogas: T = approx. 20 °C
Sulfur: < Limit value

## Gas compressor/ supply pressure regulator

The gas compressor provides the appropriate supply pressure for the CHP plant.

Nominal plant gas pressure



## 2G CHP plant

Generates electric current and heat

# Biogas treatment.

The biogas generated in the fermenter has 100% moisture saturation and, in addition to hydrogen sulfide, contains other gas impurities. These substances can damage the downstream 2G plant. Therefore, biogas treatment as described above is beneficial for extending the service life of the individual components. An alternative, particularly for CHP plants with a gas line length > 500 m is a gas wash dryer in combination with an active carbon filter.

# Effectively dehumidify and clean biogas.

The biogas treatment comprises three components: gas cooling, reheating and active carbon filter (see figure to the left). Alternatively, a gas wash dryer can be combined with an active carbon filter. The gas wash dryer cools the biogas down to 2-4 °C and cleans the biogas more thoroughly, which is advantageous for micro gas networks.

### Active carbon filter

| Product | Active carbon | for electrical output |
|---|---|---|
| **AKF 650** | 250 kg | up to approx. 160 kW |
| **AKF 1000** | 500 kg | up to approx. 637 kW |
| **AKF 2000** | 1000 kg | up to approx. 1200 kW |
| **AKF 3000** | 1500 kg | up to approx. 2000 kW |

### Gas cooling/reheating

| Output | for electrical output |
|---|---|
| **75 m³/h** | up to approx. 160 kW |
| **150 m³/h** | up to approx. 250 kW |
| **300 m³/h** | up to approx. 600 kW |
| **450 m³/h** | up to approx. 889 kW |
| **600 m³/h** | up to approx. 1200 kW |
| **750 m³/h** | up to approx. 1487 kW |
| **900 m³/h** | up to approx. 1560 kW |
| **1050 m³/h** | up to approx. 2000 kW |

### Gas purifying and drying

| Output | for electrical output |
|---|---|
| **75 m³/h** | up to approx. 160 kW |
| **150 m³/h** | up to approx. 250 kW |
| **300 m³/h** | up to approx. 600 kW |
| **450 m³/h** | up to approx. 889 kW |
| **600 m³/h** | up to approx. 1200 kW |
| **750 m³/h** | up to approx. 1487 kW |
| **900 m³/h** | up to approx. 1560 kW |
| **1050 m³/h** | up to approx. 2000 kW |


## Fermenter

Biogas is generated

Biogas: T = approx. 35 °C
Sulfur: 100 ppm

## Gas cooling

- Cold water eplacement
- Tube bundle heat exchanger
- Pipework

The temperature is reduced to extract the moisture from the gas

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## Gas compressor/ supply pressure regulator

The gas compressor provides the appropriate supply pressure for the CHP plant

Nominal plant gas pressure

## 2G CHP plant

Generates electric current and heat

# Biogas processing.

Before the biogas in the 2G plant can be converted into electric current and heat, it passes through several plant components. The gas compressor provides the appropriate supply pressure for transport to the 2G plant. If there is a large amount of available biogas that can no longer be stored, it must be burned off with a flare in a safe and environmentally friendly manner.

# Gas pressure adapted.

The gas compressor provides the appropriate supply pressure for the 2G plant in biogas operation and thereby assures constant plant operation. The filius, patruus and agenitor series, as well as the avus 500 plus, require a supply pressure of approx. 50 mbar and the avus series requires 80 mbar in the gas regulating line. Biogas and natural gas lines are frequently operated at different pressures, so that a supply pressure regulator adjusts and prepares the pressure according to the requirements.

# Disposing of excess biogas in a safe and environmentally friendly manner.

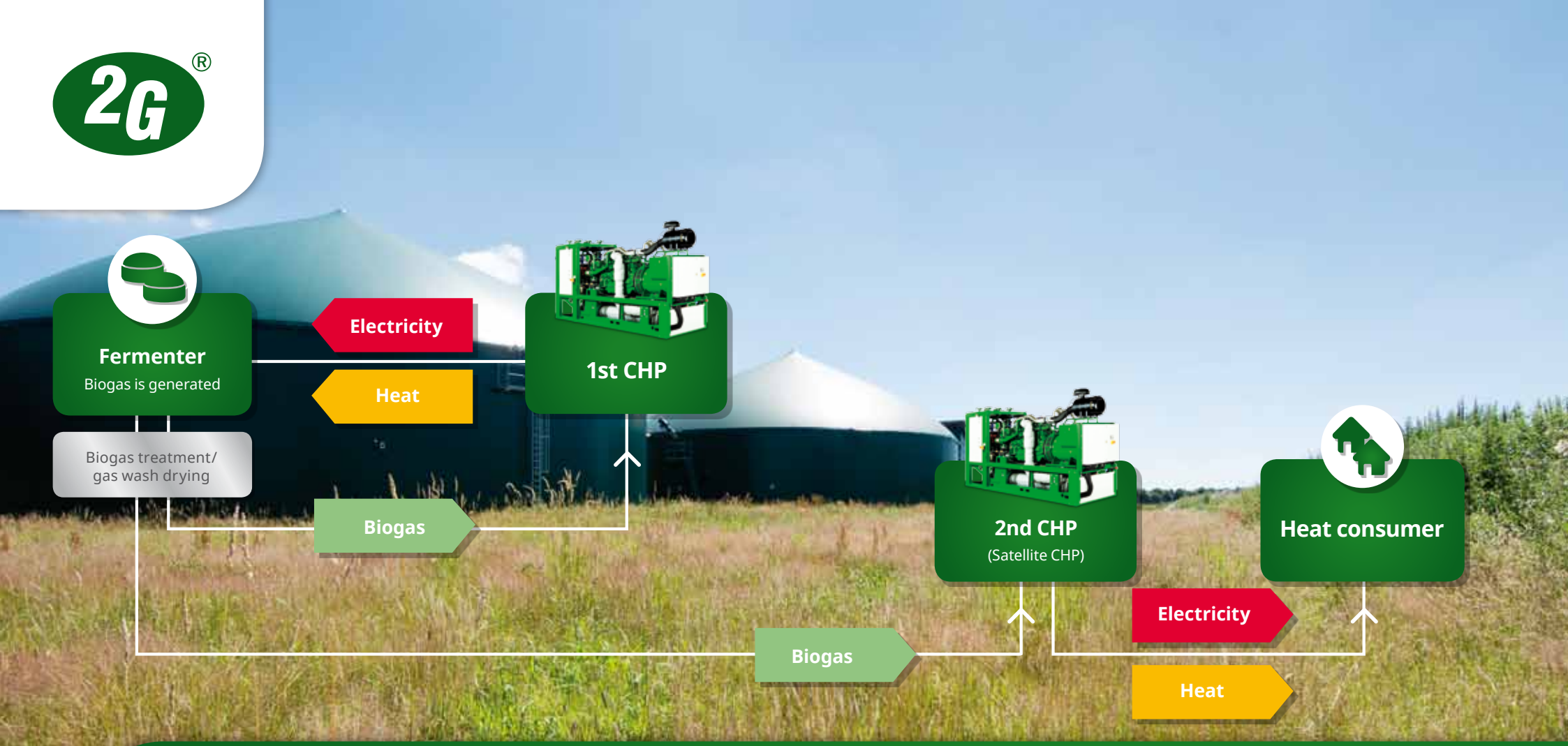
If the gas storage volume is exhausted or the CHP is shut down for maintenance work, etc., the biogas must be burned off with a flare, because it cannot simply be released to the environment due to its composition. Gas flares are available in different versions:

- Fully concealed emergency flare
- Semi-concealed emergency flare
- Fully concealed HT emergency flare for compliance with strict regulations

It is also possible to use the gas flare as an operating flare, i.e. in parallel operation with the existing CHP.

**Gas flare output classes**

| Output | for electrical output |
|---|---|
| 75 m³/h | up to approx. 160 kW |
| 150 m³/h | up to approx. 250 kW |
| 300 m³/h | up to approx. 600 kW |
| 450 m³/h | up to approx. 889 kW |
| 600 m³/h | up to approx. 1200 kW |
| 750 m³/h | up to approx. 1487 kW |
| 900 m³/h | up to approx. 1560 kW |
| 1050 m³/h | up to approx. 2000 kW |




# Micro gas network.

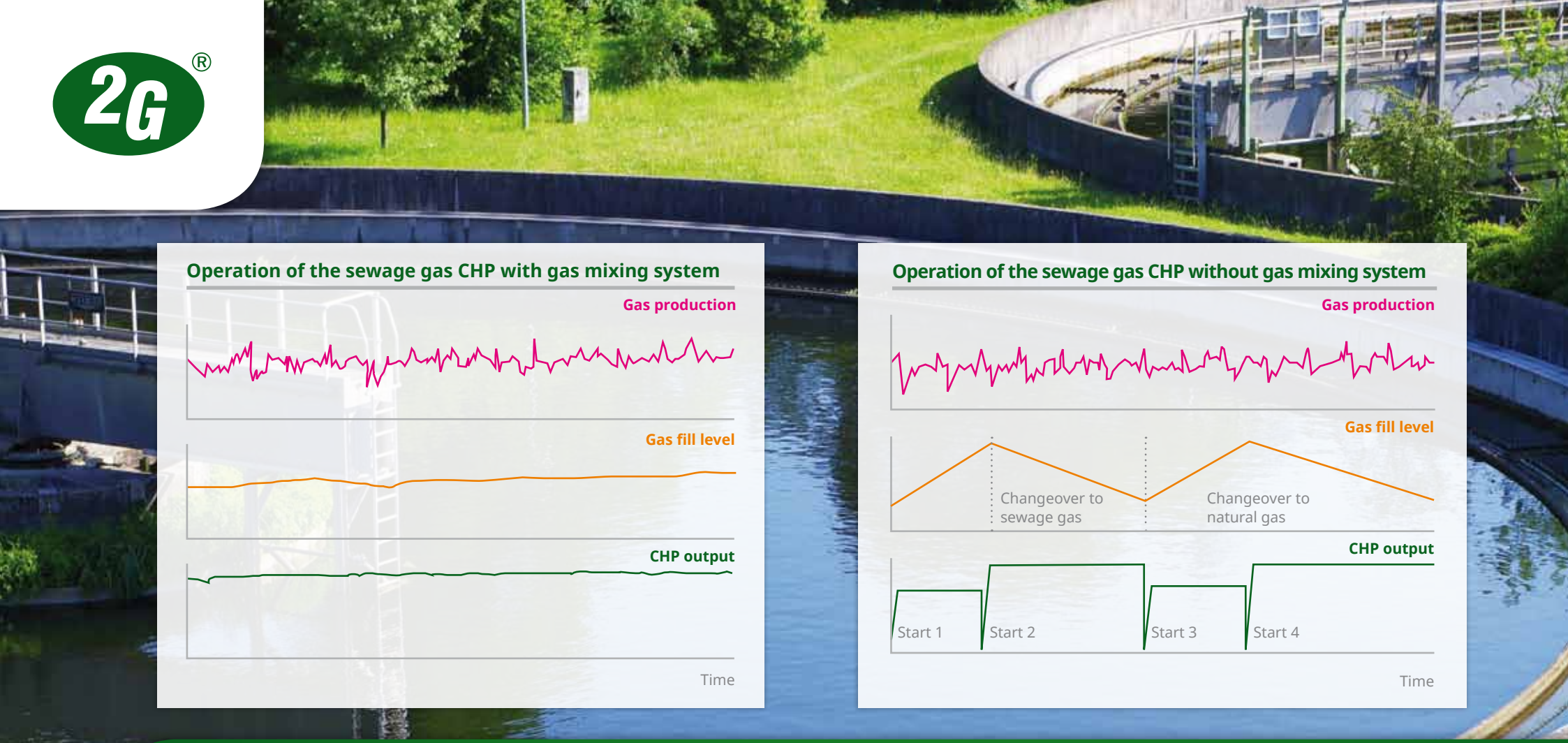
Some applications require use of heat and electricity in a location removed from the biogas plant.
This is possible with a satellite CHP.

# Transport biogas to the heat consumer.

A micro gas network is a pipeline which conveys produced gas to a remote location. This pipeline transports the produced biogas produced at the CHP to a second CHP, which can be located next to a facility to be supplied, such as a hospital or production building.

However, the biogas must be dried or washed before it flows through the lines installed for this purpose. This prevents condensation and dirt accumulation that could damage the pipelines. This is possible with biogas treatment or a gas wash dryer installed directly at the biogas plant. A gas compressor may also be necessary so that the biogas can reaches the satellite CHP at the required pressure.

The dimensioning of the pipeline is determined by the biogas plant manufacturer or an engineering firm prior to the excavation work by a specialist company.

### Operation of the sewage gas CHP with gas mixing system




### Operation of the sewage gas CHP without gas mixing system




# Addition of gas.

If lean gas is not available in a sufficient quantity or the quality is inadequate, the CHP shuts down.
With the gas mixing system developed by 2G, it is possible to continuously operate lean gas CHPs at high load.

# Lean gas CHP continuously operated at full load.

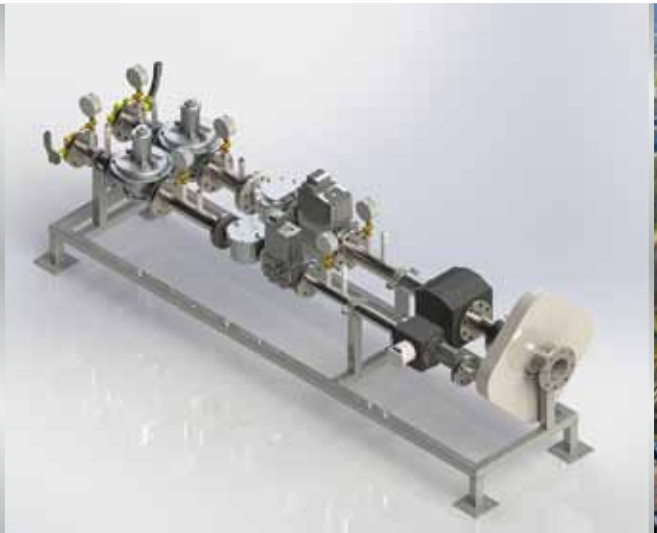
If sufficient gas is not available, the CHP automatically reduces its output to match the minimum gas quantity available. However, in order to be able to continue operation of the CHP at high load and optimally supply the property with electricity and heat, a 2G gas mixing line can be installed. This line mixes the lean gas from sewage treatment plants, landfills or mines with up to 100% natural gas. The gas mixing line contains the following components:

- Second gas meter for detection of the lean gas quantity and natural gas quantity
- Pneumatic valve with electrical actuation
- Complete mixing line, including all necessary sensors, actuators and safety valves
- Separate control unit for the mixing line

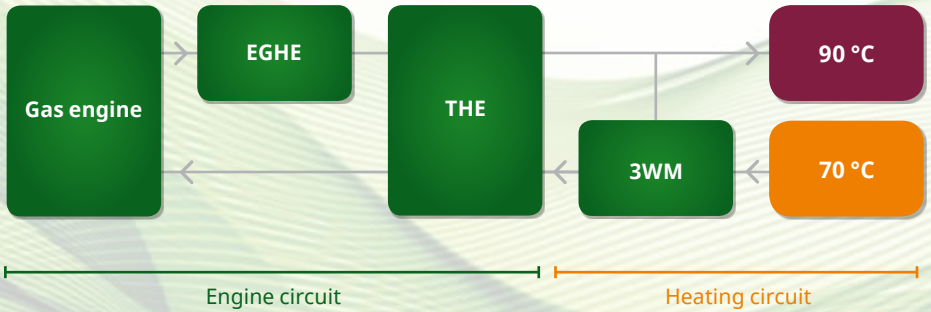
However, it is also possible that there is a sufficient quantity of lean gas, but the quality is inadequate. In this case, the 2G gas mixing line can add natural gas to the lean gas in order to assure constant operation of the CHP. The following components are provided for this version:

- Methane sensors
- Pneumatic valve with electrical actuation
- Complete mixing system, including all necessary sensors, actuators and safety valves

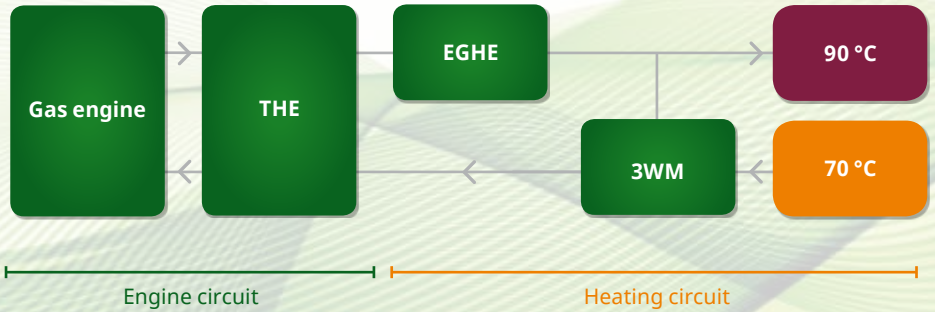
The addition of all types of gas always takes place in compliance with applicable regulations for exhaust gas emissions.
With this opportunity it is possible to design the gas storage smaller and act more flexible regarding gas production.



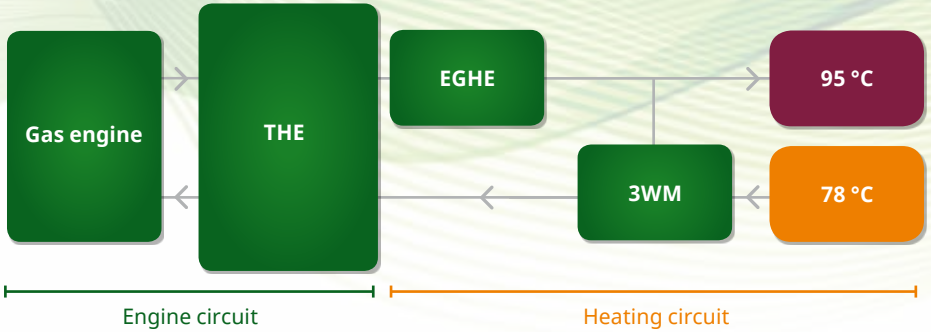
### Heat extraction standard biogas 70/90 °C



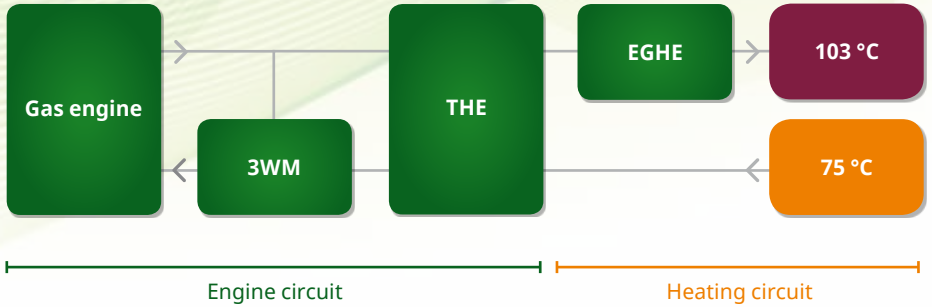

### Heat extraction standard natural gas 70/90°C




### Heat extraction 78/95°C




### Heat extraction 75/103°C




EGHE - exhaust gas heat exchanger| THE = transfer heat exchanger| 3WM = 3-way mixer

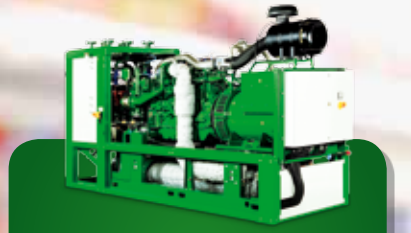
# Temperature levels.

2G plants are configured by standard for a supply temperature of 90 °C and a return temperature of 70 °C. Some customer-specific circumstances necessitate a deviation from this, which 2G can easily accommodate based on extensive experience.

# The right temperature for every application.

Variants heat extraction standard biogas 70/90°C and heat extraction natural gas 70/90°C are also required for older heat networks, absorption cooling systems and applications with process heat. When plants use steam generators for water preheating, etc., variant heat extraction 78/95°C is necessary.

| | Heat extraction 78/95 °C | Heat extraction 75/103 °C |
|---|---|---|
| Temperature level | 78/95 °C | 75/103 °C |
| Exhaust gas heat exchanger is integrated in the heating circuit (with standard exhaust gas heat exchanger) | x | x |
| Additional safety temperature limiter in the heating circuit | x | x |
| Pressure monitoring in the heating circuit | x | x |
| Adapted recipe with warning and limit values for temperatures | x | x |
| Larger plate heat exchanger | x | |
| Speed-regulated pump | | x |
| Supply temperature can be adjusted by the customer from 95 °C to 103 °C | | x |



2G CHP plant

Electricity

Heat

Heat

Absorber

Chilled water

# Trigeneration.

Some applications require chilled water instead of heat. Examples include computer centers, hospitals and production plants.

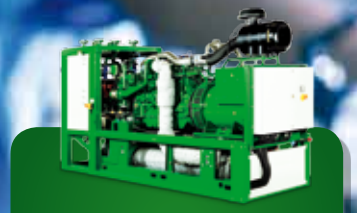
# Cooling with heat.

Absorption cooling systems are thermally powered cooling machines with direct connection to the CHP, which are frequently operated with water/lithium bromide. The heat generated by the CHP can be entirely or partially diverted through the absorber in order to produce chilled water with an average temperature of 6-12 °C. The size of the cooling system is always configured specifically for the project.

With the use of an absorption cooling system, it is possible that heat-operated natural gas CHPs can be designed correspondingly larger and thus feed additional electrical power into the mains.

The heat generated by the cooling system can also be used for low-temperature circuits, such as floor heating.

2G has served numerous properties that also required chilled water.



2G CHP plant

Heat

Steam generator

**Process heat**
for industrial applications

# Steam generation.

Every property has its own requirements for its environment. In some industrial applications, such as food industry or hospitals, steam is required as a medium.  Steam generators are a proven and widespread technology. They are characterized by high energy density. 2G's extensive project experience makes it a specialist in this field.

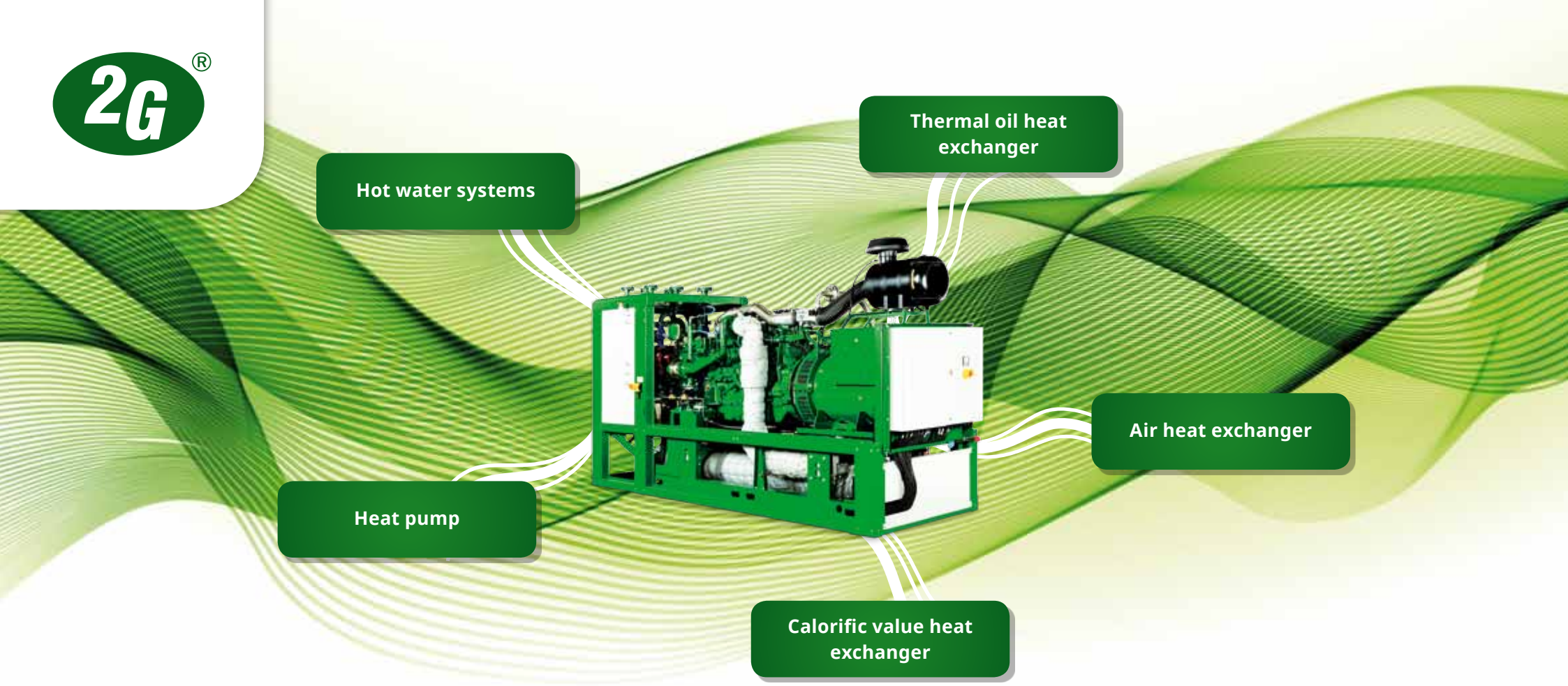
# Use steam safely.

A steam generator heats water with the waste heat from the exhaust gas of the CHP to a temperature above the boiling point so that it evaporates. The generated steam can be used for processes or in combination with an absorption cooling system for building cooling. Steam systems with an operating pressure > 1 bar contain the following additional components, which assure the safety of the system:

- Water level limiter (NW)
- Water level regulator
- Optical water level indicator
- Conductivity monitor
- Safety valve
- Maximum pressure limiter
- Maximum pressure monitor
- Sediment drain valve (automatic)
- Sludge valve (automatic)
- Maximum water level controller

Every application that requires steam is individual and the requirement parameters vary greatly. Therefore a project-specific configuration of the parameters is always necessary.

Approval is mandatory for installation of a steam generator. Regular inspection must be carried out by inspection authorities.




# Additional heat applications.

The usage possibilities for the thermal energy prepared by the 2G plant are practically limitless. Projects do not have to be based on the CHP, the CHP can be based on the project.

# Use waste heat efficiently.

In general hot water at a temperature of 90 °C is provided by the 2G plant. The waste heat can be used in the following ways:

**Hot water systems**

- High temperature level with increased system pressure
- Frequent use for the heat supply of a district heating plant or for process heat in industry

**Thermal oil heat exchanger**

- Is used instead of the standard heat exchanger
- The heat carrier is thermal oil, which can provide a high temperature level (up to 350 °C) in a quasi-pressureless system
- Good cost/benefit ratio
- Frequently used for biogas treatment plants

**Air heat exchanger**

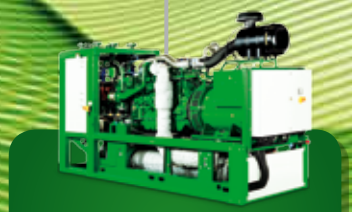
- Air is heated instead of water
- Typical application: Drying of textiles
- Space-consuming

**Heat pump**

- Generates ample heat from little electric current in order to provide additional heat to the district heating network, etc.
- The average difference between the head reduction outlet and heat source inlet should not exceed 50 K
- A suitable compressor concept is required that takes the thermal load into consideration
- Additional increase in efficiency of the 2G plant is possible, e.g. using the waste heat of the CHP as a heat source for a heat pump

**Calorific value heat exchanger**

- Installation of a second heat exchanger after the first one or direct configuration of calorific value heat exchanger
- Additional energy is extracted from the exhaust gas in the form of heat and efficiency increases
- Requirement: low return temperatures (e. g. in swimming pools or heat networks)



2G CHP plant

Buffer storage

Consumer

# Heat storage/distribution.

The heat generated by 2G plants is often supplied to multiple consumers or the heat should be stored.
2G also provides a suitable system for distribution of the heat.

# Distribute heat as needed. Or store it.

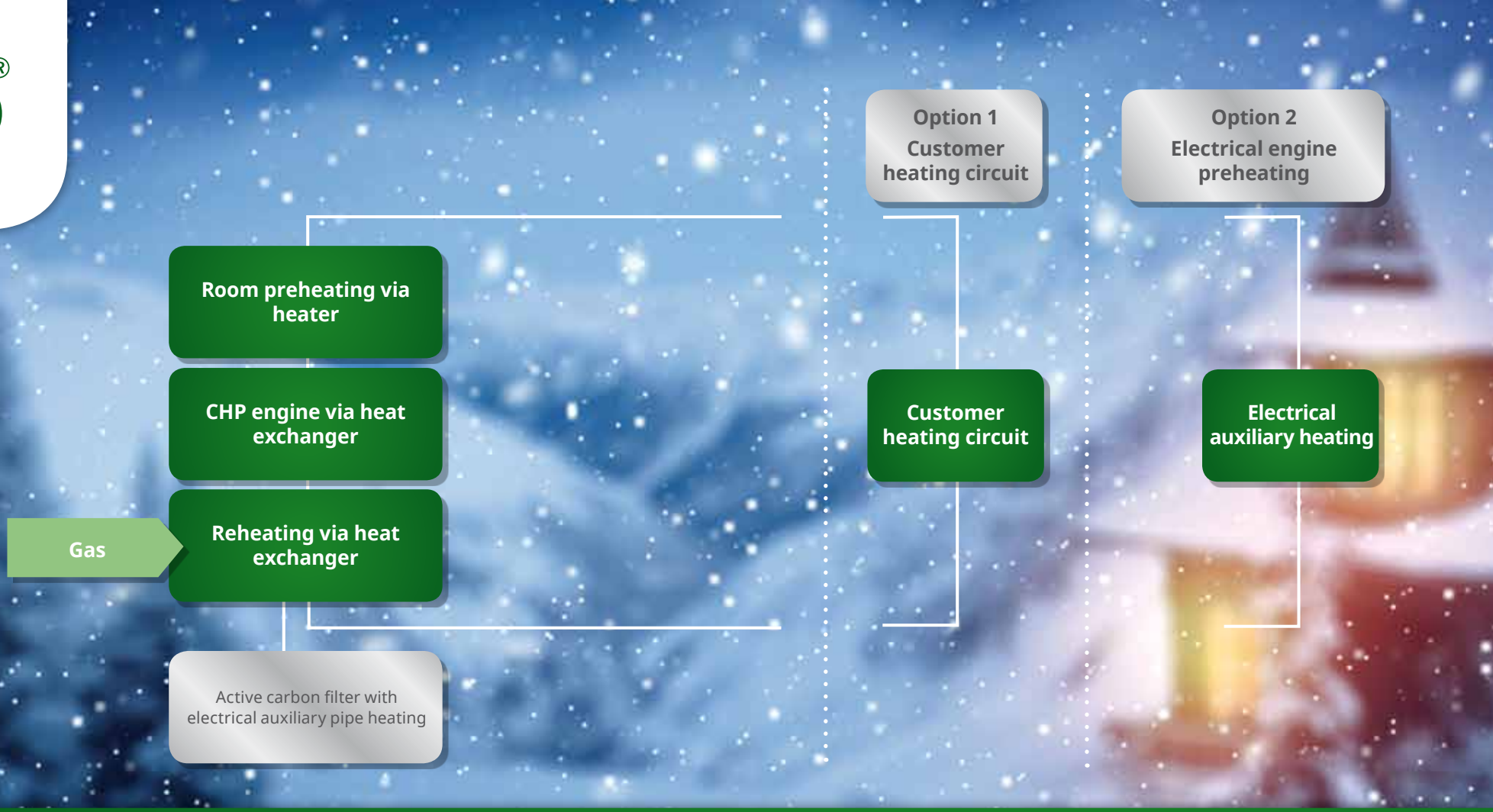
With a heating circuit distributor, a fermenter dryer can be operated with the supplied heat in parallel to the biogas plant. Or a natural gas CHP supplies a heating and cold absorption system.

## Heating circuit distributor.

The heating circuit distributor comprises a hydraulic switch that separates the supply circuit and consumer circuits and a distributor manifold that distributes the thermal output to the respective consumer circuits. The main components of the heating circuit distributor is a 3-way mixer that divides the process regulating groups into the primary circuit (coming from the heating circuit distributor) and consumer-side secondary circuits. Depending on the heat requirement, the 3-way mixer adds more or less hot water to the secondary circuits, which are equipped with a heat pump in order to generate constant volume flows

## Buffer storage.

An additional option for regulation of various heat requirements is the time-independent variant of buffer storage. This is advantageous for operating the CHP independently to the heat requirement. The heat (and/or hot water) is delivered to the buffer storage. Therefore, the CHP does not have to be shut down and can continue to produce electricity, which makes it especially interesting for control energy. 2G has already implemented projects with buffer storage systems ranging from 1,000 to 130,000 liters.




# Flexible equipment.

With cold environmental temperatures, particularly in winter, increased demands are placed on management with repeated start/stop operation of a 2G plant.

# Safe engine start in any weather.

In flexible operation and with repeated starting and stopping, certain systems of the 2G plant must be kept ready for operation in order to prevent increased wear and damage to various components and assure safe plant operation.

To maintain the optimal temperature of approx. 20 °C in the installation room, it is heavily insulated and heated and louvers are integrated in the supply and exhaust air frames. It is thereby assured that electrical components are not damaged and engine start-up difficulties due to viscous lubricating oil are avoided.

For full-load operation, the engine requires a temperature of approx. 60 to 65 °C, so it should always be kept warm. Engine preheating is specifically required in flexible operation.

The gas reheating and active carbon filter, in particular, must be kept warm for gas treatment while the 2G plant is shut down. The active carbon filter is protected from cooling down by auxiliary pipe heating.

This equipment is available as a complete "flexible package" or as separate items and can be operated via an on-site heating circuit or electrically.

2G CHP plant

Customer system

Current temperature and pressure values, output data, operating times and other operating data

# Data interfaces.

An interface can be set up via a bus system for simplified data exchange between the 2G plant and the customer system.

# Transmit data simply, reliably and securely.

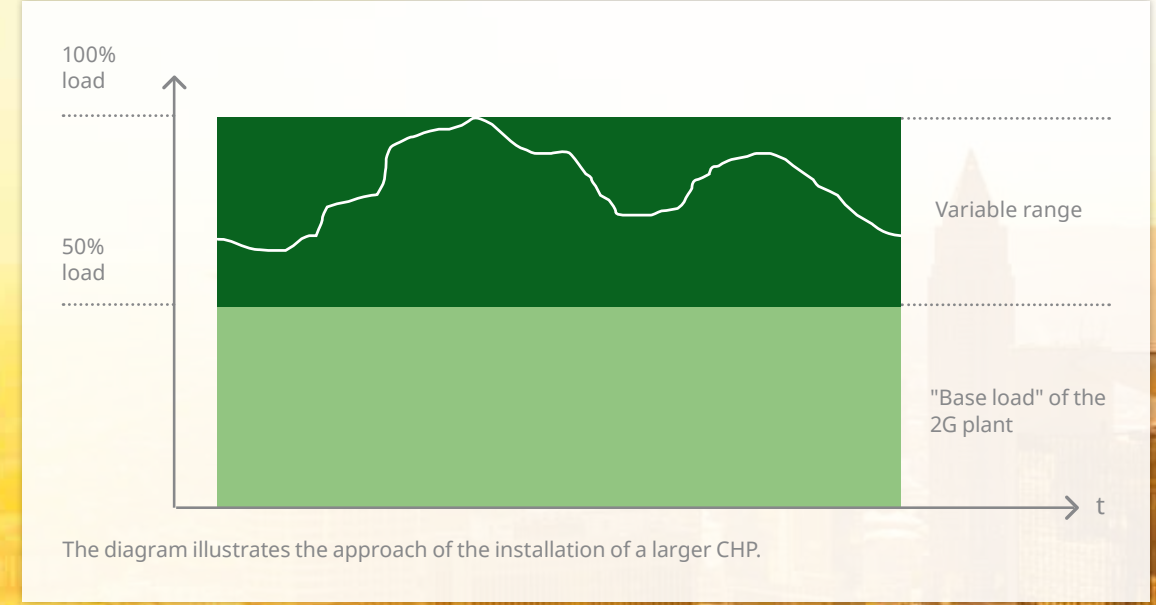
Interfaces with various bus systems can be offered for connection to the CHP plant control unit. The following variants are available:

- Ethernet IP
- Modbus RTU
- Modbus TCP
- Profibus DP

The data that can be exchanged can be determined based on the corresponding interface lists. They are provided as technical information. Examples include start/stop requirements ("TI"), various temperatures and pressures. Extensive data can be exchanged with minimal wiring thanks to the data interface. An additional advantage is that analog signals requiring elaborate processing can be transmitted reliably. This data can, for instance, be read in a customer-specific control unit in order to establish a visualization or to communicate status messages and monitor the plant based on the data.

In addition to the interfaces mentioned above, other data interfaces are available on request.

Hardware interfaces can also be provided along with the bus interfaces. However, this is not as comprehensive as a bus interface and only exchanges the most important signals. Digital and analog values are exchanged via terminals.




The diagram illustrates the approach of the installation of a larger CHP.

# Partial load and zero reference control.

2G plants are increasingly operated on a requirement basis – without the need to switch off the CHP. A variant of requirement-based operation is zero reference control: Only the amount of current that is actually required by the consumer is produced and not fed into the public mains. In these cases, the 2G plant can react flexibly and the output can be adapted automatically to the local circumstances.

# React flexibly to the requirement. Automatically.

Basically, all plants can be operated with a partial load of up to 50%, particularly with temporary limitations.

**50% partial load**

2G plants which run on natural gas or purified lean gas may be run at 50% rated load on a long-term basis. In the case of purified lean gas, the sulfur content must be recorded on-site on the plant control unit for the purpose of long-term measurement.

2G plants which run on unpurified lean gas may be run at 75% rated load on a long-term basis. Operation at less than 75% of the rated load may only be conducted for a certain amount of time. After each interval at under 75% rated load, the 2G plant must run at an output of over 75% rated load for defined minimum duration so that the condensate in the exhaust tract can be discharged.

# Mains backup and isolated operation.

In some regions there are supply networks that cannot provide uninterrupted electric current or in which it is not even available. In these cases a 2G plant in isolated operation can be a remedy for electric current supply. With a "black start", the 2G plant can even be started without external auxiliary energy and an isolated network can be established for independent supply. This works for individual 2G plants as well as for multiple engines connected in parallel.

# Reliable electric current despite a mains failure.

Isolated operation cannot be equated to emergency power operation. In this case, there are requirements based on standards that necessitate the re-establishment of the power supply in case of a power failure – e.g. in hospitals. However, a 2G plant guarantees numerous possibilities for assuring independent supply in case of a mains failure.

**Manual isolated operation**

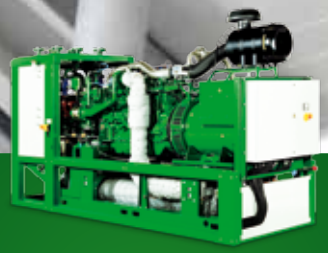
The simplest variant is manual isolated operation. As soon as the mains power fails, the CHP plant and customer system switch over to isolated operation. Now the engine can be restarted and the loads are activated successively. With a return of the mains power supply, the machine must be shut down again. The switchover of the CHP plant and the customer system is followed by the switchover back to mains-parallel operation.

**Automatic isolated operation with back synchronization**

The basic process in the case of a mains failure and the subsequent start-up of the 2G plant is the same as for manual isolated operation. However, when the mains returns, a re-connection to the public mains can take place with the help of a superordinate on-site coupling switch. The 2G plant can be back-synchronized with the mains once a secure supply is provided.

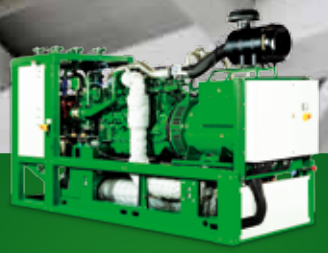
**Automatic isolated operation with load transfer and back synchronization**

The entire load can be assumed by the 2G plant in case of a main failure without the necessity of a shut-down. The back synchronization takes place as described above. In this variant an additional zero reference control can be installed (see page 30). Using this control, the CHP plant generates as much energy as is actually required.



## 2G CHP plant with starter battery

- Affordable standard solution
- Mains-independent starting process
- Advantageous with many operating hours per start



## 2G CHP plant with mains starter device

- Improved starting behavior with higher start-up speed
- Environmentally-friendly
- Reduced maintenance

# Mains starter device.

If a mains starter device is used instead of a starter battery, a 2G plant can be started in a more environmentally-friendly manner, with reduced maintenance and better starting behavior, because a higher start-up speed is reached, which enables a secure engine start at colder environmental temperatures, in particular.

## Energy for startup from the mains.

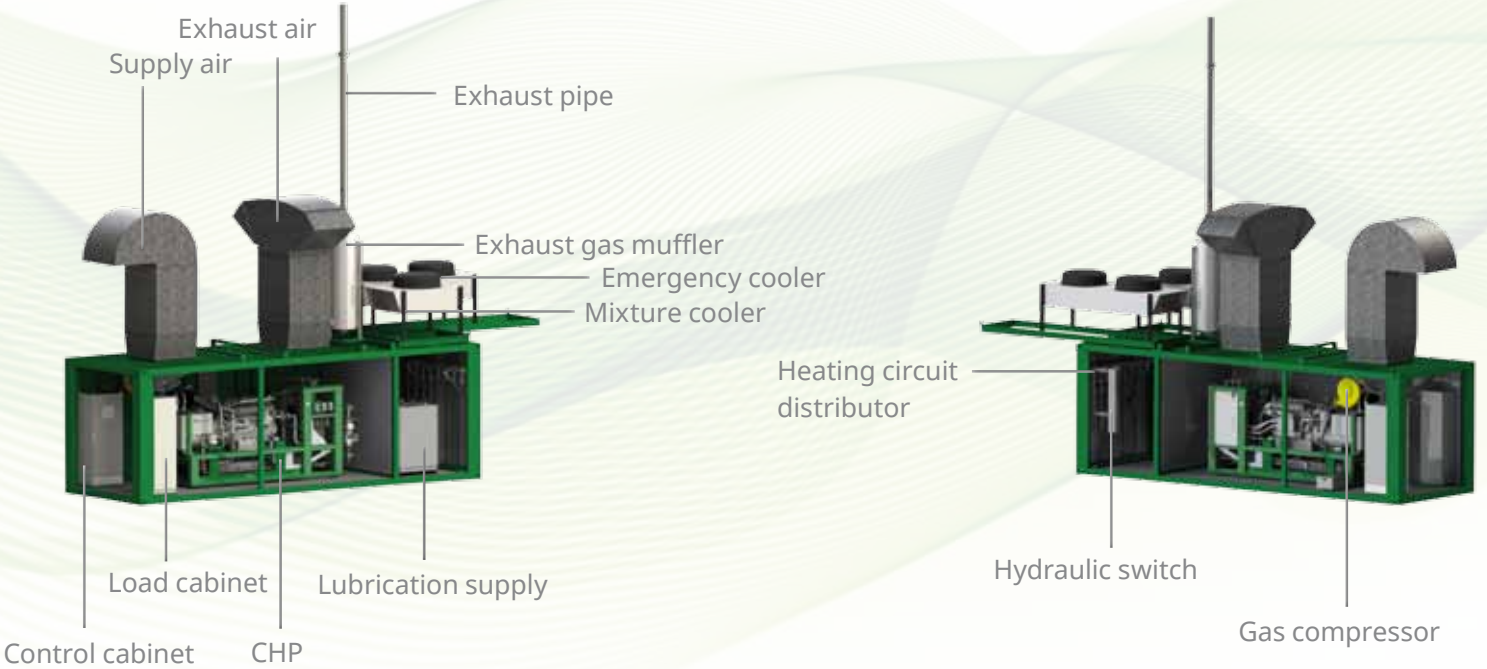
2G plants are started with a starter that is normally supplied with energy by starter batteries. A common alternative is the mains starter device designed by 2G. It comprises a transformer and an inverter and is adapted to the output of the starter. The mains starter device converts energy from the mains so that the starter can start. The alternating current drawn from the mains by the starter device is inverted in order to provide the direct current required for the starter. Normal starter batteries can be omitted.

## Optimized starting process.

Unlike batteries, the mains starter device does not have to be replaced or maintained in regular intervals. The starting process can also be optimized with a higher start-up speed. The use of the mains starter device is also beneficial if adequate battery ventilation in accordance with EN 50272 cannot be provided. Use of the mains starter device is possible for all 2G plants with synchronous generators.

The 2G mains starter device is maintenance-free, does not form gases and is free from charge-current monitoring.

If isolated operation is desired, the use of starter batteries is necessary, because they can also be used independently of the mains to start the engine.


# Integrated solutions.

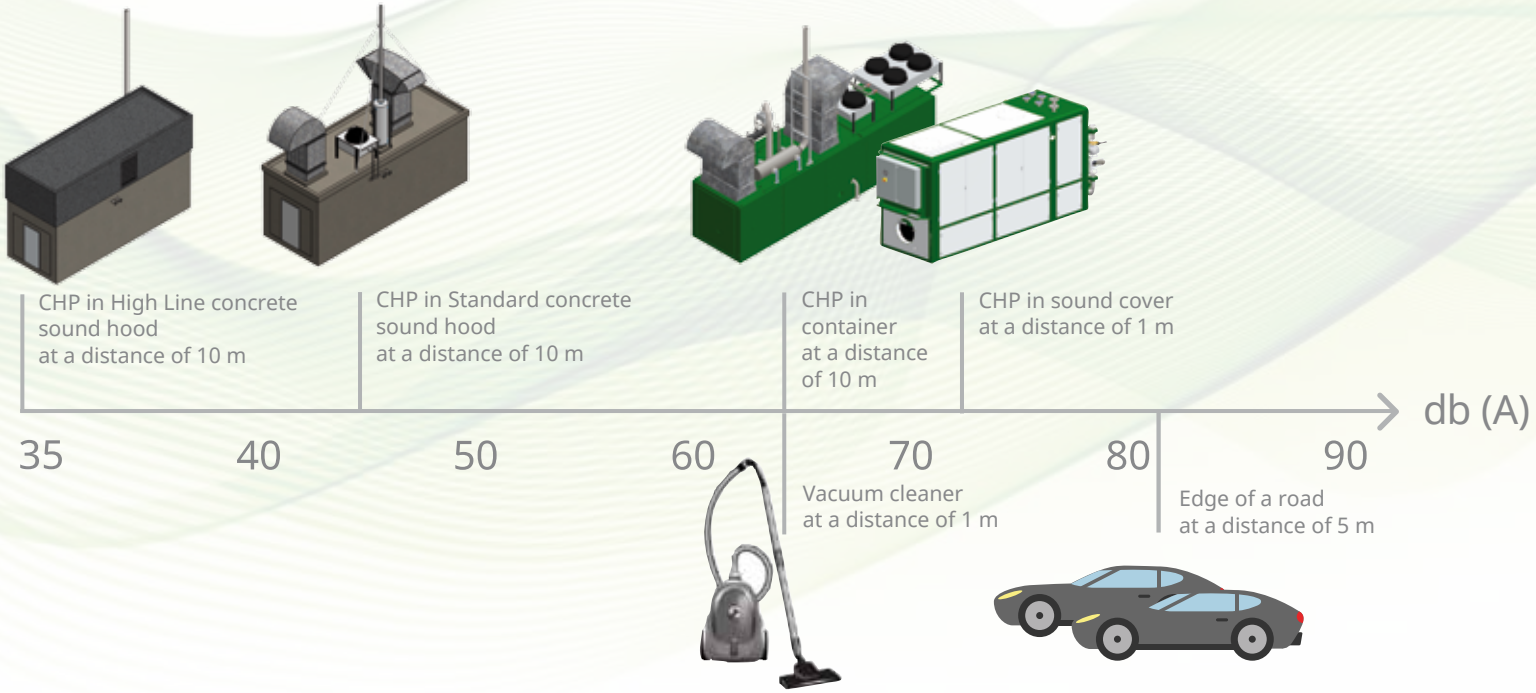
2G offers turnkey solutions with installation of the plant in a container or with a concrete sound hood. The pipework is pre-installed for all components at the factory, so that only a few transition points have to be connected on site before the 2G plant can be set up to perform its work.

# Delivered turnkey and quickly commissioned.

With their special design, the 2G containers and concrete sound hoods offer a few advantages for customers. They are designed for low noise emissions and equipped with an integrated oil collection trough. With the somewhat wider version – in contrast to ISO containers – it is also possible to carry out service tasks with the doors closed. There is also better heat distribution within the housing. The following components are normally found in and on the container and/or concrete sound hood: the CHP, load cabinet for transfer of generated energy to the distribution network, the control cabinet with touch screen, gas compressor (provides the appropriate supply pressure), the emergency cooler (releases the heat from the engine cooling circuit), the mixture cooler (releases the heat from the mixture cooling circuit) and optional components such as oil tanks for fresh and used oil, heating circuit distributor (distributes the heat to the consumers), exhaust gas silencer and secondary silencer.

| Variant (length) | up to 6.5 m | up to 9 m | up to 10.5 m | up to 12 m | up to 13 m | up to 15 m |
|---|---|---|---|---|---|---|
| filius container | 6 x 2.44 x 2.8 | 9 x 2.44 x 2.8 | | | | |
| Standard container | 6.5 x 3 x 3 | 9 x 3 x 3 | 10.5 x 3 x 3 | 12 x 3 x 3 | | |
| High Line container | | 9 x 3 x 3.7 | 10.5 x 3 x 3.7 | 12 x 3 x 3.7 | 12 x 4.3 x 5.34 | |
| Twinpack container | | | | | 13 x 3 x 3 | 15 x 3 x 3 |
| Standard concrete sound hood | | 9 x 3.3 x 3.7 | 9.15 x 4.3 x 3.7 | 11.4 x 4.3 x 3.7 | | |
| High Line concrete sound hood | | 9 x 3.3 x 5.36 | 9.15 x 4.3 x 5.36 | 11.4 x 4.3 x 5.36 | | |

## Noise emissions




# Noise protection.

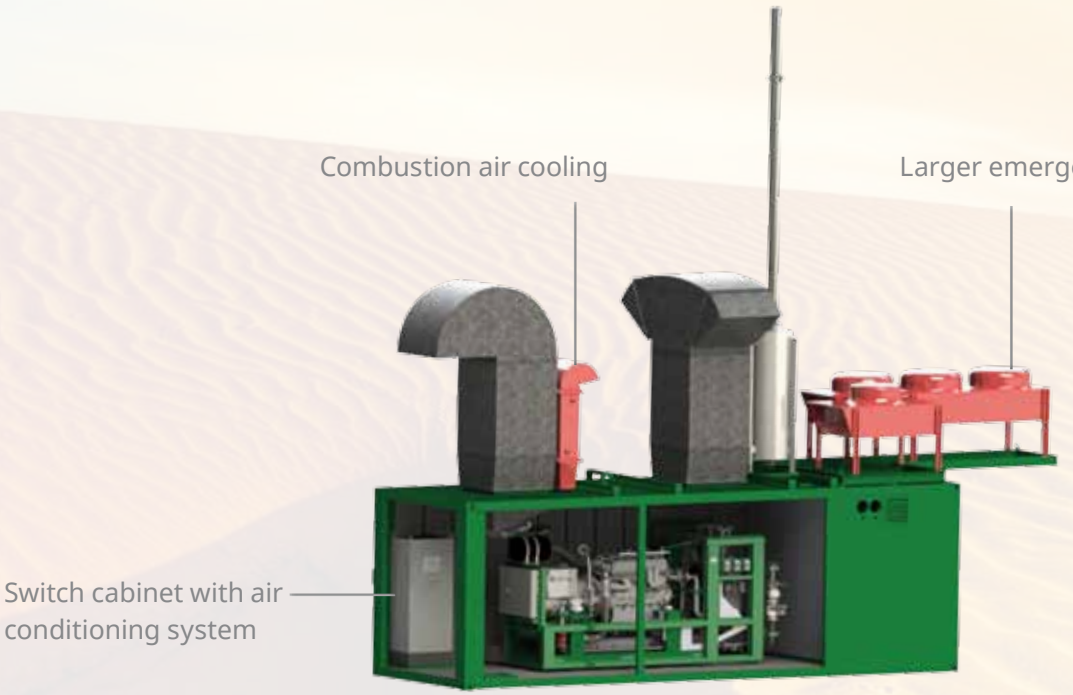
Whether they are schools, swimming pools or hospitals, all of these properties are predestined for CHP solutions. They are often in residential areas with high demands on noise protection.

# Sound insulation according to requirements.

2G have various solutions to meet different noise level requirements. For instance, the choice of housing and the design of the housing can influence the perceptible volume.

- Emergency and mixture coolers are easier to eliminate, because the fan speed can be reduced and lower noise emissions are created.
- The exhaust gas silencer is supplemented with a secondary silencer.
- The ventilation system receives larger silencer.
- The insulation of container walls, ceilings, floors and doors is increased.

| Housing | Sound pressure level in dB (A) at 10 m in open area conditions | |
|---|---|---|
| | Standard version | SuperSilent version |
| **filius container** | 65 | 55 |
| **Standard container** | 65 | 52 |
| **High Line container** | 65 | 45 |
| **Twinpack container** | 65 | 52 |
| **Concrete sound cap** | 45 | 35 |
| **High Line concrete sound cap** | 45 | 35 |
| **Engine room** | individually | 35 |




# Warm country version.

Worldwide installation of 2G plants necessitates adaptation to climate conditions. With a few modifications, 2G plants can also be ideally equipped for locations with a very warm climate.

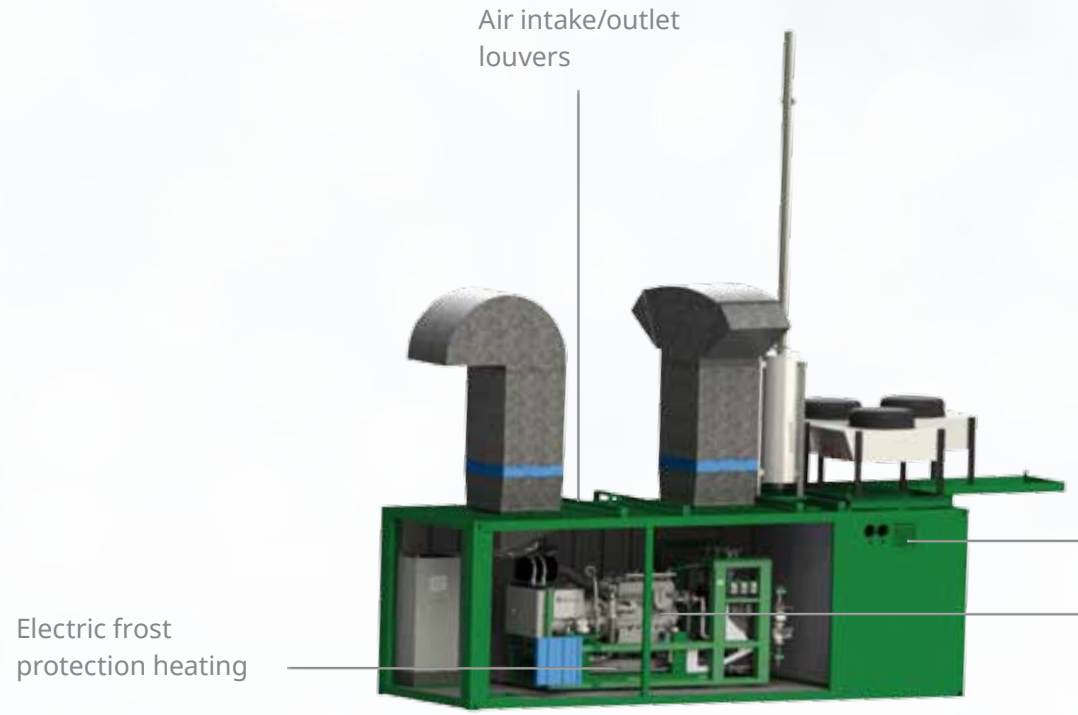
# Full output even in warm climates.

In Germany, there are only a few days each year that the temperature outside is above 40 °C. By contrast, countries in tropical climates have entirely different conditions. If it becomes too hot in the inside of the container, the electronics can be damaged. Consequences: The CHP automatically reduced its power or performs an emergency shut-down. Apart from any potentially damaged components, these two scenarios affect the efficiency of the CHP.

In order to prevent overheating of the 2G plant, 2G offers the following components with the warm country version:

- Switch cabinet with air conditioning system
- Combustion air cooling (so that no warm air enters the container interior)
- Larger mixture and emergency cooler (higher cooling capacity)

With these adaptations, as shown in the drawing to the left, full output can also be provided at high temperatures and an emergency shut-down can be prevented.




# Cold country version.

2G also delivers reliable technology for cold regions and offers power supply assurance even at very low temperatures.

# Optimal operation even with severe frost.

The 2G plant is operated optimally at a temperature of approx. 20 °C. This can even be achieved with outside temperatures that temporarily reach as low as approx. -10 °C, thanks to the thermal radiation released by the CHP.

However, if lower temperatures arise for an extended period, the cold country version of 2G is highly recommended for protection of the components.

The cold country version is designed for a temperature of -35 °C and includes the following components:

- Air intake and outlet louvers with servo motor so that no cold air can be drawn in
- Electric engine preheating in order to prevent a cold start of the engine, which would entail increased wear and additional maintenance work
- Electric frost protection heating for the container room
- Cover flaps on the ventilation in the oil room
- Auxiliary heating and insulation of the exhaust gas condensate line in order to protect the lines carrying fluids



# Individual country packages.

2G has already installed thousands of plants in more than 40 countries and is familiar with the local requirements on CHP technology.

# The right package for every country.

Every country has its own directives and legislation that are authoritative for CHP suppliers. In some cases, it is only necessary to install additional components and in other cases the CHP technology must be adapted. The 2G team can conform to the national conditions and meet the mandatory requirements.

2G has already created country-specific packages that fulfill all of the national requirements and include the following components:

**The UK package**

- Electric or pneumatic quick-action gas shut-off valve outside of the container
- Separate maintenance switch for all 230/400 V auxiliary drives
- G59/3 mains protection relay including G59/3 acceptance during commissioning
- Surrounding anti-fall protection on the container roof

**The French package**

- DEIE Box
- Ex-protected escape route lighting
- Interface for external mains monitoring, including external meter output
- 4-pole circuit breaker
- 3 or 4 pole generator switch, depending on mains type
- PE disconnecting links in the load cabinet
- Exhaust gas measuring opening in accordance with the standard NFX 44052

**The Italian package**

- MID-certified power meter
- Electric gas solenoid valve or shut-off valve
- Surrounding rail on the container roof with ladder
- Measuring ports according to Italian standard
- Mains monitoring ports according to Italian standard

**Additional local requirements**

- 50 Hz (standard) or 60 Hz (partially for Japan, Canada, USA)
- Snow and wind load zone (Snow and wind load zone 2 is standard; container statics for Zone 4 are also possible)
- Height installation
- Installation in coastal areas (air containing salt can accelerate wear of some components). There are a few options that can be implemented depending on the proximity of the coast. Container paint coating with increased anti-rust protection, air frames can be produced in stainless steel, special coating of the emergency and mixture cooler (vinyl coating of the cooler fins), and additional air filter.

2G CHP plant

Exhaust gas

Oxidation catalytic converter

Formaldehyde reduction: 20/40/60 mg/Nm³* and carbon monoxide 300 mg/Nm³* @ 5% $O_2$*

SCR catalytic converter

Nitrogen oxide reduction: 500 mg/Nm³* @ 5% $O_2$*

Post-combustion

Hydrocarbon reduction: 1000 mg/Nm* @ 5% $O_2$*

*current limit values of the German TA-Luft

# Exhaust gas post-treatment.

Like most technical combustion processes, small amounts of harmful substances are also created in the combined heat and CHP plant and must be reduced. Oxidation catalytic converters, SCR catalytic converters and post-combustion systems can assist the reduction of emissions and compliance with applicable regulations.

# Reduce harmful substances.

**Oxidation catalytic converters**

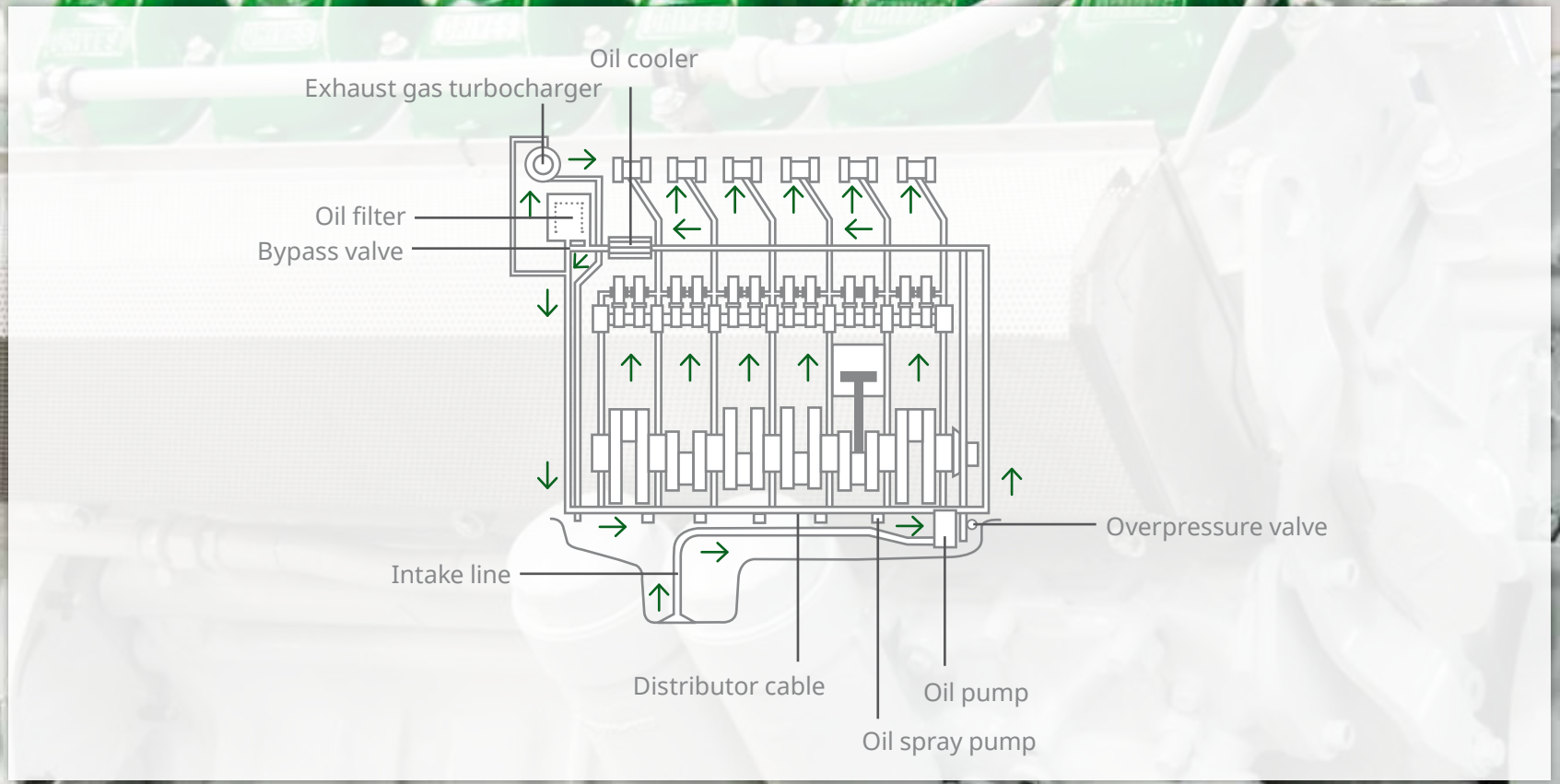
The oxidation catalytic converter installed in the exhaust tract of the 2G plant assures a reduction of carbon monoxide and formaldehyde emissions. A chemical reaction converts the undesired substances into inert components. The catalytic converters can be designed depending on the required target values so that applicable regulations can always be fulfilled.

**SCR catalytic converter**

For reduction of nitrogen oxide emissions, with certain requirements, the use of a so-called SCR catalytic converter is necessary, because limits are set within the engine and a simple oxidation catalytic converter cannot achieve the desired effect. With the "selective catalytic reaction", a urea mixture is added to the exhaust gas upstream from the catalytic converter. The nitrogen oxide is converted into harmless substances in the subsequent reaction. Therefore, the highest requirements on the exhaust gas quality can be fulfilled. Basically, a suitable combustion gas quality must be assured for the use of catalytic converters, particularly in lean gas operation. Therefore gas treatment is often necessary.

**Post-combustion system**

To a lesser extent, hydrocarbons contained in exhaust gas can be removed with the use of a post-combustion system. Depending on the version, these systems can be operated autothermically in stationary operation after the start-up phase so that no additional fuel is required.


# Variants of oil supply.

Oil is required in an engine for friction-free interaction of the moving parts and a fine seal of individual components. To protect the engine, it is important to use a high-quality oil. Periphery equipment that are well-matched simplify the entire CHP operation and extend the service life.

# Reduce expenses for oil changes and supply.

The engine oil is an important operating material for the 2G plant and must be replaced regularly. In order to reduce the related expenses, a good oil supply is necessary. 2G offers periphery that meets the requirements. The following possibilities can be realized:

**Lubrication oil supply consisting of:**

- 1 x 1000 l fresh and 1 x 1000 l used oil tank, double-walled with tank content indicator
- Used oil tank overfill protection device
- Lubricating oil pump

**Pump lance system comprising**

- 2 x 200 l drums
- Lubricating oil pump
- Oil collection trough

**Lubricating oil container**

- Dimensions: 3000 mm x 2500 mm x 2500 mm (WLH)
- Storage capacity 2 x 1000 l tanks
- 1000 l collection volume

**Automatic oil refilling unit**

In order to minimize the cost of oil supply, 2G offers the option of an automatic oil refilling unit. This system, including oil storage tank with sight glass for visual oil level control guarantees the optimal oil level in the engine over an extended time.

In the filius series the oil reserve tank is not installed on the frame; it is arranged externally.

**Automatic oil refilling unit**

In addition, an oil volume expansion can increase the volume of oil circulating in the engine system. The aim is to extend the oil change interval and save on expenses due to downtimes and to increase the operating time of the 2G plant.


# Operating materials and spare parts.

In order to guarantee efficient operation of a 2G plant, high quality spare parts and operating materials are required.
Based on extensive experience and an internal team of developers, 2G understands the requirements on the technology.

## Operating materials.

A 2G plant requires oil, cooling liquids for protection from frost and corrosion and water circulation for the heating circuit for smooth operation.

The 2G team of developers can demonstrate the interplay of mechanical components and operating materials on the basis of extensive experience. Some operating materials can be used to optimize service life and thus savings. In addition to the selection of suitable products, the mechanical components were also optimized so that oil consumption could be reduced. This includes the use of a top land ring with which the optimal pressure ratio at the piston ring is assured.

Oil analysis also takes place continuously to determine the right time to change the oil. The customer receives an oil sampling set and sends it to a laboratory specified by 2G where the results are sent quickly and reliably via email.

## Spare parts.

2G only uses original 2G spare parts or spare parts from renowned manufacturers. As a result, high quality, operational reliability and assured availability can be guaranteed.

Spare parts that are developed in-house include spark plugs, cylinder heads and air and oil filters. 2G grants a pro rata regulation for some components that provides for a proportional assumption of costs in case of wear before the planned maintenance interval.

In case of an overhaul or in case of damage, 2G offers the possibility of a replacement engine. This involves a freshly painted state of the art engine, including all attached components. The use of this engine can considerably reduce downtimes.


# Measurement instrumentation.

With the use of various meters, both the operator and the 2G control center have a continuous overview of the plant and can react to the slightest changes.

# Visualize meter statuses.

In order to register a 2G plant to the German Federal Office of Economics and Export Controls, various meter statuses must be recorded. This is important for the mains operator to know how much electricity has been fed into the public mains or how much natural gas was drawn. Some specifications that the 2G app can visualize are also important to the customer. Therefore, the plant proprietor always has the latest operating statuses of their plant on hand.

**Gas meter**

- Measurement of the amount of gas drawn
- With MID certification (is frequently desired by customs for energy tax reimbursement)
- Calibrated with calibrating report, specification in operating and standard cubic meters and M-bus readout (used in natural gas applications)
- Uncalibrated (use in biogas applications, not mandatory)

**Electric current meter**

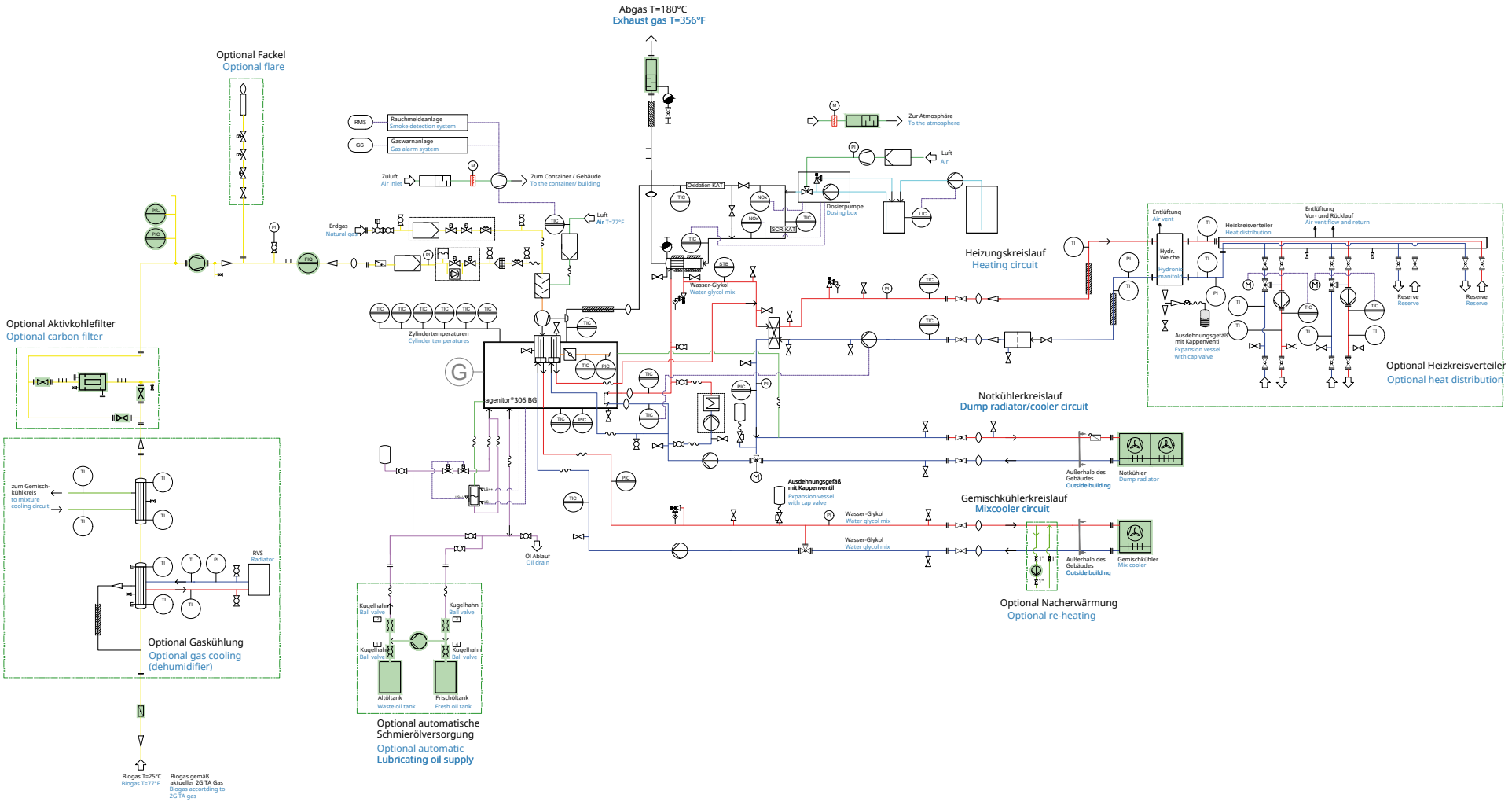
- Measurement of the amount of electricity fed into the mains
- If applicable, the energy supply company requires a registered output measurement with installation of their own current meter
- An electric current meter is provided by the energy supply company. In natural gas applications, additional electric current meters are normally installed (one meter for recording of the total output and another meter for the measurement of internal current consumption)

**Heat quantity meter**

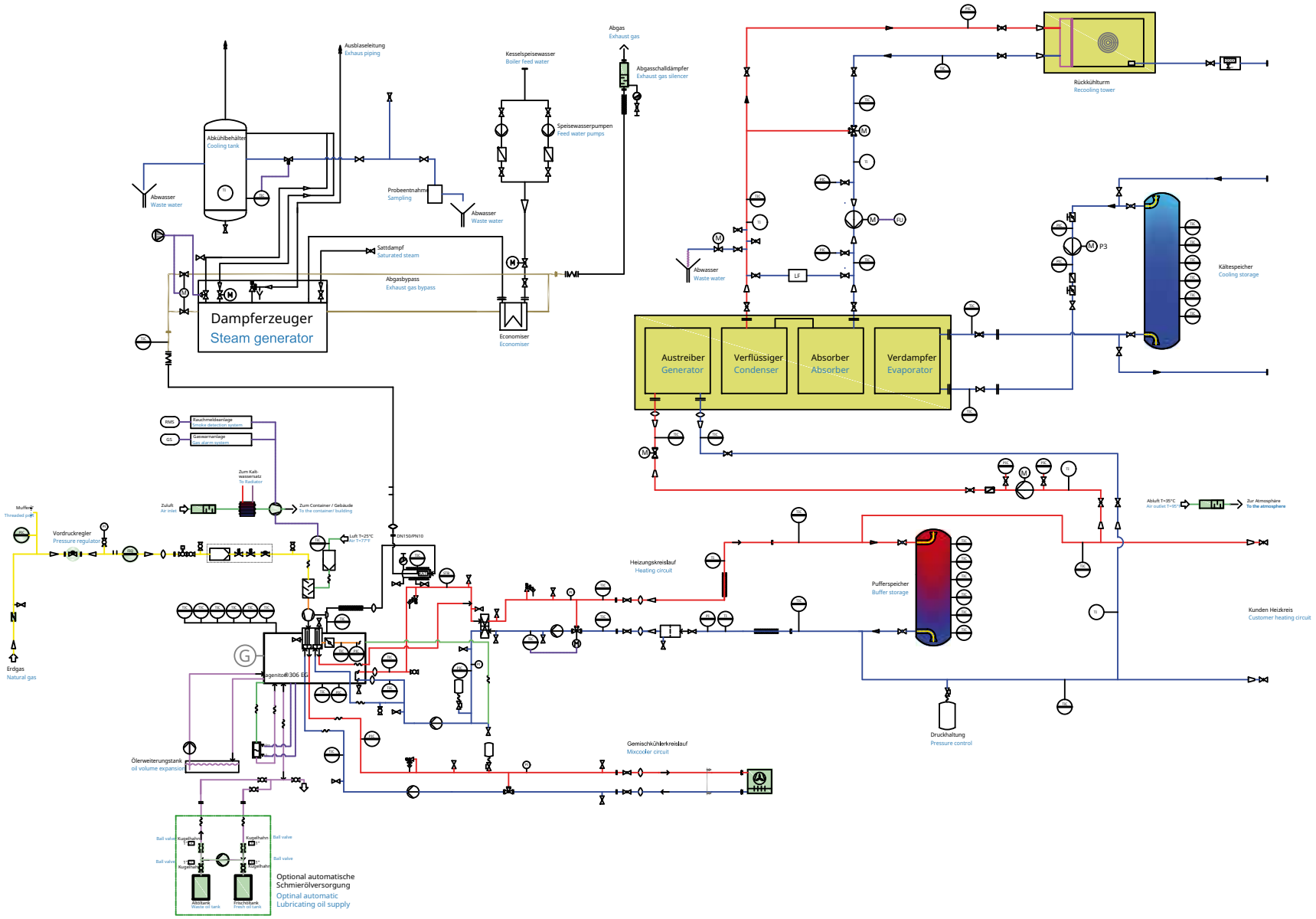
- Measurement of delivered heat (e.g. to a swimming pool or a hospital)

In addition to the meters mentioned above, sensors for the protection of persons can be installed. A gas warning system detects escaping gas and a $CO_2$ sensor measures the carbon monoxide concentration in the CHP plant room.


# Example of use: biogas application.



# Example of use: natural gas application.



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