

Green-MAC-LCCP: Suggestions for improvement

Dr. Armin Hafner
(Armin.Hafner@sintef.no)

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Main Messages

- The GREEN MAC LCCP is a very good tool, however, it still needs improvement if it is to become a real global standard, to be applied in global carbon trading issues.
- During the last years several OEM's and Tier 1 suppliers have gained important performance data of R744 MAC system implemented in real cars (see Examples).
- With the current Green-MAC-LCCP tool, these important data cannot directly be applied in the LCCP model. A global tool, as base for a standards, should integrate these type of results from real-life testing, next to bench testing data.

What are we talking about?

Flexibility is only missing at a vital point:
A/C System Operation



GREEN-MAC-LCCP[®] Model Framework

Direct Emissions due to:	Indirect Emissions from Fuel Consumption due to:
Regular Emissions	A/C System Operation
Irregular Emissions	Manufacturing of Components
Service Emissions	Manufacturing of Refrigerant
End-of-Life Emissions	A/C System Transportation Onboard the Vehicle
Refrigerant Leak from Production and Transportation	End-of-Life Recycling of A/C system

http://www.vda-wintermeeting.de/fileadmin/downloads2008/presentations/Stella_Papasawa_GM.pdf

Additional MAC Bench test results:

Medium size car with externally controlled compressor
Test bench results

Cool down test points

	R-134a Blown air T°(°C)	R-744 Blown air T°(°C)	
CD1	11,5	8,6	} Better Cool Down
CD2	6,4	4,8	
CD3	4	2,0	
CD4	10	9,8	} Same IDLE

Western European test matrix for Annual Power Consumption

NEDC Cycle (iso cooling capacity)			
Temperature (°C)	R-134a Shaft power (W)	R-744 Shaft power (W)	Difference (%)
35	1130	1155	2%
30	1150	1175	2%
25	820	630	-23%
20	585	455	-13%
15	305	280	-8%

Annual Power Consumption : - 14% with R-744



Paper presented at the 2nd MAC & Auxiliaries Workshop
29 - 30 November 2007, TORINO (Italy)

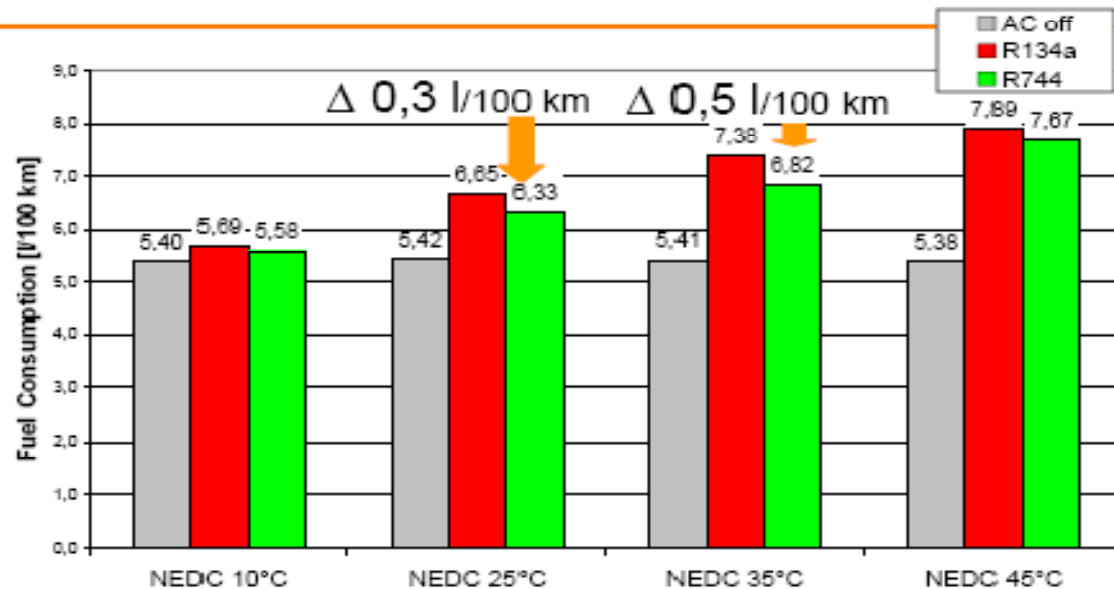
Viabile additional/alternative A/C performance input

Examples of real-life testing data from R-744-based vehicles that cannot be used directly on the current Green MAC LCCP tool:

1. Visteon
2. B-Cool Project (CRF/Fiat)
3. Ongoing Research

Example 1: Visteon

Test Results: Fuel Consumption



- ⇒ Significant, absolute fuel reduction of 0,3 and 0,5 l/100 km at ambient temperature of 25°C and 35°C for R744
- ⇒ Add on fuel reduction of 25 % at 25°C and 35°C of R744 in comparison to R134a

Visteon Confidential – all rights reserved 2007

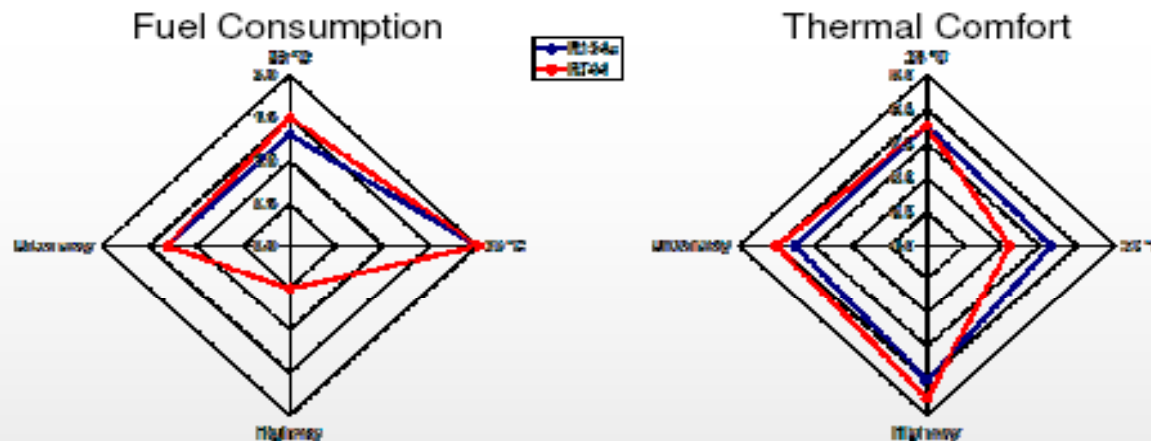
071215 Small Cars with R744, VDA Wintermeeting

http://www.vda-wintermeeting.de/fileadmin/downloads2007/12-FlorianWieschollek_Visteon.pdf

http://www.r744.com/news/files/Visteon_vda_wintermeeting2007.pdf

Example 2: B-Cool Project (CRF/Fiat)

Fuel Consumption and thermal comfort results



Cycle	Fuel Over consumption		Comfort	
	R134a	R744	R134a	R744
ECE+EUDC+ECE (28 °C)	1.3	1.5	7.5	7.5
ECE+EUDC (35 °C)	2.0	2.0	7.3	6.2
Highway	0.5	0.5	8.0	8.5
Urbanway	1.3	1.3	7.5	8.0

Nov 29-30, 2007

MOBILE AIR CONDITIONING AND AUXILIARIES

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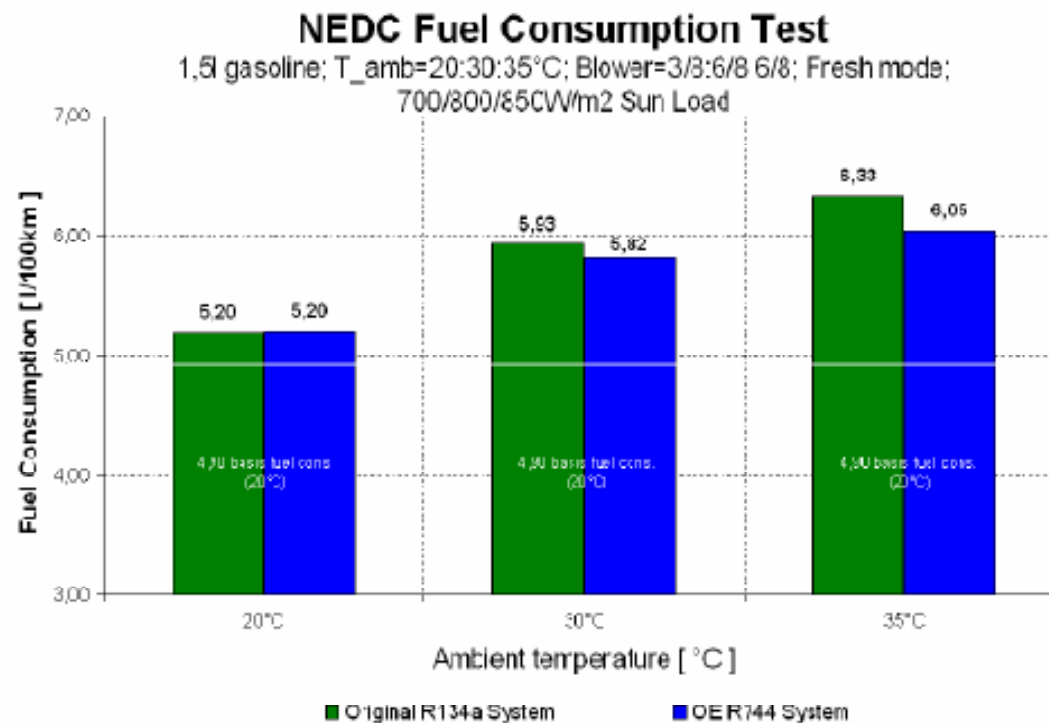
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Example 3: Ongoing Research



Improved System Efficiency – Small Car / low cost R744 MAC



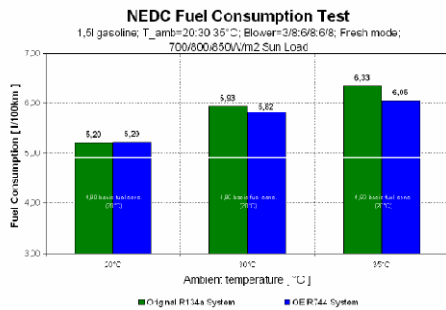
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Ref: 10. Karlsruher Kfz-Klima-Symposium, 10.04.2008

Methodology to improve LCCP

To integrate data from vehicle testing during driving cycles in the LCCP tool:



Indirect Emissions from Fuel Consumption due to:

A/C Operation
(Which is the largest part of the total LCCP)

Climate-Drive Assumptions
VDA Association of Automotive Weather Modeling

CLIMATE-DRIVE INPUT
Ambient Temperature and Humidity -TMY2 Weather Database (1950-1991)

% Drive Time in Ambient during GAM - 24PM

Ambient Temperature (°C)	USA										Japan				India				Australia		China	
	Phoenix	Houston	Boston	Miami	Frankfurt	Atlanta	Tokyo	Kagoshima	Sapporo	Bangkok	Bombay	New Delhi	Sydney	Beijing	Shanghai							
-5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
0	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%			
5	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%			
10	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%			
15	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%			
20	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%			
25	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%			
30	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%			
35	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%			
40	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%			
45	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%			
50	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%			

DRIVING TIME & VEHICLE LIFETIME

Climate Database	Phoenix	Houston	Boston	Miami	Frankfurt	Atlanta	Tokyo	Kagoshima	Sapporo	Bangkok	Bombay	New Delhi	Sydney	Beijing	Shanghai
Climate Database (h)	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Driving Time (h)	407	410	402	420	420	411	420	420	420	420	420	420	420	420	420
Vehicle Lifetime (h)	1,517,200	1,524,800	1,523,200	1,539,200	1,541,600	1,531,600	1,527,200	1,527,200	1,527,200	1,527,200	1,527,200	1,527,200	1,527,200	1,527,200	1,527,200

CABIN COMFORT - % Time with A/C ON

Percent of Manual	USA										Japan				India				Australia		China	
	Ambient	Phoenix	Houston	Boston	Miami	Frankfurt	Atlanta	Tokyo	Kagoshima	Sapporo	Bangkok	Bombay	New Delhi	Sydney	Beijing	Shanghai						
-5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
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Methodology to improve LCCP

Additional features

- **g_{CO_2}/km Output graph:**

Use (row 67; sheet: 'ref-name'-LCCP-output), which is [CO₂ emissions / km] to create a graph in addition to the bars only showing the total emissions -> to show the MAC related CO₂ emission / km reduction potential.

[In case vehicle data are available (AC-off mode), the share of MAC to the total CO₂/km emission can be analyzed and compared]

- Other output results in common standards values (i.e. liter of fuel/a) are a convenient way of comparison

Remark to a global LCCP model suggested: Output table [*Example*]

City/Climate: Europe/ S Car type: small car	MAC System A	MAC System B
Fuel over-consumption [liter/a]	51	69	
Vehicle Emission (xx-driving cycle) AC off; [g _{CO2} /km]	145	145	
Vehicle Emission (xx-driving cycle) AC on; [g _{CO2} /km]	157	169	
Total release of refrigerant [kg _{xxx} / lifetime]	XX	XX	
LCCP [kg _{xxx} / 12 years]	1808	3525	

Conclusions

- MAC performance data obtained from vehicle testing during driving cycles are viable and representative input data for a global LCCP tool.
- There is a simple way to modify the LCCP tool to integrate these data from real-life testing, which are complementary to bench-testing data.

Questions?

We are looking forward to your feedback.
Have a nice day!