

Konvekta CO₂ heat pump variants

Busklimatisierung
Bus air conditioning

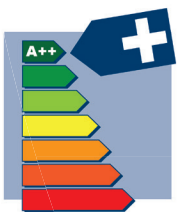


Konvekta CO₂ heat pump variants -

for year-round emission-free heating and cooling of electric buses



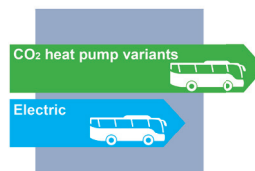
Natural refrigerant R744 (CO₂)



- Maximum energy efficiency



- Up to 50% cost savings



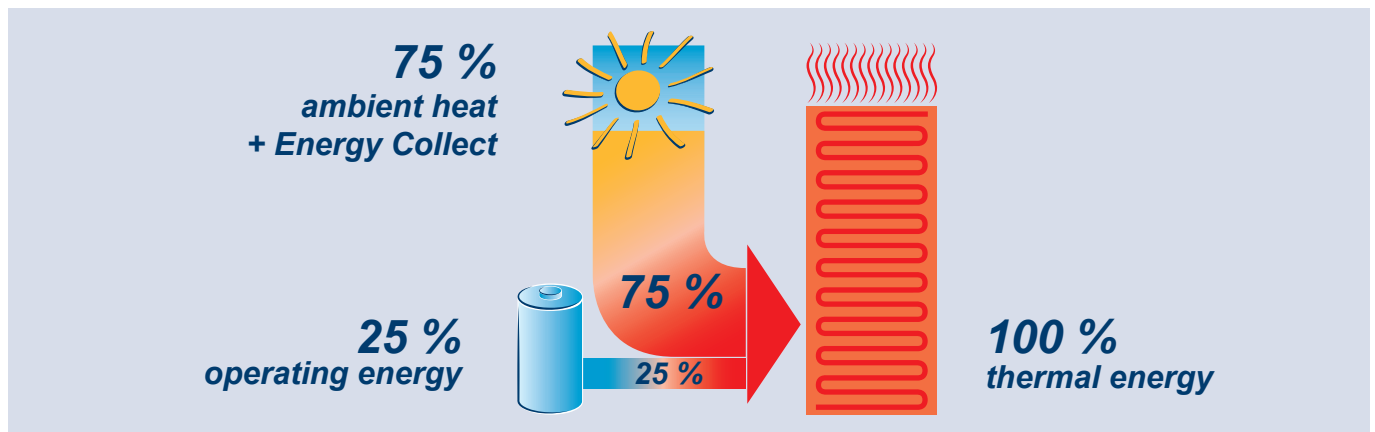
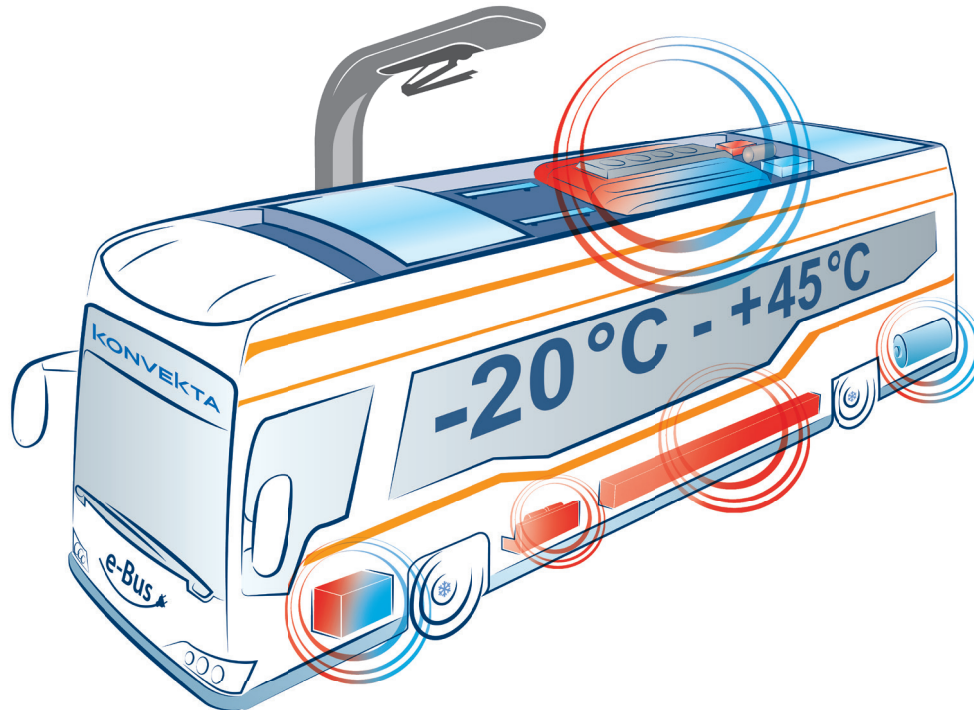
- Up to 60% higher range



- Eco-friendly cooling and heating system with natural refrigerant R744 (CO₂)

KONVEKTA CO₂ HEAT PUMP VARIANTS – highly efficient and environmentally friendly

For emission-free and year-round heating and cooling of electric buses and all temperature-dependent components



Up to 75 % of the necessary heat energy is extracted free of charge from the environment. The system requires at most 25 % operating energy.

This means: up to 4 kW heating capacity is achieved from 1 kW battery energy = up to COP 4*

* COP = coefficient of performance

The ratio of the generated cooling or heating capacity to the electrical energy used

KONVEKTA CO₂ HEAT PUMP VARIANTS

Konvekta CO₂ heat pumps are air conditioning systems for electric buses that provide optimum comfort for people, maximum energy efficiency for the vehicle and the best environmental characteristics.

Konvekta CO₂ heat pump systems can provide both warm and cold energy in the form of air and/or water simultaneously. As a result, the batteries, the driver and the passenger area can all be taken care of at the same time, and in accordance with requirements.

Operating range

- Cooling mode up to +43 °C
- Heating mode down to - 20 °C (for R134a only possible to + 7 °C).

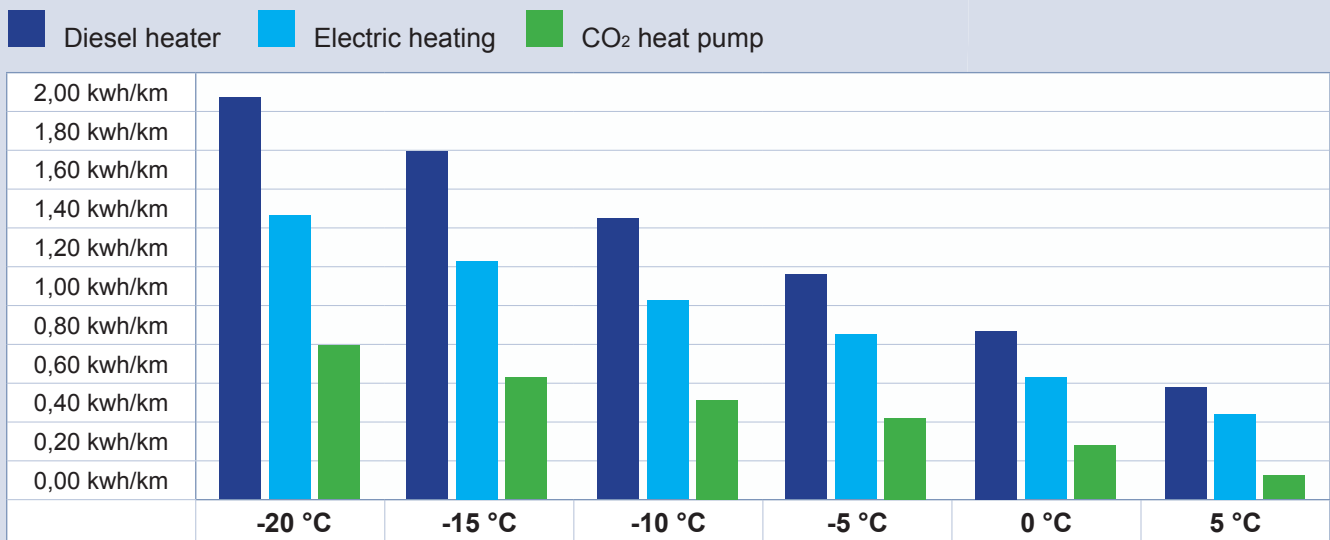


Rather than using fossil fuels (diesel) or electricity, the system takes up to 75% of its required energy (heat or cold) from nature - i.e. from the surrounding air (COP = up to 4).

Energy savings are also achieved via:

- the CO₂ refrigerant (R744)
- specifically developed components (e.g. heat exchanger)
- Energy Collect (heat recovery from heat-generating components = 15 - 20% energy saving)
- the Konvekta control system "CleverControl"

Energy consumption of different air conditioning concepts: An overview of the three possible versions for cooling and heating of an electric bus



Boundary conditions: City bus 12 m / Target value in the interior = 20 °C
Passengers = 35 persons / Speed = 15 km/h / Weather: cloudy

Comparatively speaking, in regard to the energy consumption of the possible variants for air conditioning an electric bus, the CO₂ heat pump is the most energy efficient option.

Cost and environmental saving potential - energy consumption



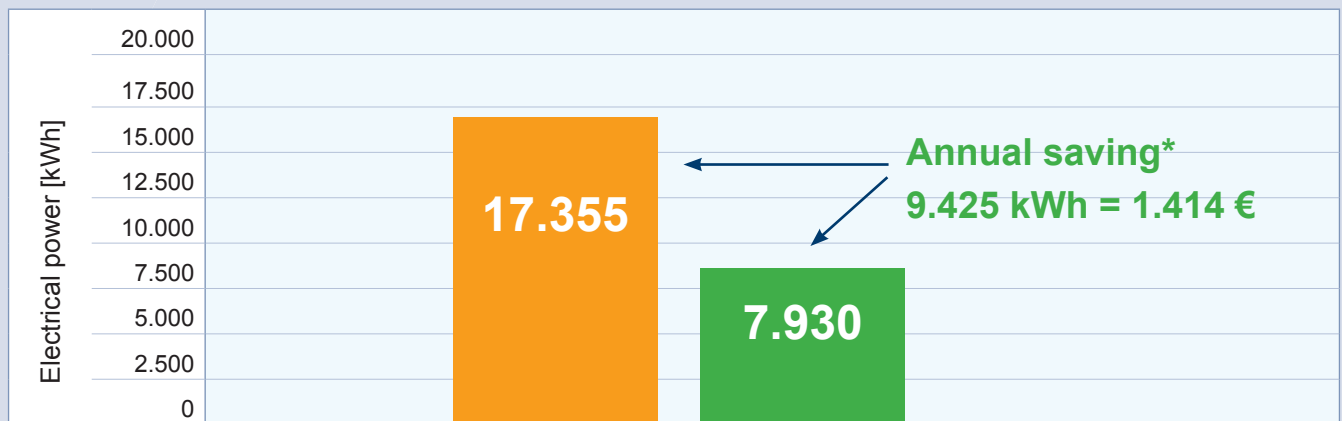
The heat pump reduces energy consumption with zero emissions e.g. by 60% at -10°C in comparison to classical electric heating systems.

If you look at the entire year, including air conditioning, the energy requirement is reduced by more than 50%.

Comparison of air conditioning systems - annual consumption for heating and cooling

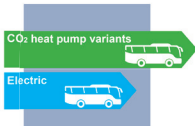
■ R134a A/C with auxiliary heater [kWh]

■ CO₂ heat pump with Heat2Go [kWh]



* at 6.500 operating hours per year

Increasing the range



These energy savings could be used to increase the range.

The increase in range is dependent upon the weather conditions and the type of vehicle.

► **Increasing the range by 60 %**

Cost savings and environmental benefits



The heat pump requires a maximum of 50 % of the drive power in comparison to an electrical heating device, therefore only half of the additionally installed battery capacity will be required. Including the battery change that is required, this results in a

► **Saving of € 18,250** (in addition, the service life of the batteries will be increased)

The batteries can also be designed to be smaller, and at the same time their service life will be increased. This represents another major benefit for the environment and a considerable cost saving.

The benefits of using CO₂ as the refrigerant



R744 (carbon dioxide / CO₂) is extremely suitable as an alternative to the current refrigerant R134a. CO₂ (R744) is a natural component of air and has a greenhouse potential of only Factor 1. Therefore, there are no legal restrictions for the use of CO₂.



Economic benefits

- **120 % efficiency through higher efficiency = reduced energy consumption**
- Costs per kg refrigerant are around 90 % lower and are available for the long term
- Lower service charges /servicing times
 - no recycling required, fewer components and simple, risk-free handling
- No legal restrictions or limitations

Environmental benefits

- Sustainable and approved refrigerant
- Non-flammable (R744 = fire extinguishing agent)
- **No greenhouse effects**
- Non-toxic, no poisonous by-products or decomposition products
- No fossil fuels required

Sponsorships and subsidies in the following countries for climatefriendly refrigerants

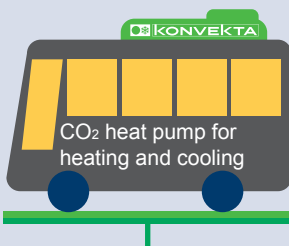
- | | | |
|-----------------|-------------------|---------------|
| ■ Germany | ■ Belgium | ■ Austria |
| ■ Great Britain | ■ The Netherlands | ■ Switzerland |

In Germany:

Since January 2019, there has been a funding programme for CO₂ bus air conditioning units for electric buses. Funding of between € 4.000 for an electric single bus and up to € 6.500 euros for an electric articulated bus is therefore available.

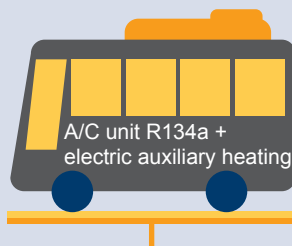
The three different versions for the cooling and heating of an electric bus

CO₂ heat pump for heating and cooling
0 % Emissions



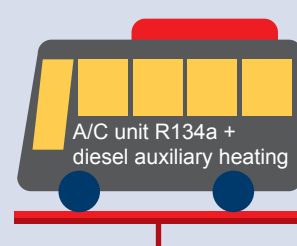
Natural refrigerant CO₂ +
20 % energy efficiency

Annual additional consumption with electric auxiliary heating
21.600 kWh



Chemical refrigerant R134a
+ € 1.200 energy costs

Annual output of diesel auxiliary heating
68.364.000 mg NOx
7.144 kg CO₂



Exhaust gases produced and costs +
chemical refrigerant R134a

2.700 l

Why are the current refrigerants a problem?

Chemical refrigerants are potent greenhouse gases and therefore contribute to climate change. Refrigerant discharge always happens: be it during maintenance, accidents or leakages.

The amount of refrigerant released from buses corresponds to 140,000 tonnes of CO₂ equivalents per year. This corresponds to an annual CO₂ output of 90,000 economical small cars with an average driving style.

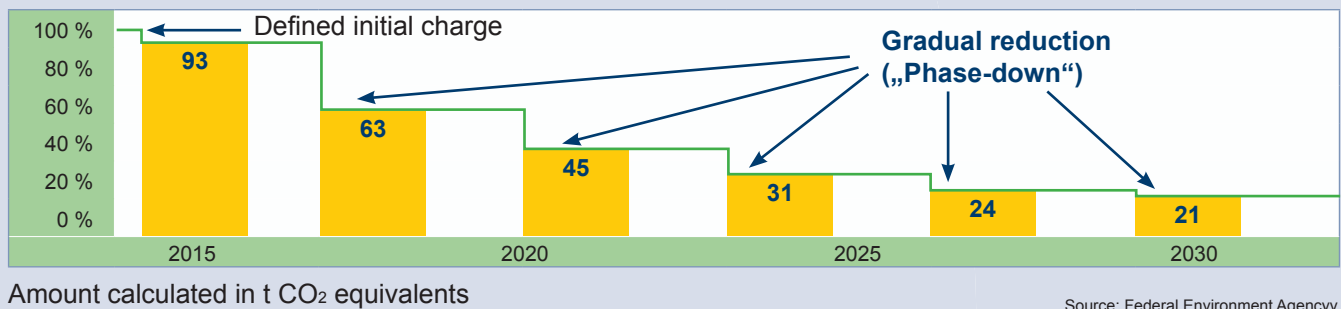
Amount of refrigerant released from buses = 140,000 CO₂ equivalents per year
Typical driving of 90,000 small cars = 140,000 CO₂ equivalents per year

Measures

With the climate and energy strategy, also known as the „20-20-20 targets“, the EU has enacted legislation, which includes a **20 % reduction in greenhouse gas emissions by the year 2020**.

New regulations, such as the ban on refrigerants with high global warming potential, aim to help achieve the EU climate targets. Europe is therefore setting new global standards for the reduction of CO₂ emissions.

Phase Down - Implementation of the legislation to control F-gases



The result is that the refrigerants available on the market are becoming very expensive and will not be available in the future.

KONVEKTA AG

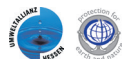
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