Air Pollution as a Climate Forcing
April 4-6, 2005
Honolulu, Hawaii

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

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California Environmental Protection Agency
Air Resources Board

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Presentation Overview

- California's GHG regulation
- Why MACS are Important
- MACS – a Global Perspective
- Opportunities for Reductions
- Conclusion

Clear Public Support for Action

"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 (CO_2, CH_4, N_2O, HFCs, …)
  - All vehicular GHG sources (tailpipe, air conditioner)
- Standard expressed as "CO_2-equivalent"
  - Emissions weighted according to "global warming potential"

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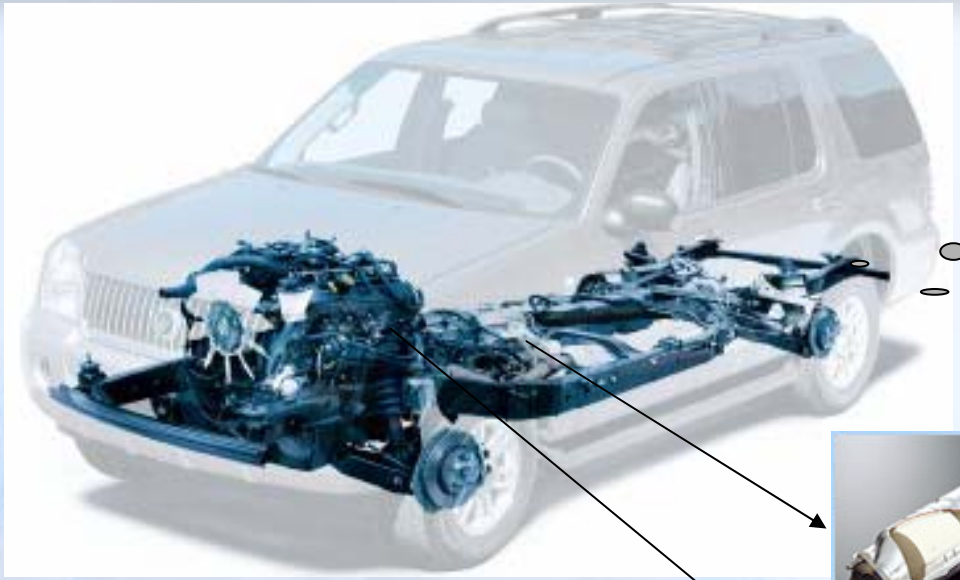
ARB Technical Review



Engine

Transmission

A/C compressor

CO_2

Methane

Nitrous Oxide

Direct Emissions

HFCs

Indirect Emissions

CO_2

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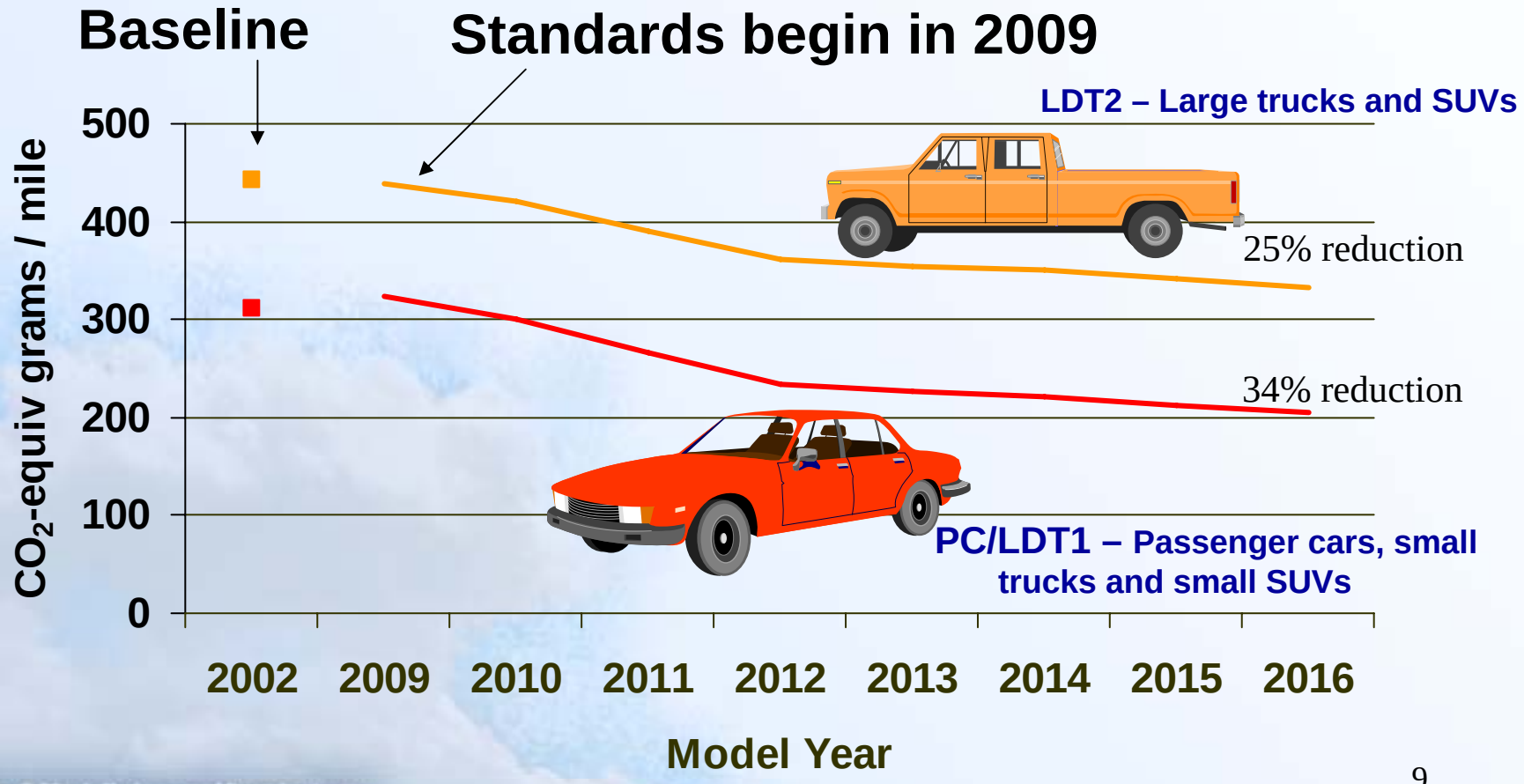
Technology Package Selection

- 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 CO_2-Equivalent Emissions Standards



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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)

	Near Term (2012)	Mid Term (2016)
Monthly Payment Increase	$7	$20
Monthly Operating Cost Savings	$18	$23
Monthly Net Savings	$11	$3

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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

NY Times Editorial
6/15/04 A22

California Leads on Warming

San Francisco Chronicle
THE VOICE OF THE WEST

EDITORIALS

A new standard for cleaner air

THE NEW YORK TIMES, FRIDAY, JUNE 11, 2004

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

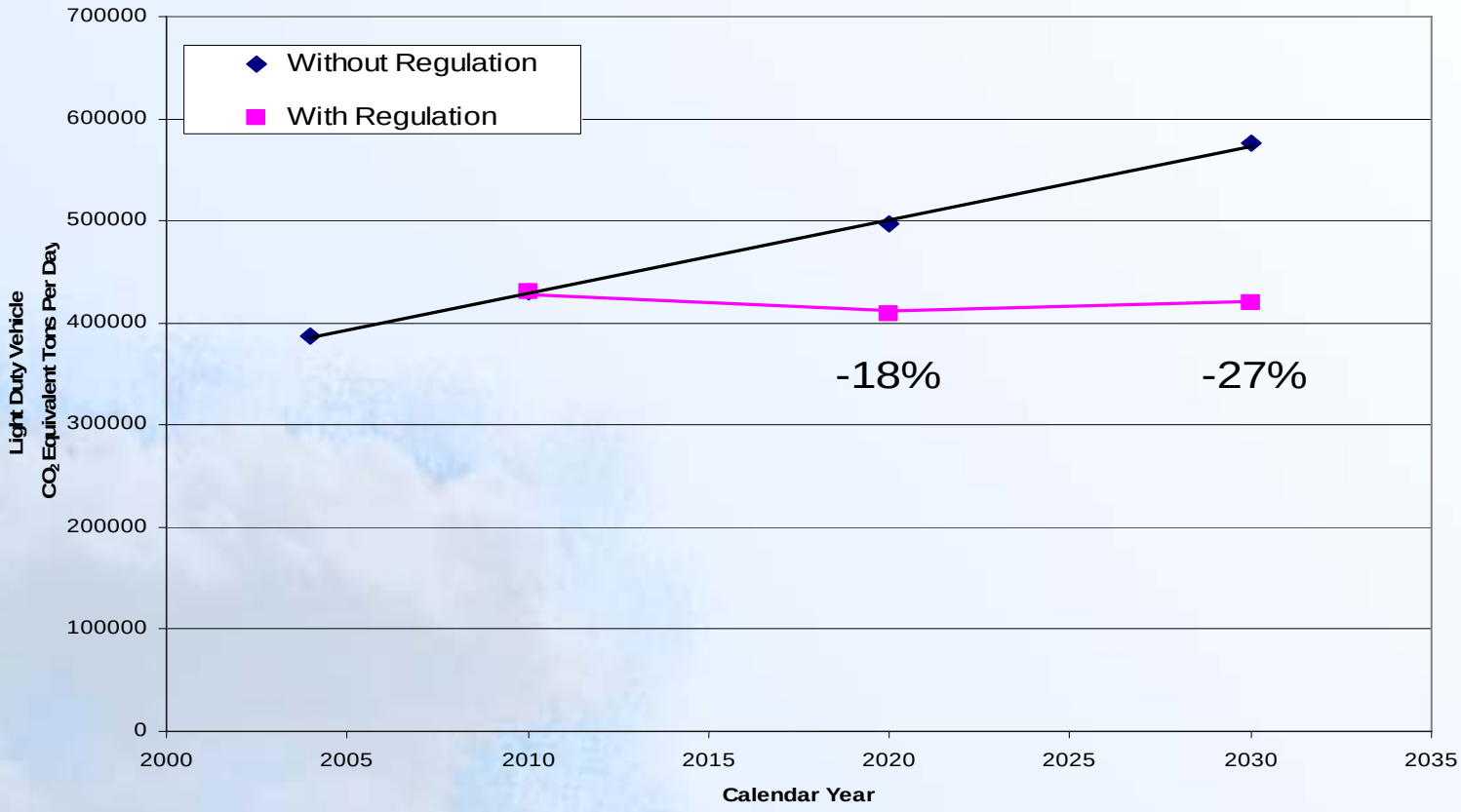
FresnoBee.com

CARB comes through

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

California again serves as a national model.

Regulation Reduces Climate Change Emissions



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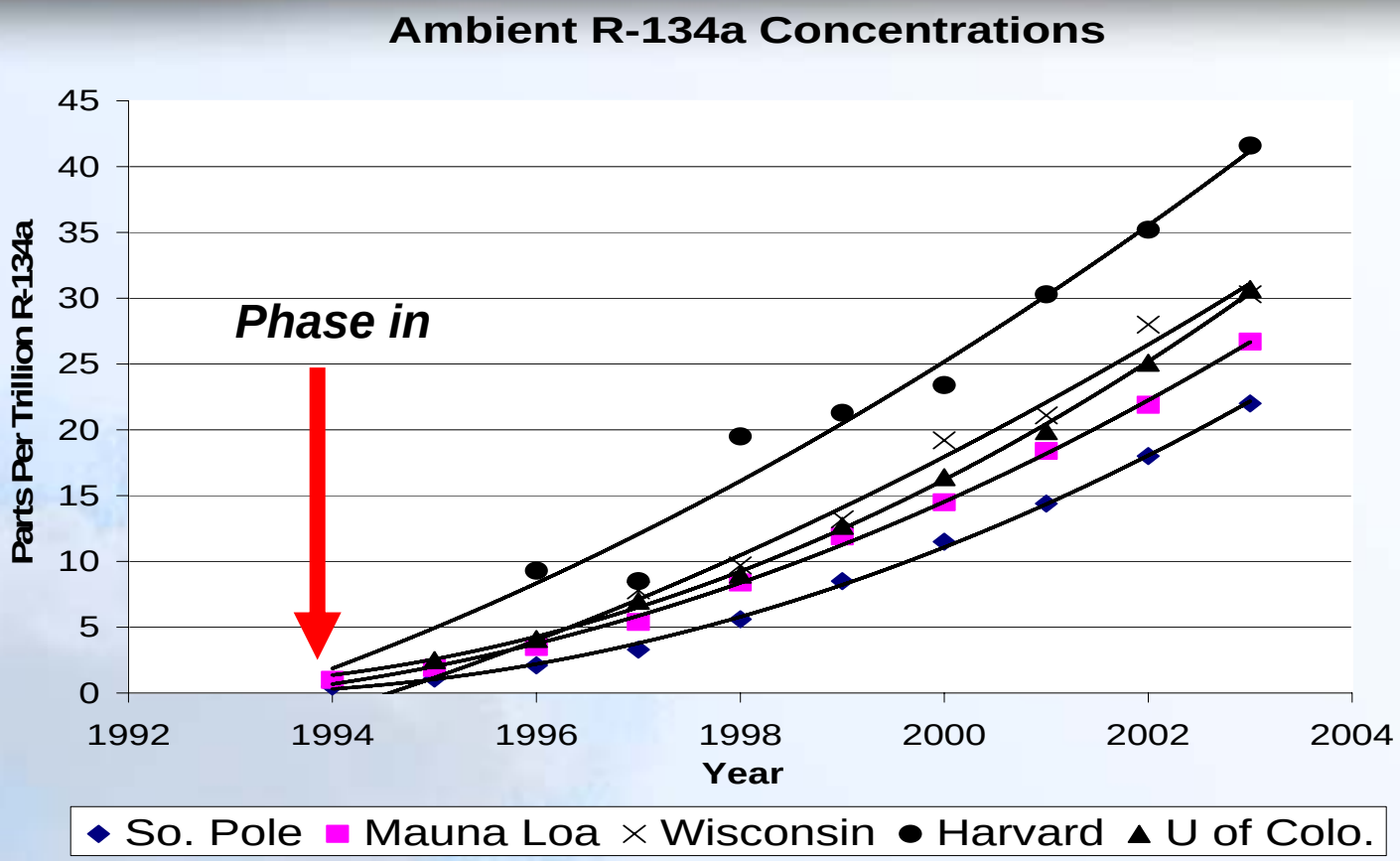
Why are MACS Important?

- 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



***Source*: National Oceanic and Atmospheric Administration**

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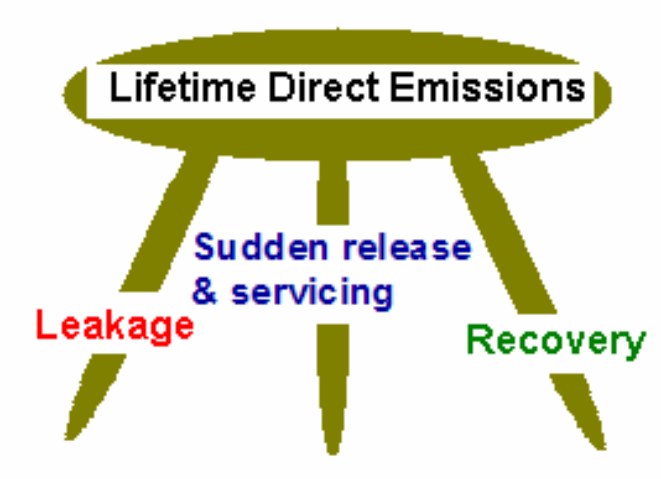
MAC Emissions

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

Indirect emissions - CO_2 emissions from MACS operation



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Lifetime Emission Model

$$LE = C * (1 - g + N*f)$$

C -- capacity (kg)

"1" -- initial charge

g -- fraction of charge recovered at scrapping

N -- number of recharges

f -- fraction of capacity recharged

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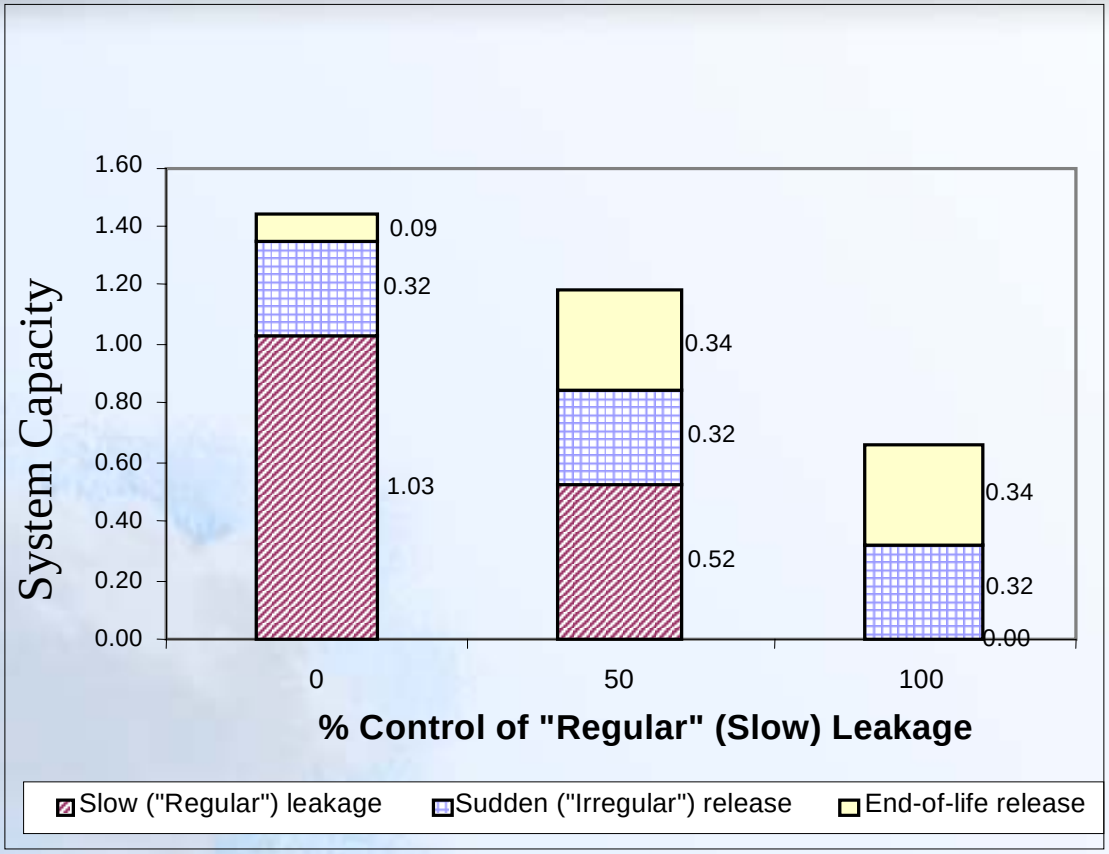
Comparisons

	Loss, grams/yr
Measured leak rates* (Ford)	26
Long-term loss (Öko-Recherche)^	53
Tunnel study (Swiss)	123
- - -

Total Lifetime Refrigerant Emissions



"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

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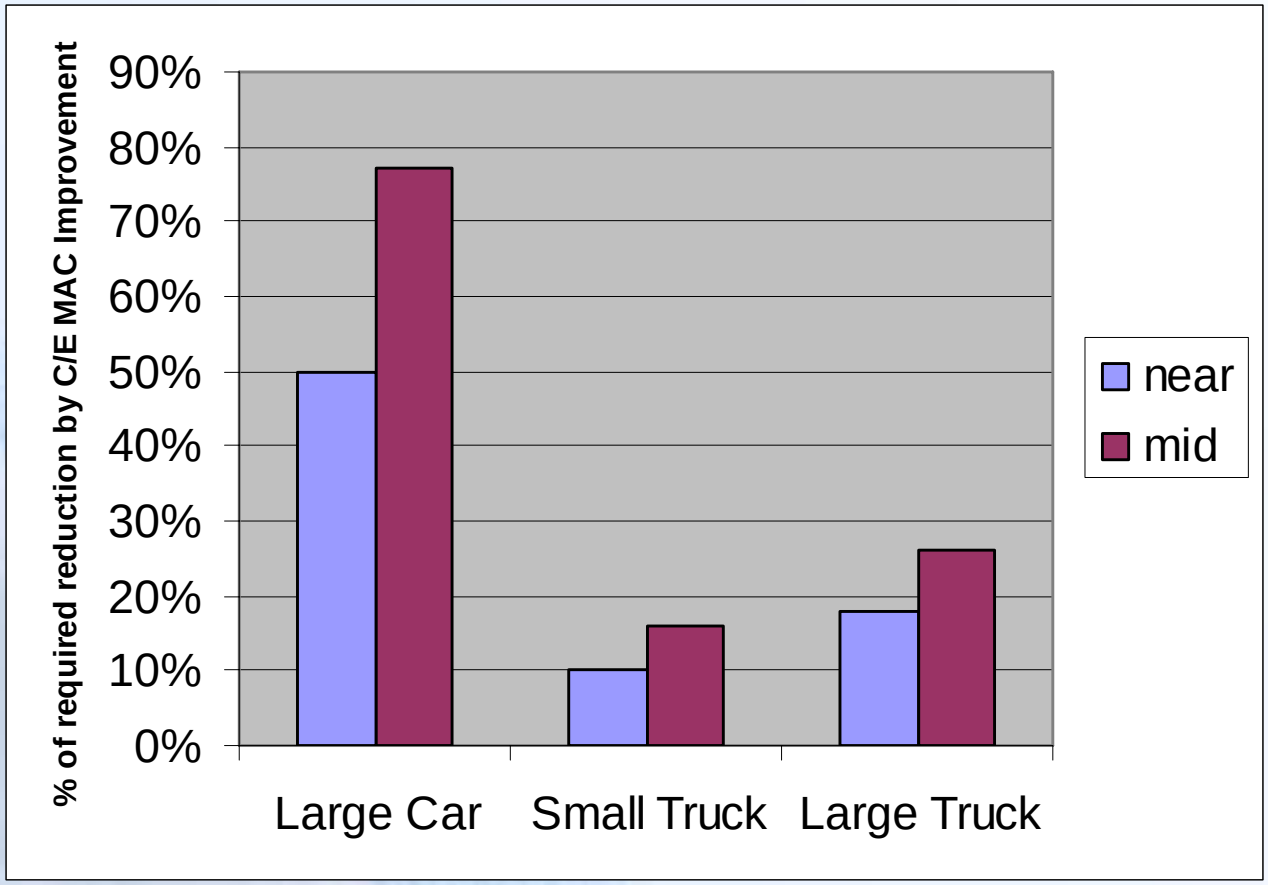
Treatment of MAC Emissions in the Regulation

- 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
  - need additional reductions from other technologies

Incentive for MAC Improvements (2009)



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Example of MAC Improvements Net Savings for Consumer (PC/LDT1)

Monthly Payment Increase	$1.70
Monthly Operating Cost Savings	$2.00
Monthly Net Savings	$0.30

* 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%

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MACS: A Global Perspective

- Unprecedented growth of motor vehicles in developing countries
- All equipped with AC
- Following developments in U.S. and EU

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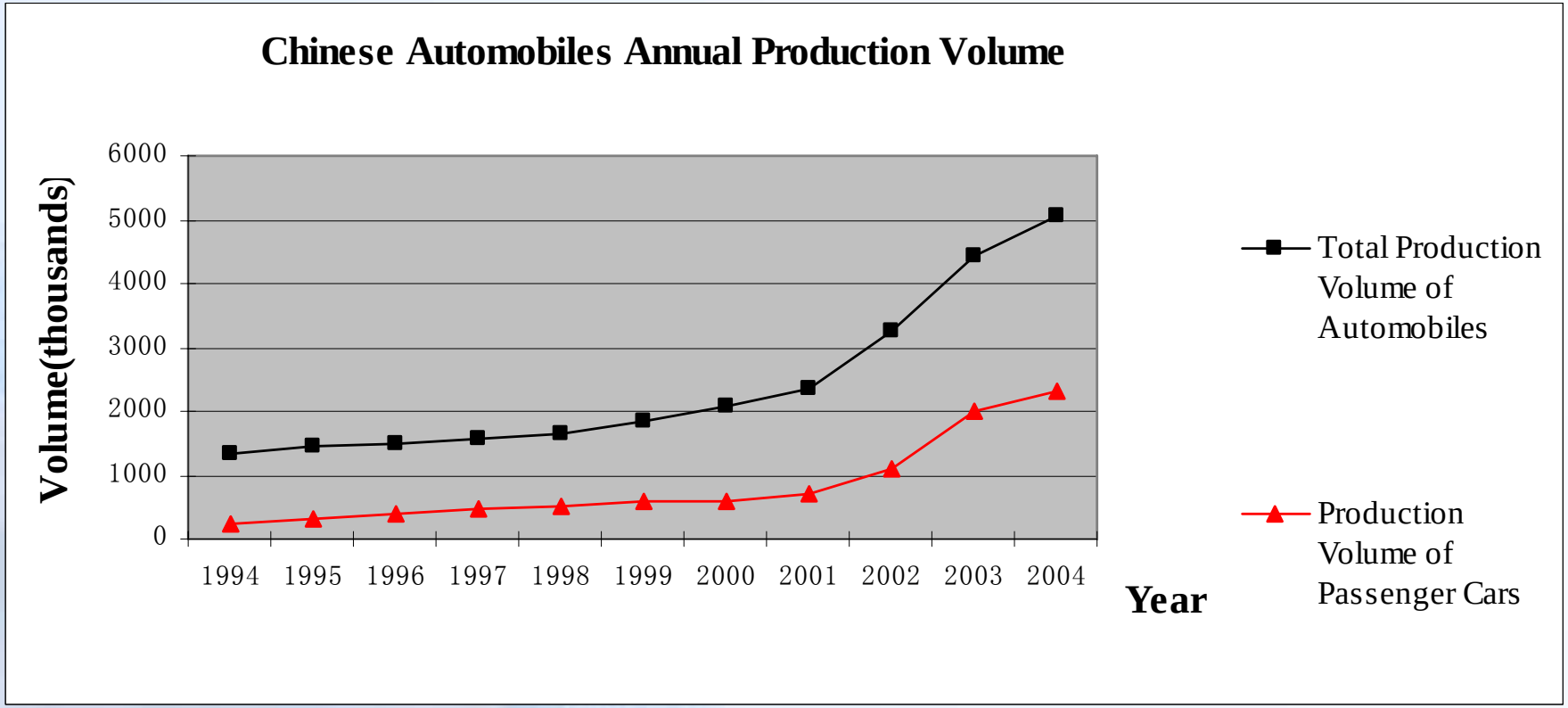
Rapid Development of Chinese Automobile Industry



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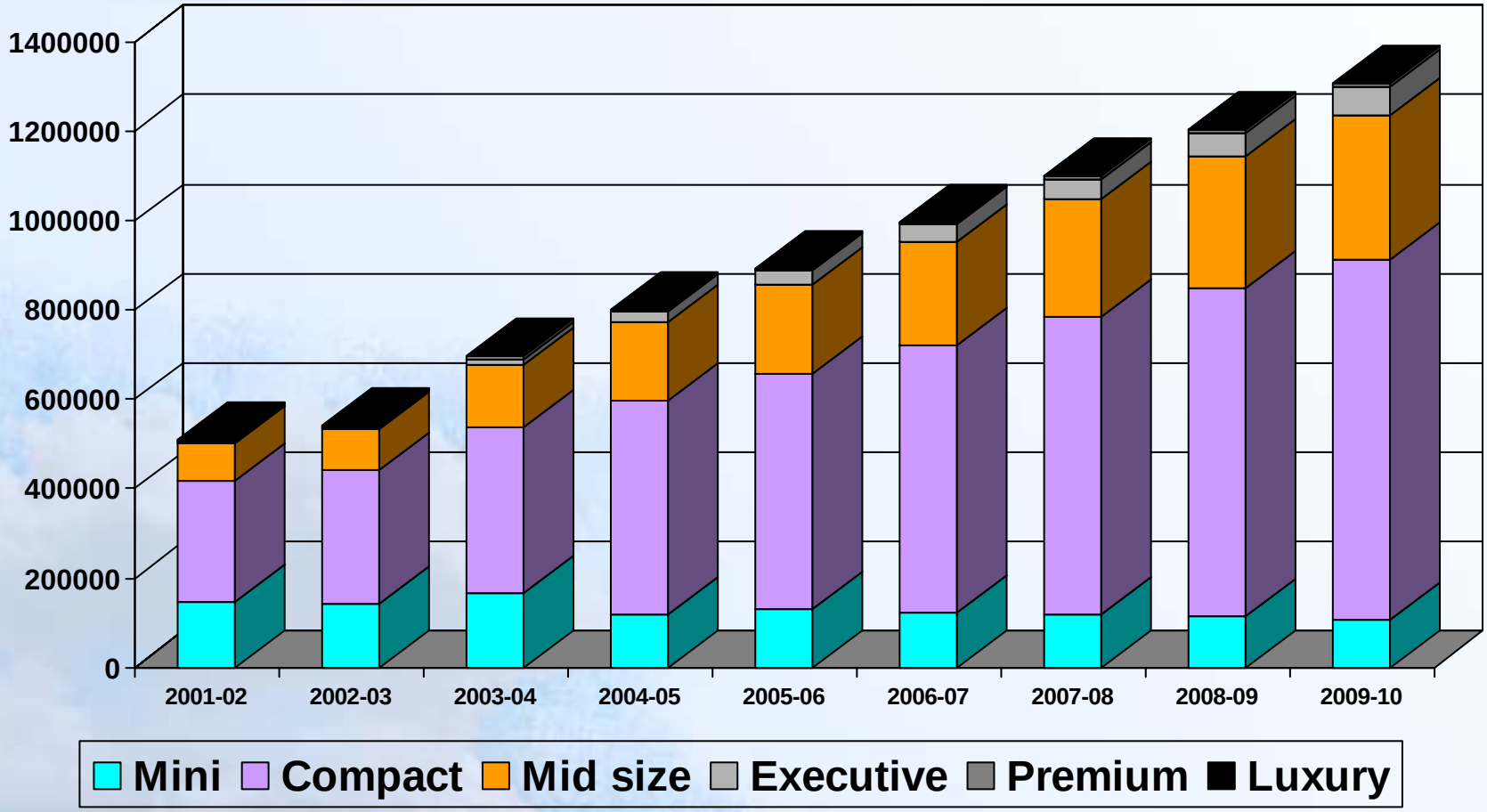
Domestic Sales Trend in India Passenger Cars
(2001-02 to 2009-10)



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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

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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 $\leq$ 50 g/yr/veh

(including R134a into R12 vehicles)

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Recovery from Vehicles at End-of-Life

- 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

Conclusion

- 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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