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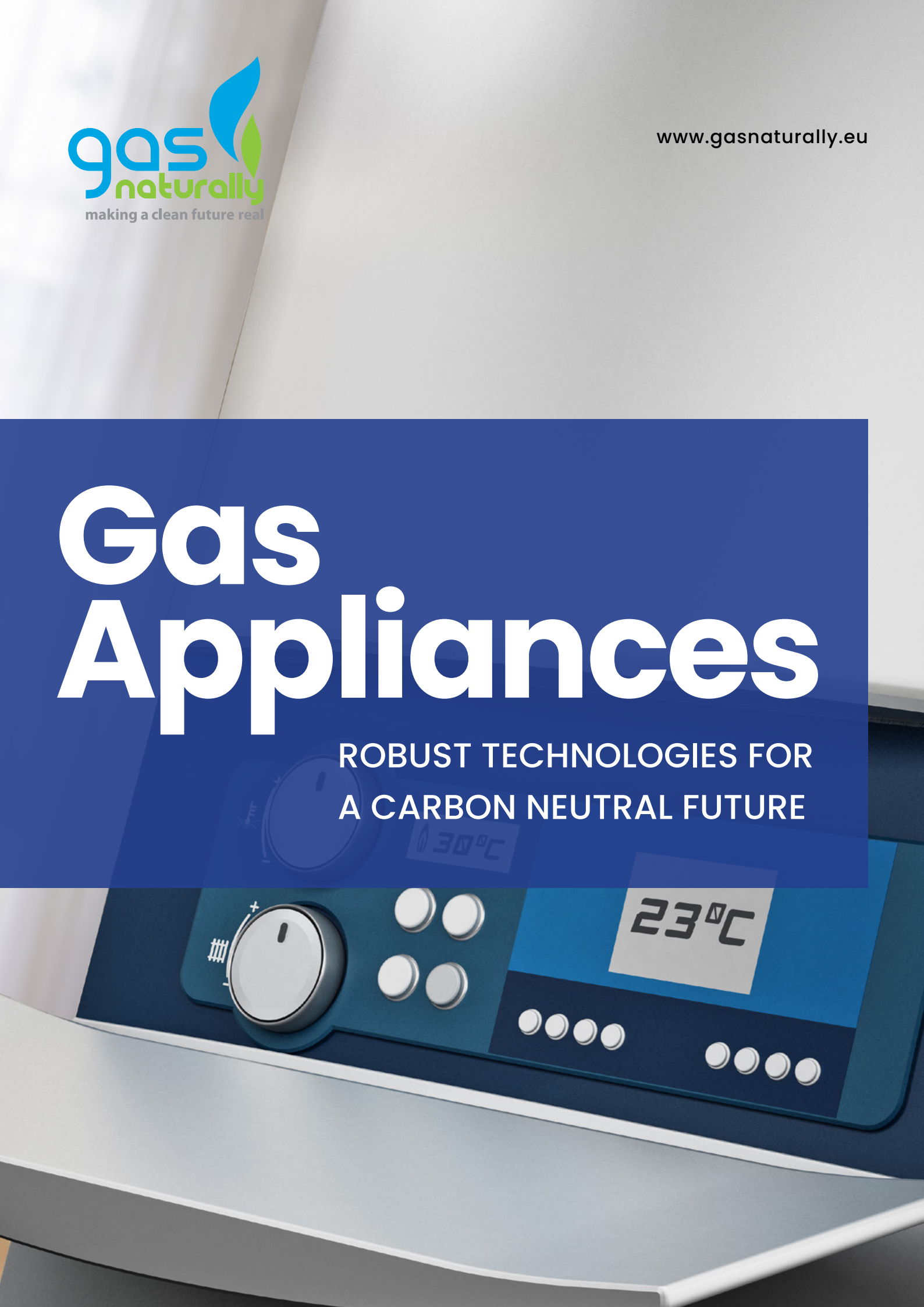
Gas Appliances

ROBUST TECHNOLOGIES FOR A CARBON NEUTRAL FUTURE



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Scenarios and priorities for gas appliances

A balanced energy mix to achieve the 2050 EU climate and energy priorities

A balanced energy mix is key to achieving the EU climate objectives – including net-zero greenhouse (GHG) emissions in 2050 – in a resilient, efficient and affordable way. Renewable and decarbonised gas – biomethane and hydrogen from power-to-gas, pyrolysis and steam methane reforming with carbon capture and storage – will be all present in increasing amounts in the energy system towards 2050. As each energy source has intrinsic advantages and challenges, the overarching need is to combine and optimise available sources in ways that meet the different energy demands of each country, city, district and building. With a focus on the evolving role of gas, this brochure explores scenarios for technology and market development in residential, commercial and industrial sectors.

The Advantages of Gas

- Flexible and immediately available
- Competitive and cost-effective
- Able to balance intermittent renewables
- Least carbon-intensive of the hydrocarbons
- Benefits from developed, reliable networks with high storage capacity and simple, efficient technologies
- Is becoming increasingly renewable, low-carbon and decarbonised

Three pillars underpin achievement of the EU objectives: improved energy efficiency, integration of renewables and smart control of energy systems for an optimal use of local resources.

Energy efficiency

Boosting energy efficiency across the entire energy value chain - generation, transmission, distribution and consumption - offers tremendous potential for reducing both energy demand and associated emissions, with key actions including:

- using highly efficient energy and heat generation systems
- mainstreaming high-quality building renovation
- construction of high-efficiency new buildings
- adopting eco-friendly gestures.

Renewable and decarbonised gas

The use of renewable and decarbonised gas - through gas infrastructure can save society €217 billion annually across the energy system by 2050, according to Gas For Climate study (2019). To support overarching EU goals, each country should develop its own production sector according to the availability of resources and the structure of its own national market. This will contribute to maintaining the security of supply by producing renewable, storable and transportable energy. Adapting gas appliances to these new gases will be key to successfully transitioning to a lower carbon energy system.

Smart energy systems

The current gas distribution model will evolve towards increased decentralisation and a circular economy:

- biomethane and other renewable gases will be produced closer to consumption points and integrated with digitalized systems, delivering potential to boost local economies.
- networks will be increasingly developed at a local and national level to maximise the potential of each energy medium and optimise energy consumption and production
- smart gas grids and local energy communities will empower final users in a new paradigm in which citizens will choose the best energy mix to use, according to the locally available natural resources.

Global System Management

Across all sectors, efficient heating systems are key to maximising the benefits of gas appliances. This implies optimizing three interrelated aspects:

- **Heat distribution** throughout the building, using pipes, valves, pumps and control technology that ensure an even flow of heat and a hydraulic balance that maximises uses while reducing fuel and electricity consumption.
- **Heat storage** systems that help reduce energy demand and facilitate integration of renewable energies. Several system-specific storage technologies already exist such as heated storage tanks and unvented cylinders.
- **Intelligent controls and communications** to maximise energy use and efficiency while facilitating integration of renewable energies by system operators and direct management of consumption in relation to actual needs by users.

Residential

In the residential sector, highly efficient, new products will progressively be added to existing boiler units, with hybrids playing an important intermediary role.

Commercial

In the commercial sector, gas condensing boilers and mini-CHP are likely to dominate initially; subsequently, gas heat pumps are likely to progressively penetrate the market.

Industrial

Key priorities for the industrial sector include the decarbonisation of gas, decentralisation of steam production, uptake of waste heat recovery and development of innovative burners.

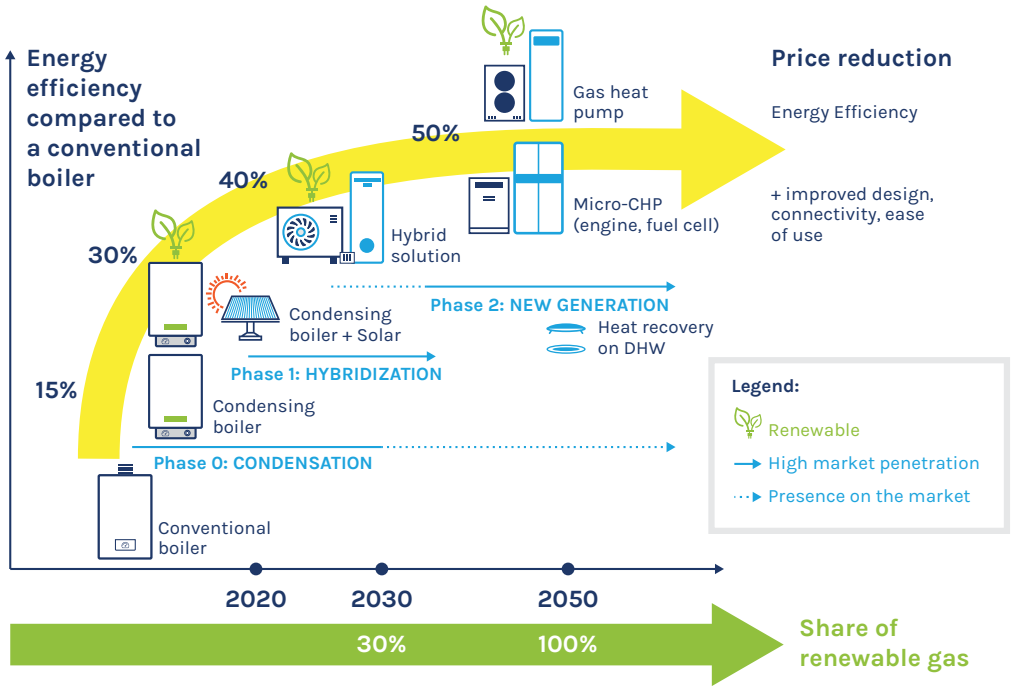
THE RESIDENTIAL SECTOR

By 2050 two phases of market development for gas appliances in the residential sector can be expected:

Phase I will see the uptake of gas-fired condensing boilers in existing housing to replace old inefficient gas and oil boilers. This lever can be easily and rapidly activated by increasing number of household connected to gas grid to accelerate the EU decarbonisation agenda and will require the development of innovative, efficient and low-carbon technologies. Initially, the focus will be on promoting hybridisation. Next, the focus will be on growing the market for gas-fired condensing boilers in combination with solar thermal and PV.

Phase II will be characterised by a new generation of high-efficiency gas appliances such as gas heat pumps and micro-CHP with fuel cells. These appliances could progressively overtake hybrids if the sector, including manufacturers, installers and maintainers, becomes sufficiently mature and costs decline.

Gas appliance roadmap



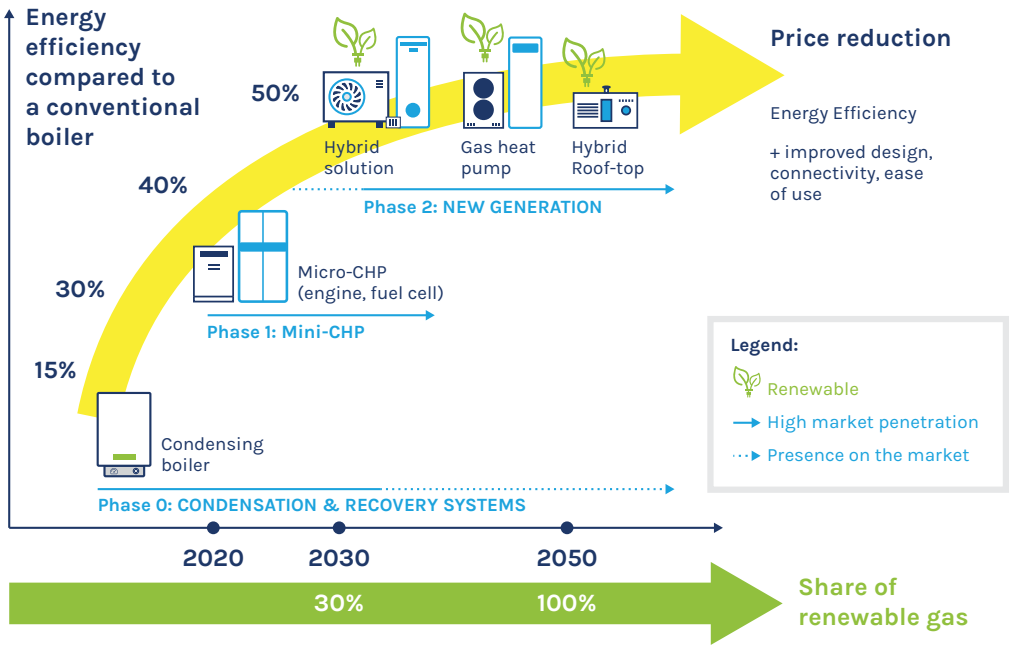
THE COMMERCIAL SECTOR

Commercial sector, as compared to residential, presents important needs for cooling as well as electricity for lighting, air conditioning and ventilation. These sectors are more prone to innovation. Again, two phases are anticipated in the 2050-timeframe.

Phase I will leverage broader roll-out of mature, well-established solutions. The condensing boiler will remain the key solution for all commercial markets, as it provides efficient heat and in-house hot water at a reasonable cost and with reduced CO2 emissions. The mini-CHP, with its broad range of products, is also well positioned in this phase, especially in sectors that have relatively stable heat needs but are sensitive to electricity prices and quality of supply. Waste heat recovery systems are also very relevant for sub-sectors that have important in-house hot water consumption, such as hotels, health facilities or catering.

Phase II will see gas heat pumps progressively replacing condensing boilers as the reference solution, with costs declining as the market becomes structured. By increasing efficiency – by up to 50% compared with conventional boilers – and offering full compatibility with renewable, low-carbon and decarbonised gas, uptake of gas heat pumps will greatly contribute to decarbonise the heating and cooling sector in Europe. With reversible versions, gas heat pumps could help meet cooling needs, particularly when integrated into expected innovations such as hybrid rooftop units that combine gas solutions with solar PV systems.

Gas appliance roadmap



THE INDUSTRIAL SECTOR

The high capacity needed in industry combined with the relatively low cost of access makes gas particularly suitable to produce steam for efficient appliances such as boilers and equipment - including economisers and condensers - heat pumps, condensation, improved burners, ovens and CHP.

All of these solutions are mature and can be used across a broad range of industries. To date, disruptive innovation is rare in the industrial sector; rather, **appliances evolve in an incremental way,** with technical advances steadily increasing their efficiency and environmental performance. Given the context of fierce international competition and the reality that appliances have long lifespans, efficiency is the top priority – one that can be met with gas technologies.

Switching to green gases and decarbonised gases (such as biomethane and hydrogen) and **application of hybrid solutions** (e.g. gas-PV installations) can contribute to decarbonisation of industry. If combined with development and deployment of high-efficiency burners, decentralisation of steam production for hot water and the use of waste heat recovery whenever possible, gas can help achieve a high level of energy efficiency while significantly reducing air pollution.

Mature Technologies, Hybridisation and Improvement

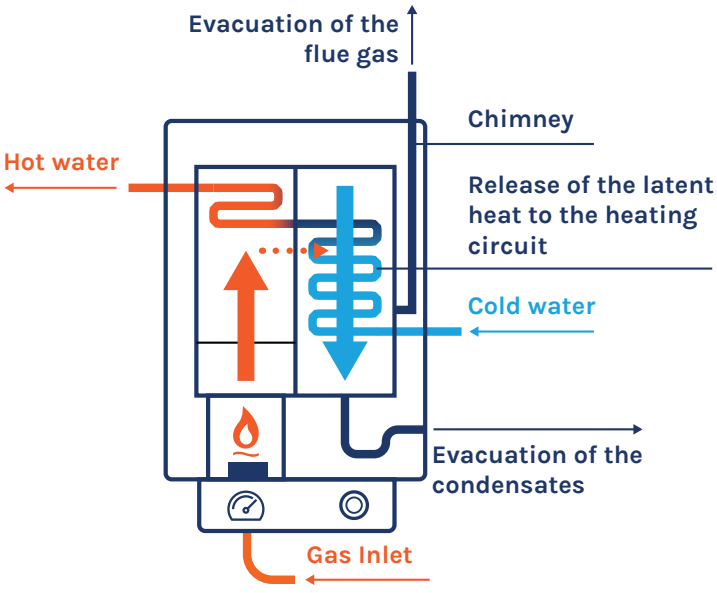
CONDENSING BOILER

Gas condensing technology is highly convenient as well as resource- and cost-efficient for heat generation. A condensing boiler can be coupled with one or more solutions.

residential use

commercial use

maturity level +++



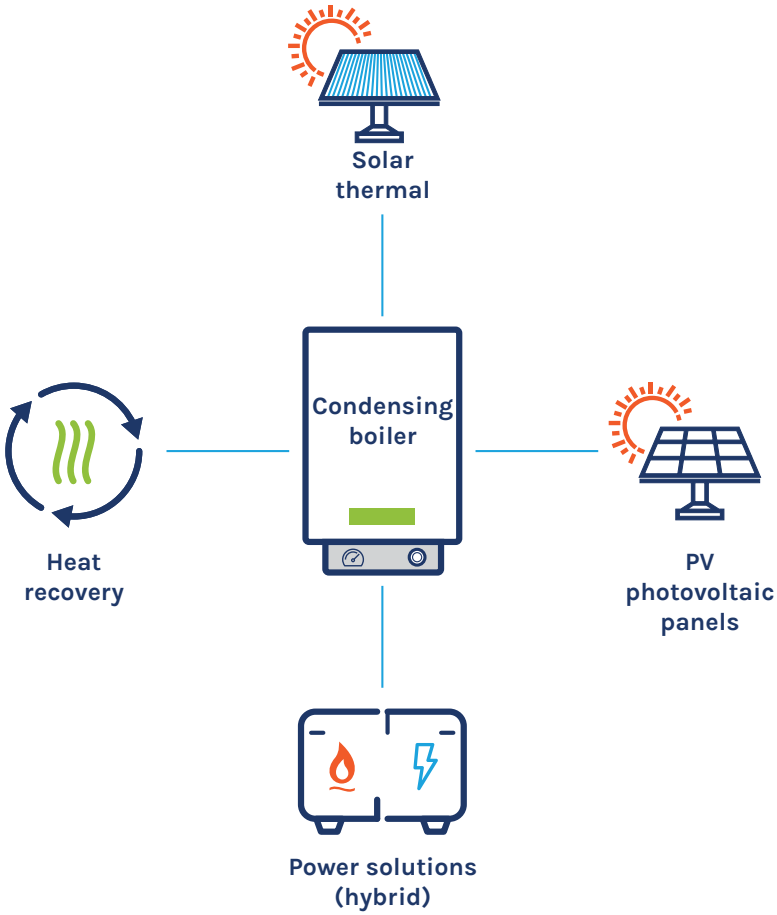
Schematic illustration of a gas condensing boiler

How does it work?

These boilers increase system efficiency by condensing the water vapour produced in combustion processes back into liquid form. The resulting latent heat can then be used to pre-heat cold water entering the boiler.

What are the benefits?

- Energy savings up to 30% compared with older boilers
- Increased overall energy efficiency and reliability
- Competitive prices
- Easy installation and maintenance
- Simple, reliable and continuously improving technology
- Little retrofitting work required to run on renewable and decarbonised gas



A condensing boiler can be coupled with one of more solutions

How does it work?

Condensing boiler + solar thermal

The integration of solar energy helps to produce hot water and provide space heating in a more sustainable way.

Condensing boiler + PV

Condensing boiler provides energy for heating and domestic hot water while solar photovoltaic (PV) panels generate renewable electricity to supply household appliances, lighting etc.

Condensing boiler + heat recovery from domestic hot water (DHW)

This option offers the possibility to recover heat from wastewater sourced from diverse domestic uses and apply it to additional domestic hot water production.

What are the benefits?

Condensing boiler + solar thermal

- Energy savings of 10% to 30%, depending on insulation levels of the building
- Savings on electricity bills
- Local production of renewable electricity
- Reduction of CO_2 emissions

Condensing boiler + PV

- Local production of renewable electricity
- Savings on electricity bills

Condensing boiler + heat recovery from domestic hot water (DHW)

- Energy savings
- Reduction of CO_2 emissions

HYBRID SOLUTIONS

residential use

commercial use

maturity level ++

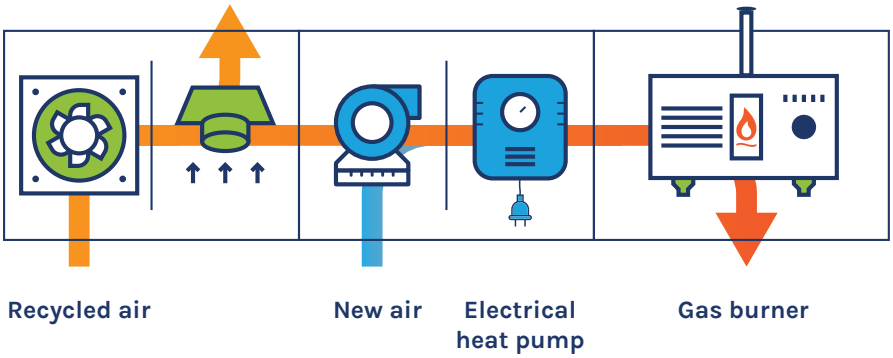


Illustration of the hybrid rooftop unit

How does it work?

Example: Hybrid rooftop unit - Condensing boiler coupled with an electrical heat pump

The term 'hybrid solution' refers to a single appliance or a system of appliances that combines at least two different energy sources – one of which is renewable – and having its operation managed by a single control system.

What are the benefits?

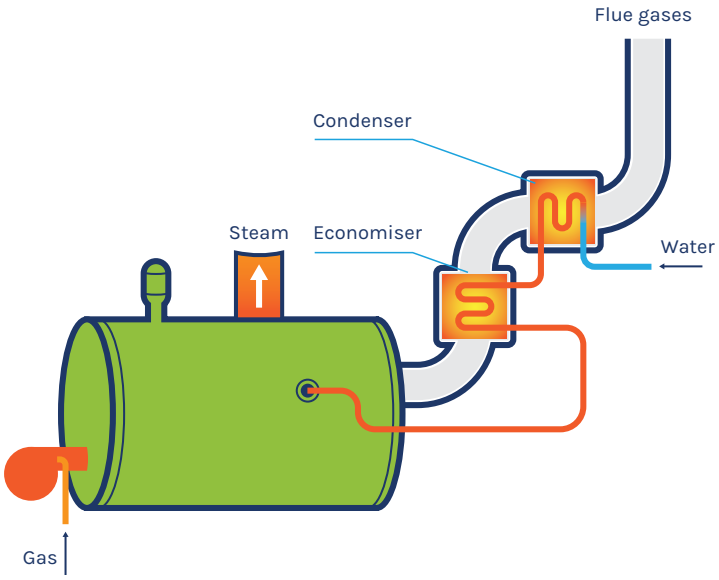
The idea behind hybrid solutions is to optimise the characteristics of each energy source to increase the overall system efficiency. This reduces primary energy consumption, thus lowering energy bills. A condensing boiler coupled with an electrical heat pump:

- Saves up to 15% of primary energy compared with a simple heat pump.
- Ensures security of supply and avoids peak consumption.

INDUSTRIAL STANDARD BOILER

industrial use

maturity level



Schematic illustration of a couple economiser/condenser installed on a steam boiler (preheat of boiler feed water mode)

How does it work?

For steam production, three main types of standard boilers exist, all of which are mature and efficient technologies.

- **Fire-tube boilers** are composed of a gas burner and a cylindrical tank filled with water, which is crossed by several tubes.
- **Water-tube boilers** have a gas burner that produces a flame in a large combustion chamber; several tubes filled with water cover the boiler's inner wall and cross the combustion chamber vertically.
- **Instant steam boilers** have a gas burner and a coil in which water circulates in the opposite direction compared to the flue gases the burner produces.

What are the benefits?

- Mature, efficient, cost-effective solutions
- Low maintenance

What are possible improvements?

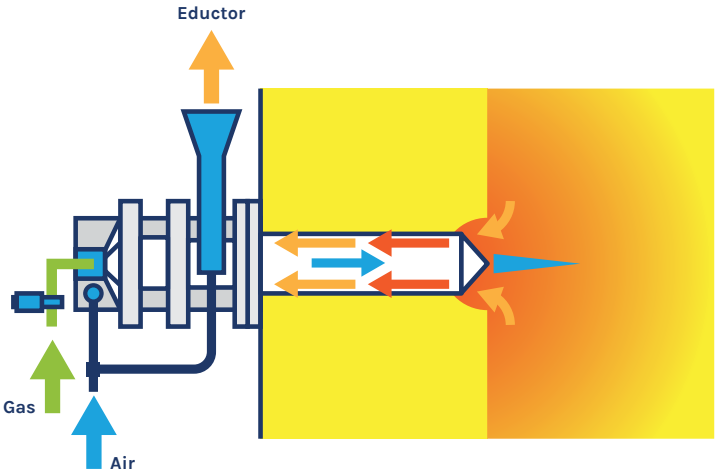
Given the long lifespan of gas appliances in industry compared with other sectors, it is possible to improve efficiency by adding diverse equipment to an existing installation:

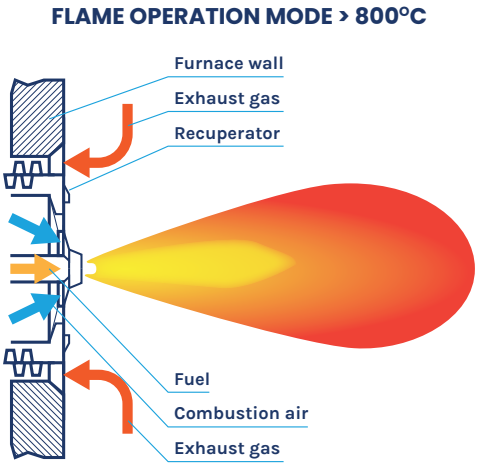
- **Economisers** are a type of heat exchanger, usually installed between the boiler and the chimney, that preheats the boiler feedwater.
- **Condenser** is a heat exchanger installed at the boiler exhaust and behind an economiser, which cools the flue gases below the condensation temperature of the water that the gases contain. The resulting heat is exchanged in addition to the heat of the gas, to preheat the boiler feed water or to produce hot water for a process.
- **Modulating burners + oxigen (O_2) probes:** to enhance the efficiency of combustion, these burners can modulate both power and O_2 levels.

PROCESS EFFICIENCY SOLUTIONS

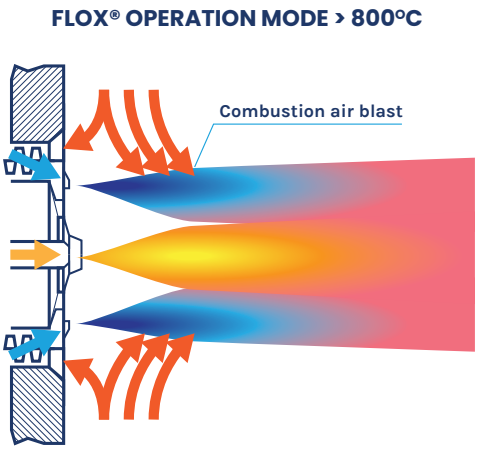
industrial use

maturity level





Illustrations of a self-recovery burner



How does it work?

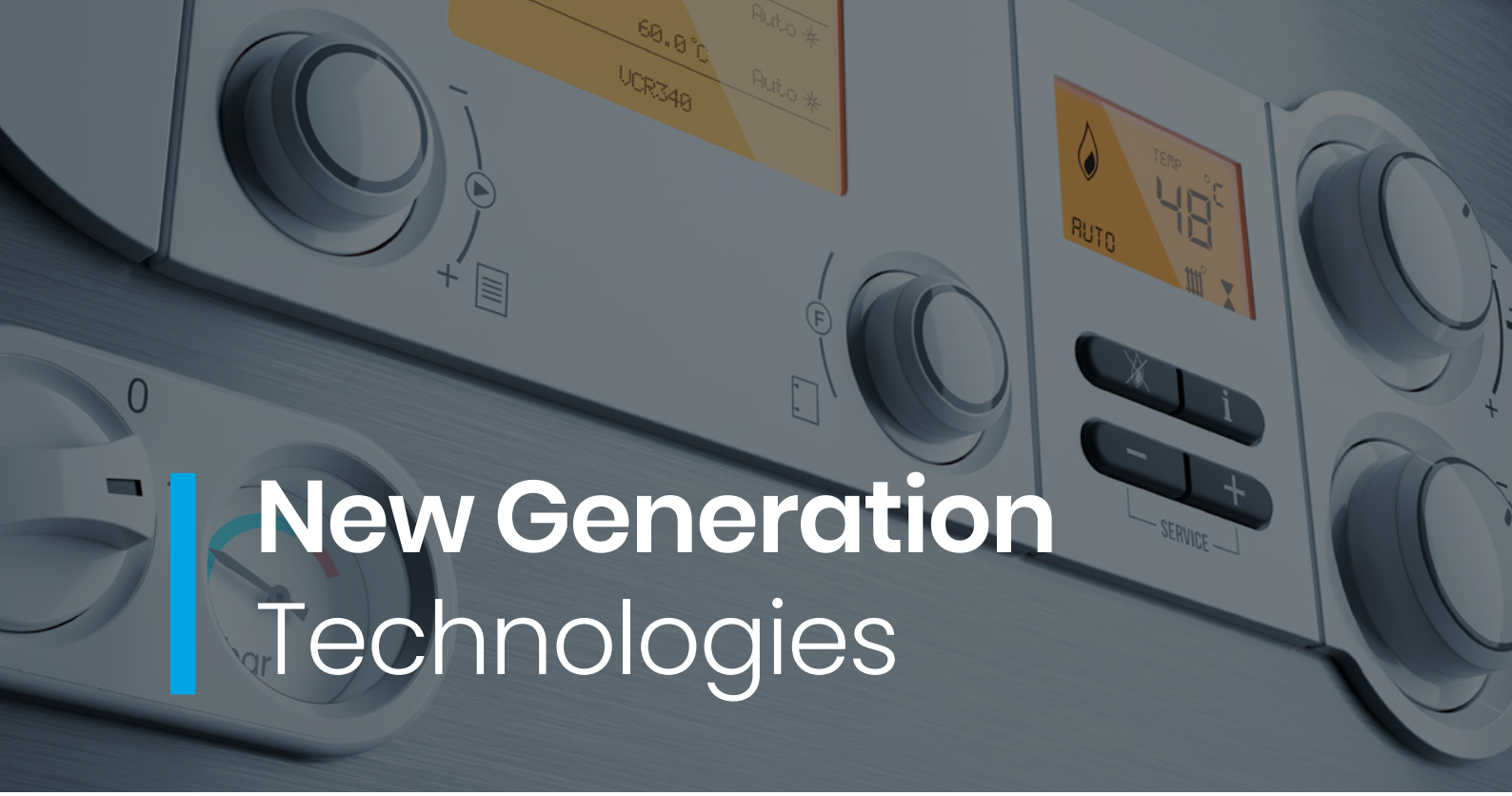
Regenerative burners work in pairs, each acting alternatively as a burner and a chimney. One burner begins the combustion, producing flue gases that cross a refractory material and release the heat generated to this material. The roles are then reversed: the combustion air, which is in contact with the refractory material, warms up.

Self-recovery burners have a metallic or ceramic tube that is open at the exhaust as a combustion chamber. The combustion air enters close to the flue gases, exchanging heat. To increase the exchange surface with incoming air, the burner is equipped with a recirculating system for the flue gases. Energy savings range between 50% and 70% with these systems.

Flameless oxidation burners designate a separate injection system of combustion air and combustible gas at high speed and temperature. The specific geometries of the burner and the combustion chamber prompt recirculation of combustion products towards the burner, diluting them with the combustion air and the combustible.

What are the benefits?

- Mature technologies
- Important primary energy savings
- Very low NO_x emissions
- Suitable for a broad range of high temperature processes



New Generation Technologies

COMBINED HEAT AND POWER SYSTEMS (CHP)

residential use

commercial use

industrial use

maturity level

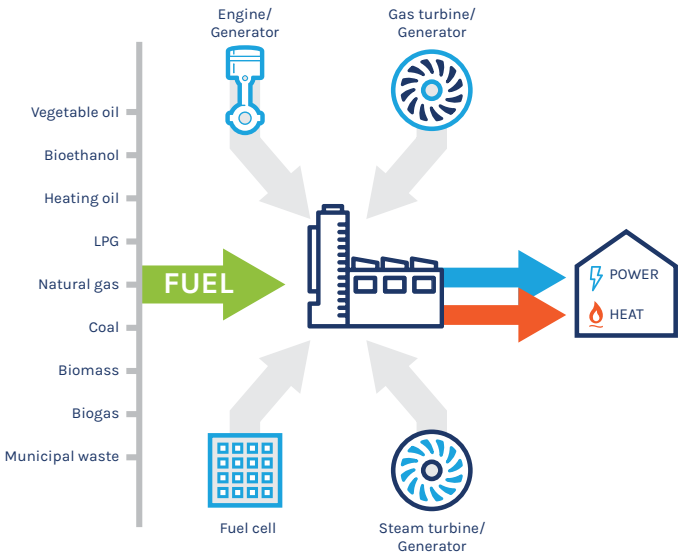
How does it work?

Using a single source of energy, combined heat and power systems (CHP), also known as 'cogeneration', simultaneously generate heat and electricity, avoiding the waste of energy by means of raising the global performance of the system. Electricity generated can be used for on-site demand or injected into the grid to generate revenue. Captured heat provides useful thermal energy that can be used for space heating/cooling, domestic hot water production and industrial processes.

A CHP plant can rely, for example, on an internal combustion gas engine that drives an alternator to produce electricity with the thermal energy produced by the engine or embedded in the exhaust being used to heat water.

A CHP with a gas fuel cell is a high-efficiency technology that uses hydrogen, currently obtained from natural gas through a reformer via an electro-chemical reaction (rather than combustion), to produce electricity and heat.

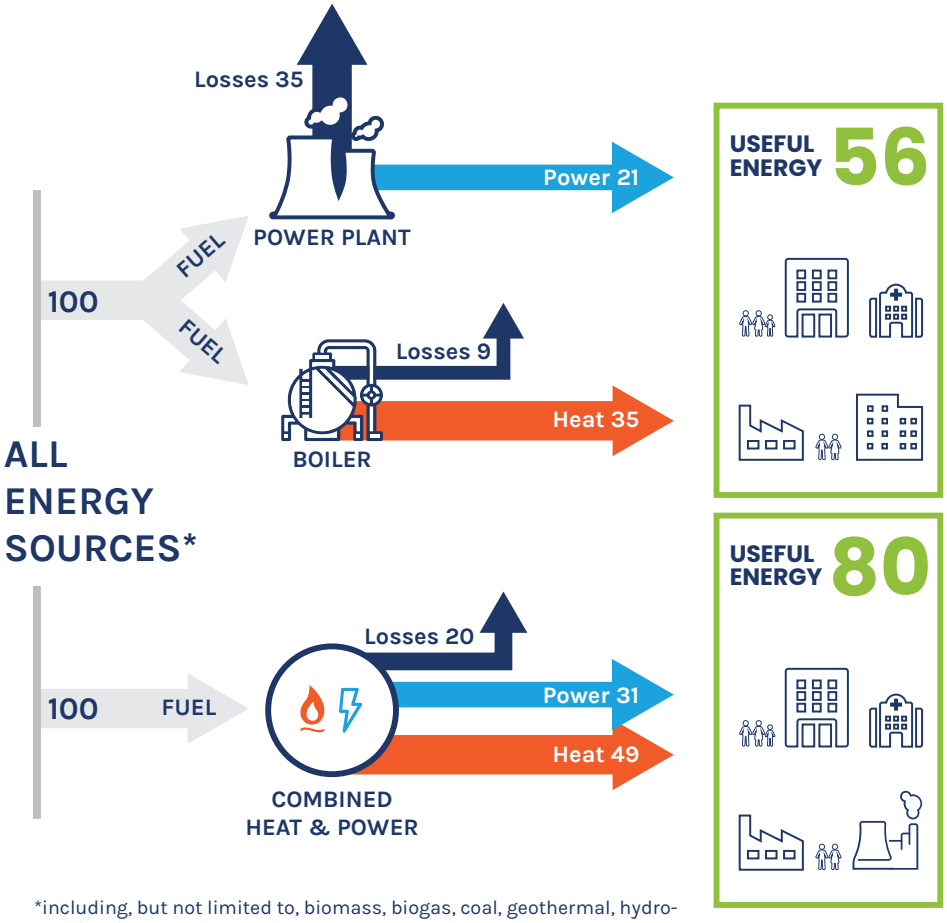
The cogeneration principle



*CHP also runs on waste heat, geothermal, CSP (concentrated solar power) and nuclear energy sources.

COMBINED HEAT AND POWER SYSTEMS (CHP)

residential use | commercial use | industrial use | maturity level



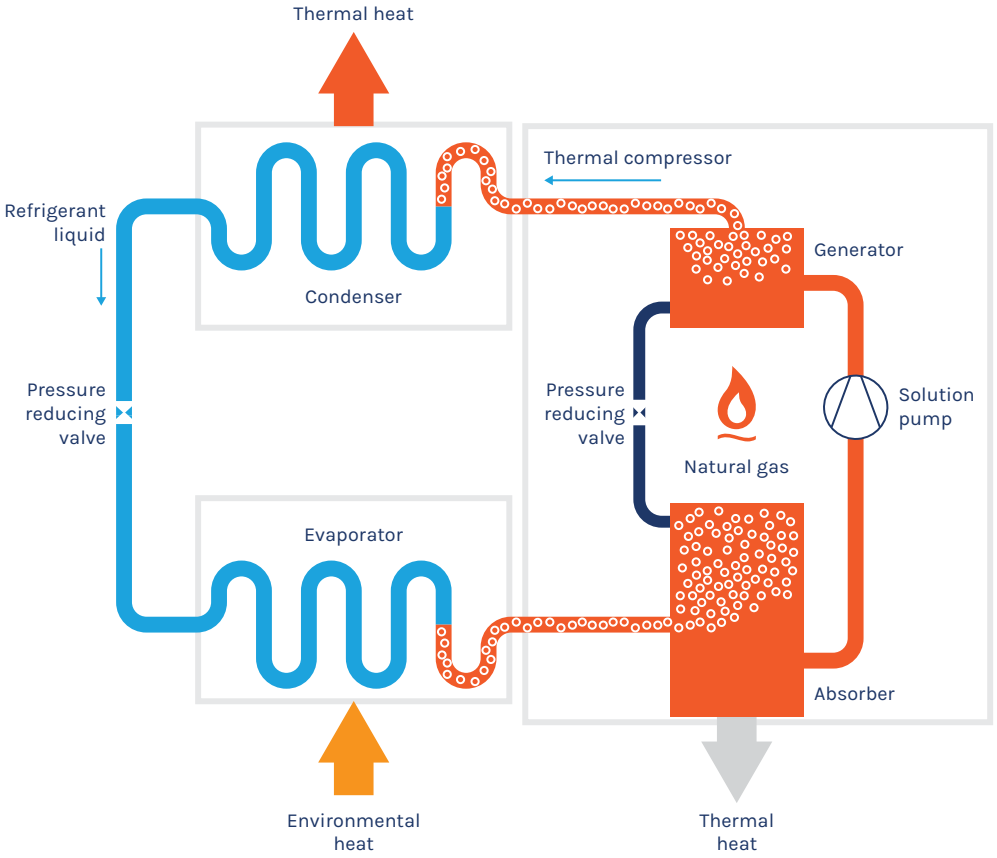
*including, but not limited to, biomass, biogas, coal, geothermal, hydrogen, (bio-)LPG, natural gas, residual waste and solar thermal

What are the benefits?

- Mature technology (engine) with wide range of products
- Very high energy efficiency
- Controllable power production
- Contributes to peak shaving and savings on power grid reinforcement

GAS HEAT PUMP

residential use | commercial use | industrial use | maturity level



Gas Heat Pump

How does it work?

A gas-fired compression heat pump operates like a refrigerator in reverse. A refrigerant contained in the device extracts low-temperature heat from the surrounding environment, which could be the soil, groundwater or ambient air, causing the refrigerant to evaporate. The gas engine then compresses the refrigerant, which leads to the heat being released in a condenser. In turn, this heat is transferred to the water circulating in the heating system or boiler.

Thanks to their high range of power, gas heat pumps are particularly suited for commercial applications. They usually come with an auxiliary boiler.

*High temperature heat pumps produce water or steam at a temperature below 90°C, which makes them particularly suitable for some industrial uses.

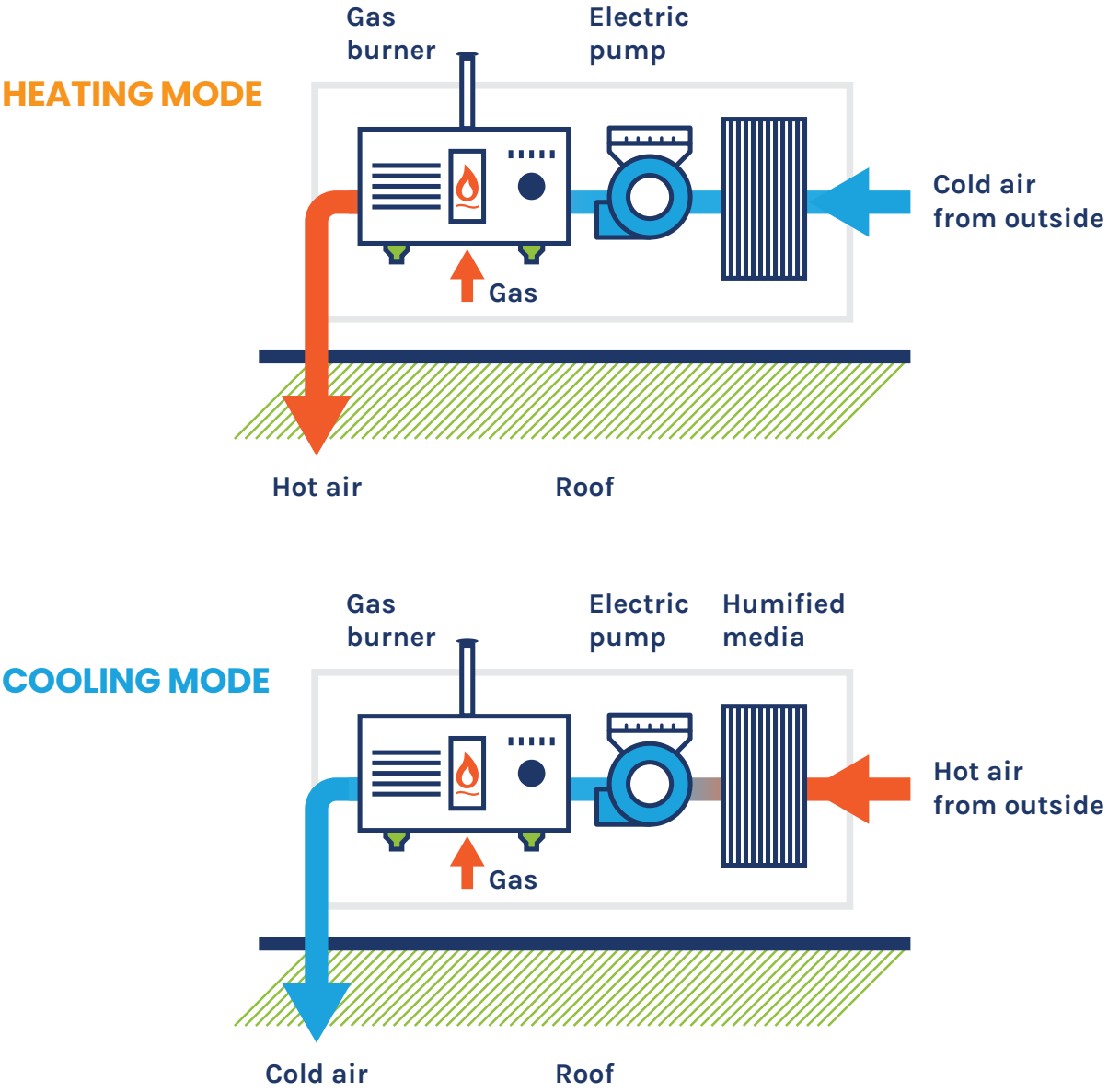
What are the benefits?

- Maximizes use of fuel and renewable energy with very high level of energy efficiency
- Suitable for low and high temperature heating systems, including for new and existing buildings
- Compared against an electrical heat pump, performance is less affected by outside temperature

ADIABATIC ROOFTOP UNIT

commercial use

maturity level ++



How does it work?

An adiabatic rooftop unit is a packaged solution that provides heating and cooling in large-volume premises (either new or existing). Composed of a gas burner tube for heating and a moistened media for cooling, it blows air inside the building at the desired temperature. In winter, the air heating is carried out by the gas burner tube, which has a 92% efficiency (NCV) and runs at 90% on recycled air.

What are the benefits?

- Single unit provides efficient, optimal heating/cooling solution for large-volume premises
- Reduced electricity consumption and contract power thanks to the absence of electricity-driven compressors

The gas industry has been delivering a reliable, affordable and clean fuel to EU consumers for decades. We understand that this alone does not guarantee future success and we need to continue innovating to address the societal challenges. We are ready to meet these challenges by providing low-emission solutions that will help the EU meet its climate goals.

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