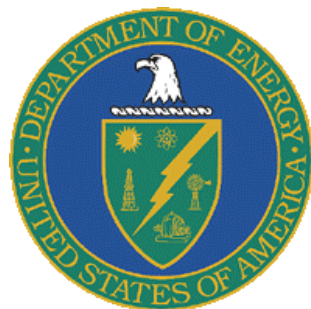
Comparison of Two Mobile A/C LCCP Analyses

John Rugh

National Renewable Energy Laboratory

2004 Alternate Refrigerant Systems Symposium

June 28-July 1, Scottsdale, Arizona



Objective

- Compare 2 analyses from 2004 MAC Summit
- Identify similarities/differences
- Lay the foundation for a common MAC LCCP analysis approach

A Comparison of R134a, R134a Enhanced, R744 and R744 Enhanced Automotive Refrigerant Systems Based on Life Cycle

Stella Papasavva, General Motors Corporation
Bill Hill, General Motors Corporation
Greg Major, General Motors Corporation

MAC Summit 2004
Washington DC, April 13-15, 2004

GM

Life Cycle Climate Performance (LCCP) of Mobile Air-Conditioning Systems with HFC-134a, HFC-152a and R-744

MOBILE AIR CONDITIONING SUMMIT
2004 Washington D.C.

Armin Hafner and **Petter Nekså**,
SINTEF Energy Research, Trondheim – Norway

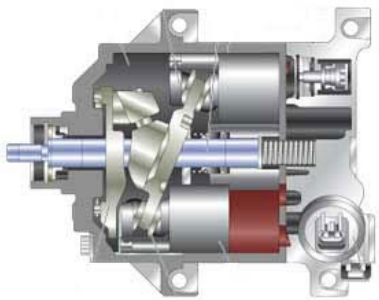
Jostein Pettersen
Norwegian University of Science and Technology – NTNU
Trondheim – Norway

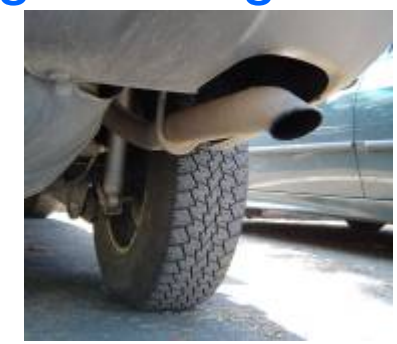
Outline

- Objective
- What is LCCP?
- Overview of Methodologies
- Comparison of Results
- Conclusions

What is Life Cycle Climate Performance?

- CO_2 equivalent global warming impact over the total lifetime of the unit
  - Direct – refrigerant release directly to atmosphere
  - Indirect – energy consumption over lifetime and recycling
    - Fuel use to power compressor and blower
    - Fuel use to carry around mass of A/C system
    - Manufacturing of refrigerant and A/C components

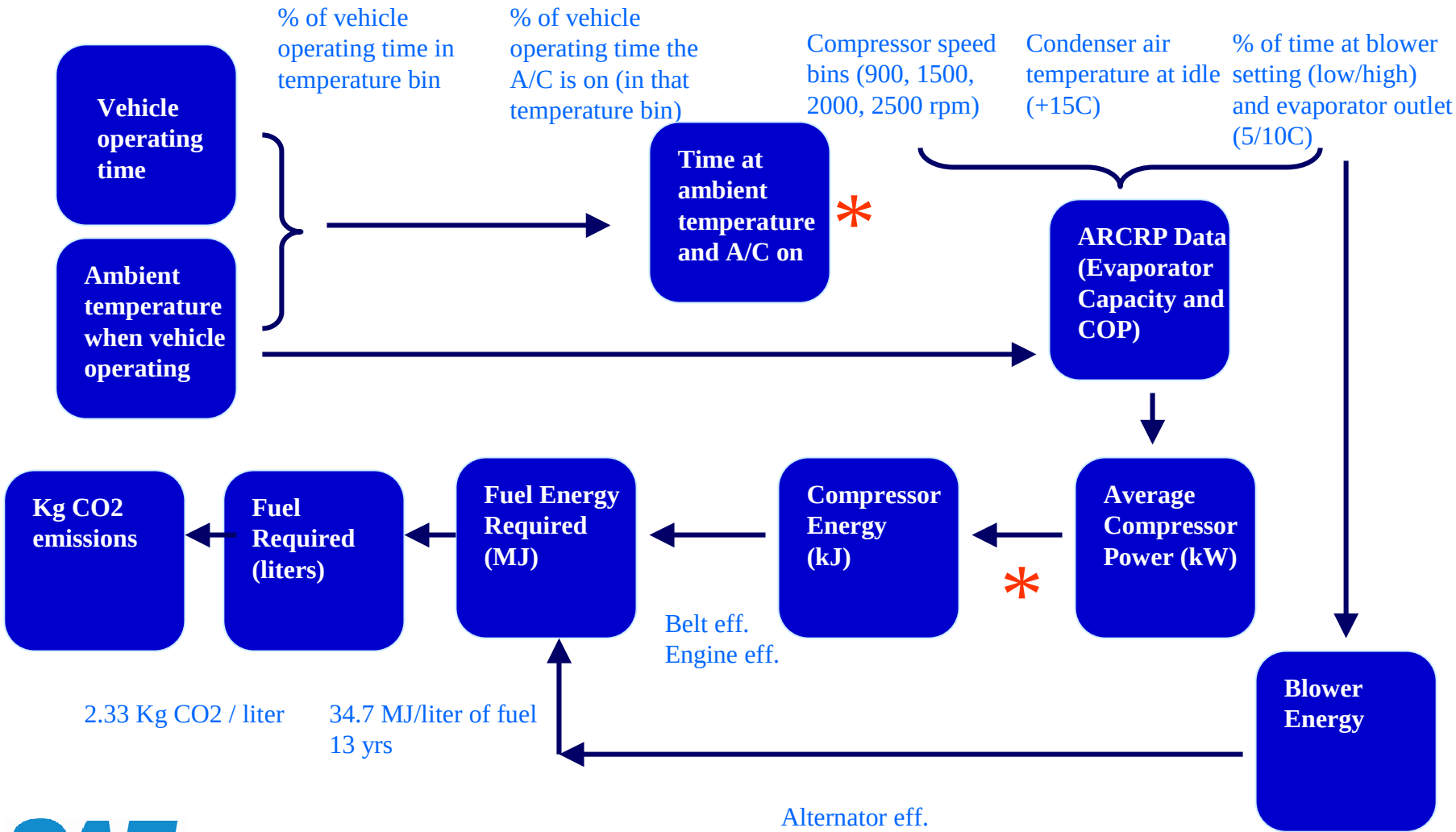




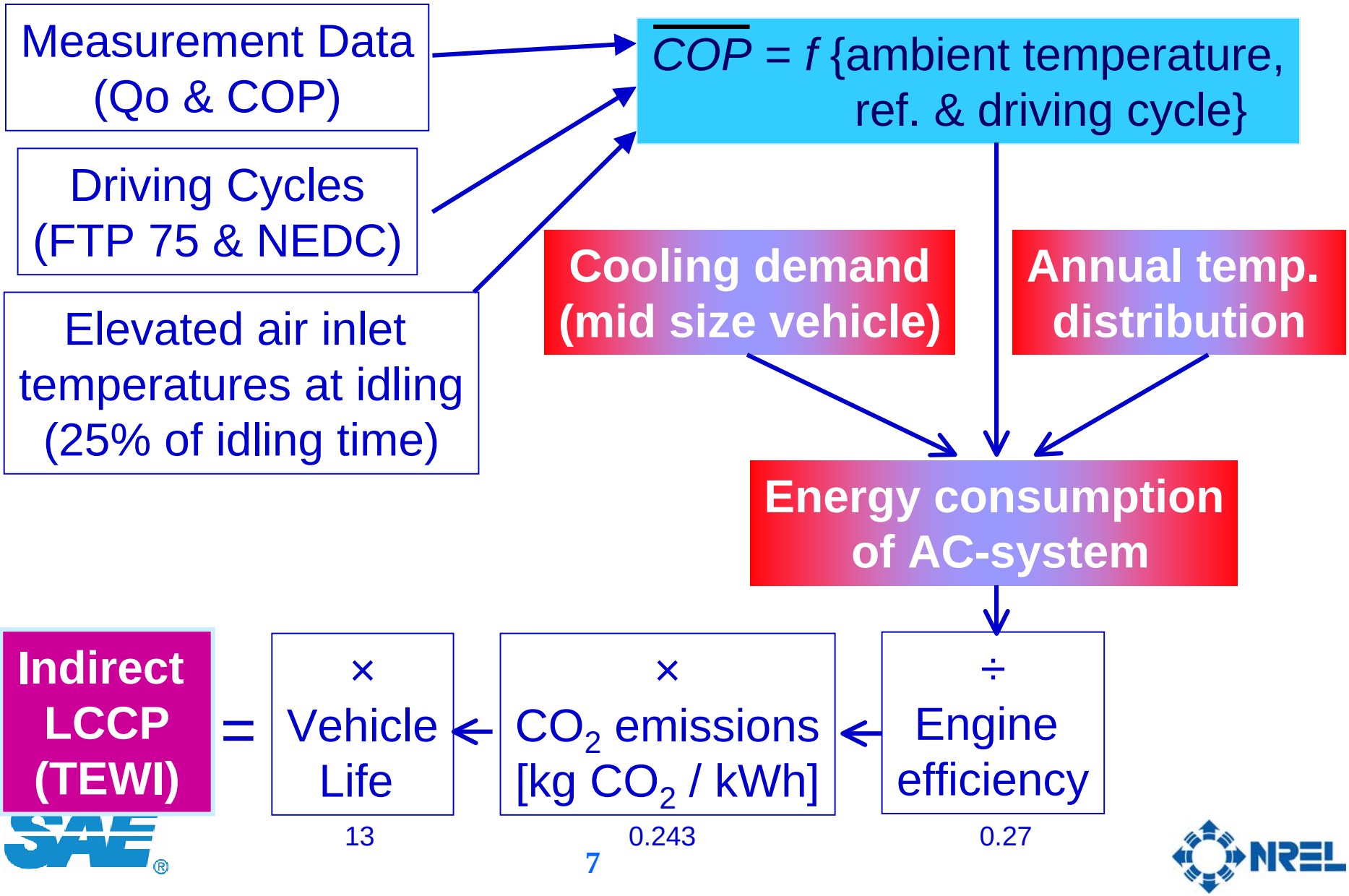
Direct Emission Calculation

- Regular (e.g. seal & hose leakage)
- Irregular (e.g. accident)
- Service
- End-of-life
- Refrigerant manufacturing

GM Indirect Analysis Flow Chart



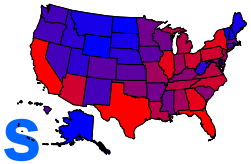
SINTEF Indirect Analysis Flow Chart

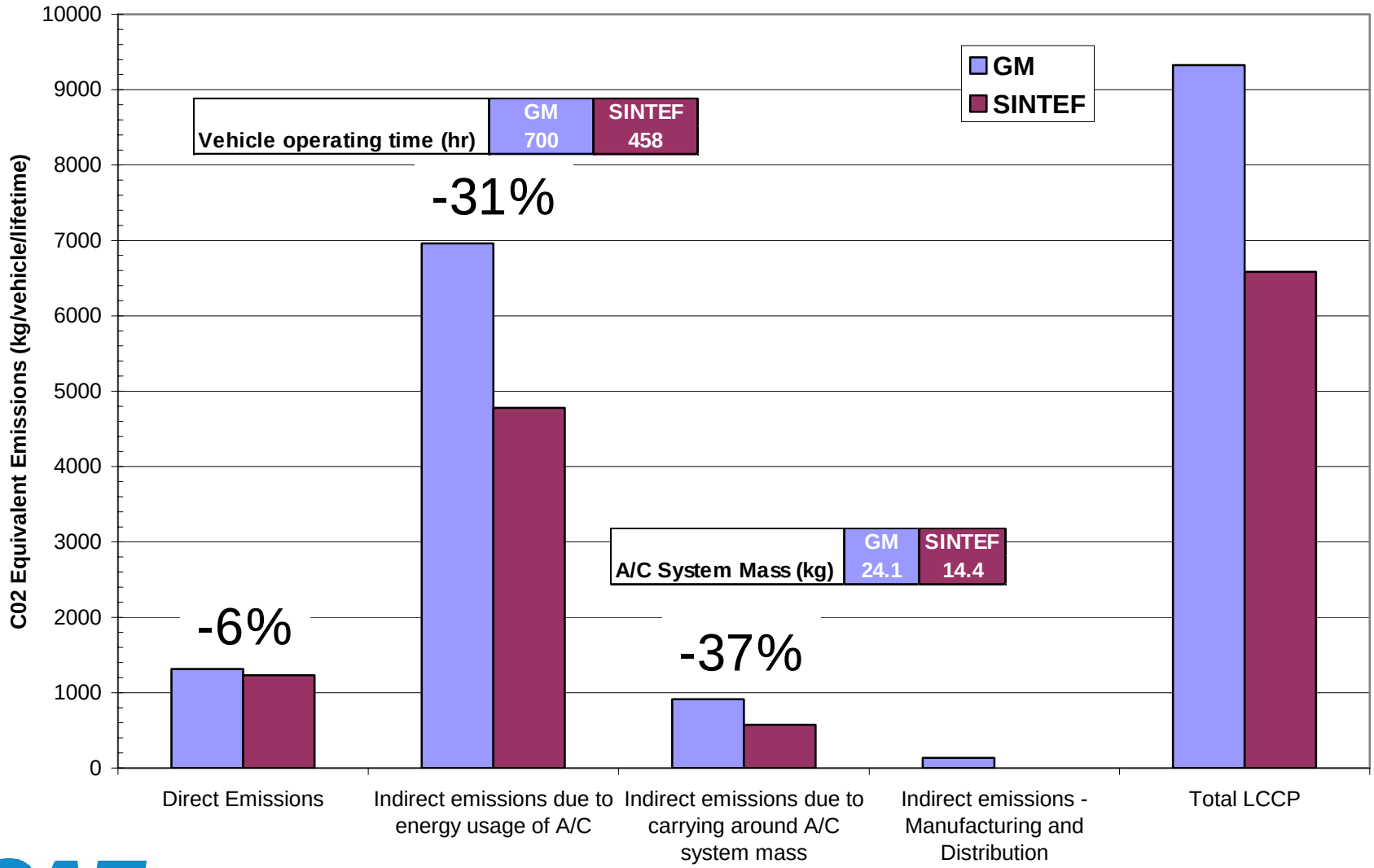


Cases compared

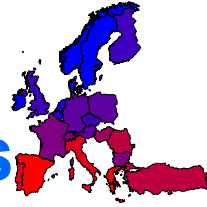
- A/C systems
  - Enhanced R134a SAE ARCRP 2002
  - Enhanced R744 Pilot Project SAE ARCRP 2002
- Environment
  - Phoenix
  - Germany

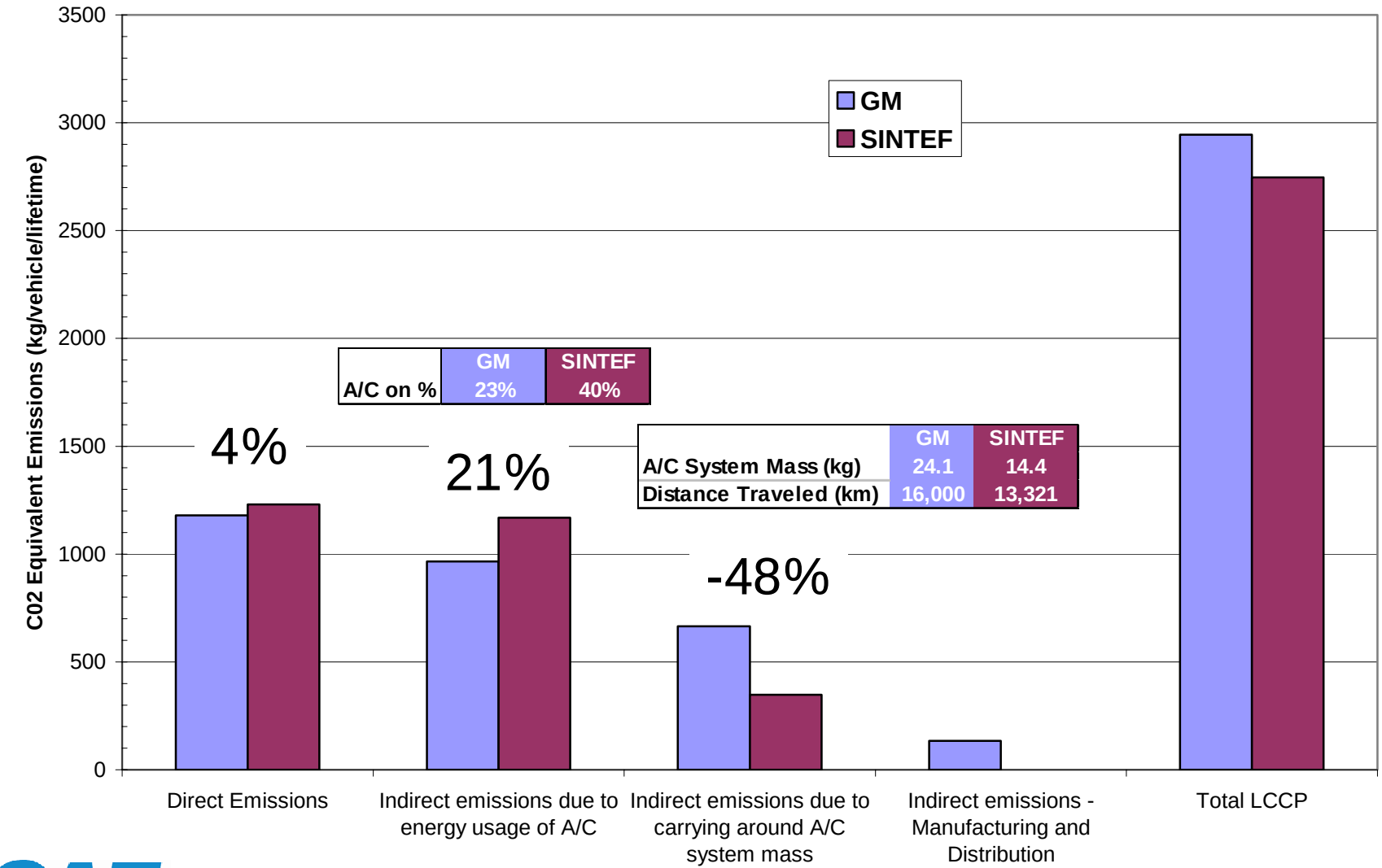
Phoenix, R134a, CO2 Equivalent Emissions



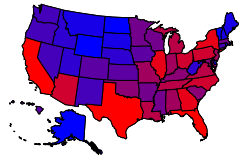


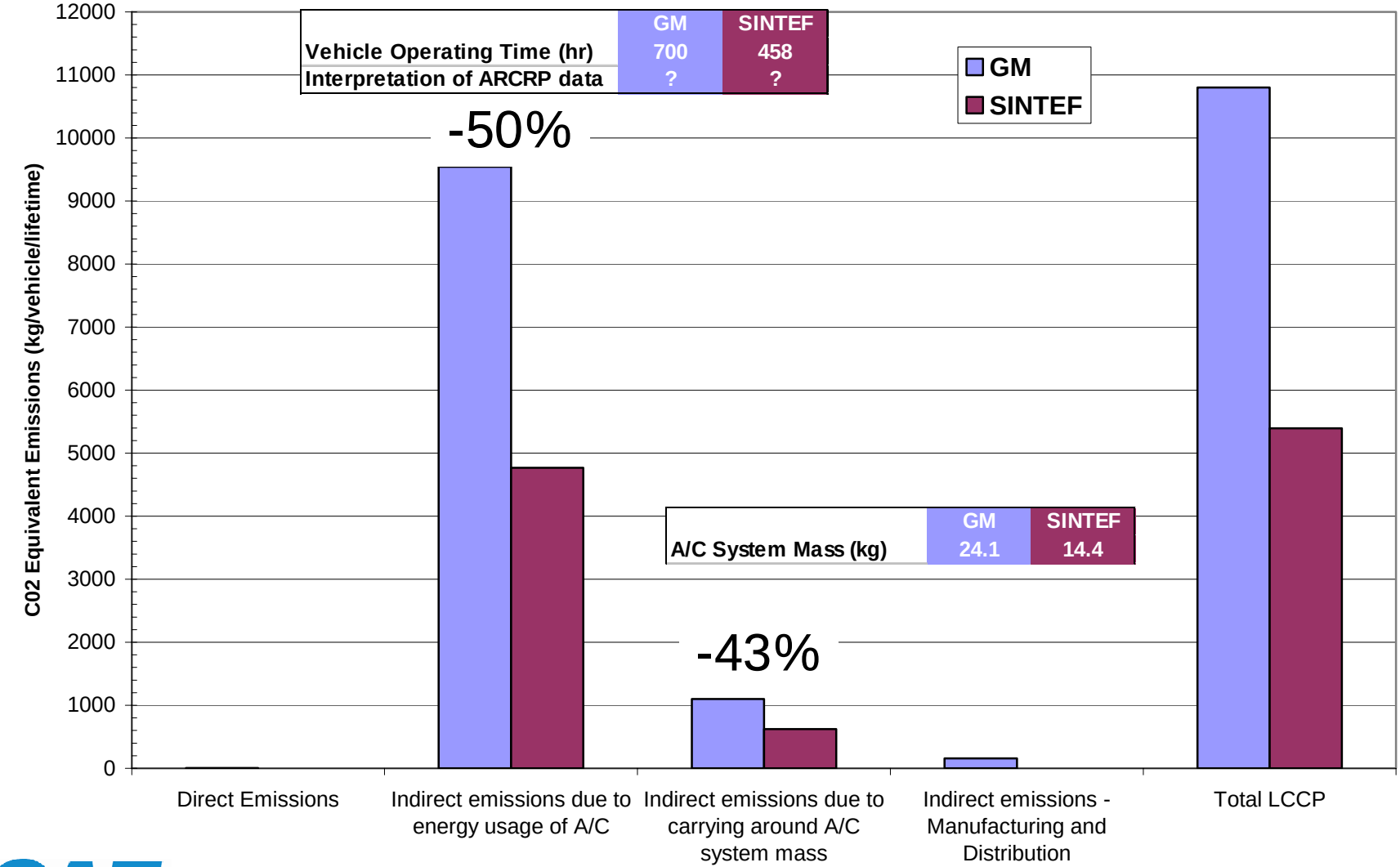
Germany, R134a, CO2 Equivalent Emissions



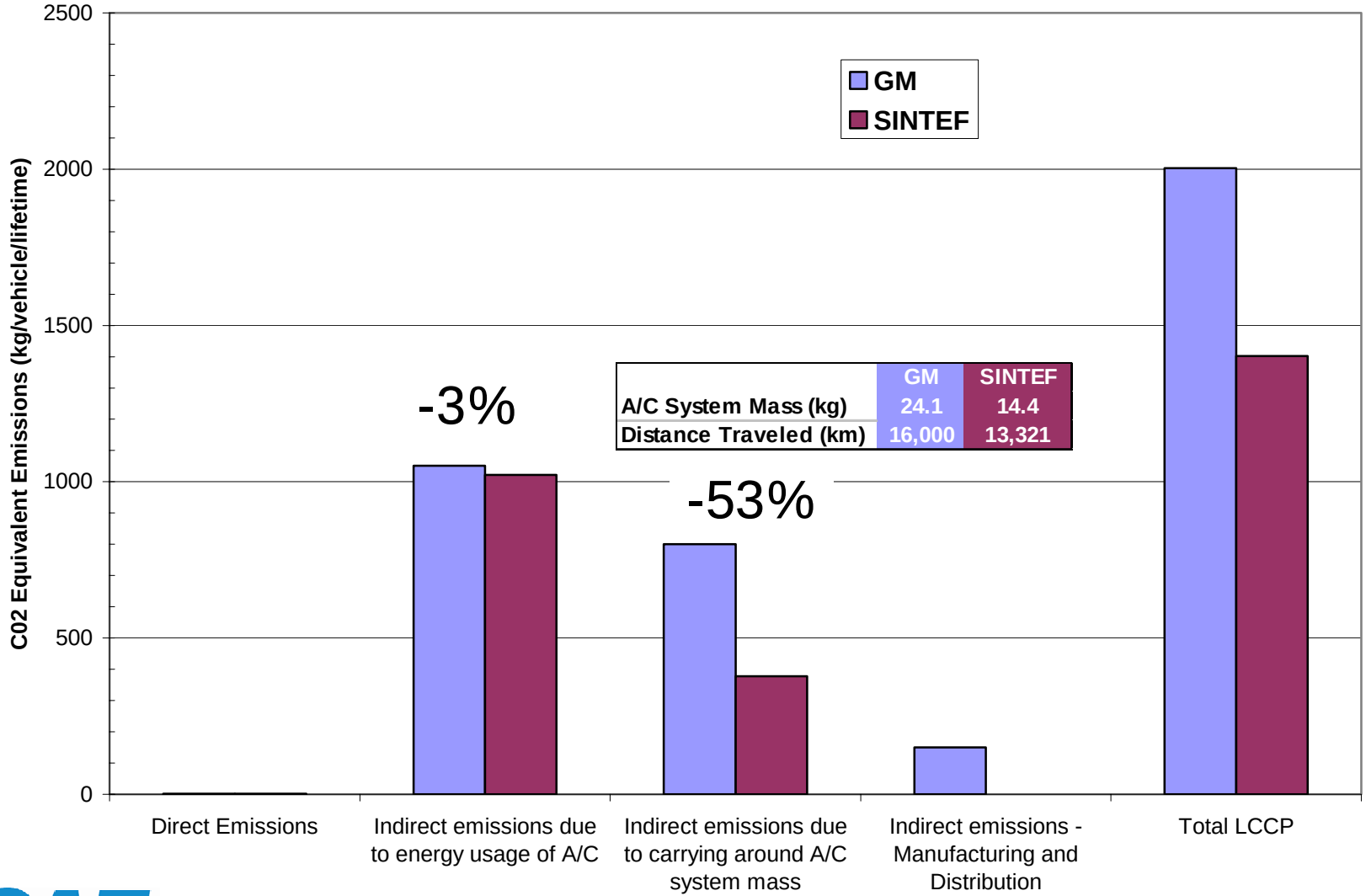


Phoenix, R744, CO2 Equivalent Emissions

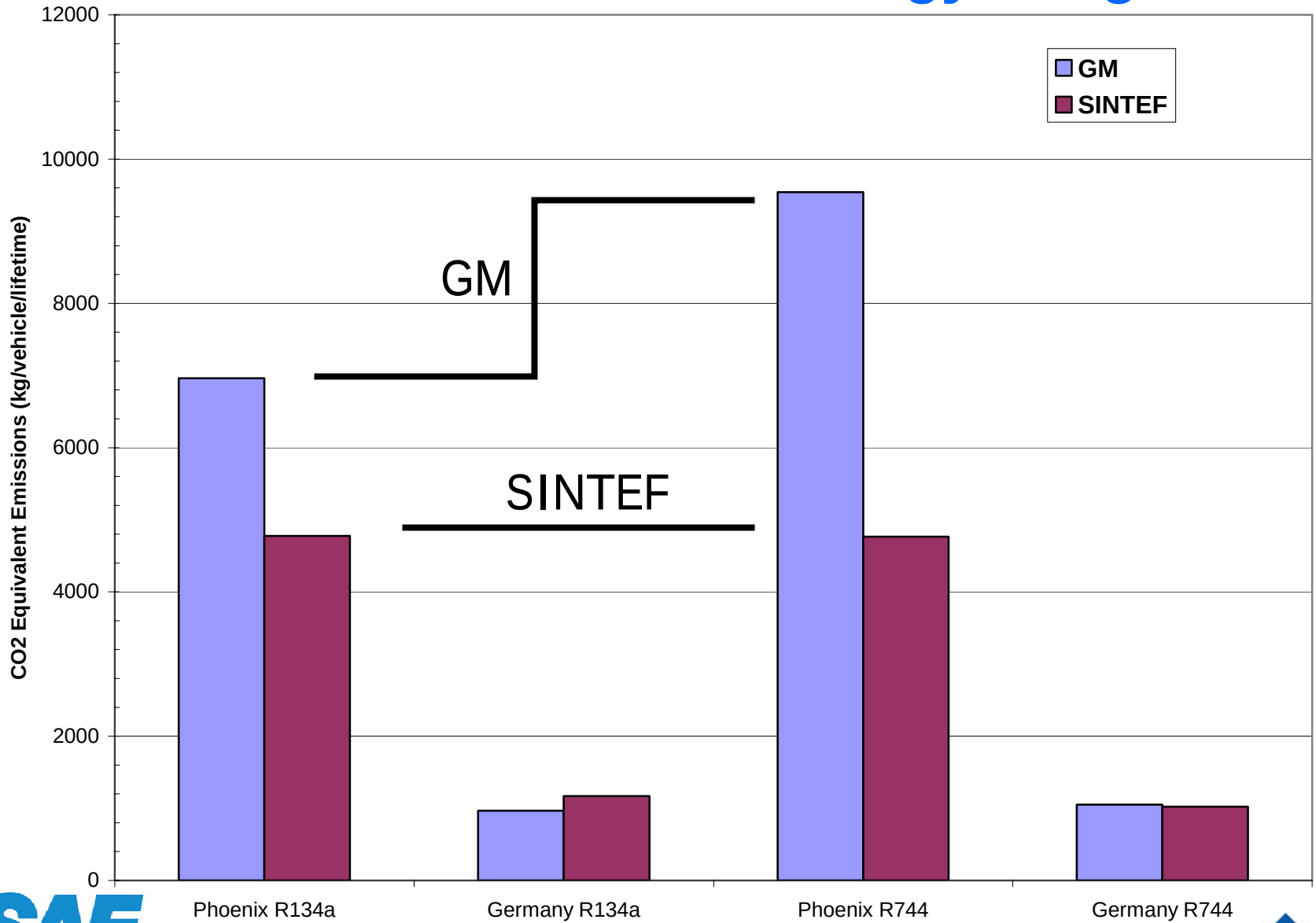




Germany, R744, CO2 Equivalent Emissions



Indirect Emissions due to Energy Usage of A/C

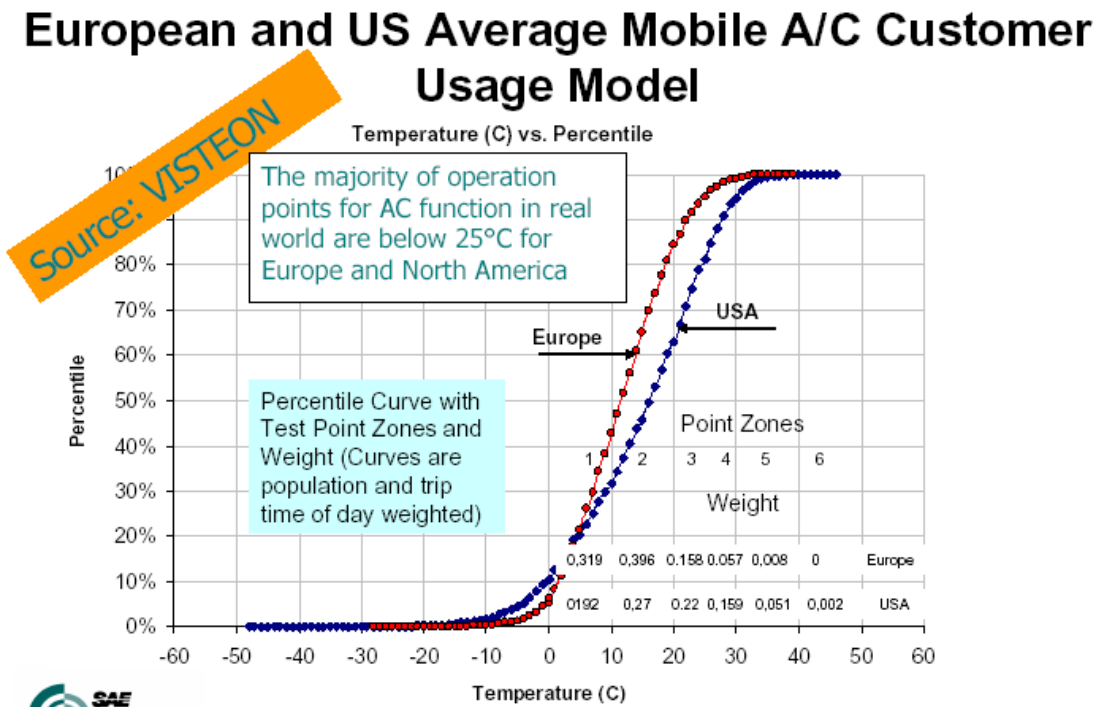


Major Differences

- Interpretation of Visteon “S” Curve
- R744 in Phoenix, use of ARCRP data
- Method of determining capacity
- Vehicle operation time
- Vehicle distance traveled
- Vehicle speed
- A/C system mass
- Demist
- Blower power
- Engine parameters

Interpretation of the “Visteon S Curve”

GM	SINTEF
% of vehicle operation time the ambient temperature is below x°C	% of time the A/C is on if the ambient temperature is x°C
Ambient temperature bin distribution from Visteon	Ambient temperature bin distribution from Oak Ridge data



Details on Assumptions

	Phoenix		Germany	
	GM	SINTEF	GM	SINTEF
Hours of vehicle operation (hr/yr)	700	458	509	521
A/C usage for demist included?	yes, adjusted NREL % A/C on data	yes, assumed included in Visteon S curve		
Condenser air temperature assumption at idle	Tamb+15C	75% Tamb, 25% Tamb + 15C		
Average speed (kph)	39	48	58	26
A/C system total mass-R134a (kg)	24.1	14.4		
A/C system total mass-R744 (kg)	29.0	16.0		
Distance traveled (km)	22,000	22,000	16,000	13,321
Engine efficiency	0.32	0.27		
Compressor rpm/engine rpm	1.3	1.5		
Yearly average % of time A/C on	61%	68%	23%	40%
Blower power	included	not included		

= assumption same as Phoenix

Conclusions

- Majority of difference can be explained by variation of assumptions
  - Distance traveled
  - Hours of vehicle operation
  - A/C system mass
- Additional communication between LCCP experts necessary before common MAC LCCP analysis approach defined
  - A/C on time
  - Power required for R744 system in Phoenix
  - Method for determining capacity
- The next step?

Thank you!

John Rugh (john_rugh@nrel.gov)
(303) 275-4413

Acknowledgement:

Bill Hill (william.hill@gm.com)
Stella Papasavva (stella.papasavva@gm.com)
Armin Hafner (Armin.Hafner@sintef.no)