Improved Vehicular Technologies for Compliance of Stringent Emission Norms

Cars

SUV

Bus

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Workshop on
"Cleaner liquid fuels and improved vehicular technologies"
May 31, 2011, Silver Oak, India Habitat Centre, New Delhi

Contents

- Improvement avenues
- Challenges of stricter compliance
  - Fuels & Lubricant quality
  - Power-train technologies
  - Exhaust treatment devices
  - Vehicle construction
  - Eco-driving practices
- Conclusions

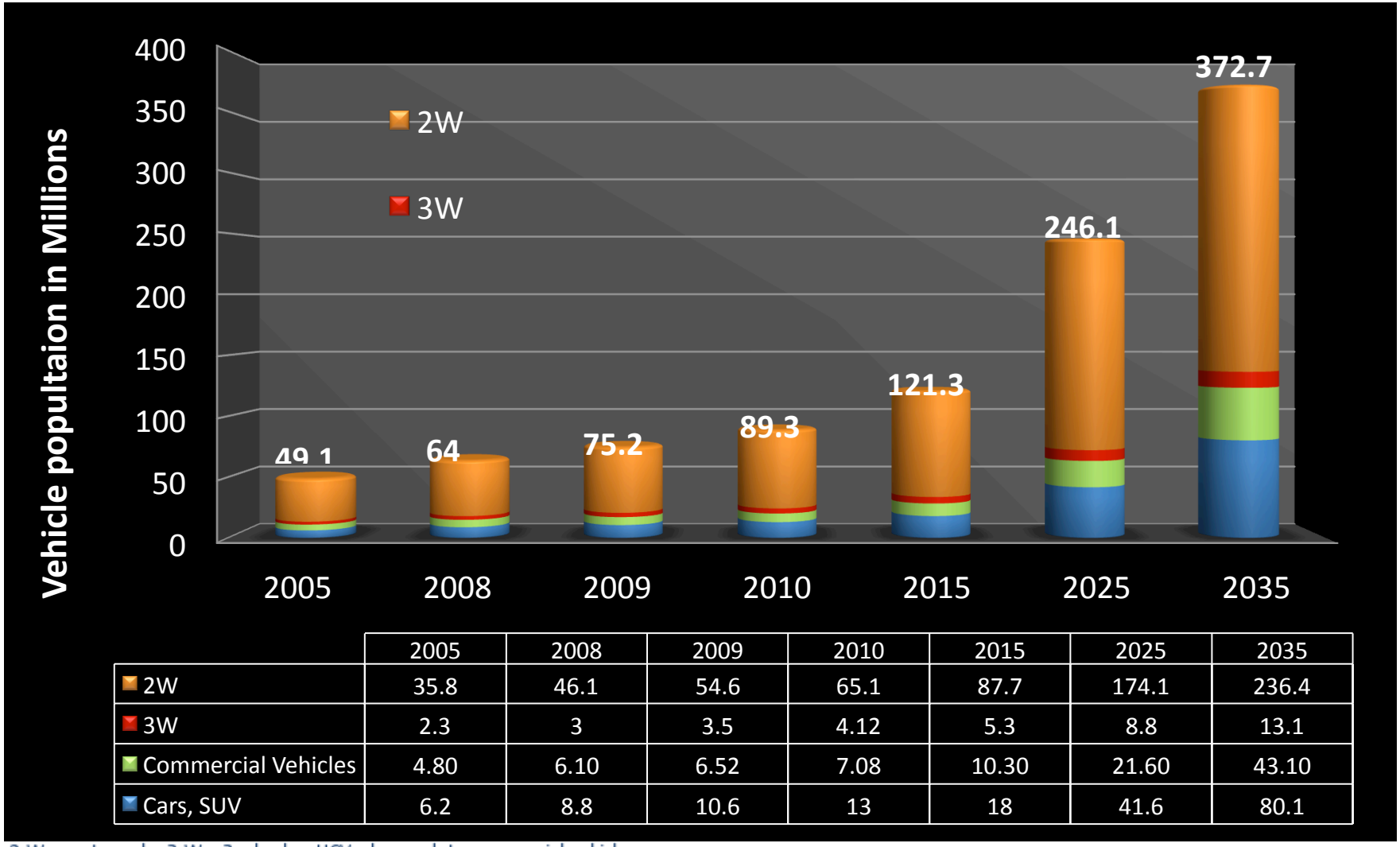
Contents

SIAM Mission-Growth with Responsibility

To become a growth engine of Indian economy by propelling the Indian auto industry to a global $145bn industry by 2016 whilst by promoting sustainability by addressing the multiple challenges arising out of emissions, climate change, energy security and safety

"Need for safer & affordable mobility for developing economy can not be ignored."

On-road Vehicle Population Projection in India

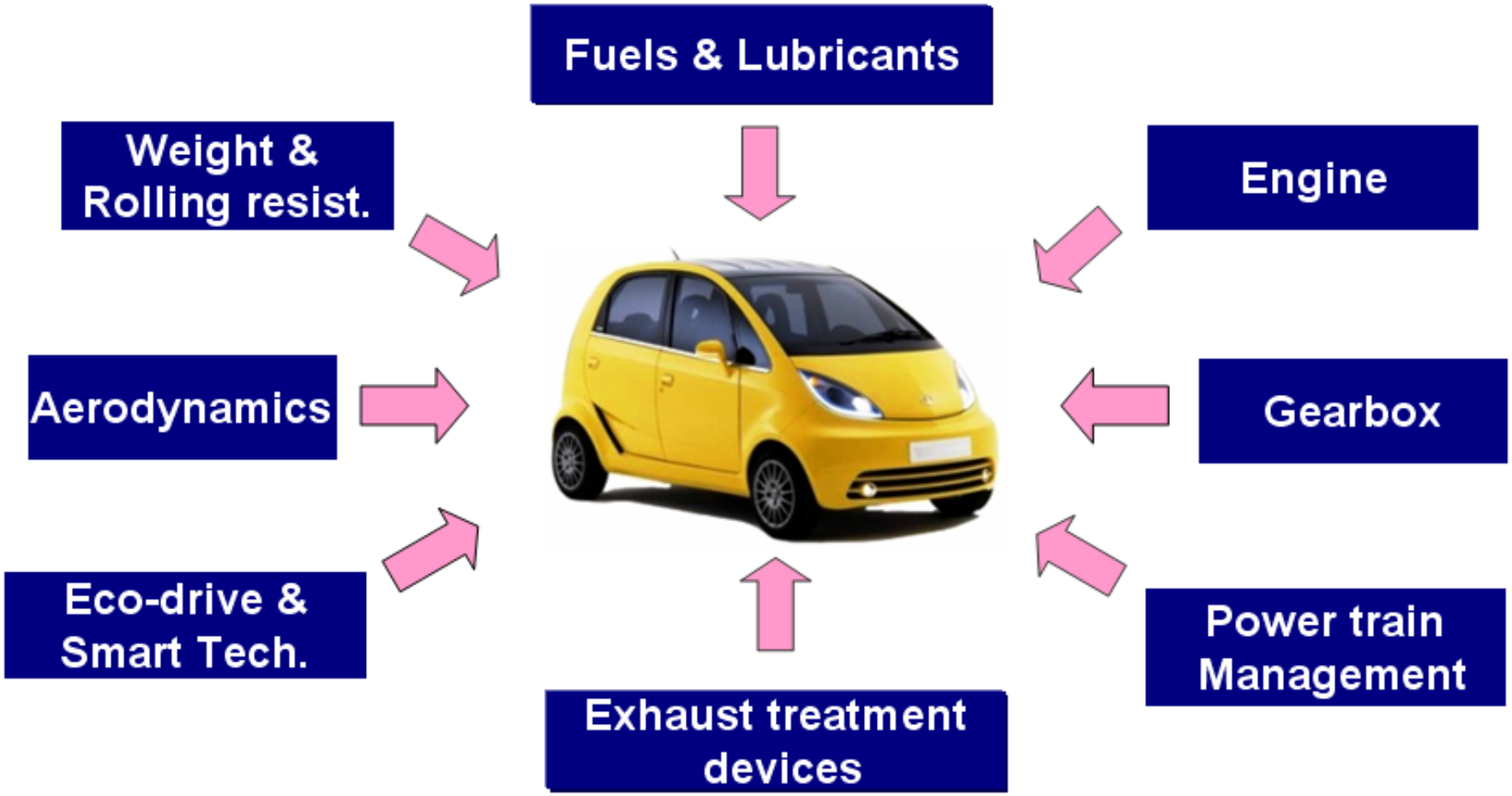


	2005	2008	2009	2010	2015	2025	2035
2W	35.8	46.1	54.6	65.1	87.7	174.1	236.4
3W	2.3	3	3.5	4.12	5.3	8.8	13.1
Commercial Vehicles	4.80	6.10	6.52	7.08	10.30	21.60	43.10
Cars, SUV	6.2	8.8	10.6	13	18	41.6	80.1

2-W = motorcycle; 3-W = 3-wheeler; HCV = heavy-duty commercial vehicle;
LCV = light-duty commercial vehicle; SUV = sport utility vehicle.
Note: Total may not add due to rounding. Source: Segment Y Ltd.

Data Source: Segment y Ltd.

Technology Improvement Focus for Stricter Emission



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Fuel & Lubricant Quality

Fuel has an influence on ...

Data Source: VW

Fuel Quality Challenges

- **Petrol**
  - Reduction of benzene
  - Reduction of olefins
  - Reduction of sulphur
  - Increase in Octane
- **Diesel**
  - Sulphur reduction
  - Cetane increase
  - Aromatic control
  - End point reduction
  - Density reduction

Data Source: MSIL

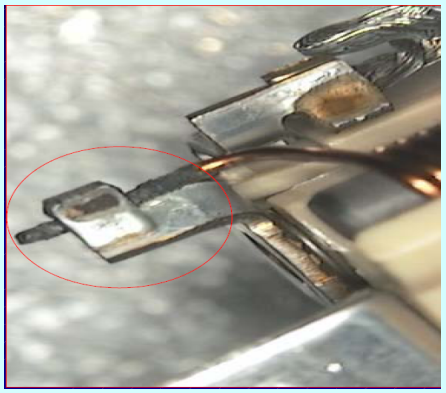
Effect of Low Fuel & Lubrication Quality

SN	Problem	Cause
1	FP Coil corrosion	Acidic nature of fuel
2	FP bearing Sulphuration	More “S” in fuel
3	Injector clogging	More “S”, Gum
4	Abnormal bore wear	More Chlorides & KOH
5	Rust problems	Traces of H_2O
6	Intake valve deposits	More Gum
7	O2 sensor poisoning	Pb in fuel
8	More vapor formation & wear	Addition of ethanol

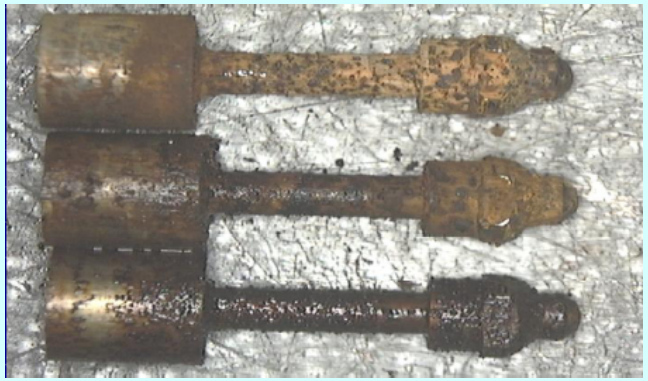
Data Source: MSIL

Effect of Low Fuel & Lubrication Quality

Fuel Pump Problem



Fuel Injector Problem



Intake Valve Deposits

Abnormal Bore wear

Data Source: MSIL

Sulphur Effects on Gasoline Passenger Vehicle Emission

Study	Vehicles	Sulphur Level	Test Cycle	NMHC/ HC%	CO%	NOx%	Reference
AQIRP	Tier 1	320→35	US FTP	-18.5%	-16.4%	-8.9%	Rutherford et al. -1995
EPEFE	Euro 2	382→18	NEDC	-8.6%	-9.0%	-10.4%	Petit et al.-1996
CRC E-60	LEV and SULEV	150→5	FTP	-2.2%	-6.4%	-31.0%	Durbin et al.-2003
			US06	-64.1%	-10.2%	-70.8%	

Data Source: icct

Sulphur Effects on Diesel Vehicle After-treatment Devices

After-treatment	Test Conditions	Effects	S level → Efficiency	Reference study
DPF	ESC-13 mode on Caterpillar I-6, 7.2L, 275 hp	• Increasing sulphur level reduces DPF efficiency with respect to engine-out values • Filter regeneration temperature increases with S level	PM reduction eff. 3 ppm→95% 30 ppm→73% 150 ppm→0% 300ppm→-130%	DECSE (NREL, 2001)
		• No deterioration in PM control • Fuel economy was reduced by 7%	No effect on DPF efficiency	JCAP (2003)
DOC	FTP 75 on Cummins ISM370, I-6, 11L, 280 hp	• PM emission increases if S ≥150 ppm at high load. • HC oxidation capacity is reduced for some DOCs (depending on catalyst formulation) • CO emissions are not affected.	HC reduction eff. 3 ppm→100% 350 ppm→91%	DECSE
LNT	Engine prototype I-4, 1.9L, 81hp	• Sulphur compounds interfere with NOx storage function.	NOx reduction eff 3 ppm→90%	DECSE & MECA (2007)
SCR	Simulated diesel exhaust gases	• Vanadium SCR system can operate at S level of 50-500 PPM • Zeolite SCR systems are susceptible to S>50 ppm levels	For Zeolite SCR: Exposure at 600 ppm reduced the NOx conversion efficiency from 90 to 50%.	Girard-2009, Chatterjee-2008

Data Source: icct

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Power Train Technologies

- Combustion System
- Fuel Injection System
- Turbocharger System
- In-Cylinder Emission Reduction System
- Exhaust After-Treatment System
- Base Engine Friction Reduction

Power-train Technology Movement– Diesel Engine Passenger Cars

PM Trap and/or DeNO$_x$ catalyst for MUV range

New engine with centralised injection and 4 valves

Euro IV

Variable Geometry Turbocharger (VGT)

Common Rail

On Board Diagnosis (OBD) on MUV range

On Board Diagnosis (OBD)

Euro III /Bharat Stage III

Electronic Diesel Control

Direct Injection (MUV range)

Oxycat

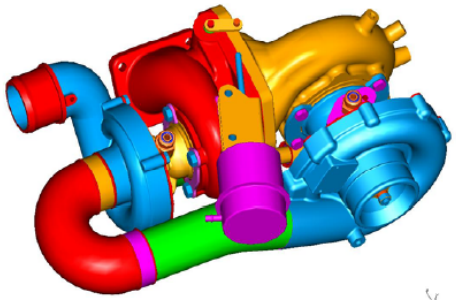
Euro II / Bharat Stage II

Exhaust Gas Recirculation (EGR)

Turbocharger and intercooler

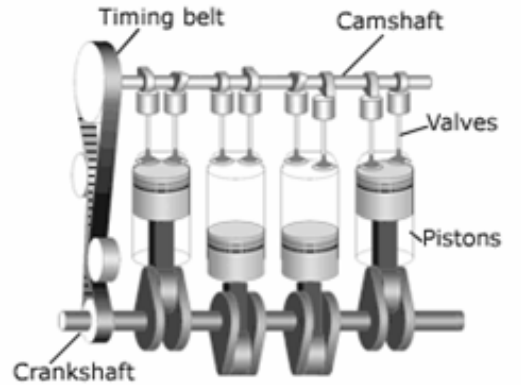
Euro I / Bharat Stage I

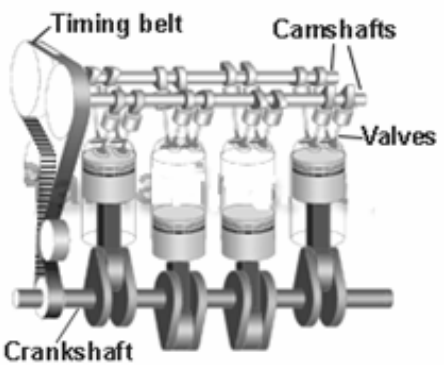
IDI engines



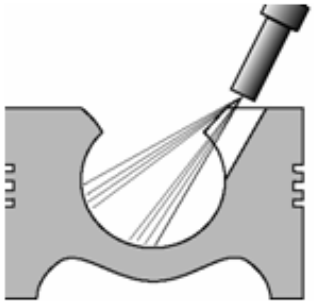
Combustion System Technology Evolution-Diesel Engine

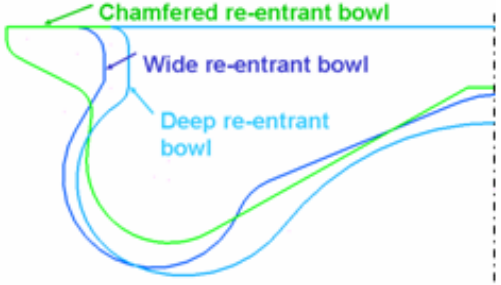
Cylinder head/ports → 2 valves / Cylinder → 4valves / Cylinder, centralized injection





Combustion Chamber → Pre-combustion chamber → Open Bowl → Re-entrant Toroidal → Deep Re-entrant Toroidal, low squish

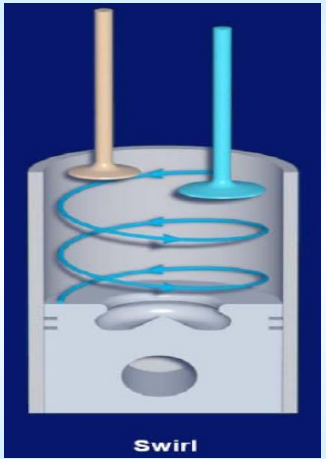




Combustion System Technology Evolution-Diesel Engine

➢Intake Swirl:

- Plays a major role in Diesel Combustion
- Swirl is generated by intake Port & valves
- Helical Port Design increases the Swirl.
- Variable Swirl is used to vary the Swirl ratio at different conditions.



➢Nozzle type

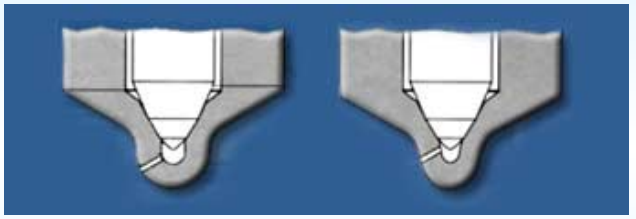
- Technology Improvement from low SAC to Zero SAC Nozzles

-Low SAC Nozzles

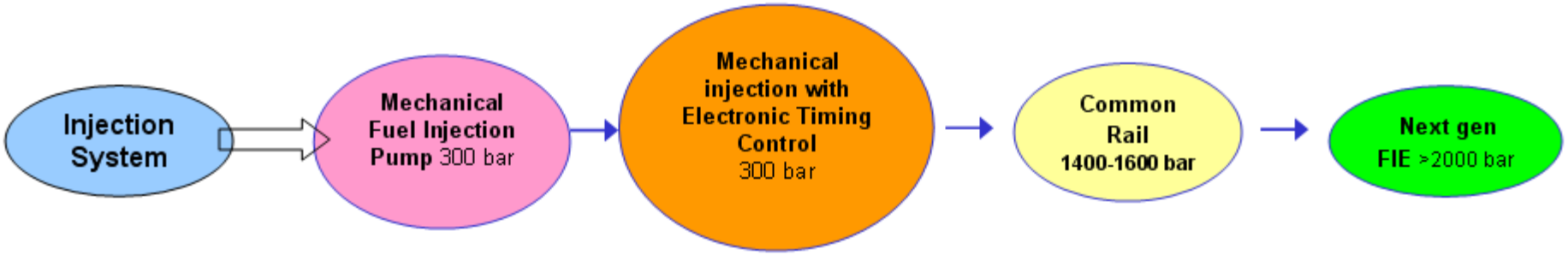
- Small fuel gallery (SAC) between
- needle & nozzle body

- Zero SAC Nozzles

- Zero SAC volume
- Further reduction in HC
- Improved design to overcome nozzle clogging



Fuel Injection System Technology Evolution-Diesel Engine



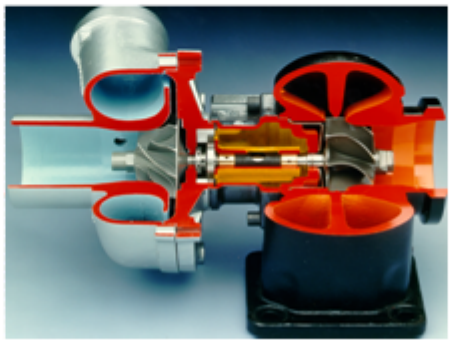
Distributor FIP
- Pressures up to 300 bar
- Injection quantity, timing & pressure dependent on engine speed

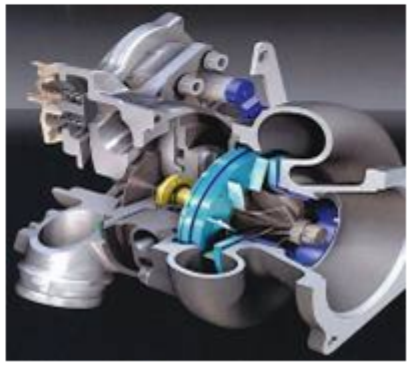
Distributor FIP
- Pressures up to 300 bar
- Injection quantity & pressure dependent on engine speed
- Injection timing Controlled Electronically

Common Rail
- Pressures up to 1600 bar & beyond
- Flexibility in Quantity, timing & Pressure
- Multiple injections possible

Turbocharger Technology Evolution-Diesel Engine

Turbo system ⇨ Natural aspiration → Waste Gate Turbocharger → Variable Geometry Turbocharger

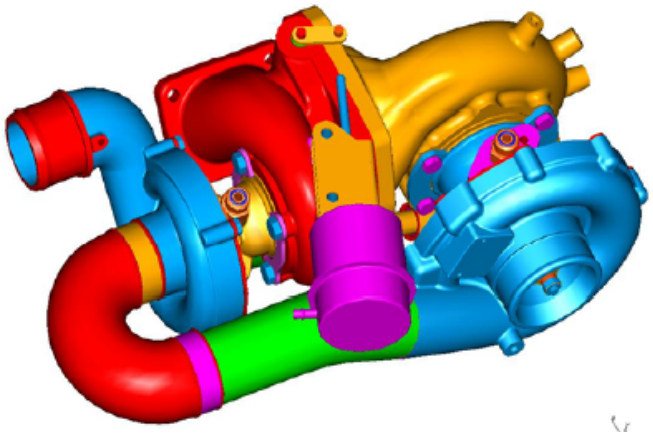




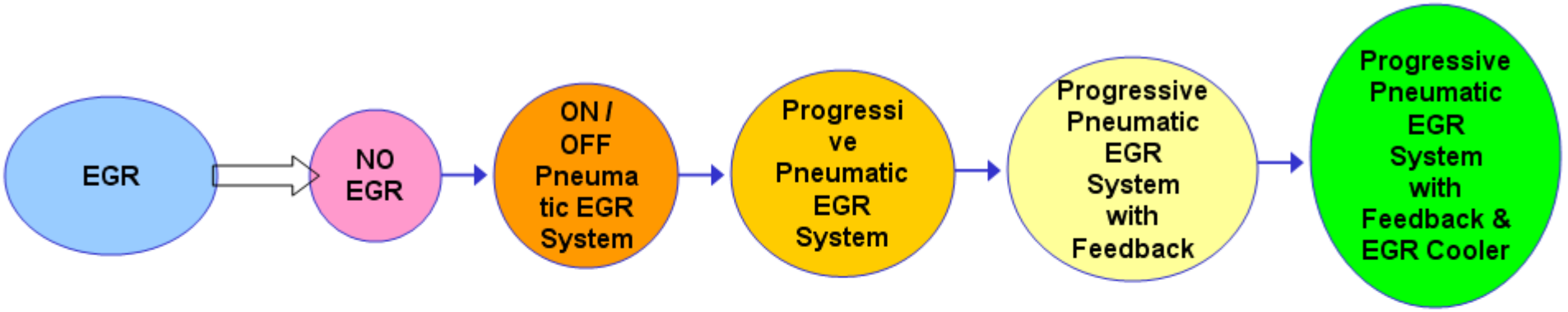
➢Future – Two Stage Turbocharger

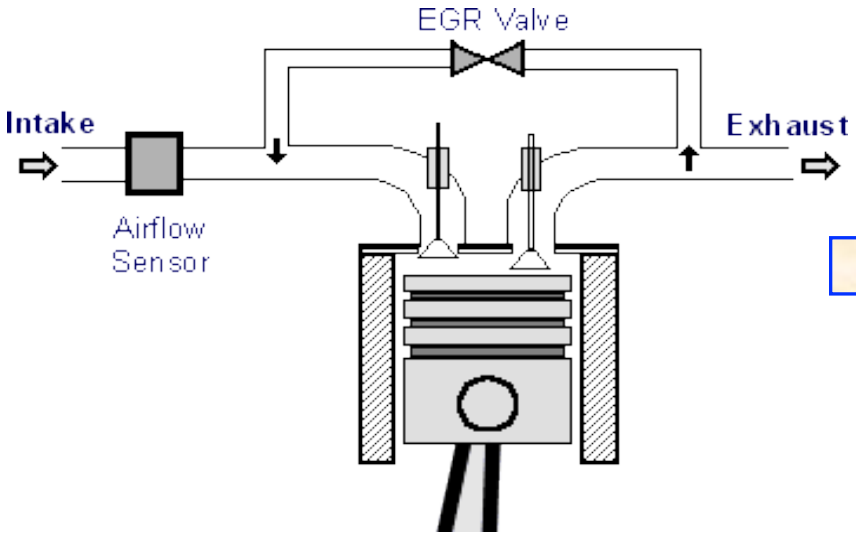
- ❑ High Power Output (entire speed range)
- ❑ Good Drivability
- ❑ Good SFC

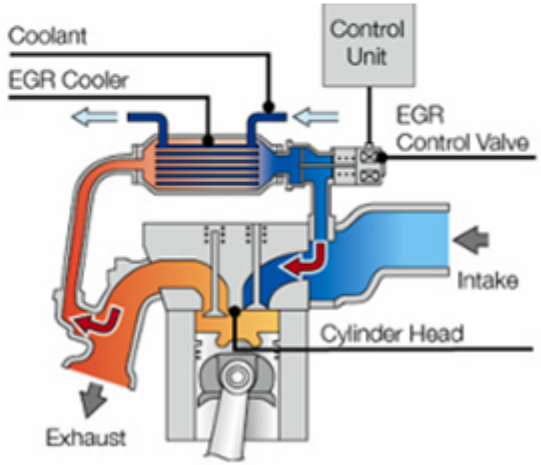
⇨



EGR System Technology Evolution



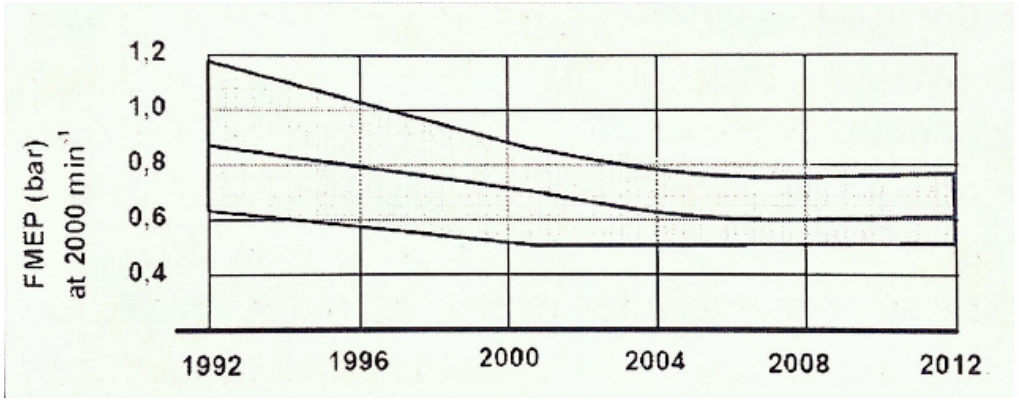




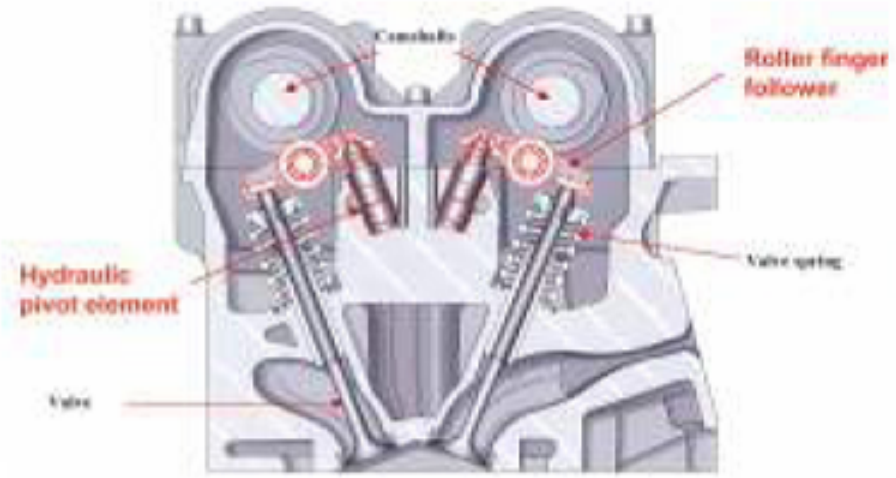
Future: Electrical EGR System with EGR Cooler & Bypass

Engine Friction Reduction - Technology

- Low Friction leads to
  - Low emissions
  - Low Fuel Consumption
- Friction reduction trend over years



- **Valve Train Friction**
  - Valve train Friction – 2%
  - Currently, Roller Finger Follower is being used for the following reasons
    - ✓ Low Friction
    - ✓ Low Maintenance
    - ✓ Adequate Engine Performance
  - Future - Coatings like DLC, CrN



Power-train Technology Movement– Gasoline Engine Passenger Cars

Drive by wire (ETC),VVT, ISAD, GDI, Variable Intake Tuning, Eletromechanical Valvetrain, Variable CR.

Supercharging/Turbocharging

Close Coupled Catalyst with duel cat.

4 valve engine with EMS for ALM

On Board Diagnosis (OBD)

Dynamic knock control for Indica

LPG engines

CNG engines

MPFI with EMS on Indica

Dynamic knock control for MUVs

3-way Catalyst

EGR

MPFI with EMS & 4 valves (2.0 lt)

Carbureted engine (1.4lt)

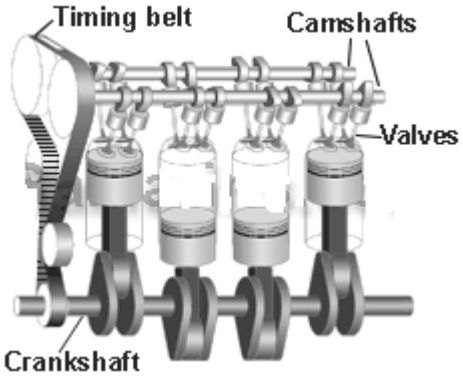
Euro V

Euro IV

Euro III /Bharat Stage III

Euro II/Bharat Stage II

Euro I/Bharat Stage I



Power-train Technology Movement– Heavy Duty Diesel

More Focus on Exhaust Treatment Devices

PM Trap and/or DeNO$_x$ catalyst

On Board Diagnosis

Common Rail

Cooled EGR

Euro IV

Centralized injection / 4 valves / Extended block, ladder frame

Injector outside Cyl. Head cover

High pressure ratio Turbocharging

Electronic Diesel Control (EDC) / VP37 FIE

Euro III /Bharat Stage III

LPG engines for bus and LCV

CNG engines for bus and LCV

Intercooler

EGR on 207DI

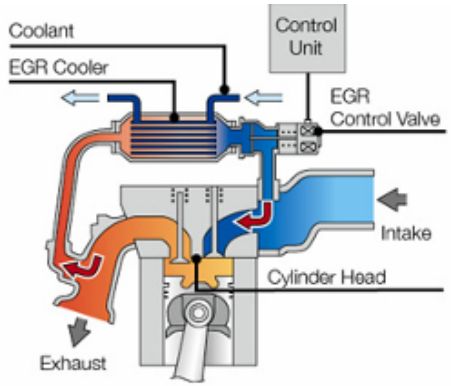
Euro II/Bharat Stage II

High Pressure rotary FIP

Turbocharger

Re-entrant torroidal combustion chamber

Euro I/Bharat Stage I



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Exhaust Treatment Devices

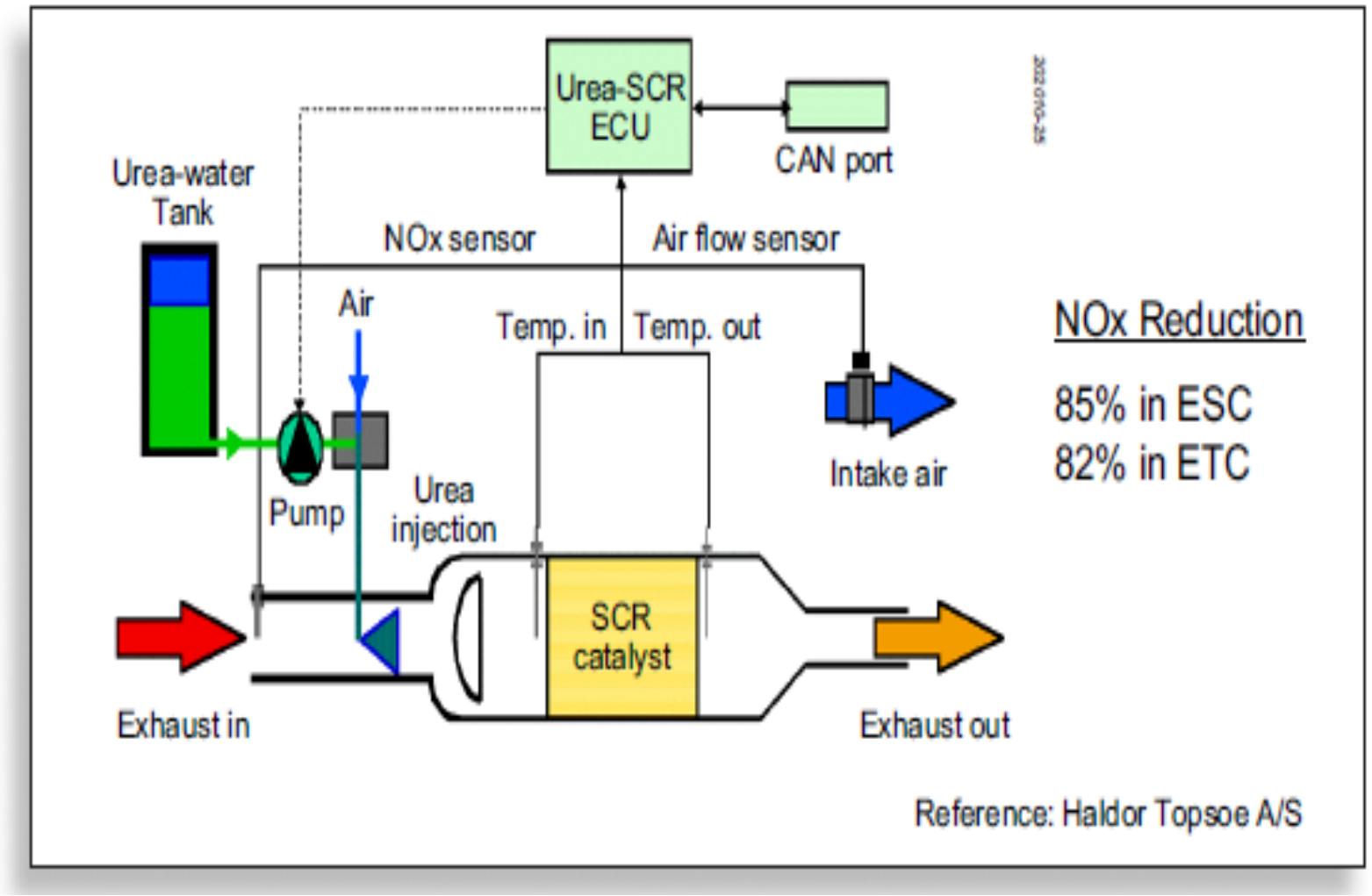
- Predominantly used After-treatment system till meeting BSIV Emission norms is Diesel Oxidation Catalytic converters (DOC).

DOC's – Metal or Ceramic

Future Evolution: DPF / SCR

Exhaust Treatment Devices

SCR



Data Source: ARAI

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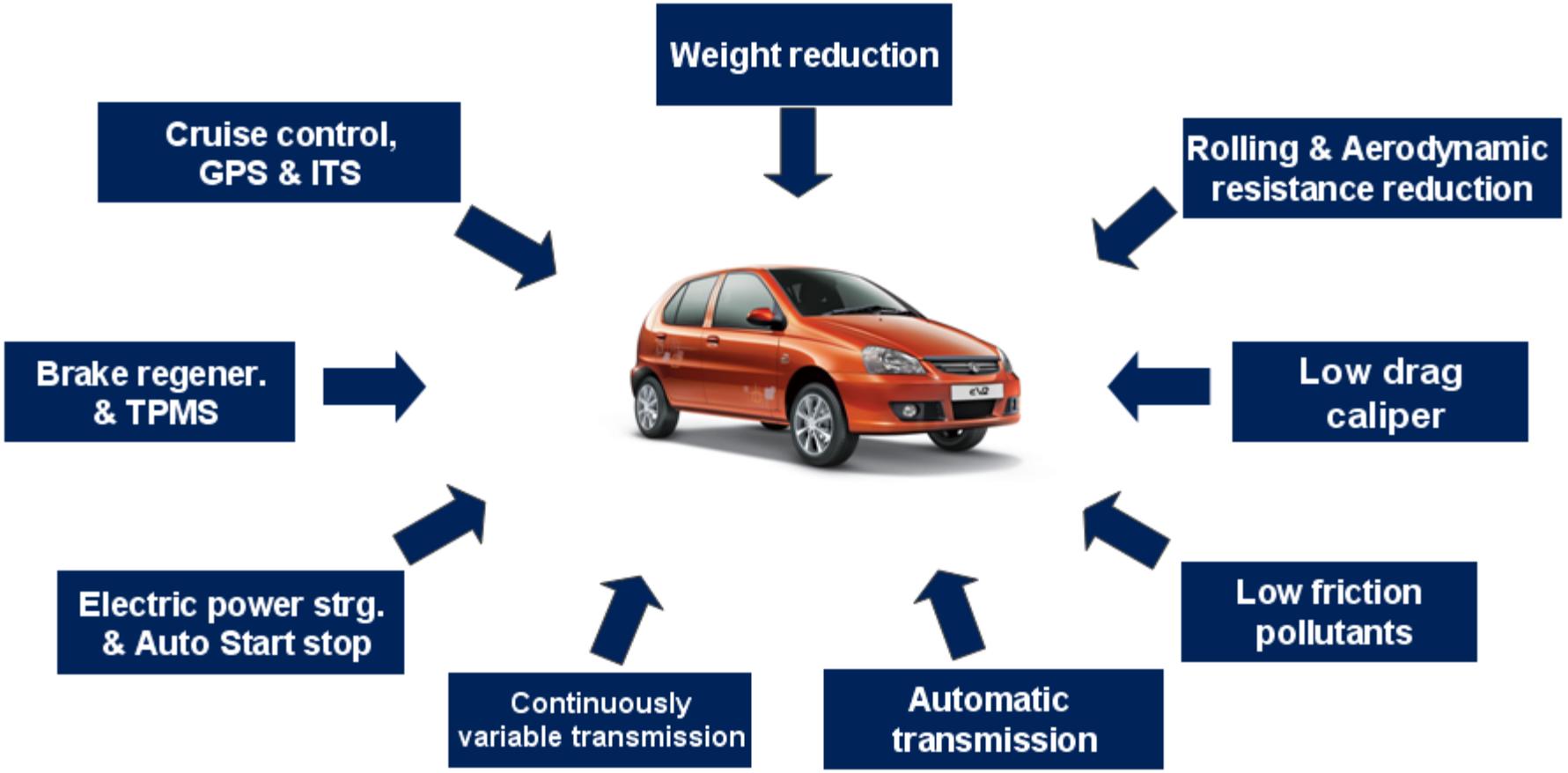
Vehicle Construction



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Eco-Driving

- **The Eco-driving has significant potential to reduce emission pollutants**

- **However, India is losing the benefits due to –**
  - » inadequate driving schools,
  - » lack of motivation for eco-driving
  - » technical unawareness among the drivers.

- **Most of the drivers are unaware that emission performance of vehicle can be improved by -**
  - » optimum vehicle speeds,
  - » reduced idling time,
  - » better acceleration practices,
  - » right gear shifting technique,
  - » route choice,
  - » minimizing number of stops.

Aggressive Driving
(Hard Acceleration and Braking)

Running Improperly
Maintained Vehicle

Driving with Heavy Loads

Excessive Idling

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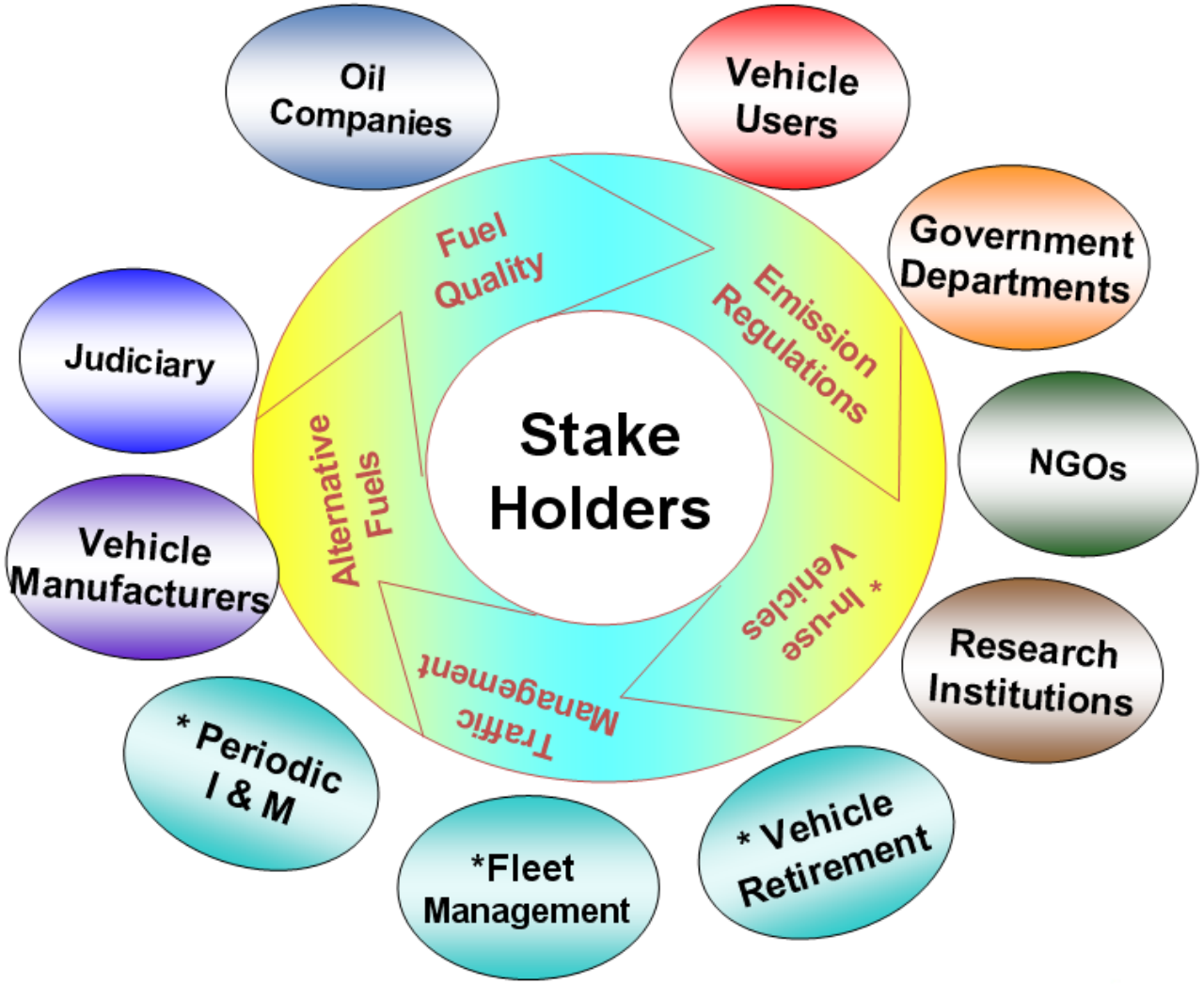
Need for an Integrated Approach for Successful Control of Emissions from Transport Sector



Data Source: ARAI

In-use Vehicle Management

Periodic Inspection and Maintenance

- Proper inspection and maintenance of vehicle help to reduce emission pollutants.
- In India most of the old vehicles, maintenance and servicing is done at road side garages.
- Generally maintenance is done after breakdown instead of preventive maintenance.
- Many 2 & 3 wheeler drivers are least habitual about regular servicing and maintenance of their vehicles.

There is need of strong legislative mechanism for inspection of in use vehicles.

In-use Vehicle Management

Fleet Renewal / Modernization

- Older vehicles are more emission pollutants compared with new vehicles.
- In India, since 1951, 100 million vehicles registered till 2007 (Approximately 80 million vehicles registered after 1991 and most of them are plying on the road).
- In 2006-07, 10 million new vehicles registered which contributes 10% of overall fleet.
- Unlike other developed countries there is no administrative mechanism to ensure end-of-vehicle life.
- It leads to use of very old and more emission pollutant vehicle in large numbers.

In-use Vehicle Management

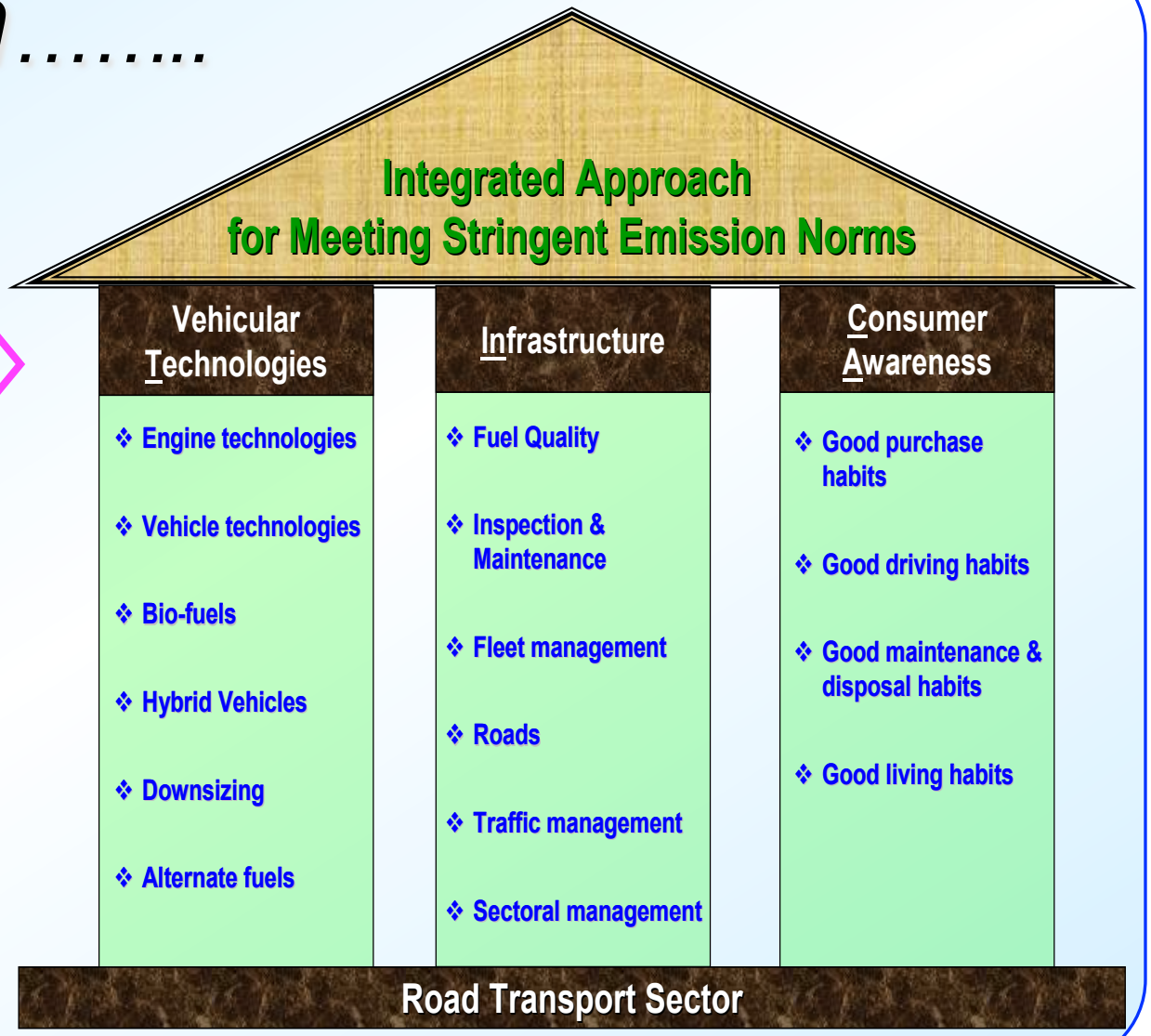
Vehicle Retirement Policy

- There is no limit on the age of the vehicle that one can ply on the Indian roads.
- Given the progressive degeneration of the engines of these vehicles due to lack of proper maintenance as well as their being manufactured when emission norms were far lax, they tend to emit inordinate level of pollutants
- Hence, development of a rationale vehicle phase out program all over the country hold an important place in future govt. policies.
- Further assessment of exact working life of a catalytic converter in vehicles needs to be carried out for development of policies.
- Development of appropriate vehicle scrappage guidelines are very essential after implementation of old vehicle phasing out program in India.

Conclusion.....

T – Technology
In – Infrastructure
CA – Consumer Awareness

3 - Pillar "TInCA" Approach



THANK YOU!!

Questions?