



# **Open Issues and New Development Trends for MACs**

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**OBRIST**  
— ENGINEERING —

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California Environmental Protection Agency

 **Air Resources Board**



# State of the Art R134a

- **R134a: 0 ODP and GWP 1410**

## **Development status**

**Reduced leakage during operation (D. Clodic /Torino)**

**Alternate Refrigerant Corporate Research Program**

**has shown that R134a systems can be improved**

**I-MAC 30/50 Great Job thanks to the US EPA**

**Important steps towards lower  
overall emissions**





# State of the Art R134a

## ➤ R134a: 0 ODP and GWP 1410

### Open issues

600million vehicle fleet is increasing

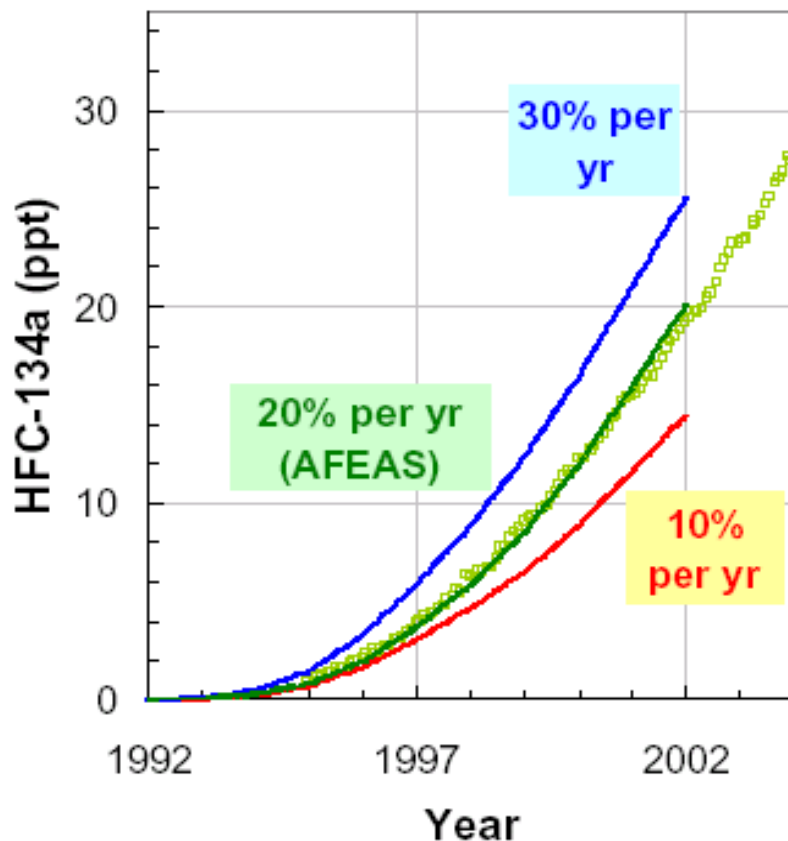
20% of the total R134a production in the atmosphere

How much of the R134a refrigerant will and can be recycled

**Leakage reduction at any stage is needed  
until a sustainable solution  
has made its way on a global basis**



# HFC-134a Refrigerant Emissions



Points are global mean measurements

Comparison of calculated atmospheric concentrations to measured concentrations shows that about **20% of refrigerant in equipment is emitted to atmosphere each year**

Information from:

**Stephen Montzka**

NOAA – CMDL, Boulder, CO USA



# Non Natural Alternatives

## ➤ R152a: GWP 122

Not a strong trend in the market

Possible main reasons for a weak position

No support from the refrigerant makers

Flammability and lethal byproduct (HF)

Complexity of secondary loop systems

**Fulfils the MAC Directive  
but will not fly**





# Non Natural Alternatives

## ➤ R????

Du Pont and Honeywell have made announcements claiming the development of more sustainable refrigerant solutions.

**The F-Gas Regulation and the MAC Directive  
do already show a positive impact  
in making the refrigerant market leaders react**





# Non Natural Alternatives

## ➤ R ?????

Requirements on a new refrigerant:

Zero ODP and Low GWP

Pressure drop, Performance and COP

Stability & Miscibility

Acceptable flammability

Acceptable toxicity before and after decomposition

Cost

Heating capability

Kyoto Protocol basket?

Acceptable to worldwide existing regulations regarding chemicals





# Non Natural Alternatives

- A look back
  - CFCs like R12: Ozone Depletion (& Global Warming)
  - HFCs like R134a: Global Warming
- However it took us a long time to understand the impact of Ozone Depletion and Global Warming
- If such a solution is chosen then let's hope that we understand possible new impacts early enough
- However competition is good for all us





# The Flammable Natural Alternatives

- R600(a): ODP 0 and GWP ~20
- R290: ODP 0 and GWP ~20

Some documented MAC use in Australia

Possible main reasons for weak position

Flammability / Pending court rulings

Complexity of secondary loop systems

**Environment friendly alternatives are  
out there but safety is major issue**





# The Natural Alternative R744

- R744: Zero ODP and a GWP of 1

## Development Status

Great progress since 1989 when R744 was reinvented

Significant lower direct emissions

Significant lower indirect emissions in the most relevant temperature range between 20 and 30 degC

Higher performance density leads to lower weight and reduced packaging space

Heating option



# Phase II Simulation results for energy

Vehicle	Mid – size	Full Size
Drive cycle	NEDC	US FTP 75
Cycle duration	1180 sec.	2138
System Demand	Energy/ cycle [kJ]	Energy/ cycle [kJ]
R 134a	Base	Base
R 152a	-3%	-7%
R 744*	-11%	-9%
*Optimized Refrigerant Controls		

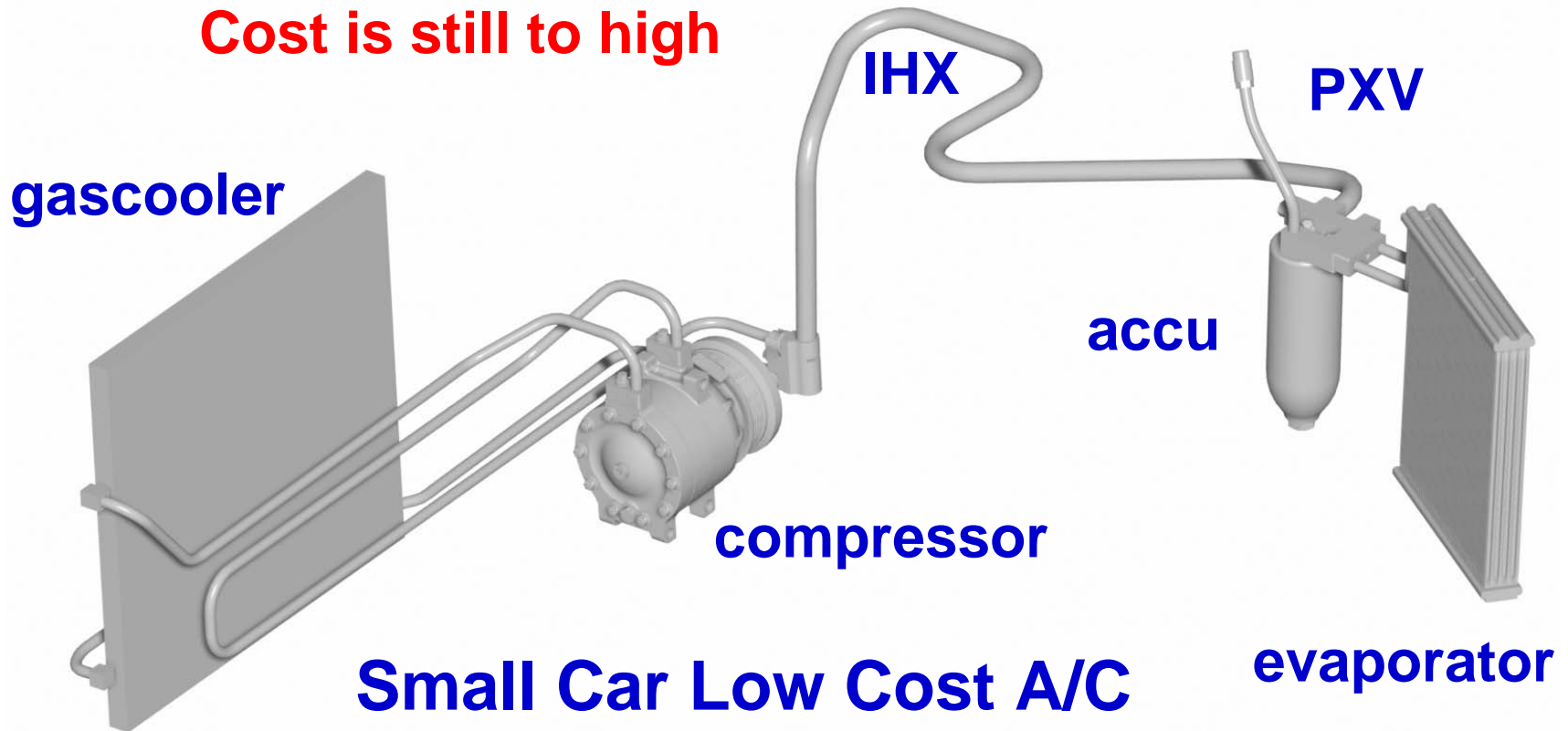
Based on analysis of the accuracy and repeatability of the data, it is estimated that these values are within +/- 6%.



# The Natural Alternative R744

- R744: Zero ODP and a GWP of 1
- Open Issues

**Cost is still to high**



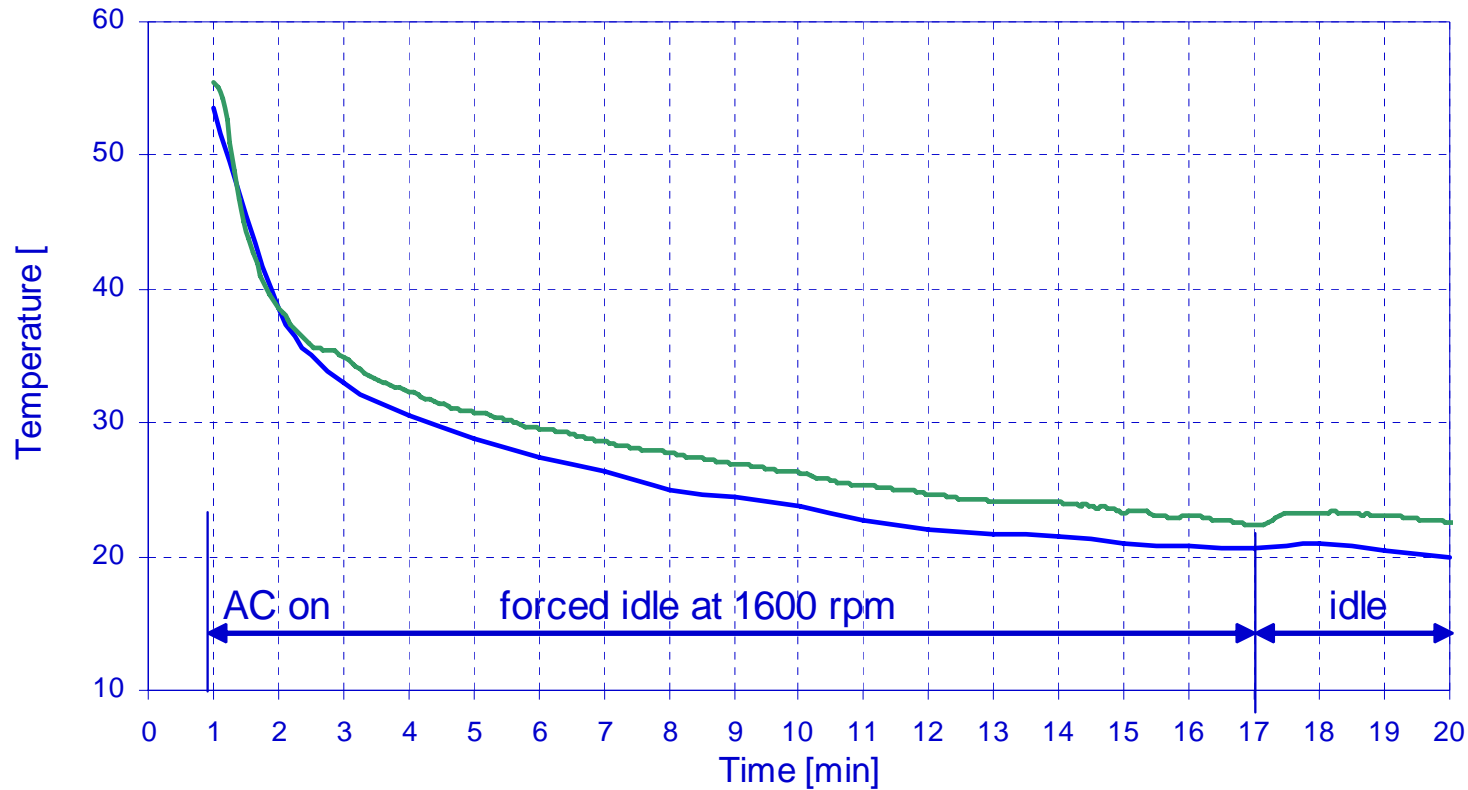


# The Natural Alternative R744

## AC Pull Down, Head Temperature; Small Car

20.02.2004\_1 ; t<sub>amb</sub>= ca 35°C; A/C Measurement

R744 vs R134a Recirc Air, Blower max



— R744

— R134a





# The Natural Alternative R744

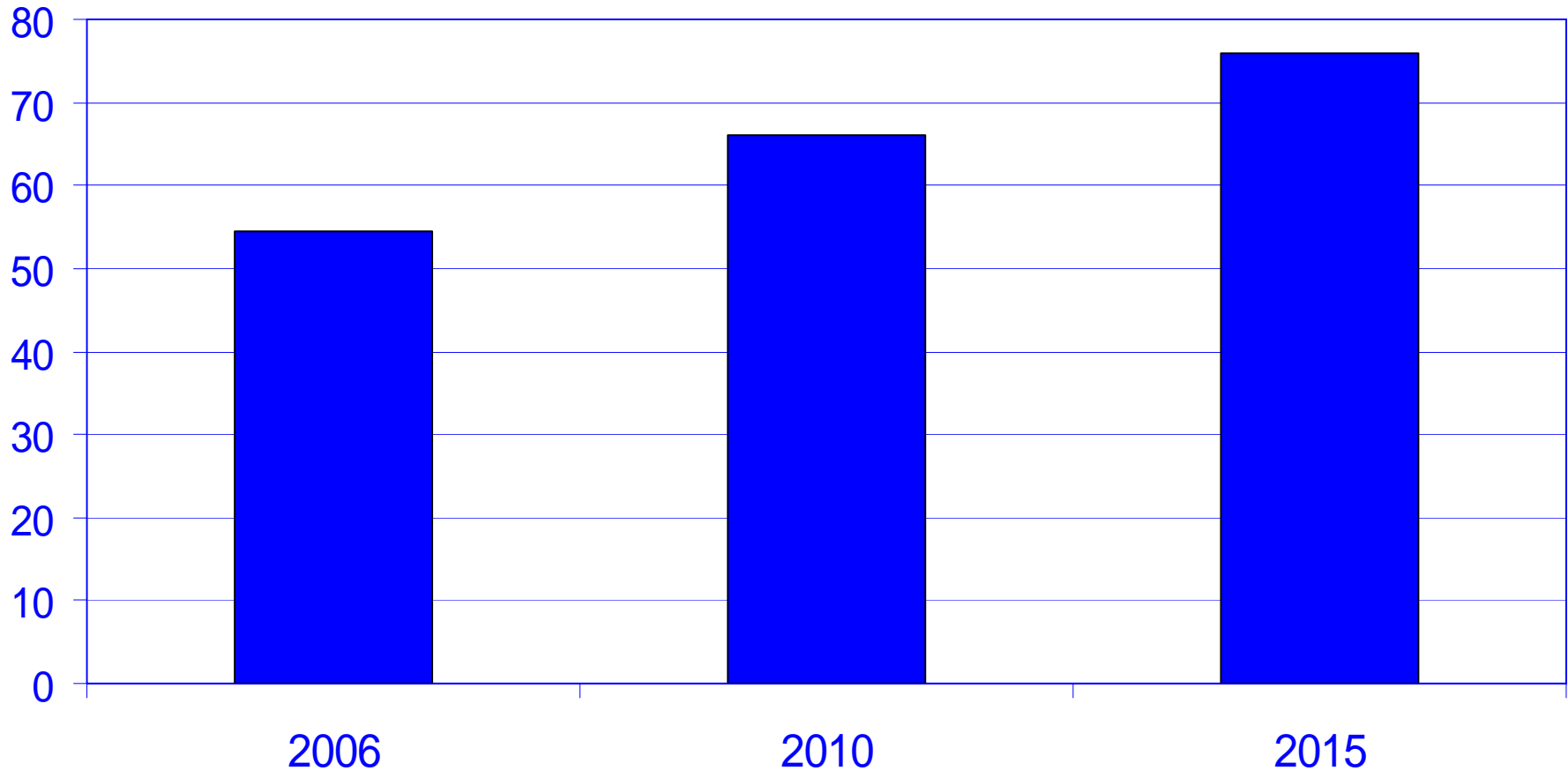
- R744: Zero ODP and a GWP of 1
  - Open Issues
    - Full scale mass production maturity
  
- 11 Co-operation with OEMs, Tier one's, and Tier two's for
  - Joint Patents
  - Licenses
  - Know how transfer
  - Joint development
  - Specifications
  
- Developments for the EU and the Global market





# World MAC System Production Forecast

in Million vehicles





## Ramp up of R744

- Intended SOPs by more than 3 market players in 2008 with an estimated volume of 100kMACs
- Gradual ramp up to 2011 to an estimated 2300kMACs
- By 2015/6 we think the EU market will be fully converted
- The decision to go global depends on further development achievements and manufactures strategy
- Further incentives or legislation by players outside the EU may accelerate the process





## The Natural Alternative R744 COP

- R744: Zero ODP and a GWP of 1

Future potential

New system layouts will lead to a further improved COP also at high ambient temperatures

Ejector system development

New system layout

Development target >30% COP @ 45degC

**The race for fuel efficiency has just started**





# Summary

**As long as R134a is still in the market the joint community should make sure that leakage is low and that recycling works.**

**A new refrigerant is a good opportunity and will at least help to keep the pace in the search of alternative solutions.**

**R744 is the most mature and therefore promising option out there.**



# Thanks to all of you



**RENAULT**

DAIMLERCHRYSLER

**DENSO**

**Valeo**



**BEHR**



**DELPHI**  
Driving Tomorrow's Technology

**DOOWON**



**HCC** Halla Climate Control Corp.



**BOSCH**

**LIEBHERR**



**KATECH**  
KOREA AUTOMOTIVE TECHNOLOGY INSTITUTE

California Environmental Protection Agency

 **Air Resources Board**