

hotmodule
Fuel Cell



The future of **energy supply.**

Energy is the driving force in all areas of our modern world. And the demand is increasing. Today's challenge is to create a sustainable supply of energy.

Fuel cell technology is one of the most innovative and future-capable solutions to this challenge. With low emission levels unmatched by any competing technology, the system achieves very high energy efficiency.

As a leading manufacturer, CFC Solutions relies on biogas to fuel carbonate fuel cells (CFC) in localised energy systems as a source of environmentally friendly, CO₂-neutral electricity and thermal energy. These high-temperature fuel cell systems turn the vision of environmental friendly energy supply into reality using localised units with electrical capacities of 200 kW to 2 MW.

- Highly efficient
- Reliable
- Environmentally friendly
- Low maintenance
- Versatile
- Cogeneration
- Cogeneration + cooling

Strong brands under a single roof.



With its companies and brands – MTU, MTU Detroit Diesel, Katolight, MDE, CFC Solutions, L'Orange and Rotorion – the Tognum Group is a leading international producer of Diesel engines and complete drive systems for ships, heavy road and rail vehicles, industrial drives and localised power plants based on Diesel or gas engines and fuel cells.



The solution

Brilliantly simple. – Highly efficient. Simply brilliant.

Brilliant simplicity is the principle behind energy generation using fuel cells – the entire system is clean, reliable and highly efficient.

The HotModule converts the energy of the gas directly into electricity and heat without combustion or moving parts subject to wear, such as rotating turbine blades or moving pistons. Electrochemical processes not only make it possible to achieve very high efficiency, but also restrict emissions to an admirably low level. Pollutants such as nitrogen oxide and sulphur compounds are not generated. With the same amount of gas, up to 30 percent more electricity can be produced than with conventional power plants in the same size class. In addition, the exhaust of the HotModule consists exclusively of water vapour, nitrogen, and the residual oxygen content of the air.

Characteristics

Highly efficient

- Up to 90% over all utilisation
- Gross electrical efficiency of 50%

Environmentally friendly

- Low emissions
- SO₂ and NO_x not detectable
- Approx. 30% less CO₂ for each kWh of electricity

Fuel flexibility

- Natural gas
- Biogas
- Sewage gas
- Methanol

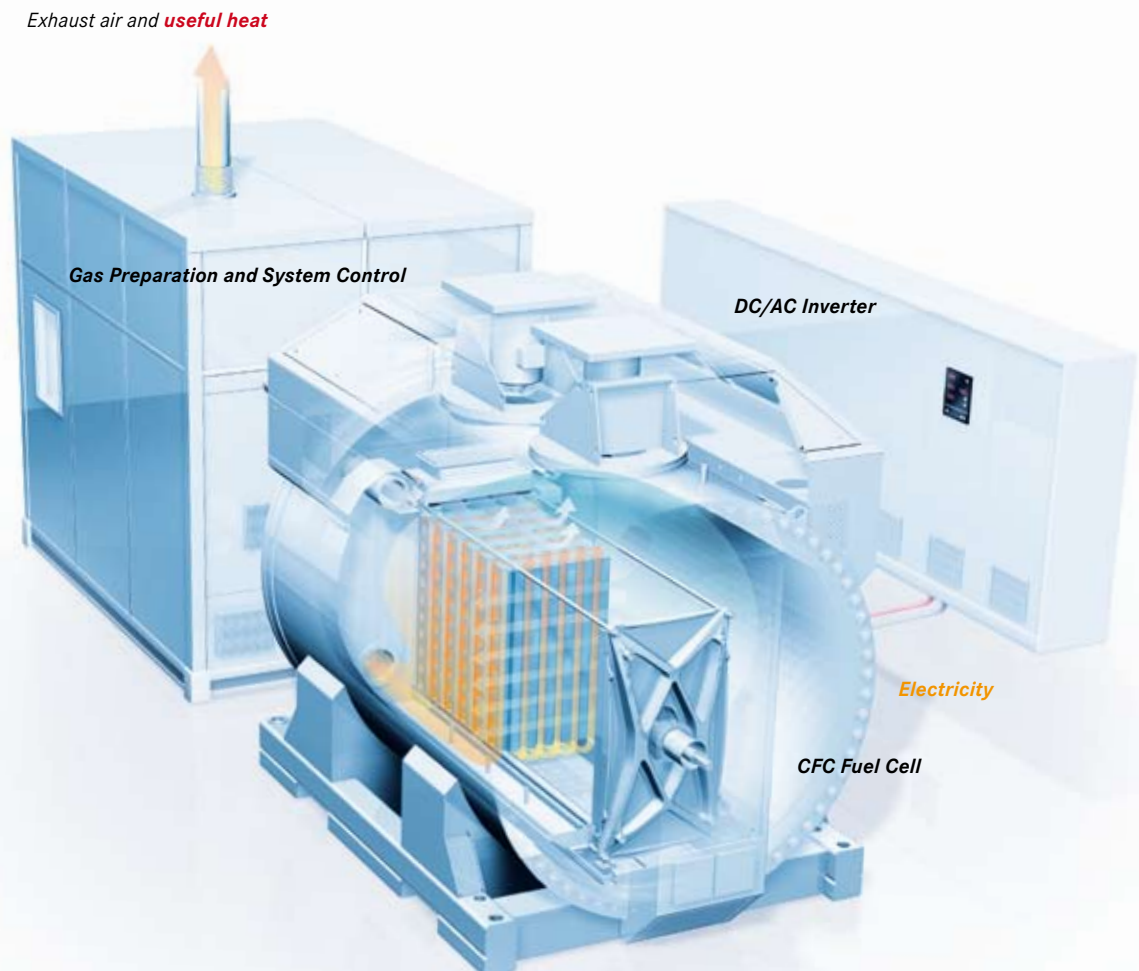
High-quality heat

- Temperature 400°C
- Variable cogeneration index

Low maintenance

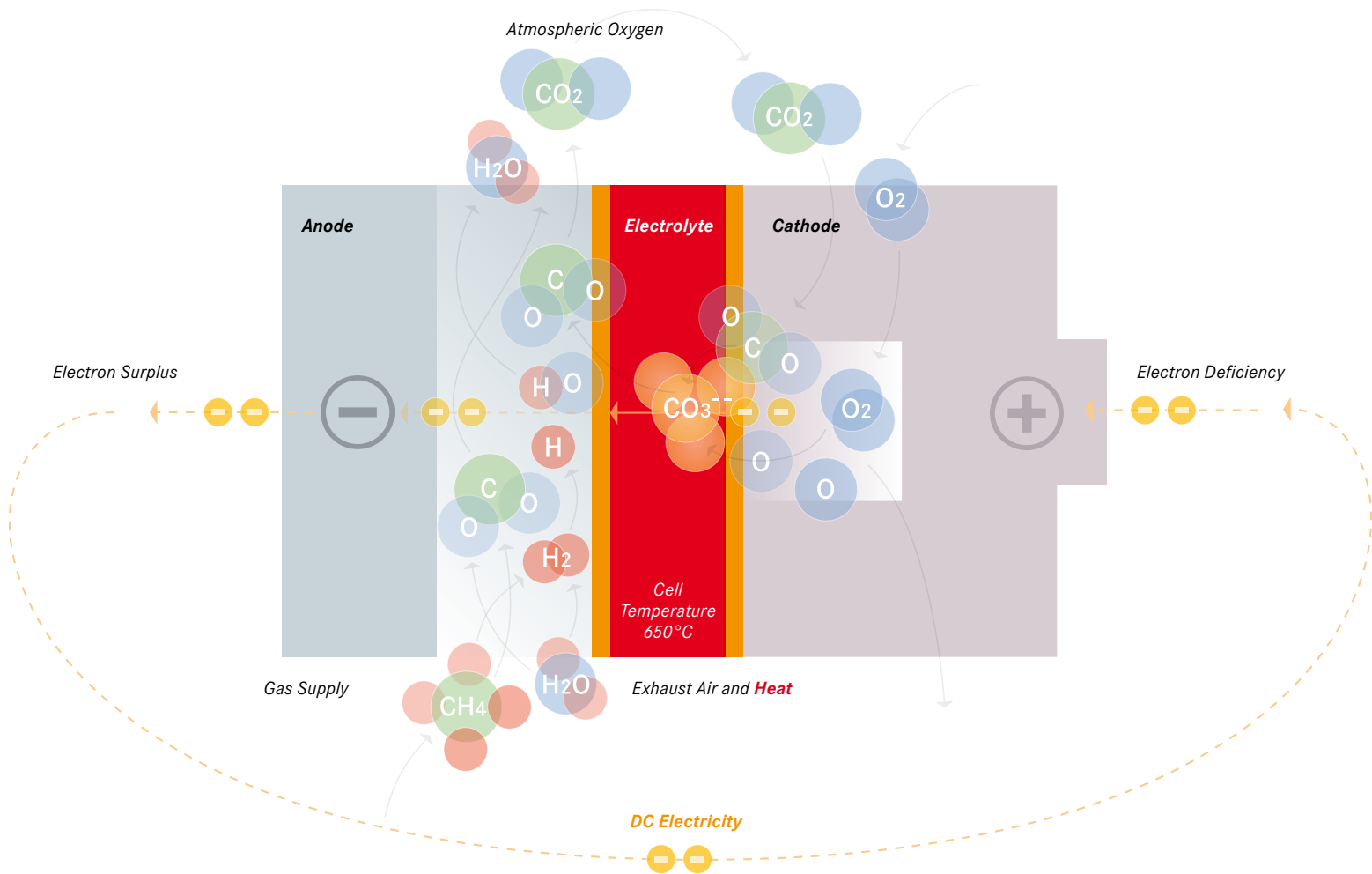
- Low maintenance costs
- No moving parts
- Nickel-based catalytic converter

The system





Efficiency is the outstanding property of the HotModule. All hot components have been integrated into a single common housing, which does more than just make peripheral components redundant. It also enables an efficiency level of 50 percent, which sets a new standard.



A glance at the how the carbonate fuel cell works clarifies its simple electrochemical operating principle.

The cell is built like a sandwich. It generates **electricity** and **heat** when **hydrogen** [H_2] is supplied to the **anode** and **oxygen** [O_2] is supplied to the **cathode**. An **electrolyte** composed of lithium carbonate and potassium carbonate is located between the two electrodes.

If the carbonate fuel cell is supplied with a carbohydrate fuel such as methane [CH_4] and water [H_2O], hydrogen [H_2] is released. The hydrogen [H_2] reacts with the carbonate ions [CO_3] of the **electrolyte** to form water [H_2O] and carbon dioxide [CO_2].

► This reaction releases **electrons** [--].

The carbon dioxide [CO_2] is fed to the **cathode** along with atmospheric oxygen [O_2]. New carbonate ions [CO_3] are constantly formed at the cathode with the consumption of **electrons** [--].

► This process also releases **heat**.

The carbonate ions migrate through the **electrolyte** to the **anode**. This completes the **electrical circuit**.





The modular system of a complete fuel cell power plant consists of only three components, which incorporate all the functions of the system.

1. Upstream gas preparation unit: the gas for the fuel cell is prepared here. It is desulphurised, heated and moistened.
2. Core fuel cell module: comprises the fuel cell stack, a mixing chamber for fresh air, anode gas and cathode air, a collection hood for the cathode exhaust, two recirculating fans, and a radiator to bring the system up to operating temperature.
3. Control and inverter module: the system control functions are located here, and the direct-current electricity from the fuel cell is converted to alternating-current electricity.

Intelligent energy supply

Electricity

- High efficiency
- High quality
- Noise-free and reliable
- Localised
- Environmentally friendly

Steam

- High temperature
- For process heat
- For sterilisation
- For heating

Hot air

- High temperature
- Low pollutant level
- For heating
- For drying

Cold

- For chilling using an absorption refrigeration unit
- High cold utilisation
- Constant cold production, independent of the mains power grid

The principle

With the power of the fuel cell.

The result: up to 50 percent more electricity relative to conventional power plants, with supplementary useful heat and extremely low emission levels.

The HotModule occupies a special position in the market for fuel cells. To date, hardly any other fuel cell has managed to prove its worth in as many different applications as this system from CFC Solutions GmbH in Ottobrunn, Germany.



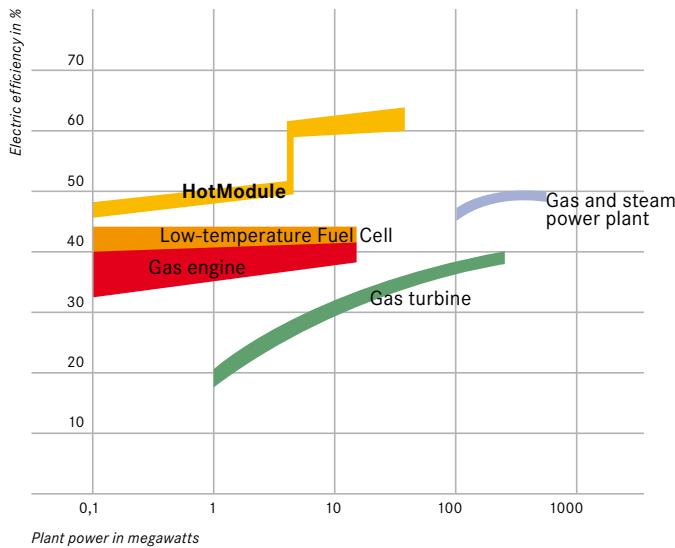
Type of energy source used:

Conventional energy sources:

- Natural gas
- Methanol

Renewable energy sources:

- Biogas
- Sewage gas
- Mine gas
- Synthetic gas



The HotModule can be used almost anywhere. The system independently generates the necessary hydrogen from a wide variety of fuels, which means that it can be integrated into practically every existing infrastructure.

Unprecedented high efficiency. If desired, the net efficiency can be increased even further by using a downstream turbine for conversion of the thermal energy.

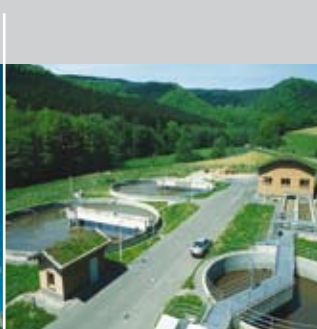
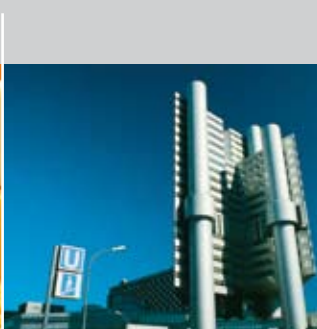
The result



Application areas

Clean, high-efficiency energy supply at the point of consumption





Especially environmentally friendly with **biogas**.

Using biogenic fuels to achieve new performance records.



Fossil fuels have been used intensively in the last 200 years. However, these resources are limited. The HotModule fuel cell technology provides an innovative approach here, since the HotModule converts renewable energy sources into useful energy and does so with high efficiency. In addition to natural gas, it can operate on biogenic gases such as gas from biomass, sewage gas, mine gas and synthetic gas. The only product is exhaust air. There is no emission of nitrogen oxides or sulphur oxides. There is no exhaust gas, but instead only exhaust air at a temperature of approximately 400°C.

- **Environmentally friendly**
30% less carbon dioxide
- **Low noise**
No noise isolation necessary
- **Highly efficient**
Electrical efficiency as high as 50%

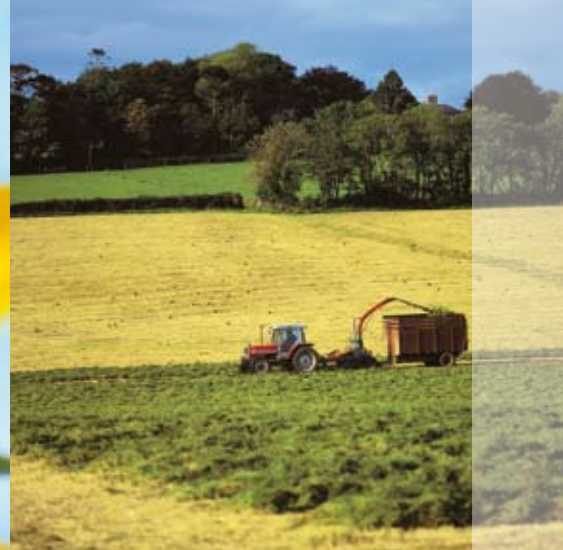
The HotModule: a clean solution in every respect.



Leonberg Digestion Plant

The world's first biogas-fuelled HotModule has been operating with biogas from a digestion plant near Leonberg since the fall of 2006. The fuel is generated by fermenting potato peels and garden waste, vegetable waste and food residues – everything that the 375,000 inhabitants of the Böblingen district toss into their compostable waste bins. The generated electricity is fed into the public electricity grid and is paid for at the EEG rate, while the thermal energy heats the fermentation tower and dries the fermentation residues.

- Highly efficient
- Environmentally friendly
- Simple operating principle
- Reliable
- Quiet
- Low maintenance
- Flexible in use



Compensation	Ct/kWh _{el}
Basic compensation	
$P_{el} \leq 150 \text{ kW}$	10,99
$150 \text{ kW} < P_{el} \leq 500 \text{ kW}$	9,46
$500 \text{ kW} < P_{el} \leq 5 \text{ MW}$	8,51
$5 \text{ MW} < P_{el} \leq 20 \text{ MW}$	8,03
Regenerable raw materials bonus	
$P_{el} \leq 500 \text{ kW}$	6,00
$500 \text{ kW} < P_{el} \leq 5 \text{ MW}$	4,00
Cogeneration bonus	2,00
Technology bonus	2,00
Maximum compensation	20,99

The rate of compensation is fixed for 20 years plus the year in which the system is put into service.

Sample case

A food processing plant with a large demand for energy in the form of electricity, heat and/or cold operates a fuel cell. The fuel cell generates 2 million kWh of electricity and 1.6 million kWh of heat (in the form of hot water) each year. To produce this amount of energy, the company utilises its own biogas from its water treatment plant and from waste substances. The rate of biogas production is approximately 2,400 m³ per day. The company feeds the produced electricity into the public electricity grid at a fixed compensation rate of approximately 14 cents for every 2 million kWh. The returns from electricity infeed are approximately 280.000 euros.

By using residual heat from the fuel cell, the company realises annual cost savings for heating in the amount of 64.000 euros. Taking into account operating and maintenance costs, the investment can be amortised within a few years.

Uninterruptible electrical supply.

**A reliable source of electricity,
heat and cold that pays off.**

The fuel cell is a constant source of energy. In the event of a mains failure, the fuel cell automatically switches over from operation in parallel with the mains to independent, stand-alone operation. It reliably supplies electricity, heat and cold to sensitive electronic loads.

Operators with an especially strong demand for quality electricity and dropout reliability, such as computer centres and the telecommunication and It industries are already relying on CFC fuel cell technology in order to generate a reliable supply of electricity and cooling.

- **A constant source of electricity and cold**
The mains grid can serve as a back-up system
- **Uninterruptible electrical supply**
Extremely high availability
- **DC electricity**
Extremely high-quality electricity

The HotModule is the talk of the town.



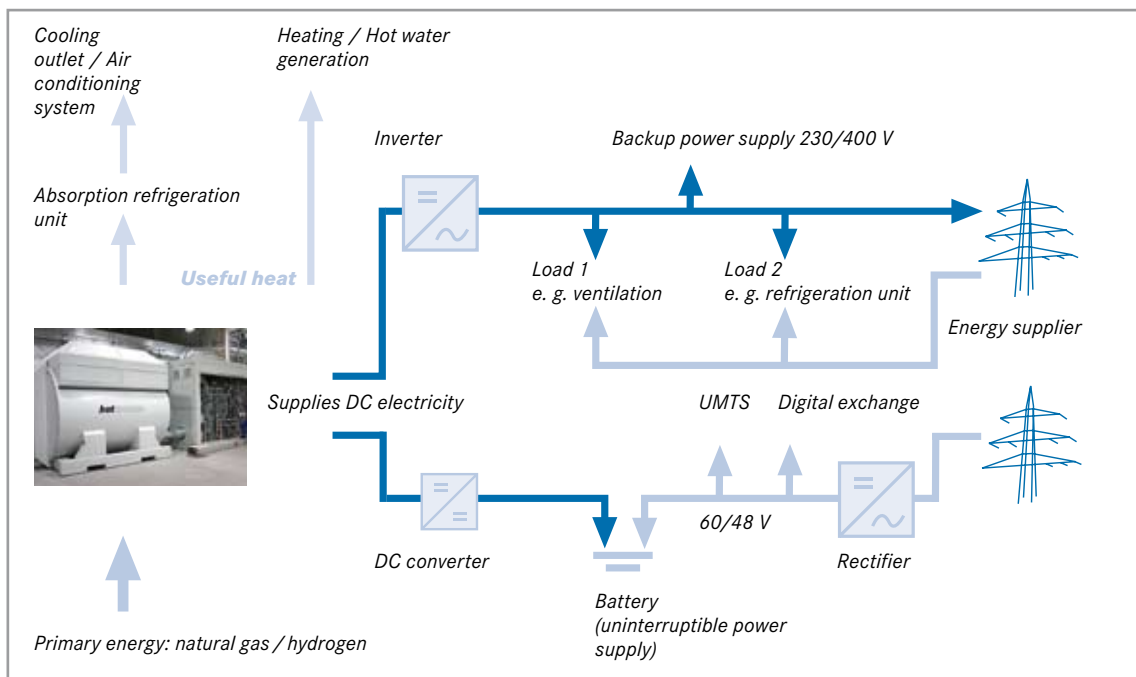
DeTeImmobilien in Munich

In October 2002, a HotModule was installed in the premises of DeTeImmobilien (Deutsche Telekom Immobilien und Service GmbH), located in the centre of Munich. The system supplies premium power. The thermal energy is used to power an absorption refrigeration unit for air conditioning of the office building. The electrical energy is flexibly available in the form of DC and AC power. Due to the cleanliness of the exhaust air, the building and operating licences for using the HotModule in an urban-core environment were obtained easily and quickly.



- Highly efficient
- Environmentally friendly
- Simple operating principle
- Reliable
- Quiet
- Low maintenance
- Flexible in use

Integrating the fuel cell into the infrastructure of the telecommunication industry



The HotModule is a reliable source of **electricity and heat**.

And that's exactly what matters in a hospital.

Ensuring reliable provision of electricity and heat where they are needed is one of today's most important tasks. The optimum solution is localised energy generation. Customers can generate electricity and heat on their own and use them directly on site – all without transmission and distribution losses.

- **High availability**
Uninterrupted, continuous operation
- **High-quality useful heat**
Hot exhaust air at 400 °C
- **Low emissions**
No pollutants and low noise level

The HotModule: clinically tested – and found to be optimal.



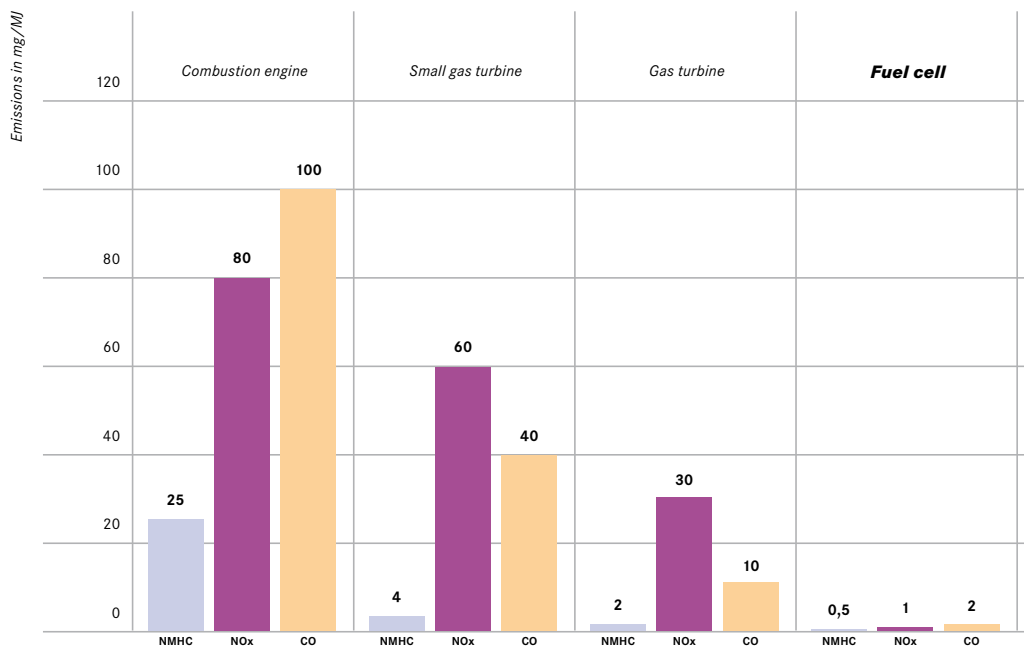
Central Hospital, Bad Berka

Successful operation of a HotModule in the Rhön Hospital in Bad Neustadt lay behind the decision by Rhön Klinikum AG in 2003 to also use a HotModule in its Central Hospital in Bad Berka. The HotModule fuel cell supplies the hospital with electricity, heat and cold. Using the absorption refrigeration unit installed there, hot and cold water can be produced flexibly according to demand.

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- Simple operating principle
- Reliable
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Relative emission values



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