

*Fuel Conversion Programmes:
Perspective of a Three Wheeler Producer*

N.V. IYER

(General Manager, Bajaj Auto Ltd., Pune, India)

**Regional Workshop for Reducing Vehicle
Emissions:**

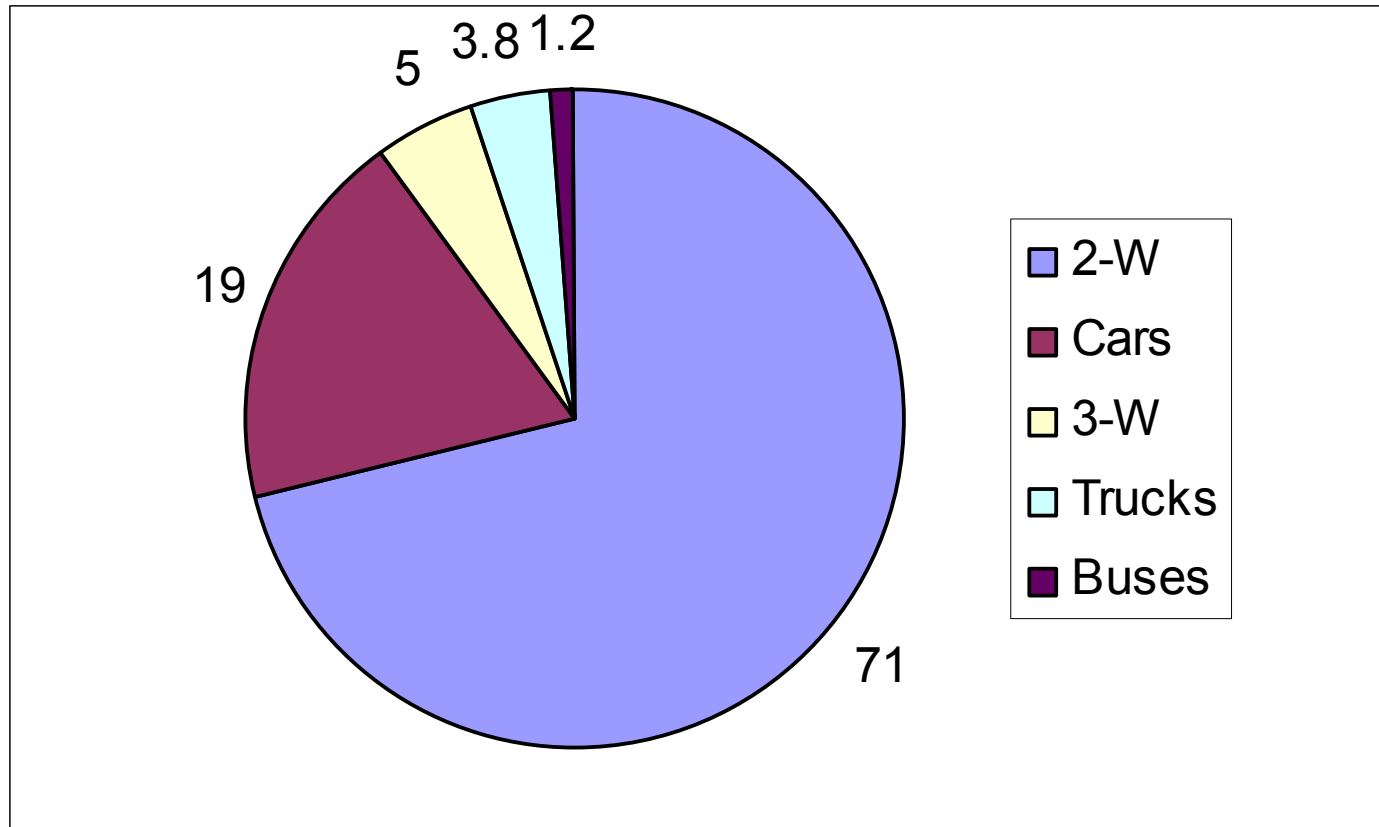
**Reduction of Emissions from 2 - 3
Wheelers**

September 5 - 7, 2001, Hanoi, Vietnam

FLEET COMPOSITION OF INDIAN VEHICLES (1997)

(Source: TERI)

(Two wheelers (71%) & Three wheelers (5%) occupy significant places in the Indian transportation sector)



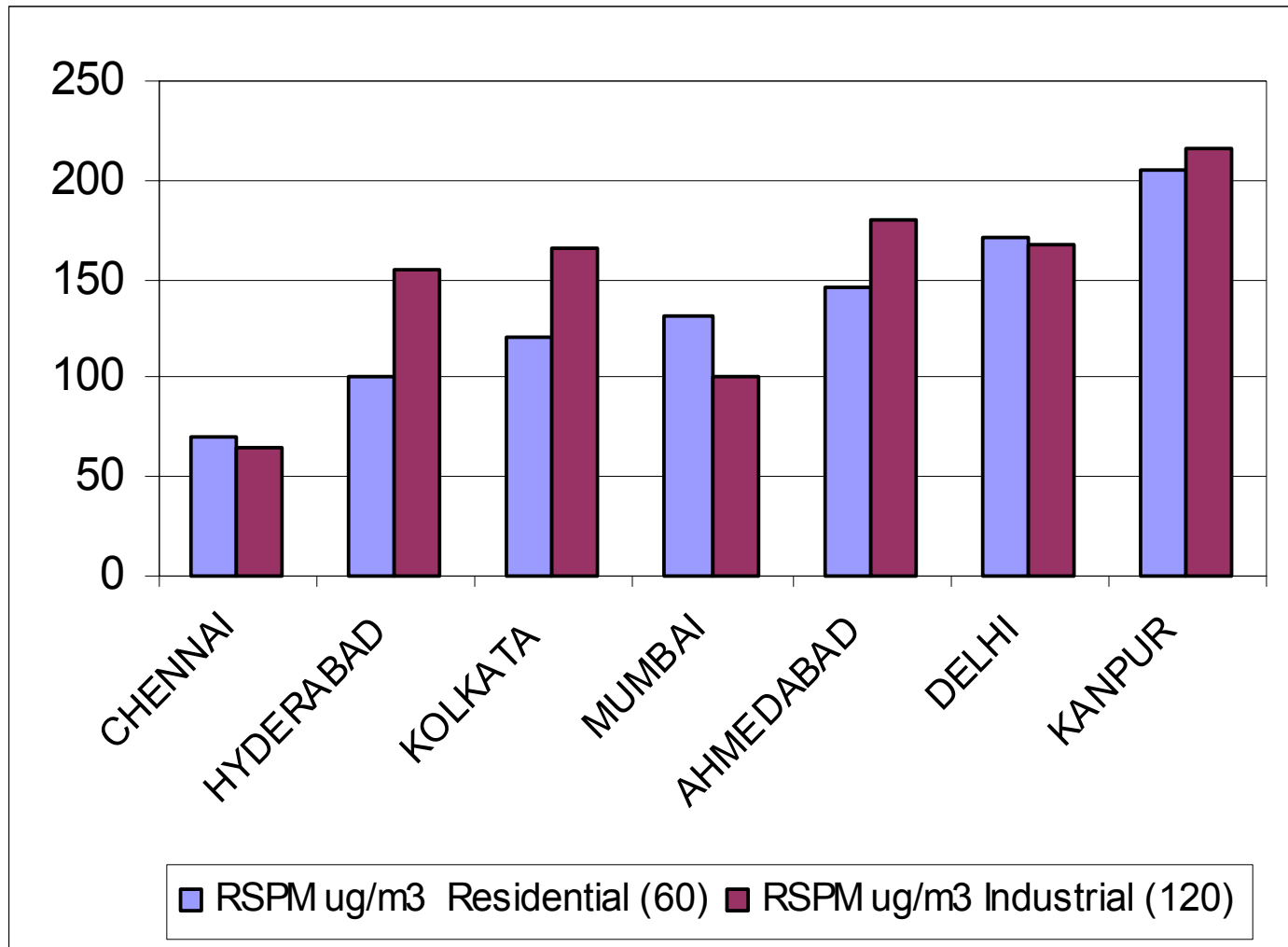
EMISSION CONTROL STRATEGY FOR 2 & 3 WHEELERS: THE RESULT AND ENVIRONMENTAL IMPACT

- ***THE STRATEGY:*** Rapid evolution of new vehicle emission standards for 2 & 3 wheelers
 - First introduction 1991
 - First major revision 1996
 - Second major revision 2000 - among the tightest in the world
 - Next revision expected in 2005
- ***THE RESULT:*** Significant technological advances and the introduction of very low emission vehicles
- ***THE ENVIRONMENTAL IMPACT:*** Arrested further deterioration of air quality, but no significant reduction in ambient pollution levels of of PM₁₀ and CO.
- *(Note: Significant contributions of PM₁₀ come from diesel vehicles and CO from passenger cars)*

AMBIENT RSPM (PM₁₀) LEVELS IN MAJOR CITIES IN INDIA (1999) (Annual Average, $\mu\text{g}/\text{m}^3$)

(Source: CPCB, 2001)

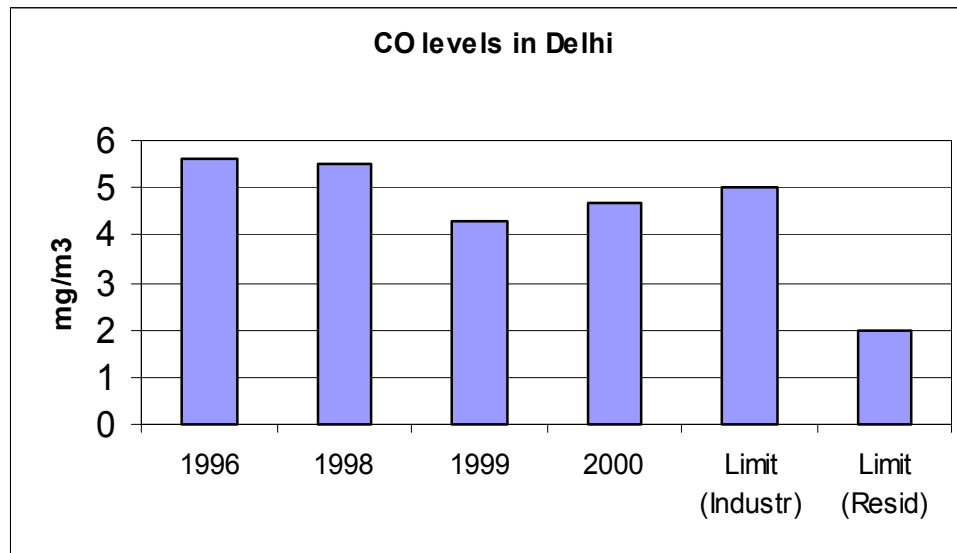
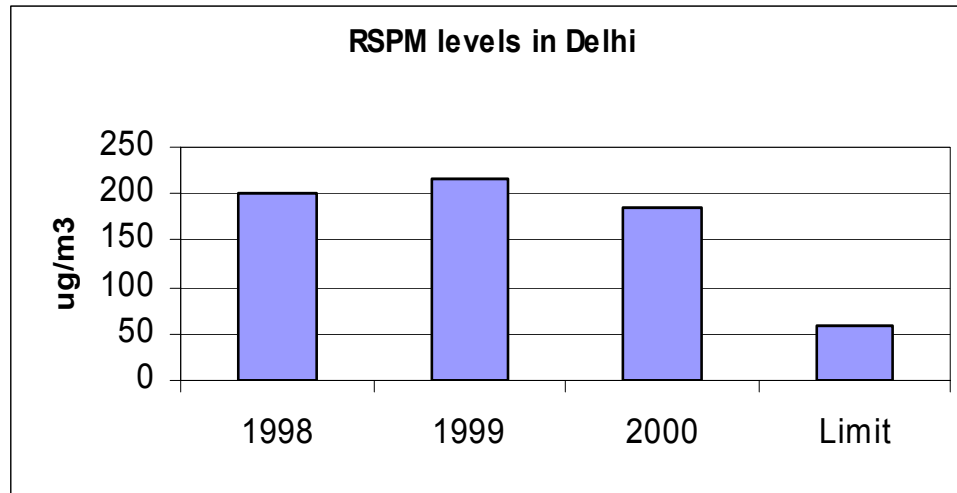
(PM₁₀ exceeds the air quality standards in most cities)



PM₁₀ & CO IN DELHI'S AMBIENT AIR (Annual average)

Continue to exceed prescribed ambient air quality standards

(Source: CPCB, 2001)



COMPLEMENTARY STRATEGIES TO CONTROL EMISSIONS FROM IN-USE VEHICLES: IMPORTANT ROLE OF ALTERNATIVE FUELS

- ***THE RATIONALE:*** Environmental benefits obtained from cleaner new vehicles negated by the pollution contribution of large number of in-use vehicles (poorly maintained and without emission control)
- ***THE STRATEGIES:*** The Supreme Court of India, has ordered, among others, the following for Delhi:
 - Selective replacement of old vehicles with new ones on clean fuels (pre-1990 taxis, auto-rickshaws and 8 year old buses)
 - Selective retro-fitment of clean fuel kits on old vehicles (option available to post-1990 taxis and auto-rickshaws and 8 year old buses)
 - *(Note: The order also called for setting up of 80 CNG filling stations throughout the city of Delhi)*

“BAJAJ AUTO’ AND ITS VISION OF ALTERNATIVE FUEL VEHICLES (AFV) PROGRAMME

- ***ABOUT BAJAJ AUTO:***
 - Largest manufacturer of two and three wheeled vehicles
 - Sales turnover of ~ US \$ 760 million in fiscal 2000-01
 - Domestic market share ~30% in 2-wheelers (~1.05 million vehicles) & > 75% in 3-wheelers (~0.16 million vehicles)
- ***BAJAJ AUTO’s VISION ON AFV***
- *The company’s AFV programme is derived from its vision to develop and market vehicles that are*
 - *environmentally clean*
 - *safe*
 - *durable and*
 - *can be owned and operated at low costs*

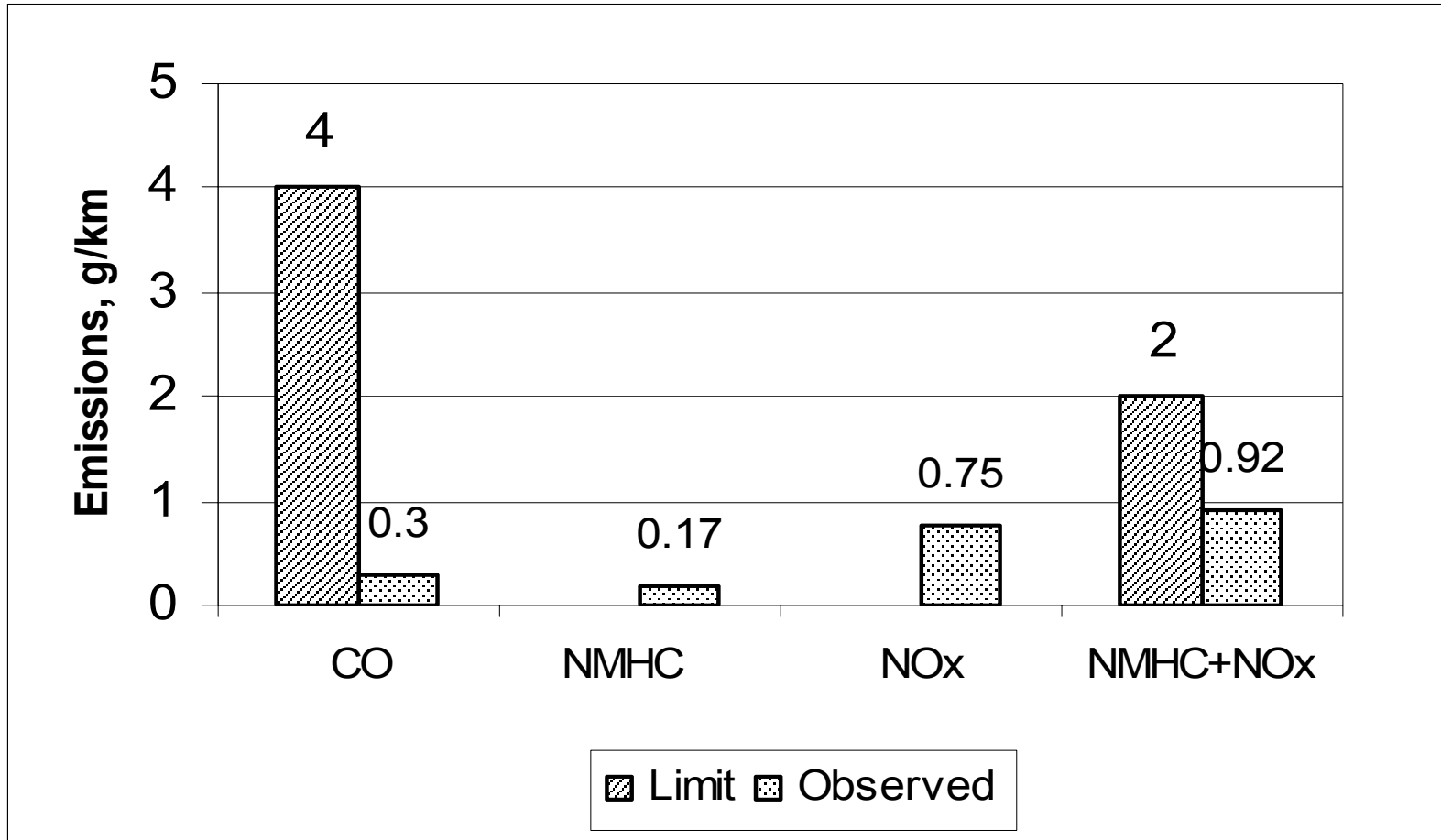
“BAJAJ AUTO’ AND ITS ROLE IN ALTERNATIVE FUEL VEHICLES (AFV) PROGRAMME

- ***Company has invested in the following AFV programmes***
- CNG: for 3-wheeled vehicles
 - auto-rickshaws for dedicated CNG operation (in production)
 - *[CNG on 2-wheelers not a viable option]*
- LPG: for 2 and 3 wheeled vehicles
 - development completed - ready for market introduction as soon as gas dispensing infrastructure is in place
- EV: for 2 and 3 wheeled vehicles (seen as the most potent zero local emission vehicle option in the near future)
 - electric auto-rickshaw undergoing user trials
 - electric 2-wheeler in prototype stage
- ***Company’s AFV programme also includes working with***
 - the energy industry to develop alternate fuel specifications
 - the regulatory authorities to develop safety specifications

“BAJAJ AUTO’,s AFV PROGRAMME: SALIENT FEATURES - 1

- **CNG AUTO-RICKSHAW PROGRAMME:**
- Successfully developed a completely indigenous CNG auto-rickshaw with following features:
 - Uses a 4-stroke,air cooled spark-ignited engine
 - Has a CNG cylinder (22 litre water capacity) capable of holding ~ 3.5 kg of CNG at 200 bar pressure
 - Delivers a fuel efficiency of ~ 45 km per kg of CNG
 - Complies with all notified safety standards
 - Is provided with a 3 litre “limp-home” petrol tank
 - Priced at ~US\$ 2000, about 25% higher than corresponding petrol version (~ 12,5% higher with Delhi incentives)
 - ***Has emissions substantially lower than the prescribed limits:***

“BAJAJ AUTO’ s AFV PROGRAMME: SALIENT FEATURES - 2
EMISSION CHARACTERISTICS OF CNG AUTO-RICKSHAW;
CO and NMHC+NOx substantially lower than corresponding limits
(limits same as for petrol vehicles except HC is changed to NMHC)



“BAJAJ AUTO’,s AFV PROGRAMME: SALIENT FEATURES - 3

- ***LPG AUTO-RICKSHAW PROGRAMME***
 - Auto-rickshaw for dedicated operation on LPG featuring a fixed LPG cylinder is in an advanced stage of development
 - Expected fuel efficiency: 45 km/kg
- ***LPG 2-WHEELER PROGRAMME***
 - A 4-stroke two wheeler (scooterette) for dedicated operation on LPG featuring a fixed LPG cylinder is in an advanced stage of development
 - Expected fuel efficiency: 75 km/kg
- *(Note: Market introduction of both products will be determined by the availability of LPG filling infrastructure)*

“BAJAJ AUTO’,s AFV PROGRAMME: SALIENT FEATURES - 4

- ***EV PROGRAMME***
- ***Advanced Technology***
 - Axial Flux Motor, interfaced directly to transmission
 - DSP Based, 4 Quadrant Sine Drive Controller
 - High Efficiency (>85%) over complete drive cycle
- ***Electric 3-wheeler Auto-rickshaw Programme***
 - Flooded lead-acid batteries
 - Direct drive to rear wheel through a transaxle
 - Range of ~ 100 km in city running conditions
 - Four vehicles undergoing field trials in Agra
- ***Electric 2-wheeler Scooter Programme***
 - Rear wheel mounted motor
 - Sealed Gel type lead acid batteries
 - Expected range of ~ 65 km/ in city running conditions

“BAJAJ AUTO’,s AFV PROGRAMME: SALIENT FEATURES - 5 (EV specifications)

ITEM	2 WHEELER		3 WHEELER	
	ICEV	EV	ICEV	EV
Performance				
Shell Weight (kg)	67	132	276	530
Payload (kg)	130	130	334	334
Top Speed (kph)	55	60	55	55
Gradeability(%)	16	19	16	19
Acceleration (sec) – 0 to 50 kph	16	18	21	30
Range (km) - IDC City	~200	>45 ~65	~160	> 80 ~100
Power Consumption IDC (kWh/Km)	–	<0.02		<0.08
Features				
<ul style="list-style-type: none"> • Battery Voltage – 48V • Throttle input for load sensing • Electric reverse (3 Wheeler) • Programmable acceleration for optimum drivability & battery utilisation • Limp home capability 		<ul style="list-style-type: none"> • Full regenerative braking • Compression brake feeling • Battery SOC monitor • On board charger for opportunity charging in 6~8 hours from 80% DOD • DC/DC converter (14VDC) for vehicle Auxiliaries 		

“BAJAJ AUTO’ s EXPERIENCE SO FAR ON AFV PROGRAMMES

DELHI CNG AUTO-RICKSHAW PROGRAMME -1

- ***THE POSITIVES :***

- Between May 2000 till date, nearly 20,000 CNG auto-rickshaws have been supplied in Delhi to replace old ones
- An enthusiastic response from the owners/operators due to
 - overwhelming fuel economy benefit resulting from superior fuel efficiency and large price differential between petrol (~ Rs 29/litre-US\$0.60) and CNG (~ Rs.15/kg-US\$0.30) leading to a CNG fuel cost of about a third of that with petrol
 - incentives provided for the phase out programme (sales tax exemption, cheaper loan and interest subsidy)

- ***THE NEGATIVES:***

- Deficiency in CNG supply system - long waiting periods at filling stations due to
 - Inadequate supply pressure at daughter cascade stations that are not provided with booster compressors
 - Inadequate number and poor turn-around of cascades

“BAJAJ AUTO’ s EXPERIENCE SO FAR ON AFV PROGRAMMES

DELHI CNG AUTO-RICKSHAW PROGRAMME - 2

- ***THE MARKET CONCERNS:***
- *Uncertain future*: Limited market after all the existing petrol auto-rickshaws in Delhi are replaced. Market potential in other cities non-existent/limited - no clear plans to promote CNG
- *Assurance of supply*: CNG programme has been implemented under Supreme Court orders, but the government is unable to assure adequate supply of gas in future
- *Uncertain fuel price*: CNG prices may not remain as low as now if it is to be imported to meet increasing demand and after the dismantling of the Administered Pricing Mechanism
- *Dependence on a single source*: CNG is supplied from a single pipeline and there is no emergency storage. The entire public transportation system in Delhi (buses, taxis and auto-rickshaws) may collapse in the event of a major disruption

“BAJAJ AUTO’ s EXPERIENCE SO FAR ON AFV PROGRAMMES

DELHI CNG AUTO-RICKSHAW PROGRAMME - 3

- ***THE TECHNICAL CONCERNS***
- *Safety :*
 - Absence of periodic inspection of CNG systems on in-use vehicles (both OE and retro-fitted)
 - Absence of guidelines for retro-fitting workshops and mechanisms to inspect and certify each converted vehicle
 - Absence of effective mechanisms to control illegal conversions (*there have been instances of accidental explosions on such vehicles*)
- *Gas specifications:*
 - Need to evolve specifications of CNG in terms of Methane content or Wobbe Index

“BAJAJ AUTO’,s AFV PROGRAMME: CONCERNS ABOUT LPG VEHICLES - 1

- ***THE MARKET CONCERNS:***
- *Assurance of supply* Recent Government notifications allow the use of LPG as an auto fuel stored in fixed cylinders but there are hardly any LPG filling stations - no clear plans
- *Uncertain fuel price* LPG for kitchen use attracts a large subsidy (price ~Rs 16/kg-US\$ 0.34, subsidy ~ Rs 10/kg-US\$ 0.20). Since the auto LPG price would be based on market forces, its price is likely to be higher and variable. Users may not be attracted to LPG if the fuel economy benefit is too small.
- *Uncertain future*: Increasing LPG demand (due to its use in automobiles) may lead to shortages and drive up the prices
- *Illegal diversion*: Unscrupulous elements may find ways of diverting subsidized kitchen gas to automobile cylinders

“BAJAJ AUTO’,s AFV PROGRAMME: CONCERNS ABOUT LPG VEHICLES -2

- ***THE TECHNICAL CONCERNS***
- *Safety :*
- Due to easy accessibility of domestic LPG cylinders, a large number of illegal conversions of cars, 2-wheelers and 3-wheelers have been taking place in many cities; several accidents have also been reported
- Proposed safety codes of practice allow only fixed cylinders on all categories of vehicles
- Legally approved vehicles can be introduced only when dispensing infrastructure is in place
- A mechanism will be required to discourage illegal conversions

“BAJAJ AUTO’,s AFV PROGRAMME: CONCERNS ABOUT LPG VEHICLES -3

- ***THE ENVIRONMENTAL CONCERNS***
- ***“Opinion divided on whether LPG is a truly environment friendly alternative to advanced engine technology and clean fuels”***
- ***Emission levels:***
 - The total Hydrocarbons (THC) emission of LPG vehicle is higher (~15 to 30%) than that of corresponding petrol vehicle; though, according to the Indian regulations for LPG vehicles, the HC limit is required to be met by Reactive Hydrocarbons (RHC) obtained by multiplying THC by a factor of 0.5
 - The CO and NO_x emission levels are comparable to those of corresponding petrol versions

“BAJAJ AUTO’,s AFV PROGRAMME: PERCEPTIONS ABOUT EV PROGRAMMES

- **EV TECHNOLOGY FOR 2 AND 3 WHEELERS IS READY FOR DEPLOYMENT, BUT THE PRODUCTS ARE NOT YET “MARKET READY”**
- **REASONS:**
- due to high costs of “high energy density” batteries, lead acid batteries remain most viable option - hence range limitation
- gains in system efficiency offset range limitation only partially
- high product cost (presently more than twice the cost of ICE vehicle -may reduce with volume build up)
- low running cost due to cheap electricity is partly offset by the need for periodic battery replacement
- long charging times (over 8hours) a major user concern
- **Short term promotion of EV’s may require policy interventions and government support by way of mandates and/or incentives**

***“BAJAJ AUTO’,s* AFV PROGRAMME: THE EXPECTATIONS -1**

- **FROM NATIONAL GOVERNMENT AGENCIES:**

- Develop a long term integrated environment-transport-energy policy
- Evolve a long term environmental strategy and establish vehicle emission standards
- Give freedom to the automotive and the energy industries to choose the most appropriate technology options, including conventional and alternative fuels
- Develop a policy framework that encourages, rather than mandates, the adoption of alternative fuels
- Facilitate open dialogue among government, private sector, civil society and academe to overcome possible confrontations and arrive at the most cost-effective solutions
- Establish specifications and safety standards for alternative fuels and vehicles and build capacity to enforce these standards
- Provide clear information to the public on emissions, safety, and end-user financial benefits

“BAJAJ AUTO’,s AFV PROGRAMME: THE EXPECTATIONS -2

- **FROM THE ENERGY INDUSTRY:**

- Develop long term investment policies with the government to expand supply infrastructure
- Assure reliable and safe supply of alternative fuels in quantity, quality and at least costs
- Assure easy access to alternative fuels at a large number of outlets
- Develop, with the auto industry, the specifications of alternative fuels
- Promote R&D to develop fuels with superior environmental and performance characteristics

- **FROM INTERNATIONAL DEVELOPMENT AGENCIES**

- Promote/support demonstration and pilot projects
- Provide seed money for start-up programmes
- Prepare Life Cycle Assessment of AFV programmes
- Compile and disseminate information on AFV programmes