



YOUR MARKET PLACE FOR CO<sub>2</sub> TECHNOLOGY, NEWS & POLICY

## NEWS:

- Latest news
- Product News
- Company News
- Policy News
- Conference News
- General News
- Eco Cute Flash News
- Subscription

[Home](#) [News](#) [Latest News](#)

### GREEN-MAC-LCCP lacks real-life testing data

The GREEN-MAC-LCCP model, a tool to calculate the environmental performance of car air conditioning systems worldwide, is currently under development. R744.com asked Dr. Armin Hafner, member of the working group and R744 expert at SINTEF, about its rationale, basic assumptions, and still existing challenges.

2008-04-01

**R744.com: Dr. Hafner, you are a widely recognized expert in the field of CO<sub>2</sub>-based Mobile Air Conditioning, having worked for over 10 years on the development of R744 (CO<sub>2</sub>). As a member of the working group refining the Green MAC LCCP model, could you quickly explain the rationale behind this model?**

**Armin Hafner:** The GREEN-MAC-LCCP was developed to compare the life cycle climate performance (LCCP) of Mobile Air Conditioning (MAC). It is a comprehensive model integrating a wide set of parameters to calculate the environmental impact of MAC systems and different refrigerants, taking account both direct and indirect emissions over a car's life cycle. Direct emissions occur during the production of the MAC system and the refrigerant, their transfer to OEMs, refrigerant losses when charging the system and leakage over a car's lifetime. Refrigerant might also be released in case of an front end accident, and at a car's end of life, when the system is recycled and the refrigerant is partly recovered. On the other hand, the model calculates indirect emissions (fuel over-consumption) due to increased work of the engine to run the air conditioning.

**R744.com: What are the main objectives of this model?**

**Hafner:** Currently, it is difficult to compare the greenhouse gas (GHG) emissions from MAC systems, as different countries use different assumptions and methodologies to calculate their performance. The Green MAC LCCP model – developed by General Motors (GM holds the copyright of the software) with contribution from JAMA, SAE, U.S. EPA\* and others - tries to establish one calculation tool to be applied in all world regions, be it India, Europe, or the U.S. Its working group, involving around 20 experts from around the world, is meeting regularly to discuss latest updates and refine the data input. At present, the model compares the current refrigerant R134a and alternatives, which have to be specified by the user of the tool.

**R744.com: Some argue that the Green LCCP Model should be used as a reference to develop a common SAE standard in the U.S., possibly to be later adopted by other countries to calculate the environmental impact of MAC. Is the model in its current state suitable to serve as a common reference?**

**Hafner:** Although the underlying idea to have one globally accepted standard is surely a positive one, the Green LCCP definitely needs further discussion and development before it can be the clear and transparent tool it intends to be.

In its current state, the model does not open for fuel over consumption input data from real-life testing, collected by carmakers and suppliers. The calculation is solely based on bench tests carried out in one laboratory in the U.S. to ensure consistency. By simulating all different driving cycles around the world based on that test bench data, the model avoids to actually drive these test cycles in reality. This of course saves costs but also poses the risk that important dynamic effects influencing the MAC performance only while driving outside are not taken into account. Here, the complex calculation definitely lacks one spreadsheet where real-life test data can be entered. Only then the result will be precise enough to serve as a global reference. The danger is that once the Green LCCP model is accepted as a standard, carmakers will no longer invest in more accurate real-life testing but solely rely and refer on its data output. Taking the present version, this would mean to build on model assumptions and partly idealized values.

**R744.com: So the Green MAC LCCP is too optimistic?**

**Hafner:** In some parts, yes it is., e.g. when calculating the direct emissions. One of the major drawbacks

is that the model is just not in line with the environmental reality we face today. If we look at the levels of R-134a in the atmosphere, only direct emissions from MAC could make up 390 million tons of CO<sub>2</sub> equivalents only in 2017. Other studies have shown that all R134a produced in 2000 worldwide is completely released to the atmosphere only four years later.\*\* This is in line with findings by a global panel of scientists (IPCC) who calculated that over a car's life time in the EU, that means after 12 years, two complete charges of R134a are released to the atmosphere. That means that 20% of this high global warming refrigerant leaves the MAC system every year, probably not in the first years of a car's lifetime, however after one decade on the road and when shipping 'old' cars to other continents, where they are still seen as a resource and being in use for many years. This figure has been confirmed even by chemical manufacturers. Here the model is too optimistic, as it bases its calculations on a best-case scenario for direct R134a emissions. Unfortunately, the assumed 90% rate of proper recycling without any leakages for India does not correspond to reality where the actual leakage of R134a at servicing and disposal might be much higher than shown in the model. However, this will be investigated in the near future and when new information is available the model will be updated. What's more, the Green LCCP project works mostly with new cars that have small leakages. It does not account for real-life refrigerant release from accidents, for old vehicles, and bad servicing, it's up to the user of the model to adjust these input values.

#### **R744.com: How does all this affect the comparison with CO<sub>2</sub> / R744 MAC?**

**Hafner:** First of all, the low direct emissions assumed for R134a distort the picture when compared to CO<sub>2</sub>. CO<sub>2</sub> has a Global Warming Impact (GWP) of 1 - R134a a 1,400 (1420?) times higher one. If the bar for R134a is relatively low due to ideal emission / leakage assumptions, then this of course lowers the environmental benefits from switching to CO<sub>2</sub>. SINTEF's own LCCP projections, based on test data from leading automotive suppliers, show that total GHG emissions can be reduced by 40% in hot Indian climates, with a significant share of that coming from direct leakage.\*\*\*

But more importantly still, I want to insist on the fact that not taking into account real-life test data will not lead to accurate results, especially not in the case of CO<sub>2</sub>. Tests by automotive supplier Visteon have shown that, compared to R134a, CO<sub>2</sub> MAC can reduce emissions due to MAC by 12 g/km (small car, Athens climate, NEDC). The additional fuel consumption due to MAC is reduced by 25% (0.56 l/100 km) when applying an R744 MAC at 35°C outside temperature. Data calculated under the Green LCCP do not, at the moment, reflect this economic and environmental benefit. This is because a bench test cannot record dynamic effects that only occur while driving outside, e.g. compressor inertias, condenser / gascooler air flow limitations, etc. Depending on the quality of system engineering and manufacturing, automotive suppliers now achieve much better results for R744 MAC than those emerged from early Green MAC LCCP results. I admit, real-life testing is more time consuming and expensive for OEMs and suppliers than a standardized simulation test but the latter has to be in line with the actual experience of carmakers. By the way, the test Visteon applied is quite simple, using four different temperatures. The overall problem is that there is still a lack of reliable data regarding CO<sub>2</sub>. However even so, the EU supported B-Cool project has now shown that the first CO<sub>2</sub> MAC systems implemented in B-class cars are at least as efficient as the baseline systems applying R134a.\*\*\*\*

#### **R744.com: What do you recommend to make the Green MAC LCCP model more reliable?**

**Hafner:** Work on the Green LCCP model has advanced successfully and many details have been included to improve its data output. However, besides the shortcomings mentioned before, I would like to make one last point what would still be needed to increase its usability. For now the model only calculates the total GHG emissions coming from MAC over a car's life cycle, reflecting them in bars. By adding a simple calculation we could easily translate this data into the actual fuel consumption attributable to MAC. This would considerably enhance the usability for OEMs, suppliers, and even consumers, and make it easy to compare different MAC systems operating under different conditions.

To sum up: The Green MAC LCCP is a valuable tool that needs to be further developed to help us to identify and improve the economic and environmental performance of car air conditioning when comparing different refrigerants. I am positive about the working group making further progress in that respect, and about the model becoming a reliable standard for carmakers worldwide.

#### **R744.com: Dr. Hafner, thank you for this interview.**

##### **About Armin Hafner**

Armin Hafner works as research scientist in SINTEF Energy Research. He began his career in the field of refrigeration and air conditioning in 1995 at the University of Applied Science (FH) Karlsruhe, Germany. Since then, he participated in many research projects mainly related to transcritical CO<sub>2</sub> heat pumping systems. He received his PhD in 2003 from the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. The title of the PhD dissertation was "Compact Interior Heat Exchangers for CO<sub>2</sub> Mobile Heat Pumping Systems". He is a member of the B-Cool team.

##### **About the GREEN-MAC-LCCP**

The "Global Refrigerants Energy & Environmental Mobile Air Conditioning Lifecycle Climate Change Performance" (GREEN-MAC-LCCP) model was developed to provide a holistic approach in estimating all

greenhouse gas contributions emitted during the lifetime of an alternative refrigerant and a MAC operating system. It consists of interlinked spreadsheets of data required to run the model. For each global alternative refrigerant, the following information is required: component mass, refrigerant mass & global warming potential, leakage rate, Coefficient of Performance (COP) and data obtained from bench or vehicle tests. The model output provides the LCCP (in terms of CO<sub>2</sub>-eq emissions) of any global alternative refrigerant.

\* JAMA = Japanese Automobile Manufacturers Association; SAE = Society of Automotive Engineers; EPA = Environmental Protection Agency

\*\* SINTEF / OBRIST Engineering 2007: "[R744 the Global Solution - Advantages & Possibilities](#)"; OBRIST Engineering 2007: "[Emission Reductions](#)"

\*\*\* / \*\*\*\*\* SINTEF, Torino MAC workshop 2007: "[Global Environmental & Economic Benefits of introducing R744 Mobile Air Conditioning](#)"

**More information:**

[GREEN-MAC-LCCP model - U.S. EPA website](#)

[Read the related article: R744 - up to 40% less emissions in hot climates](#)

[Read the related article: Visteon: Breakthrough for CO2 technology](#)

---

[RSS](#) • [Best Viewed](#) • [Terms and conditions](#) • [Site map](#) • [Contact us](#)

Managed by Shecco™