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Alternative Fuels for Automobiles and Environment: An Indian Analysis

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ABSTRACT

India as far as financial progress has been concerned, has been growing very rapidly and went on to become the 5th largest economy of the world leaving behind the United Kingdom. It's a subject to be jocular about but we should also focus on the dark side of it, that is the pollution caused by this Industrialization. The automobile sector in our country has been burgeoning at a very tremendous rate but source at which these vehicles are running is still majorly based on the same archaic ways of using fossil fuels specially the crude oil thus causing a pollution not only by in form of emissions released by these vehicles but also while extracting these oils from their sources. This paper aims to analyse various options of alternative fuels that can be used instead of the obsolete crude and what steps the government of India has taken regarding the same. At an international level, the United Nations Sustainable Development goals has played a very crucial role to make the international community conscious about the alarming need to switch to using and exploring the other options not just to comply with the sustainable development goals but also to protect and save the environment from the crisis in which it is now. Air Pollution is one of the most challenging environmental problems faced by the countries in the 21st century specially in India where lacs of people die from it and hence it is in humanity's best interests to look into, curtail and curb this problem as soon as possible.

Keywords: *Automobiles, Alternative fuels, Emission, diversification, Green Initiatives.*

I. INTRODUCTION

Emissions and Fumes released by automobiles is one of the major sources of air pollution in the modern world. Pollutants released by vehicles that is hydrocarbons, nitrogen oxides, carbon monoxides, volatile organic compounds, sulphur dioxide and various other toxic compounds lead to reaction with sunlight thus leading to increasing in temperatures to form ground level ozone which forms an essential ingredient in smog can lead to serious respiratory disorders and lung damage which can prove to be lethal as well. According to IQAir India is the 5th most polluted country in the entire world wherein the annual average of PM 2.5 concentration ($\mu\text{g}/\text{m}^3$)

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is 58.1 times from the expected level of air quality². According to the stats given by the World Health Organisation 7 million people die pre maturely due to air pollution annually and around 2.4 billion people are exposed to risk of various disorders caused by the same.³ The last stats released by the renowned medical journal- The Lancet has shown that around one third that is approximately 2.3 million of the total deaths in India every year are caused directly or indirectly by the air pollution. This also causes huge financial loses for the government as according to the last study it was estimated to be around \$36.8 billion which comes up to be around 1.36% of India's total GDP. It's high time to take the cognizance of this issue before it results in a catastrophe and becomes too late to control. These consequences are not unpredictable as various dedicated organizations and think tanks have carried out researches and scientifically proved the detrimental impacts that can occur if swift actions are not taken to truncate the air pollution.

(A) Methodology

This paper is done and is based on secondary research sources like specialist research papers, articles, reports and other material available online. A deep analysis has been made in order to determine the cause and findings of the issue and to present certain recommendations on the matter.

(B) Literature review

- **Recent developments on alternative fuels, energy and environment for sustainability – Gopal Krishna Kumar** – This paper focuses on enhancing energy and the environmental systems and how alternative fuels play a significant role in not only saving the environment but also sustainable development and why cleaner options are important for the growing needs of the humans.
- **Alternative fuels: An overview of current trends and scope for future- Sangeeta, Sudheshna Moka**- This particular paper emphasises over the growing concerns of the rapidly depleting fossil fuels and other natural resources and how alternative fuels act as a saviour and are almost as efficient as the conventional fuels that are being used today.
- **Environmental Impact of Alternative Fuels and Vehicle Technologies- Mohd Hossein** – This paper is an attempt to tell the environmental impacts of the usage of alternative fuels as far as automobiles are confirmed, how the modern technologies are working and

² IQ Air Quality Index- <https://www.iqair.com/in-en/world-most-polluted-cities>

³ World Health Organization- Harm due to pollution-https://www.who.int/health-topics/air-pollution#tab=tab_1

comparison of the alternative options with each other.

II. Legal framework

The government has taken various steps for promotion of alternative fuels and green initiatives-

- Section 20 of the AIR (PREVENTION AND CONTROL OF POLLUTION) ACT,1981 deals with power to give instructions for ensuring standards for emission from automobiles.⁴
- The Motor Vehicles Act, 1988, inter alia, provides for prevention and control of air pollution from automobiles which constitute a major source of pollution everywhere, especially in the congested metropolis.⁵
- Sub-section (1) of section 110 of the said Act inter alia lays down that the Central Government may make rules regulating the construction, equipment and maintenance of motor vehicles.
- Amending the Central Motor Vehicles rule 1989, and included H-CNG as an automotive fuel.
- Ministry of transport exempted vehicles running on electricity, ethanol and methanol from permit for carrying goods or passengers.
- Developed a system to link Pollution under control data with VAHAN Database.
- Green number plates are made mandatory for EVs
- Issued a notification regarding blending of gasoline with methanol to reduce exhaust emissions.
- Made mandatory to meet the standards given by the ministry. (Bharat Stage (CEV/Trem)-V)
- Insertion of Quadricycles as a non-transport vehicle under Motor Vehicles act 1988.

III. FUELLING THE AUTOMOBILE SECTOR TODAY

For the transportation purposes, the fossil fuels which are being used from the beginning and are still pre dominantly used are diesel and gasoline. Some other forms of fuel which are making a mark and are increasing their share are CNG, LPG, LNG. Electronic Vehicles are also being deployed in the market at a rapid rate these days. However, these alternative fuel options are

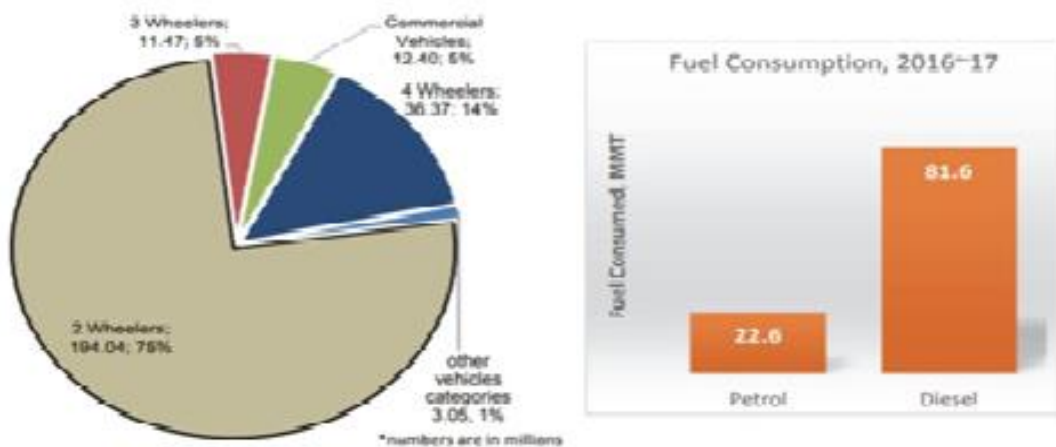
⁴ Air (Prevention and control of Pollution) Act, 1981, No.14, Acts of Parliament, 1992 (India)

⁵ The Motor Vehicles Act, 1988, No.59, Acts of Parliament, 1988 (India)

not being able to be used efficiently due to several reasons like – lack of infrastructure, proper linkage for transportation of fuels, lack of financial instruments, cutting edge technology which is required to store these fuels etc.

According to various stats given by PPAC and SIAM, the number of vehicles in India in in 2016-17 was around 257.32 million out of which two-wheelers compromised of nearly 75% of the total figures. At present the technology is not advanced enough in our country that we can run most of the vehicles on alternative fuels as it can cause failures in the field and breakdown of vehicles. Hence there is a need to develop parallel dispensing of alternative fuels into the design of the program.

The Indian transport runs mainly on diesel and petrol along with CNG in some states. The gasoline is consumed almost entirely by the transport sector while around 70% of diesel is used up in the same. Below are the stats of consumption of diesel and petrol in our country-



Share of various types of Vehicles in fuel consumption

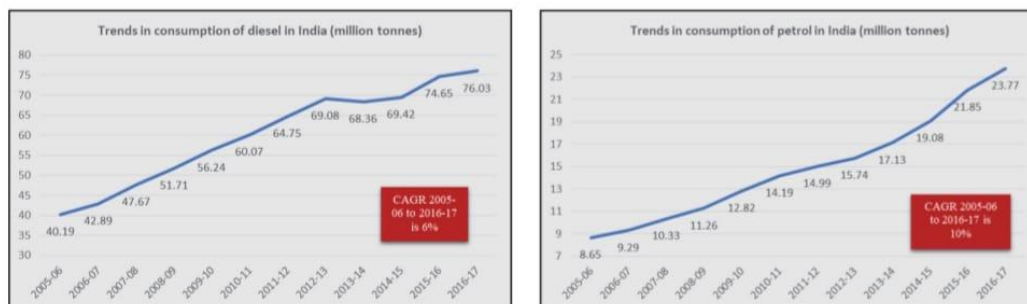


Figure 2.3: Trends in consumption of diesel and petrol in MMT (Source PPAC)

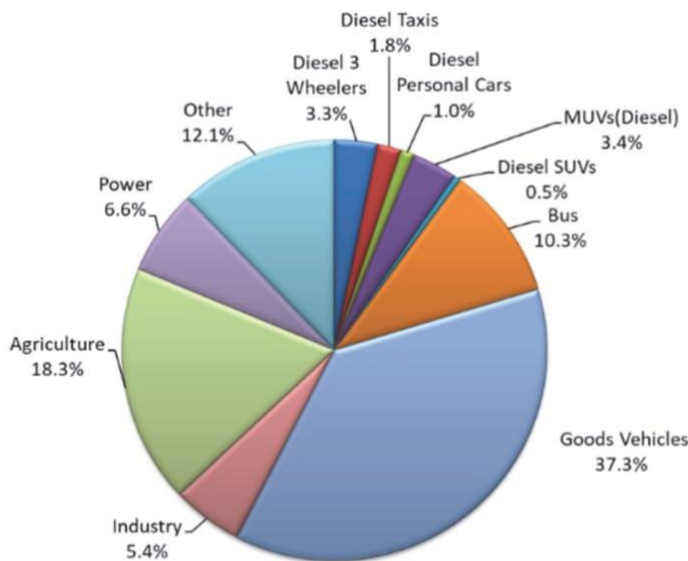


Figure 2.4: Apportionment of diesel usage in vehicle types (SIAM Estimate, 2013)

IV. ALTERNATIVE FUELS IN INDIA FOR EXCLUSIVELY FOR AUTOMOBILES

Many options of alternative fuels are available these days in India like CNG, LNG,LPG, ethanol, biodiesel etc. and the government is putting all its endeavours to achieve the targets to completely eradicate all the orthodox fuels and promote the usage of these fuels

Here are some options of fuels which are growing rapidly in our country-

1) BIO-Diesel-

Produced from non-edible vegetable oils, used cooking oil or animal fats and acid oil it is a methyl or ethyl ester of fatty acids. In 2005 the government of India initiated national biodiesel mission (NBM) that is biodiesel blend of 20% with primitive diesel by 2017 and also announced National policy on biofuels in 2009. With advancements in technology the vehicles these days have compatibility with 5% biodiesel blended diesel.

The Govt has allowed private manufacturers, authorized dealers and joint ventures to sell biodiesel directly to people but there is a rider that it should meet the prescribed BIS Standards.

The usage of biodiesel is growing at a tremendous rate as years are passing-

Biodiesel Use in India (Million Liters)									
Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Biodiesel, on-road use	15	36	28	44	44	26	42	40	44
Diesel, on-road use	39,834	42,625	45,520	49,343	49,354	49,605	52,239	55,179	57,452
Blend Rate (%)	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

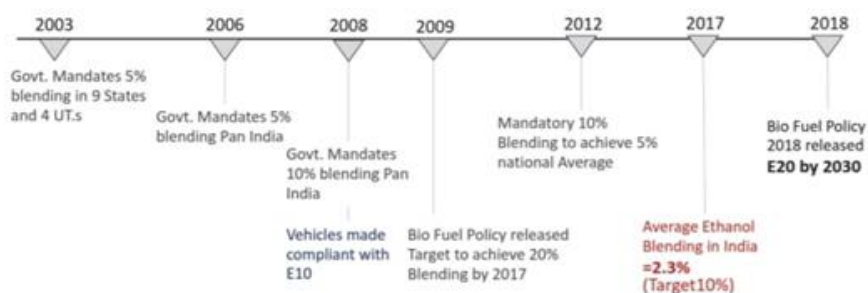
Table 3.2: Bio-diesel use in India (Source: USDA Annual Report on Biofuels, 2017)

2) Bio-Ethanol-

Produced from sugar and starch containing compounds like sugarcane sugar sorghum, corn, algae and even cellulose containing materials like wood waste, forestry residues etc bio-ethanol is the most commonly consumed biofuel. In India almost 98% of it is produced by sugarcane molasses. With growing production and need of biofuels, the two-wheelers and passenger vehicles were being manufactured in a way so that they are compatible with 10% ethanol blended fuel.

With growing demand of it, the govt established country's first 2G ethanol plant in Kashipur in Uttarakhand which has the capacity to produce 10 tonnes of biomass a day by using agricultural wastes with optimum product yields. Another advanced plant was setup in Pune in 2017 and has the capacity to produce one million litres of ethanol annually.

The government has taken various measures and steps from time to time regarding using ethanol as blend with gasoline in varied proportions-



Govt. rules on Biofuel Blending

3) Methanol-

It is a clear fuel which is an alcohol and is produced by various materials like natural gas, coal, cellulose and biomass and is very economical as far as its production is concerned and is very efficient. NITI AAYOG the think tank of government of India has initiated plans to transition to methanol economy in India as it will not only reduce the costs of importing oils but also curtail the emissions to a large extent.

Methanol is a very volatile and a reactive compound which may corrode the metals in automobiles and hence the vehicles running on gasoline are not advance enough to run on methanol blended fuels.

The Government is taking various measures and is investing in large amounts to develop a machinery that can lead to the production of vehicles which are compatible with methanol

blended fuels. India currently is at a very beginning stages of methanol production but with the availability of the resources and raw materials it has great potential to produce Methanol. It is mainly produced in the states of Gujrat, Assam and Maharashtra.

Year	Domestic Production (MT)	Net Imports (MT) (import minus export)	Consumption (MT)	Percentage of domestic production in methanol consumption	Percentage of import in methanol consumption
2010-11	0.375	0.77	1.14	33%	68%
2011-12	0.360	1.08	1.44	25%	75%
2012-13	0.255	1.21	1.47	17%	82%
2013-14	0.307	1.23	1.54	20%	80%
2014-15	0.210	1.59	1.80	12%	88%
2015-16	0.163	1.67	1.83	9%	91%

Methanol Production and imports

4) Compressed Natural Gas-

Everyone is aware of what CNG is in India nowadays as our nation has not only successfully spread it to majority of the states of the country but also efficiently utilizing it and hence enabled to completely shift to CNG run vehicles. There almost 30 lakh vehicles on road at the moment and they form a substitute for around 3% of the oil imports with an ever growing potential. Even though it has huge acceptance by the people who form the customers however the widespread availability is limited due to lack of infrastructure. The government is taking all possible steps to increase the use of CNG and hence over the last 4 years there is an increase in the sales of CNG with CAGR of approximately 9% but mainly from the areas where established infrastructure is present.

State/Source	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (Upto Dec18)
Onshore						
Andhra Pradesh	254	295	276	322	296	182
Arunachal Pradesh	69	57	55	50	43	41
Assam	4,473	4,185	4,203	4,345	4,309	3,090
Gujarat	4,653	4,461	4,605	4,591	4,626	3,527
Rajasthan	8,848	8,602	8,165	7,887	7,667	5,205
Tamil Nadu	241	261	284	345	395	310
Total Onshore	18,538	17,861	17,588	17,540	17,336	12,355
Share of PSUs (excluding JV share)	9,482	9,051	9,192	9,386	9,367	6,913
Share of Private/JV	9,056	8,810	8,396	8,154	7,969	5,442

State	No. of CNG Stations	No. of CNG Vehicles	No. of Companies	CNG Sales, TMT			
				2014-15	2015-16	2016-17	2017-18 (Apr~Sept)
Gujarat	403	872,370	6	475.9	503.0	546.3	298.1
Delhi / NCR	423	987,817	1	717.1	738.3	803.8	435.4
Maharashtra	253	740,058	2	531.4	565.0	592.6	311.2
Andhra Pradesh / Telangana	47	40,183	2	25.8	27.4	28.5	14.6
Rajasthan	3	6,421	1	2.6	3.68	4.27	2.3
Uttar Pradesh	62	124,242	8	184.8	211.6	245.4	141.2
Tripura	6	10,110	1	9.5	11.2	12.3	6.6
Madhya Pradesh	26	26,319	2	16.6	19.19	21.6	11.9
Haryana	37	125,227	3	72.3	74.6	109.0	70.3
West Bengal	7	3,274	1	1.24	1.3	1.6	0.2
Karnataka	3	224	1	0.00	0.00	0.01	0.01
Chandigarh	2	1,500	1	0.00	0.00	0.00	1.7
All India	1273	2,937,995	21	2037.2	2155.4	2365.5	1293.7

Table 3.4: CNG vehicle sales (Source: PPAC)

5) Liquefied Natural Gas-

It is a fuel with very low carbon and best suits heavy duty engines involved in transportation or travelling across long distances specially trucks and hence is stored in cryogenic tanks. It is stored in the form of liquid therefore size of tanks is smaller than that of CNG. LNG can be used in the form of monofuel in case the availability of LNG is sufficient while in areas where it is not as much available and long range of vehicle operation is required, more expensive dual fuel engines are used that is LNG + Diesel.

India is the 4th largest importer of LNG – 19BCM and the demand can even touch 30BCM in the near future. Currently India's import capacity is around 30.0MMTPA via 4 terminals that are-

Existing Terminals	Capacity (MMTPA)
Dahej	15
Hazira	5
Dabhol	5
Kochi	5
Total Capacity	30

LNG Availability in India

6) Hydrogen-

Often regarded as the next generation fuel it is a robust energy carrier with high potential for clean and efficient transportation. It can reduce the amount of carbon emissions to negligible

amounts, can enhance energy security, reduce oil dependency and greenhouse emissions and hence curb the air pollution. Hydrogen has a very high energy content and has 120.7 Kilojoules/g that is the highest energy among the known fuels. On combustion it produces only water as a by-product and hence is very beneficial not only for people but also the environment. According to a study, Hydrogen as a fuel can cause a tremendous 33-35% reduction in greenhouse gases by 2030 along with affordability and sustainable transportation.

India has developed hydrogen driven 2 wheelers and 3 wheelers as well. BHU has successfully built commercially available 2 and 3 wheelers that can operate on hydrogen. Some other universities like MCRC Chennai, IIT Kharagpur etc are engaged in production of hydrogen by using biomass and various other renewable energy routes.









7) Liquefied Petroleum Gas (LPG)-

It was seen as a clear substitute of petrol in the beginning of the century but failed gradually as it was not very compatible, very high fuel price and hence not worth to invest and also caused many severe accidents and hence was not widely accepted and ultimately discarded.

8) Dimethyl Ether (DME)-

It has a very high amount of cetane present even more than that of diesel therefore it has great burning characteristics and calorific value, with very low emissions specially that of particulate matter. It is produced by the process of dehydration reaction and catalytic reactions of methanol along with various catalysts. It has a great potential and is a promising alternative but currently is in its infancy stage and in order to use it at commercial levels a great support of R&D and government is required.

Here is the summary on how these fuels are working and helping in achieving national goals and objectives-

Criteria	CNG	LPG	LNG	Ethanol	Bio-Diesel	Methanol	DME	Hydrogen
Reduction of CO ₂ from Base fuel (Gasoline /Diesel)	+++	++	+++	+	+	+	+	++++
WTW CO ₂ emission	++	+	+	++	+++	+ (coal) ++ (biomass)	+	++++
Local Sourcing Possibility	+++	-	-	+++	++	+++	++	+
Replace / Reduce								

V. ALTERNATIVE FUELS IN DIFFERENT SEGMENTS OF AUTOMOBILES

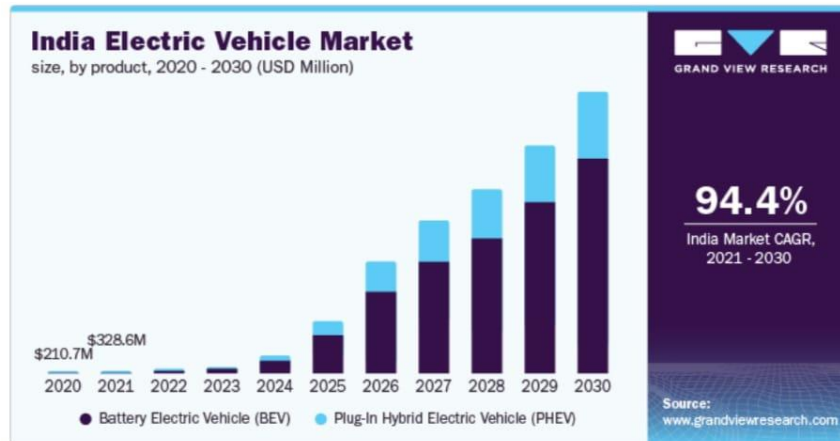
In the modern times, we have a variety of vehicles which run on various types of fuels but the drawback is that many fuels which are readily available are not feasible or the fuel which is feasible is not available in required quantity due to the lack of infrastructure and hence every fuel has its own pros and cons and depending upon that we can do a relative classification-

Alternative Fuels												
Vehicle Type / Technology	CNG	LPG	LNG	E10	E20	>E20	B7	M3	M15	M100	DME	Hydrogen
2Wheelers	X	X	X	OO	O	■	X	OO	O	X	X	X
Cars / UVs - SI	OO	OO	X	OO	O	■	X	OO	O	X	X	O
3Wheelers - SI	OO	OO	X	OO	O	■	X	OO	O	X	X	O
Buses	OO	X	O	X	X	X	OO	X	X	O	O	O
Trucks	X	X	O	X	X	X	OO	X	X	O	O	X
LCV's	OO	X	O	X	X	X	OO	X	X	O	O	X
Cars / UVs - CI	X	X	X	X	X	X	OO	X	X	X	X	X
3Wheelers - CI	X	X	X	X	X	X	OO	X	X	X	X	X
Legend:												
OO	Technology Available, Feasible Fuel											
O	Technology Needs development, feasibility to be established											
■	Technology Needs development, Feasibility of Fuel less due to availability											
X	Not a Feasible fuel for the vehicle type											

VI. GROWTH OF EV'S AND ITS PROS AND CONS

According to a study by NITI Aayog, by 2030 around 80% of two and three wheelers, 40% of the buses and 50-70% of the cars in India will be running of electricity as our nation is heading towards its ZERO-EMISSION 2070 Goal. The government is working very meticulously to deploy as much electric vehicles as possible. Subsidies are being offered for EV's with a tax exemption of 1.5 lakh rupees if bought on loan. GST is just 5% with absolutely no cess. Under the scheme called Faster adoption and manufacturing of hybrid and electric vehicles (FAME) government is taking efforts to rapidly develop infrastructure for EV manufacturing along with a plan to setup 22,000 EV charging stations.

According to CAGR and various other institutions the EV market is ever growing and has a lot of potential –



PROS-

- It is environment friendly with zero emissions.
- To battle pollution the government has been giving a lot of incentives on buying of EV's
- Running costs of EV's is very low as no fuel is required and they require almost zero maintenance.
- They provide higher energy efficiency than archaic cars which can go up to around 62% according to cars24.
- It is a onetime investment and no license or registration is needed.

CONS-

- Batteries of EVs are made up from elements like lithium nickel cobalt manganese etc which when extracted a lot of pollution is caused.
- Cost of EVs is major issue as it is very expensive.
- Lack of Infrastructure also poses a major problem as EVs can go up to 400 kilometres once charged and charging stations are required at regular intervals.
- Charging it at home is a process full of agony as it may take up to 24 hours or even more.
- The spare parts are very costly and hard to find.

VII. CONCLUSION

To lower the consumption of primitive fuels, electrification along with hybridization is required. Various National Objectives such as energy security and lowering emissions only by curtailing the use of primitive and promoting alternative fuels. Well planned positioning of biofuels is important for our nation considering huge increase in demand not just for the automobile industry but other sectors. An efficient roadmap is required with details of the steps that should

be taken by stake holders, fuel producers and car companies at individual level and should be based on sound engineering and scientific debate so that it can be successfully be implemented.

For diversification of fuel, it is necessary to consider-

- Diverse vehicles running on different fuels and having different duty cycles.
- How much fuel is consumed in different segments
- Geographical variation of India, origin of resources and logistics.

Acceptance by customer is the key to successfully bring in the alternative fuels and reduce the fossil fuel imports and march towards the goal of One Nation, One fuel.

Steps should be small but concrete so that the ecosystem grows and simultaneously there is penetration of fuel and required technologies. We should start with a lower blend of these fuels for easy diffusion in vehicles and acceptance by the customer while addressing the environmental concerns.

The automotive industry can concentrate on engineering in the vehicles and a clear roadmap with milestones is essential for all stakeholders to work in unity and accomplish the national objectives and ultimately save the environment.

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