Deutsche Umwelthilfe

Sustainable mobile air-conditioning for buses!

Air-conditioning in buses has a huge impact on the climate and is very costly for bus operators. The natural refrigerant CO_2 is an innovative solution for that problem.

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Environmental and cost issues

Nowadays, more and more buses are equipped with mobile air-conditioning (MAC) systems: almost 70 percent of new city buses in Germany are air-conditioned. By this development, transportation companies are faced with a dilemma: Passengers appreciate the additional comfort of air-conditioned vehicles. But the use of climate-damaging refrigerants and the additional energy consumption of AC systems are clearly in a contradiction to the green image buses usually have. In addition, costs for operation and maintenance are much higher for air-conditioned vehicles and burden the budget of bus operators.

R134A IS 1430 TIMES MORE CLIMATE-DAMAGING THAN CO_2

Today's buses almost exclusively use the refrigerant R134a in ACs – a chemical that belongs to the group of fluorinated greenhouse gases (f-gases). The global warming potential (GWP) of R134a is 1430 times higher than the one of CO_2. As MAC systems in today's buses aren't leak-proof, about 13-15 percent of the refrigerant are released every year. In 2011, all German buses emitted roughly 100 tons of R134a. This means 140.000 tons of CO_2 equivalents every year – which is comparable to the exhaust emissions of approximately 120.000 efficient cars.

EU REGULATION IS EXPECTED TO BE EXTENDED TO BUSES

F-gases like R134a belong to the six most important greenhouse gases which have to be reduced according the Kyoto Protocol. To diminish the environmental impact of refrigerants in mobile air-conditioning systems, the EU got the so called MAC Directive (Directive 2006/40/EC) off the ground. As per January 2011, refrigerants in new vehicle types may not exceed a GWP of 150. From 2017 on, this shall apply to all new cars and actually means a ban of the currently used R134a.

Buses are an environmentally friendly means of transport, but their refrigeration systems are not so green.

The EU wants to reduce ecologically harmful f-gases like R134a.

This regulation is also relevant for the bus sector: In the medium run, the directive should be extended to other vehicle types like buses.

But not only direct emissions from refrigerant leakages do matter in view of environment and costs: The additional energy demand of MACs increases the fuel consumption of a typical city bus with a length of 12m by about 4 liters per 100 kilometers. Practically the same applies to the ancillary heating, which is also powered by the engine of the bus.

What's the alternative?

Usually known as a climate-damaging greenhouse gas, CO_2 can be used as an environment-friendly and cost-effective refrigerant in cars and buses (see comparison of refrigerants below). In Germany, more than 40 buses already run with this innovative technology. CO_2 – or according to the typical refrigerant notation also called R744 – is a natural element of the air and has the lowest GWP of all refrigerants. In fact, CO_2 has no additional effect on the climate, because it is a by-product of industrial processes.

THE REFRIGERANT CO_2 WORKS MORE EFFICIENT THAN THE CURRENTLY USED CHEMICAL R134A

At the moment, MAC systems for buses based on CO_2 are still more expensive than comparable R134a-systems. But higher investment costs will be paid back within a few years due to less operation and maintenance expenses. In comparison with current R134a-systems, CO_2-MAC systems consume up to 25 percent less energy with the same refrigerating capacity. Additional savings are generated by lower maintenance costs and the possibility to reverse the cooling process of CO_2-systems. By this, the AC can be used as a heat pump. Up to 50 % of the additional fuel consumption for the ancillary heating can be saved this way. In contrast to the refrigerant R1234yf which is still favored by many car makers to meet the EU targets, CO_2 is neither toxic nor flammable. The occupational insurance association for transportation (BG Verkehr) confirmed that the use of the refrigerant CO_2 is safe in buses.

Comparison of R744, R134a and R1234yf

	R744 (CO_2)	R134a	R1234yf
Ecological characteristics			
ODP (R12=1)	0	0	0
GWP (100 years)	1 (0)	1430	4
Environmental effects	Known	Partly known	Unknown
Thermal characteristics			
Condensation	Transcritical	Yes	Yes
Operating pressure	High	Low	Low
Efficiency (R134a=1)	1.25	1	0.9
Heat transfer	Very good	Good	(Good)
Use as a heat pump	Good	Poor	Poor
Chemical characteristics			
Flammability	No	No	Yes
ATEX	No	No	Yes
Toxicity, MAK	5,000 ppm	1,000 ppm	400 ppm
Decomposition product	None	TFA	HF, COF2, TFA
Stability	High	Medium	Low
Economic characteristics[3]			
Life Cycle Costing (LCC)	Good	Medium	Poor
Filling of a city bus	20 €	150 €	700 to 1,500 €
Station for service and disposal	1,000 to 2,000 €	5,000 to 10,000 €	8,000 to 10,000 €
Dryer	No	No	Yes
Maintenance cost/year	1. year: 150 € / 2. year: 100 €	450 €	1,000 to 2,000 €
Additional fuel consumption for AC (city bus)	3 l/100km	4 l/100km	4.4 l/100km
Recycling required	No	Yes	Yes

(Source: Konvekta AG)

What has to be done?

The Deutsche Umwelthilfe e.V. (German Environmental Aid Association) presses ahead with sustainable air-conditioning technology for years.

In order to minimize the environmental impact of MAC systems in buses, many different measures are required:

- All leading **bus manufacturers** have to offer CO_2-technology to their customers as an option ex works.
- Apart from more efficient AC systems, buses should be equipped with **additional innovative technologies** to reduce the need or the energy consumption for cooling and heating: solar collectors on the rooftop generate energy for ventilation and air-conditioning; IR-reflective glazing and "cool paints" help to reduce temperatures in the interior in summer.
- **Transportation companies and municipalities** have to consider sustainable air-conditioning in their tenders: if air-conditioned vehicles are to be purchased, an increasing number of buses should be equipped with systems based on the natural refrigerant CO_2.
- **Public incentive programs** for buses should include criteria for sustainable air-conditioning. Specialized incentive programs have to be established to engage more transportation companies to switch to air-conditioning systems based on CO_2.
- From 2018 on, standard city buses with the German **eco-label Blauer Engel** (according to RAL-UZ 59) have to use halogen-free refrigerants – thus, the natural refrigerant CO_2 is the only future-proof alternative. This requirement has to be extended perspectivally to other types of buses – the current demand of a refrigerant with a GWP<1500 is outdated.

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