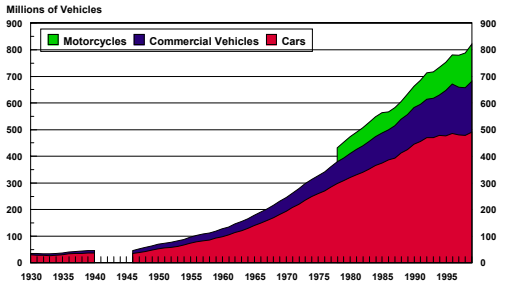
Global Trends in Motor Vehicle Pollution Control: Future Challenges For Developing Countries

SIAT 2003
Pune, India
January 2003

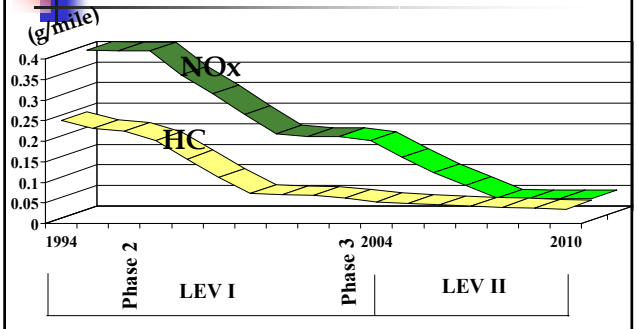
Summary

- Developing Countries Have Made Great Progress
- Future Vehicle Growth Mainly in Developing Countries – Great Health Challenges
- Progress in Reducing Vehicle Emissions Has Started But Major Steps Are Needed
- Fuel Quality in Asia is Critical
  - Current Trends
  - Desulfurization Costs & Benefits
- I/M Very Important As Well

Global Trend In Motor Vehicles

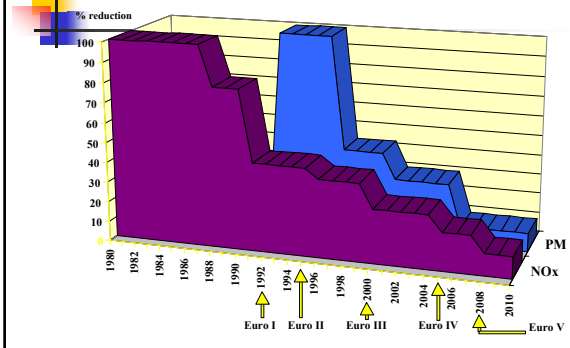


California's Standards Apply Equally To Gasoline and Diesel Vehicles

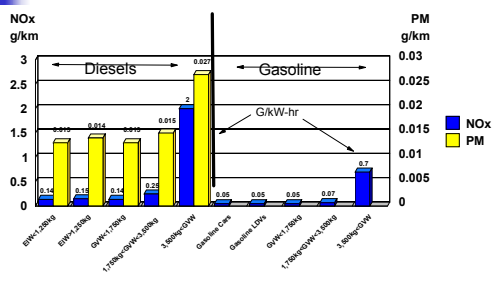


Air Quality in Losa Angeles Is Greatly Improved

Heavy-duty Vehicles Emission Reduction In Europe On ETC Test Cycle

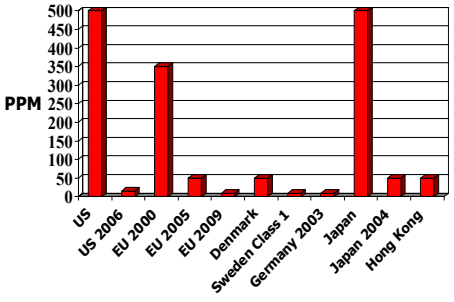


New Standards For Japanese Vehicles (October 2005)



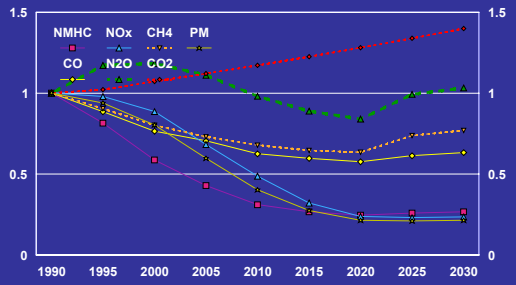
50 PPM Sulfur Maximum by 2004

Diesel Fuel Specifications Around The World

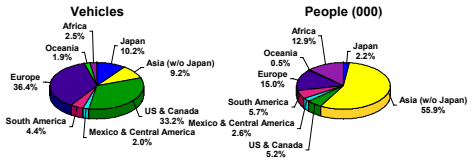


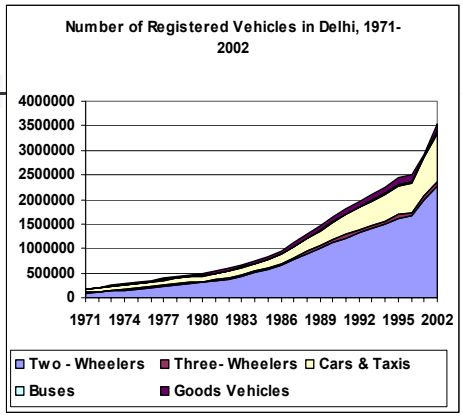
Global Trends in On Road Motor Vehicle Emissions (Normalized to 1990)

OECD Countries Only

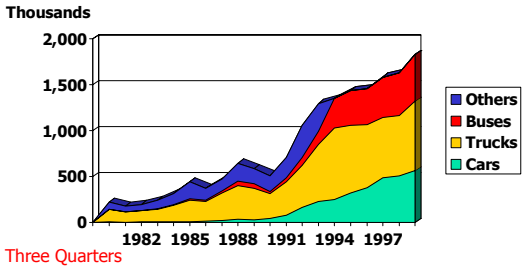


Global Distribution of Vehicles and People





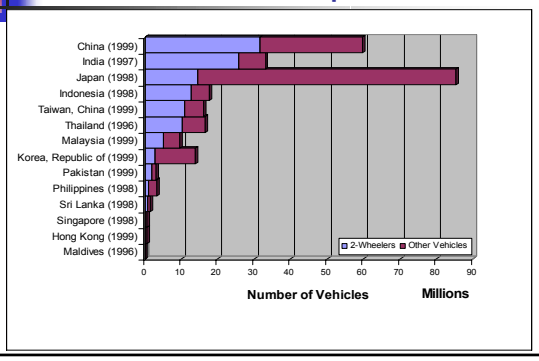
Motor Vehicle Production in China



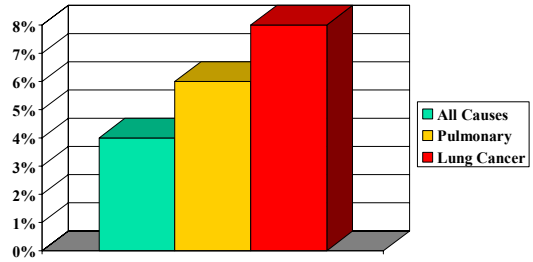
2002: First Three Quarters
Domestic Made Vehicles Up 34%
Passenger Cars Up 46%

A Love Affair With The Car Is Growing!

The Vehicle Population in Asia is Unique

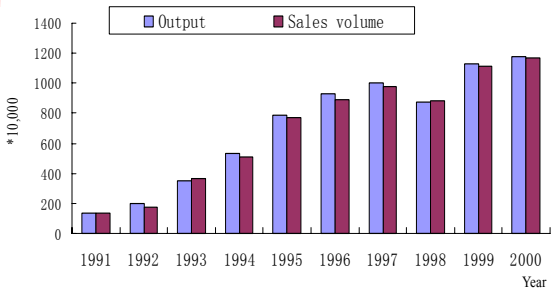


Increased Risk of Premature Mortality Due To 10μg/m^3 $PM_{2.5}$

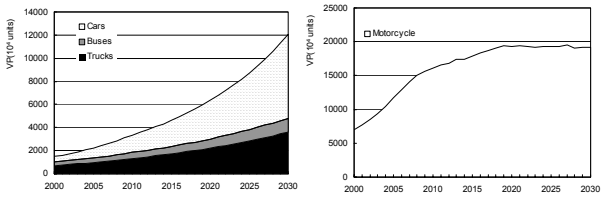


JAMA, March 2002

Motorcycle Annual Production and Sales

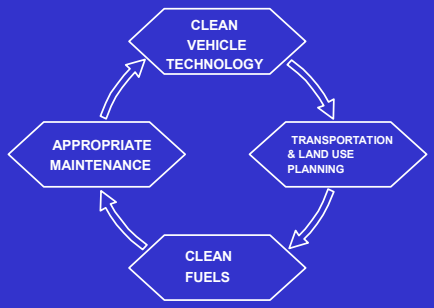


The Vehicle Population Is Expected To Grow Rapidly



A Median Estimate is 120 million Vehicles & 200 Million Motorcycles by 2030 – Tsinghua University

ELEMENTS OF A COMPREHENSIVE VEHICLE POLLUTION CONTROL STRATEGY



New Vehicle Standards In Asia

Car Standards

	95	96	97	98	99	00	01	02	03	04	05	06	07	8	09	10
Bangladesh								Euro 1 (proposed)						Red = proposed		
Cambodia																
Hong Kong	Euro 1		Euro 2				Euro 3									
India						Euro 1	Euro 2 (4 Metros)				Euro 2nd proposed			** = Euro 3 in 7 Megacities		
Indonesia							Euro 1 (proposed)						Euro 2 (proposed)			
Malaysia			Euro 1			Euro 2										
Nepal						Euro 1										
Philippines									Euro 1							
PRC						Euro 1				Euro 2						
Singapore	Euro 1						Euro 2									
Sri Lanka									Idle CO & HC/Diesel Smoke Standards							
Taipei,China					US Tier 1											
Thailand		Euro 1			Euro 2			Euro 3					Euro 4			
Viet Nam				Euro 1												

New Vehicle Standards in Asia

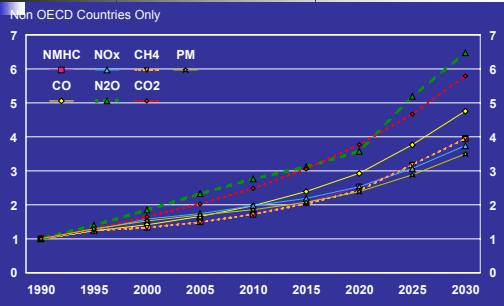
Heavy Duty Diesel Truck Standards

	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Bangladesh								Euro 1 (proposed)								
Cambodia																
Hong Kong	Euro 1		Euro 2				Euro 3									
India						Euro 1	Euro 2 (4 Metros)				Euro 2nd proposed			** = Euro 3 in 7 Megacities		
Indonesia							Euro 1 (proposed)						Euro 2 (proposed)			
Malaysia			Euro 1													
Nepal						Euro 1										
Philippines									Euro 1							
PRC							Euro 1			Euro 2						
Singapore	Euro 1															
Sri Lanka									Diesel Smoke Standard							
Taipei,China				US 91												
Thailand				Euro 1		Euro 2										
Viet Nam				Euro 1												

VEHICLE EMISSION NORMS			2WHEELERS				
2- WHEELER MASS EMISSION STANDARDS OF ASIAN COUNTRIES,g/km							
COUNTRY	VEHICLES	YEAR	CO	HC	NOx	HC+NOx	REMARKS
INDIA	ALL 2W	2000	2			2	IDC
	ALL 2W	2005	1.5			1.5	IDC, DF of 1.2
INDONESIA	ALL 2W	2001	12			10	
		2007	5			3	
NEPAL	ALL 2W	1999	2			2	
PRC, CHINA	MOPEDS	2001	6			3	ECE R 47
	MOPEDS	2005	1			1.2	ECE R 47
	M/CY, 2S	2002	8	4	0.1		ECE R 40
	M/CY, 4S	2002	13	3	0.3		ECE R 40
BEIJING	ALL 2W	2003	4.5			3	ECE R 40
	ALL 2W	2004	3.5			2	ECE R 40
TAIPEI,CHINA	< 700 CC	2002	3.5			2	CNS 11386
	<700cc,2S	2004	7			1	COLD START
	<700cc,4S	2004	7			2	COLD START
THAILAND	ALL 2W	2001	4.5			3	
	<110cc	2003	3.5			2	
	>110cc	2004	3.5			2	
VIET NAM	M/CYCLES	2004	4.5			3	
	M/CYCLES	2007	3.5			2	
	MOPEDS	2004	6			3	
	MOPEDS	2007	1			1.2	

Source: Mr. Iyer

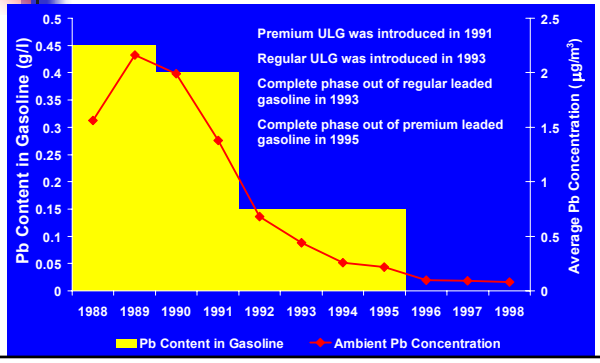
Global Trends in On Road Motor Vehicle Emissions (Normalized to 1990)

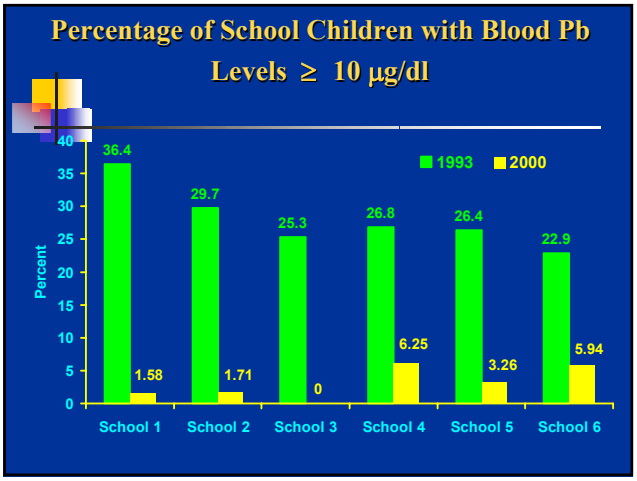


Fuel Quality is Critical

- Elimination of Lead in Gasoline Allows Catalyst Technology
- Very Low Sulfur Levels
  - Enhances All Catalyst Technology Performance
  - Necessary To Use Advanced Technologies
  - Other Benefits
- Other Fuel Properties Also Important

Ambient Pb Concentrations in Bangkok and Pb in Gasoline from 1988 - 1998

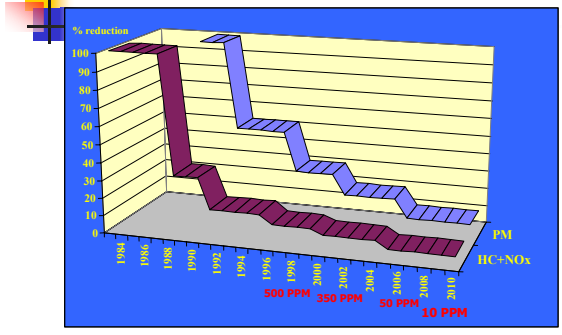




Why Are Fuels Important?

- Fuel Constituents Directly Affect Emissions
- Fuel Changes Can Immediately Impact on Emissions/Air Quality
- Fuel Composition Can Enable/Disable Pollution Control Technology

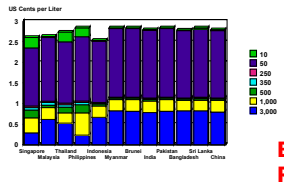
Diesel Car Standards in the EU

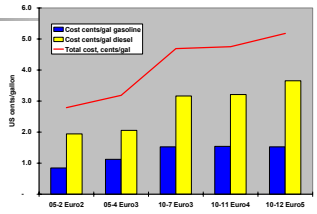


Diesel Fuel Sulfur Levels In Asia

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bangladesh							5000									
Cambodia					2000											
PR China	5000		2000													
Hong Kong		500					50									
India	5000				2500	***				500					350	
Indonesia	5000															
Japan	500									50		10				
Korea	500															
Malaysia	5000		3000				500 marketed									
Nepal																
Pakistan							4600			2500 under consideration						
Philippines	5000					2000										500
Singapore	5000		500													
Sri Lanka								3000								
Taipei,China	500															
Thailand	2500			500												
Vietnam	10000							2000		500						
United States	500										15				15	
EU					350					50				10		

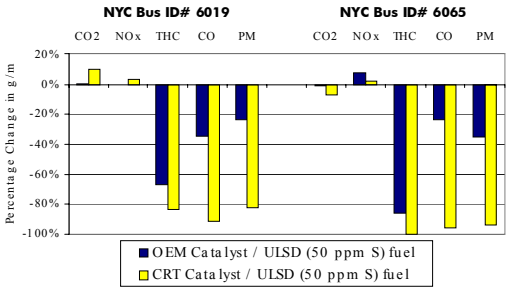
Costs of Reducing Sulfur in Fuels in China



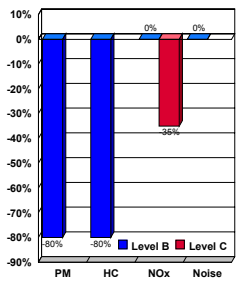


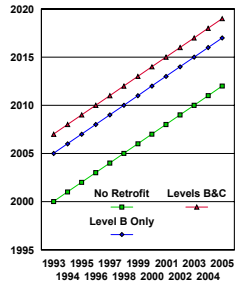
Better to Do It All At Once Rather Than in Multiple Steps

New York City Retrofit Experience



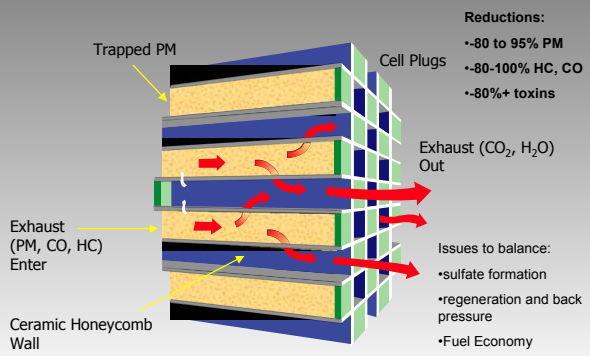
Swedish Retrofit Program All Trucks Above 3.5 Tons





Very Low Sulfur Fuel Dominates The Market

Diesel Particulate Filters



Reductions:

- ~80 to 95% PM
- ~80-100% HC, CO
- ~80%+ toxins

Issues to balance:

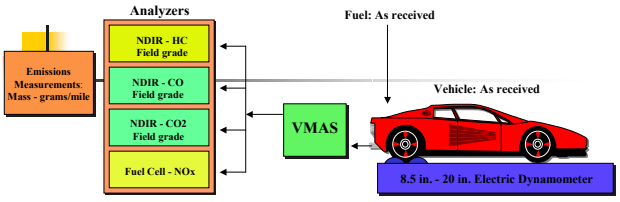
- sulfate formation
- regeneration and back pressure
- Fuel Economy

Dealing With Dirty Diesels

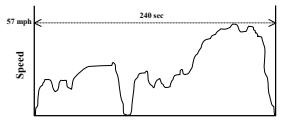
- Clean Them Up
  - ULSD
  - Oxidation Catalysts
    - PM Mass (25%)
  - Diesel PM Filters
    - PM Mass (90+%)
    - PM Number(90+%)
  - Certification Process To Do Well
- Switch To CNG
  - Fuel Availability & Infrastructure
  - New Engines Not. Conversions
  - PM Mass
  - NOx
  - Certification Process To Do Well

Bottom Line: Clean Diesels with Very Low Sulfur Fuel or CNG with OxCat Can Substantially Reduce Emissions BUT Only If Done Well

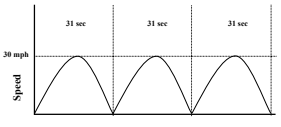
Test Type: Mass 31 or IM240 or Other



IM240 Test Cycle: Transient, loaded mode



MASS 31 Test Cycle: Transient, loaded mode



Problems with Idle CO Testing

Idle CO check :

- Proper extension pipes especially for 2&3 wheeler vehicles are not used
- Chances of leakages in the system leading to inappropriately low readings

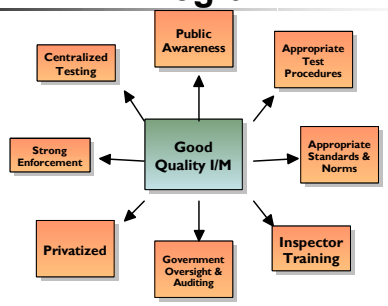
Vehicle Inspection and Maintenance (I/M) Program

- Purpose:
  - To Assure that vehicle is properly maintained and used
  - Identify Dirtiest Vehicles & Get Them Repaired

*__Centralized__
*__Match Test To Technology__

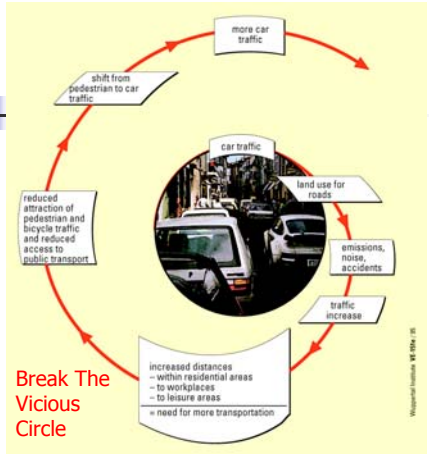
- General Attributes:
  - Relatively short
  - Relatively simple
- Types
  - Idle
  - 2-Stage Idle
  - Steady Speed Loaded
  - Transient Loaded

Elements of A Successful I/M Program



Transportation Planning & TDM Are Critically Important

- Public Transportation Alternatives
- Land Use Planning
- Road Pricing
- Other



Break The Vicious Circle

Conclusions

- Great Progress Has Been Made In Reducing Vehicle Emissions in OECD Countries
- Vehicle Population Growing Rapidly in Non OECD Countries Leading To Serious Air Pollution/Health Problems
- Lack of Low Sulfur Fuels is Major Impediment To Reducing Emissions in Developing World
- ULSD with DPFs or CNG with Ox Cats Are Capable of Substantial Emissions Reductions
- I/M Critically Important

THANK YOU VERY MUCH

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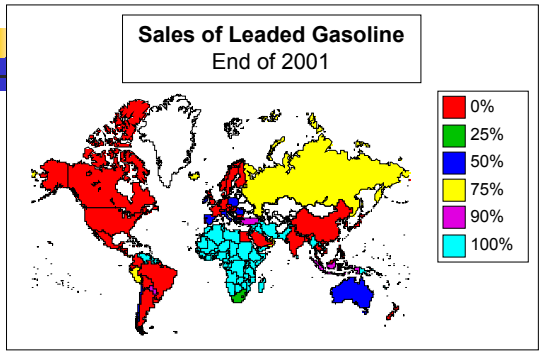
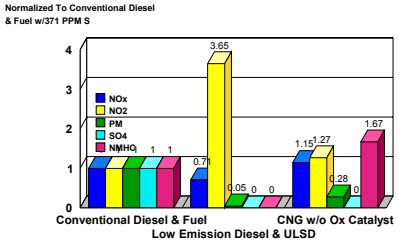


School Bus Emissions Comparison of Conventional Diesel & 371 PPM S Fuel with CNG and Low Emissions Diesel & 14 PPM S Fuel



Source:SWRI

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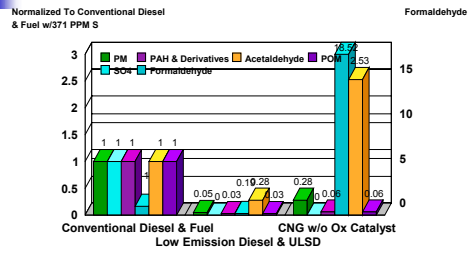

Source:SWRI

California Air Resources Board Study Of Oxidation Catalyst On CNG Bus

- Aldehydes Reduced by 95%
- NMHC Emissions Reduced by 88%
- 1,3 Butadiene Below Detection Limit
- Additional Reduction of PM, CO and Total HC
- Additional Reduction of Ultrafine PM

Bottom Line: Clean Diesels with Very Low Sulfur Fuel or CNG with OxCat Can Substantially Reduce Emissions BUT Only If Done Well