Improved Mobile Air Conditioning Systems: Part of the Solution to Climate Change

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Air Resources Board
Presentation Overview

- California’s GHG regulation
- Why MACS are Important
- MACS – a Global Perspective
- Opportunities for Reductions
- Conclusion
“What about the state law that requires all automakers to further reduce the emissions of greenhouse gases from new cars in California by 2009? Do you support or oppose this law?”

2004: 81% support
2003: 80% support
2002: 81% support
Greenhouse Gas Vehicle Emission Regulation

- Mandated by California Assembly Bill 1493
- Calls for maximum feasible & cost-effective GHG emission reductions
- Affects new 2009 & later model year light-duty motor vehicles (<8,500 lbs GVW)
- Credit for early automaker action
- Approved in September 2004
- Reviewed by California Legislature
- Text of regulation at www.arb.ca.gov/cc/cc.htm
Regulations Shall Not Require...

• Fees or taxes on vehicle, fuel or VMT
• Ban on sale of any vehicle category
• Reduction in vehicle weight
• Limitation on or reduction of speed limit
• Limitation on or reduction of VMT
Regulated Pollutants and Sources

• Standard applies to:
  – Combined GHG emissions
    \(\text{CO}_2, \text{CH}_4, \text{N}_2\text{O}, \text{HFCs}, \ldots\)
  – All vehicular GHG sources
    (tailpipe, air conditioner)

• Standard expressed as “\(\text{CO}_2\)-equivalent”
  – Emissions weighted according to
    “global warming potential”
Seventy nine technology packages modeled over five vehicle classes
- Small car, large car, minivan, small truck/SUV, and large truck/SUV

Technology packages designated as near-, mid-, and long-term according to potential for high production volume
- Near-term available for 2009-2012 phase-in
- Mid-term available for 2013-2016 phase-in
Two Emission Categories (as in California’s LEV II)

Fleet Average CO₂-Equivalent Emissions Standards

Baseline

Standards begin in 2009

LDT2 – Large trucks and SUVs
25% reduction

PC/LDT1 – Passenger cars, small trucks and small SUVs
34% reduction

Model Year

Effect on New Vehicles

• Average cost increase - Near-Term
  – passenger cars and small trucks/SUVs, about $367 in 2012
  – large trucks/SUVs, about $277 in 2012

• Average cost increase - Mid-Term
  – passenger cars and small trucks/SUVs, about $1064 in 2016+
  – large trucks/SUVs about $1029 in 2016+
## Net Savings for Consumer (PC/LDT1)

<table>
<thead>
<tr>
<th></th>
<th>Near Term (2012)</th>
<th>Mid Term (2016)</th>
</tr>
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<tbody>
<tr>
<td>Monthly Payment Increase</td>
<td>$7</td>
<td>$20</td>
</tr>
<tr>
<td>Monthly Operating Cost Savings</td>
<td>$18</td>
<td>$23</td>
</tr>
<tr>
<td>Monthly Net Savings</td>
<td>$11</td>
<td>$3</td>
</tr>
</tbody>
</table>
Economic Impacts

• More jobs (+53,000 in 2020)
• Higher personal income (+$4.8 billion)
• Increase in number of businesses
• Positive effect on minority and low income communities
• Minor effect on growth in vehicle sales
  – Slight increase for near term standards
  – Slight decrease for mid term standards
Clear Public Support for Action

California Leads on Warming

San Francisco Chronicle
A new standard for cleaner air

New air rules could lead to better efforts to curb global warming.

California again serves as a national model.

Much of Coastal U.S. May Follow California on Car Emissions

THE NEW YORK TIMES, FRIDAY, JUNE 11, 2004
Regulation Reduces Climate Change Emissions

![Graph showing the reduction in CO2 emissions due to a regulation. The graph compares Light Duty Vehicle CO2 Equivalent Tons Per Day with and without regulation. The percentage reductions are -18% and -27% by 2035.]
Why are MACS Important?

- Most vehicles equipped with air conditioning
- Direct emissions of refrigerant HFC-134a (GWP = 1300)
- Indirect emission of CO$_2$ and other pollutants due to operation
- Cost-effective emission reductions available
The Need for MAC Improvement is Clear

Ambient R-134a Concentrations

Phase in

Source: National Oceanic and Atmospheric Administration
MAC Emissions

Direct emissions - refrigerant released through leakage, accidental breach of containment, service events, & dismantling

Indirect emissions - CO$_2$ emissions from MACS operation
Lifetime Emission Model

\[ LE = C \times (1 - g + N\times f) \]

- \( C \) -- capacity (kg)
- “1” -- initial charge
- \( g \) -- fraction of charge recovered at scrapping
- \( N \) -- number of recharges
- \( f \) -- fraction of capacity recharged
Comparisons

<table>
<thead>
<tr>
<th>Loss, grams/yr</th>
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<tbody>
<tr>
<td>Measured leak rates* (Ford)</td>
</tr>
<tr>
<td>Long-term loss (Öko-Recherche)^</td>
</tr>
<tr>
<td>Tunnel study (Swiss)</td>
</tr>
<tr>
<td>ARB analysis</td>
</tr>
</tbody>
</table>

* vehicles & AC’s not operating
^ early period of vehicle life
Total Lifetime Refrigerant Emissions

- Control of "Regular" (Slow) Leakage
- Sudden ("Irregular") release
- End-of-life release
“Low-Leak MAC System” Component Prescription

• All pipe & hose connections equipped with multiple O-rings, seal washers, or metal gaskets

• Only ultra-low permeability barrier or veneer materials for hoses in contact with refrigerant

• Only multiple-lip compressor shaft seals (with either compressor body O-rings or gaskets)
Criteria for “AC System with Reduced Indirect Emissions”

• Minimizes compressor usage by managing the balance of outside and recirculated air

• Minimizes reheat by using an externally controlled compressor that may be:
  – Variable displacement
  – Variable speed (e.g. - electric motor)
  – Fully cycling fixed displacement

• Utilizes high-efficiency components
No changes to MACs are required by regulation. However, some MAC emission reductions were assumed in establishing emission standards. If MAC emissions are not reduced, additional reductions from other technologies are needed.
Incentive for MAC Improvements (2009)
### Example of MAC Improvements

**Net Savings for Consumer (PC/LDT1)**

<table>
<thead>
<tr>
<th>Monthly Payment Increase</th>
<th>$1.70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly Operating Cost Savings</td>
<td>$2.00</td>
</tr>
<tr>
<td>Monthly Net Savings</td>
<td>$0.30</td>
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*Example based on the following assumptions:
- High efficiency MAC - VDC or FDC/low-leak HFC-152a
- 30% reduction in MAC operating costs (I-MAC)
- Average annual fuel consumption due to MAC use in Ca (34.2 gal/year)
- Fuel cost of $2.30/gallon $2005
- Interest rate of 5%*
MACS: A Global Perspective

• Unprecedented growth of motor vehicles in developing countries
• All equipped with AC
• Following developments in U.S. and EU
Rapid Development of Chinese Automobile Industry

Chinese Automobiles Annual Production Volume

- Total Production Volume of Automobiles
- Production Volume of Passenger Cars

Year

Volume (thousands)

Domestic Sales Trend in India Passenger Cars
(2001-02 to 2009-10)
International Efforts to Reduce MAC Emissions

• US EPA promotes HFC-134a I-MAC 30/50 and demonstrates HFC-152a
• EU proposes to ban HFC-134a from new MACS
• California provides allowances to improved MACS
• Japan and Australia have programs to recover refrigerant at end of life
• India & China following I-MAC 30/50
• Canada establishes voluntary agreement
Opportunities for Further MAC Reductions

• Do it your self repairs
• End of vehicle life
The “12-Oz. Can” Question

• Our result does not reflect:
  – excess emissions from DIY repairs (release of system contents)
  – excess from repeated top-offs w/o leak repairs (R134a & R12 systems)

• Total excess < 50 g/yr/veh (including R134a into R12 vehicles)
Over 70 million automobiles are in use in Japan and 90% of them are equipped with MACs.

~ 4 million automobiles reach end of Life each year.

About 400g refrigerant (CFCs / HFCs) left in an ELV (1.9 million tons CO$_2$-equiv./year).

Require mandatory recovery and destruction of end-of-life fluorocarbons by placing responsibilities on relevant parties.
• MACS are standard equipment on motor vehicles
• Technological, cost-effective options to reduce direct and indirect MAC emissions
• International efforts to reduce MAC emissions
• Opportunities for further reductions (end-of-life, DIY)
Thank You

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