



Mobile Air Conditioning Summit 2006
February 17, Saalfelden, Austria

A photograph of the Golden Gate Bridge in San Francisco, California, viewed from a low angle looking up at the tower and across the water. The sky is clear blue.

***Reducing Vehicle Refrigerant
Emissions as an Important
Strategy in California's Climate
Change Protection Plan***

Alberto AYALA, PhD, MechE

and

Steve CHURCH, MS, PE

California Air Resources Board



Presentation Overview

**CARB's AB1493
Regulation -
*Reduction of
GHG emissions
from motor
vehicles***

**California's
Future Climate
Action Plan and
Mobile Air
Conditioning**

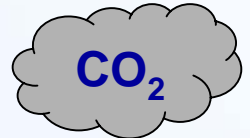
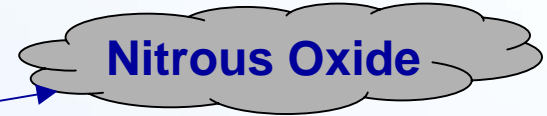
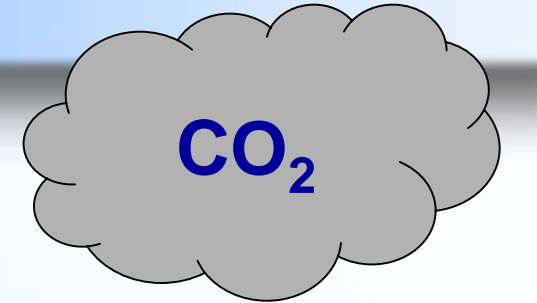
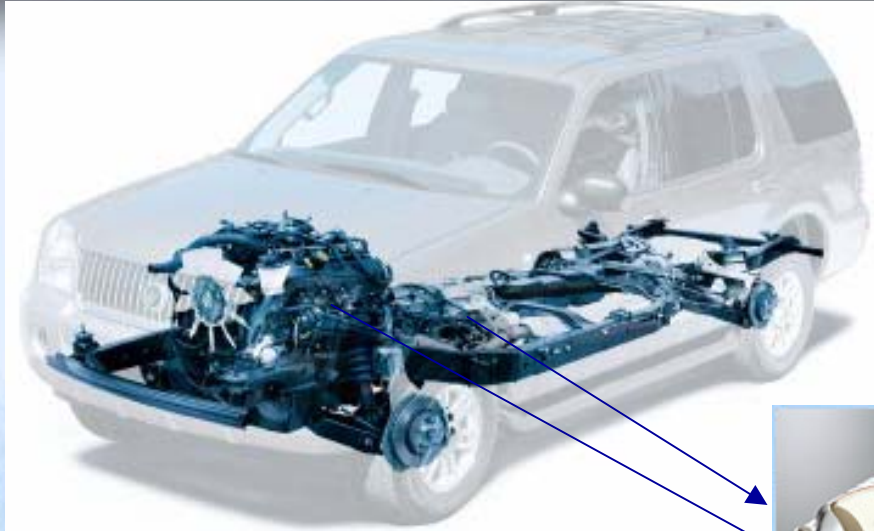


CARB AB 1493 Regulation

- **California Assembly Bill 1493 authored by Fran Pavley (D-Agoura Hills)**
- **Signed into law by Governor Davis in 2002**
- **Directs CARB to develop new regulations to reduce greenhouse gas (GHG) emissions from new motor vehicles starting with model year 2009**
- **CARB develops and approves GHG regulation in September 2004**
- **Regulation became effective January 1, 2006**
- **Automobile industry has challenged regulation in court**
- **Court date in early 2007**
- **California regulation being considered by other States including New York, New Jersey, Massachusetts, Connecticut, Maine, Rhode Island, Vermont, Oregon, and Washington**



Technology Evaluation leads to Fleet Average Emission Standards



Tier	Year	CO ₂ -equivalent emission standards (g/mi)	
		PC/LDT1	LDT2
Near-term	2009	323	439
	2010	301	420
	2011	287	390
	2012	233	361
	2013	227	355
Mid-term	2014	222	350
	2015	213	341
	2016	205	332

~22% reduction in 2012

~30% reduction in 2016

A/C compressor



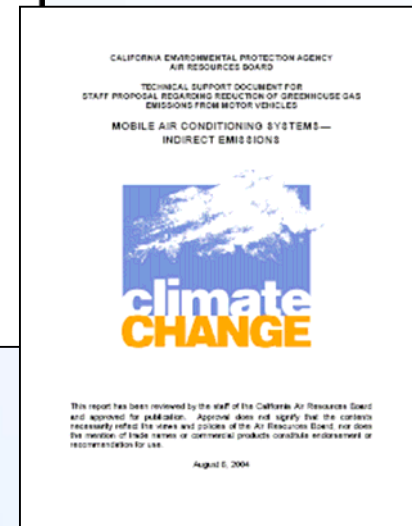
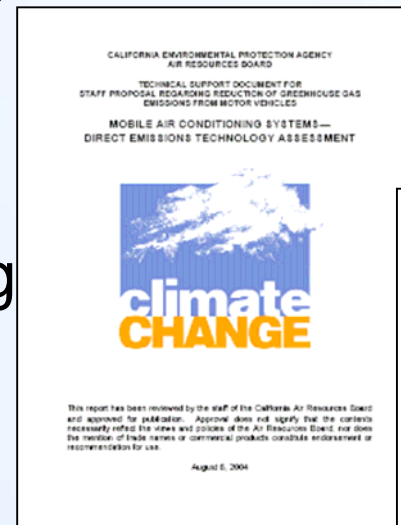
CO₂-Equivalent Standard

$$\left(\begin{array}{l} CO_2 - equiv. \\ emissions (g / mi) \end{array} \right) = \underbrace{CO_2 + N_2O * GWP_{N_2O} + CH_4 * GWP_{CH_4}}_{\text{exhaust drive-cycle emissions}} - AC_{allowances}$$

where:

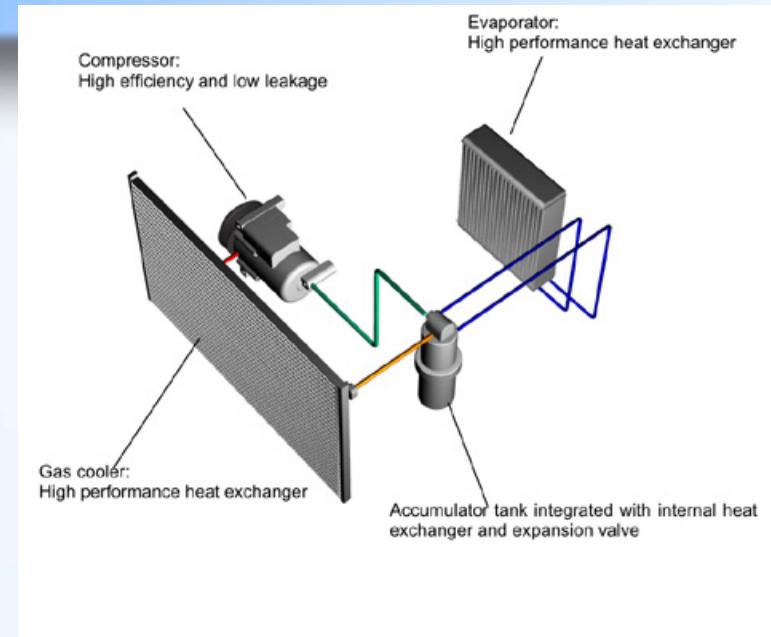
AC_{allowances} = credits for reducing direct and indirect emissions from MACS (if applicable)

<http://www.arb.ca.gov/cc/cc.htm>

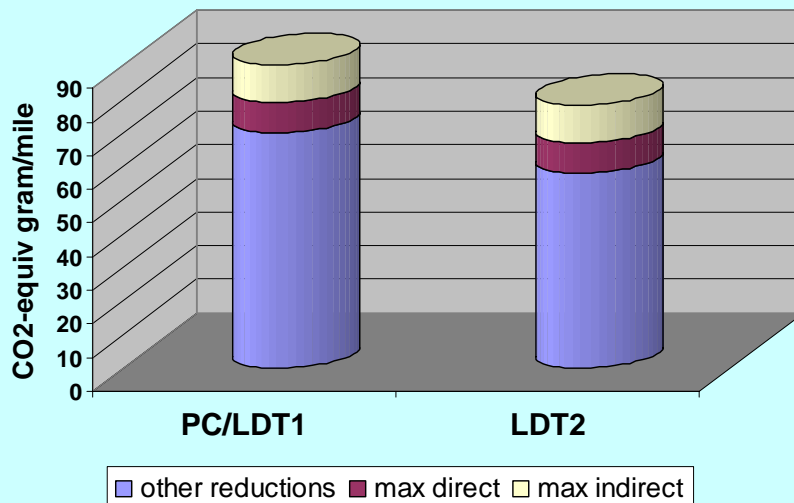


Treatment of MAC Emissions

- No changes to MACS are required
- However, some AC emission reductions were assumed in establishing emission standards
- If MACS emissions are not reduced, need additional reductions from other technologies



Near-term (2012) Required Reductions



All alternative MAC technologies (and new refrigerants?) have a role in helping California meet climate change reduction goals



Direct AC Emission Provisions :

- Qualifying as a “Low-leak AC system”
- Refrigerant substitution ($GWP \leq 150$)
- Alternative technologies
 - If reductions are demonstrated to be equal or greater than either of the above measures

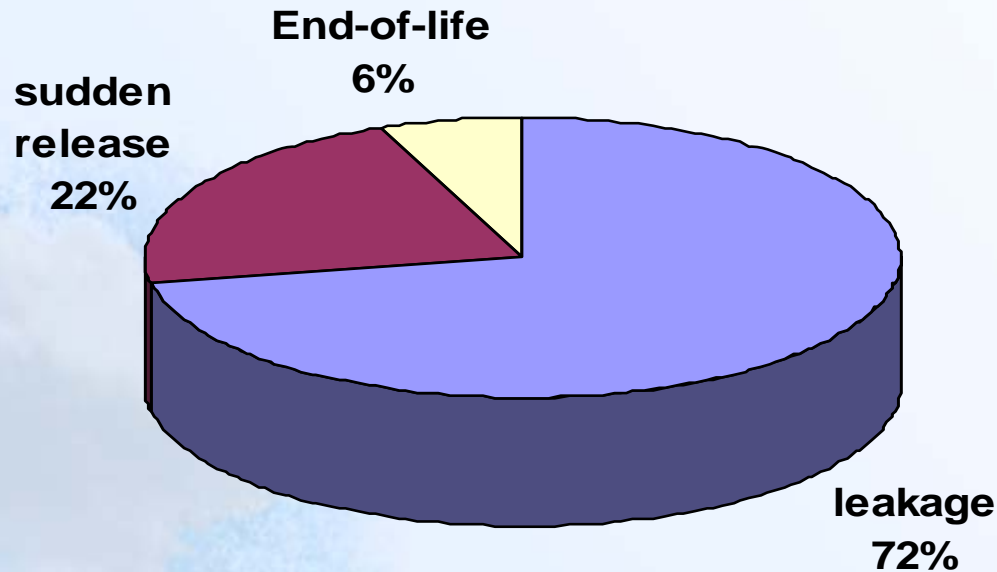
Indirect AC Emission Provisions :

- Qualifying as an “AC system with reduced indirect emissions”
- Refrigerant substitution ($GWP \leq 150$)
- Alternative technologies
 - If reductions are demonstrated to be equal or greater than either of the above measures



HFC-134a Direct Emission Factor for Inventory Development

Based on CARB's lifetime emission factor¹ of ~80 g/yr/HFC-134a veh. of which ~58 g/yr (~6 CO₂-equiv g/mi) is leakage



¹Vincent, R., K. Cleary, A. Ayala, and R. Corey, "Emissions of HFC-134a from Light-Duty Vehicles in California," *SAE Technical Paper 2004-01-2256*



“Low-Leak MACS” Component Prescription & Allowances for Direct Emissions

- 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)

Allowances for Direct Emission Reductions

“Low-leak” HFC-134a system credit may be determined via SAE J2727

	Refrigerant		
	Low-Leak HFC-134a	HFC-152a ²	CO ₂
Allowance in CO ₂ -equivalent grams per mile ¹	3.0 - 6.0	8.2 - 8.8	9.0

¹ Possible allowances for reducing refrigerant leakage and/or refrigerant substitution. Note that allowances can be obtained from refrigerant substitutions that are not shown in this table. Also note that the magnitude of the allowance for each refrigerant depends on the extent to which refrigerant leakage is reduced, if any.

² The lower range of this allowance is based on HFC-152a substitution alone, and the magnitude of the allowance increases as HFC-152a leakage is reduced.



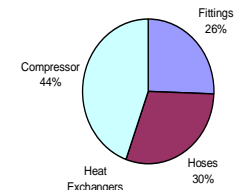
SAE J2727 Possible Baseline Case

Leakage Chart

System Component Connection							Calculated Value
Fittings							
Rigid Pipe connections	Single O-ring	Single Captured O-ring	Multiple O-ring	Seal Washer	Seal Washer with O-ring	Metal Gasket	Do Not Enter Data
Total Emissions	125	75	50	10	5	1	
Number of fittings:	9	1		2			1.220
High Side service port							
Total Emissions	60	60	40	10	5	1	
Number of fittings:	1						0.060
Low-Side service port							
Total Emissions	40	40	25	10	10	1	
Number of fittings:	1						0.040
PRV, Switches, Transducers							
Total Emissions	40	40	25	10	10	1	
Number of fittings:	2	1					0.120
							Fittings Total
							1.440
			Calculated Value	Type of Hose			
Flexible Hose				All Rubber Hose	Standard Barrier or Veneer Hose	Ultra-low Perm Barrier or Veneer Hose	Do Not Enter Data
Includes Hose and Hose Coupling Crimps [End Connections included in Component Connection]	Length [mm]	Diameter [mm]	Surface Area Do Not Enter Data				
High pressure line 1	650	10	20420		1		0.231
High pressure line 2			0				0.000
High pressure line 3			0				0.000
High pressure line 4			0				0.000
Low pressure line 1	650	16	32673	1			1.470
Low pressure line 2			0				0.000
Low pressure line 3			0				0.000
Low pressure line 4			0				0.000
TOTAL	[place a "*" in the appropriate cell]			[place a "*" in the appropriate cell]		Hose Total	1.701
Heat Exchangers							
Assumptoin = 0.001				Heat Exchange Total			0.001
	[heat exchanger value pre-set value 1]					[heat exchanger value pre-set value 1]	
Compressor							
	Type of seal						
	Single Lip+ Body O-rings	Single Lip+Body Gaskets	Multiple Lip and Body O-rings	Multiple Lip + Gaskets			Do Not Enter Data
Total Emissions	2500	2000	1200	700			
Compressor	1					Compressor Total	2.500
			[place a "*" in the appropriate cell]				

Summary	% Contribution
Fittings	25.5%
Hoses	30.1%
Heat Exchangers	0.0%
Compressor	44.3%
	100.0%

% System Component Contribution



Rating TOTAL
5.6

Rating Value

- < 1 - Leakage Enhancement Level V
- 1 to 2 - Leakage Enhancement Level IV
- 2 to 3 - Leakage Enhancement Level III
- 3 to 4 - Leakage Enhancement Level II
- 4 to 5 - Leakage Enhancement Level I
- > 5 - Standard leakage

Standard Leakage Rating > 5

Work remains to correlate "leakage enhancement level" to CARB emission credit



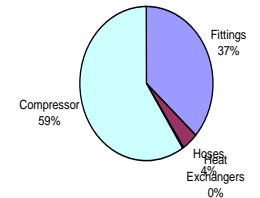
SAE J2727 Superior MACS

Leakage Chart

System Component Connection						Calculated Value	
Fittings							
Rigid Pipe Connections and Flexible Hose Connections	Single O-ring	Single Captured O-ring	Multiple O-ring	Seal Washer	Seal Washer with O-ring	Metal Gasket	Do Not Enter Data
Total Emissions	125	75	50	10	5	1	
Number of fittings:	0	0	12	0			0.600
High Side service port							
Total Emissions	60	60	40	10	5	1	
Number of fittings:	0	0	1				0.040
Low-Side service port							
Total Emissions	40	40	25	10	10	1	
Number of fittings:	0	0	1				0.025
PRV, Switches, Transducers							
Total Emissions	40	40	25	10	10	1	
Number of fittings:	0	0	3				0.075
						Fittings Total	0.740
			Calculated Value	Type of Hose			
Flexible Hose							
Includes Hose and Hose Coupling Crimps [End Connections included in Component Connection]	Length [mm]	Diameter [mm]	Surface Area Do Not Enter Data	All Rubber Hose	Standard Barrier or Veneer Hose	Ultra-low Perm Barrier or Veneer Hose	Do Not Enter Data
High pressure line 1	650	10	20420			0	0.046
High pressure line 2			0				0.000
High pressure line 3			0				0.000
High pressure line 4			0				0.000
Low pressure line 1	650	16	32673	0	0	1	0.037
Low pressure line 2			0				0.000
Low pressure line 3			0				0.000
Low pressure line 4			0				0.000
TOTAL	[place a "1" in the appropriate cell]			[place a "1" in the appropriate cell]		Hose Total	0.083
Heat Exchangers							
Assumpiton = 0.001						Heat Exchange Total	0.001
	[heat exchanger value pre-set value 1]					[heat exchanger value pre-set value 1]	
Compressor							
	Type of seal						
	Single Lip+ Body O-rings	Single Lip+Body Gaskets	Multiple Lip and Body O-rings	Multiple Lip + Gaskets			Do Not Enter Data
Total Emissions	2500	2000	1200	700			
Compressor	0	0	1	0		Compressor Total	1.200
			[place a "1" in the appropriate cell]				

Summary	% Contribution
Fittings	36.6%
Hoses	4.1%
Heat Exchangers	0.0%
Compressor	59.3%
	100.0%

% System Component Contribution



Rating Value
RatingTOTAL
2.0239

- < 1 - Leakage Enhancement Level V
- 1 to 2 - Leakage Enhancement Level IV
- 2 to 3 - Leakage Enhancement Level III
- 3 to 4 - Leakage Enhancement Level II
- 4 to 5 - Leakage Enhancement Level I
- > 5 - Standard leakage

Level IV Leakage Rating ~ 2

Possible CARB qualifying system with additional emission credit



Criteria for MACS with Reduced Indirect Emissions

- Minimizes compressor usage by managing the balance between outside and recirculated air
- Minimizes reheat by using an externally controlled compressor that may be *i)* variable displacement, *ii)* variable speed (e.g. - electric motor), *iii)* fully cycling fixed displacement
- Utilizes other high-efficiency components

Allowances for Optional Indirect A/C Emission Reductions

	Qualify as an "A/C System with Reduced Indirect Emissions"	Switch to a refrigerant with a GWP of 150 or less
Allowance in CO ₂ -equivalent grams per mile	7.5 to 11	Maximum of 0.5

The calculated indirect emission allowance is proportional to maximum A/C compressor displacement. The range for each allowance is based on system to system variation in compressor displacement.



Since MAC Summit 2005 one year ago.....



Cal/EPA Headquarters
Sacramento

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http://www.arb.ca.gov/research/mac2005/mac2005.htm

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Welcome to *California*

Air Resources Board

Mobile Air Conditioning Summit 2005

This page updated March 30, 2005

**"Thank You" to all of our sponsors and attendees for making the
"Mobile Air Conditioning Summit 2005"
a huge success!**

The MACS 2005 Summit was held at:
March 15-16, 2005
Byron Sher Auditorium
California Environmental Protection Agency Headquarters Building
1001 I Street
Sacramento, CA

Done

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UN World Environment Day

San Francisco, June 1, 2005



“The debate is over. We know the science. We see the threat. And we know the time for action is now.”



California Governor's Action Plan for Climate Change Protection

- California is going to be a leader in the US in the fight against global warming
- Governor Schwarzenegger signed Executive Order # S-3-05 on June 1, 2005
- The Executive Order established greenhouse gas targets:
 - By 2010, Reduce to 2000 Emission Levels (59 MMt CO₂-eq)
 - By 2020, Reduce to 1990 Emission Levels (145 MMt CO₂-eq)
 - By 2050, Reduce to 80% below 1990 Levels (382 MMt CO₂-eq)



California's Climate Action Plan, Dec. 2005

California Environmental Protection Agency

California Air Resources Board

California Public Utilities Commission

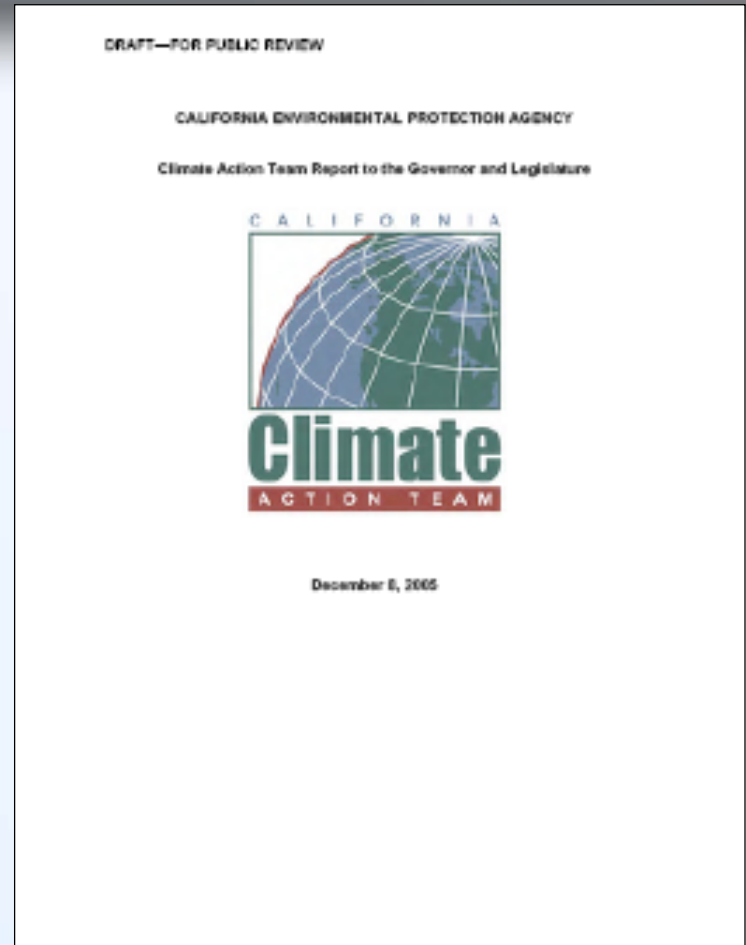
California Integrated Waste Management Board

California Resources Agency

California Energy Commission

California Business, Transportation, and Housing Agency

California Department of Food and Agriculture



http://www.climatechange.ca.gov/climate_action_team/reports/index.html



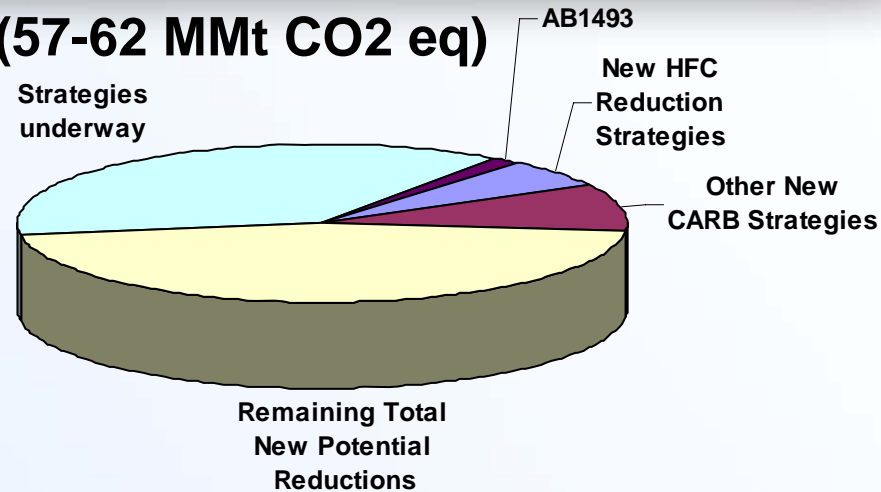
All 44 Strategies (11 underway and 33 new) Could Reduce 182-187 MMt CO₂-eqv by 2020

LIST OF 33 NEW STRATEGIES

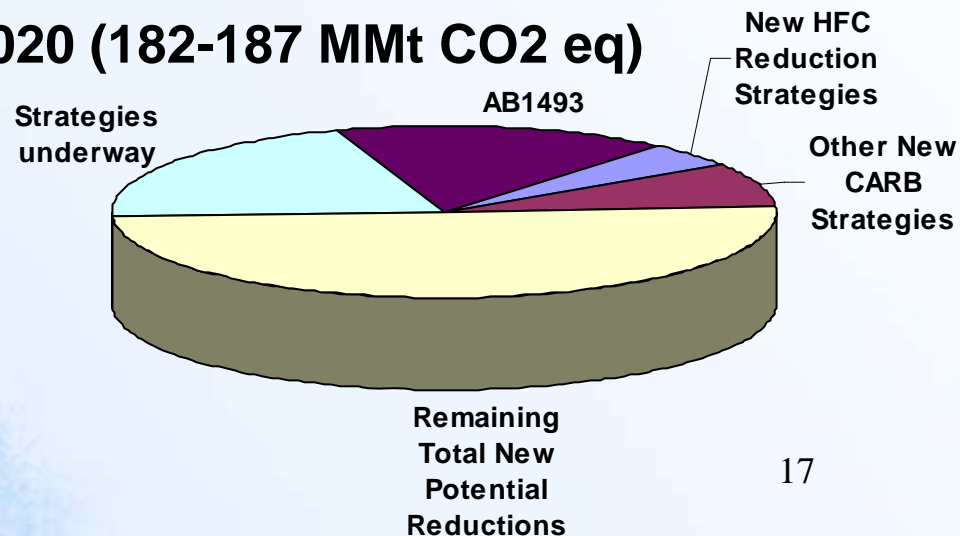
Table ES-3 Strategies Necessary to Meet California's Targets

Agency Responsible	Start Date	Climate Change Emission Reductions (Million Tons CO ₂ Equivalent) ¹			
		2010	2020		
Air Resources Board					
Other New Light Duty Vehicle Technology (New Models)	2008	0	4	2	2.4
HFC Reduction Strategies	2008	3.4	8.5	3.4	6.8
Transportation Alternative Fuels (Off Road)	2008	<1	<1	0	3.5
Electrification, Port Electrification (ship to shore)				0	12.5
Manure Management	2008	0	1	<1	1.2
Semi Conductor Industry Targets (PFC Emissions)	2008	2	2	TBD	TBD
Alternative Fuels: Biodiesel Blends	2008	<1	<1	TBD	TBD
Alternative Fuels: Ethanol	2008	<1	2.7	<1	<1
Heavy Duty Vehicle Emission Reduction Measures	2008	0	3	1	5.9
Reduced Venting and Leaks in Oil and Gas Systems	2008	1	1	<1	3.2
Public Utilities Commission					
IOU Additional Energy Efficiency Programs/Demand Response	2013	NA	6.3	3	9
IOU Combined Heat and Power Initiative	2008	1.1	4.4	TBD	TBD
IOU Electricity Sector Carbon Policy	2008	1.6	2.7	g Considered	
Integrated Waste Management Board					
Landfill Methane Capture	2008	2	3	1.8	9
Zero Waste—High Recycling	2008	0	3	5.5	18
Department of Food & Agriculture					
Conservation tillage/cover crops	2008			TBD	TBD
Enteric Fermentation	2008			<1	<1
Total Potential Emission Reductions				35-40	115-120

2010 (57-62 MMt CO₂ eq)



2020 (182-187 MMt CO₂ eq)





One¹ of CARB's New Proposed Reduction Measures

I&M Leak Test
Add refrigerant leak-tight "pass" criteria for vehicular Inspection & Maintenance Program (Smog Check)

Can Ban
Ban retail sale of HFCs in small cans

Enforce Recovery
Enforce the federal ban on releasing HFCs

New HFC Reduction Strategies

HFC134a Phase out
Require that only low-GWP refrigerants be used in new vehicles:
Light vehicles by 2017
Heavy vehicles by 2010

Improve Commercial Ref Systems
Adopt specifications (low GWP, low leak) for new commercial refrigeration

¹One out of 33 new strategies described in the Draft Climate Action Team Report to the Governor and Legislature



A Look Ahead

- **CARB seeks continued collaborations under MAC Climate Protection Partnership to refine new strategies in California's Climate Action Plan**
- **CARB research activities:**
 - Traffic tunnel *in-use screening* of HFC-134a emission¹ (in-house)
 - SHED testing (in-house) **Must consider INNOVA PAS for evap. emissions study**
 - US EPA's Container Refrigerant Transfer Study and other related activities
 - CARB's "CO2 Emission Quantification from Vehicle Air Conditioning Operation in California-Specific Conditions" by Tim Fox - CA State Univ. Northridge & Clark Bullard and Pega Hrnjack - ACRC/UIUC
 - Refinement and advancement of SAE J2727 approach
 - Seeking collaborations to advance method development for
 - Refrigerant leakage emission measurement
 - Indirect A/C emissions testing for whole vehicle with "real world" load simulation

¹ Cleary, K.W., A. Ayala, R. A. Harley and M.E. Gebel, "Pilot Study of Direct Emissions of HFC-134a Mobile Refrigerant from a California Traffic Tunnel," CRC On-Road Vehicle Emissions Workshop, San Diego, April 4-6, 2005.



California expects more!



Courtesy of J. Rugh/NREL, Dec. 20, 2005



It is no accident...

...that California is aligning its policies and strategies with those of Europe. California and its climate protection partners (about a dozen US States and 50+ local cities) recognize Europe's and Austria's leadership in the area of MACS improvement. We have high expectations for proactively working together to advance the global agenda on MACS technology development for the protection of our global climate. We recognize that in the area of refrigeration, we stand to clearly and significantly benefit from your leadership. We know that Europe/Austria can meet the challenge of being a leader