

## Vision & Recommendations

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## Alternative Fuels in India

**SIAM**

Society of Indian Automobile Manufacturers

*Building the Nation, Responsibly.*

# CONTENTS

1. Executive Summary
2. Background
3. Alternative Fuels options in India for Automotive Purposes
  - a. Status of Various Alternative Fuels
  - b. Summary of relative assessment on National Objectives
  - c. Possibility of alternative fuels in different segments of automobiles
  - d. Tradeoff's and how these can be reduced
4. Vision -Opportunity for Diversifying Fuel Usage
5. Key Enablers to Fuel Diversification
6. The way forward

## 1. Executive Summary

The automobile market has been growing at a steady pace and India is moving towards becoming the world's 3<sup>rd</sup> largest automobile market in the next few years. This growth, which is good for the economy, employment opportunities and for the Indian consumer, will put pressure on India's energy requirements to fuel the growth. At the same time this will also have an impact on the contribution of transport sector towards the CO<sub>2</sub> foot print.

**GOI target to reduce crude oil imports by 10% by 2021-22**

**India's NDC target: Reduce Energy intensity by 33~35% by 2030**

There are growing concerns about the use of fossil fuels regarding burgeoning oil import bill, rising levels of air pollution, CO<sub>2</sub> emissions and depleting stocks of mineral oils like gasoline and diesel. The Government of India, therefore has mooted a roadmap for reduction of import of crude oil dependence by 10% by 2021-22 and reducing the energy emissions intensity by 33%-35% by 2030 as per the Nationally Determined Contribution (NDC) targets agreed in COP21 at Paris, by increasing production of natural gas; promoting energy efficiency and conservation measures; giving thrust on demand substitution; capitalizing untapped potential in biofuels and other alternative fuels/renewables; and implementing measures for refinery process improvements.

Transport sector contributed 138 TMT of CO<sub>2</sub> in 2007~08 (Source: Report on Low Carbon Strategies for Inclusive Growth, Kirit Parikh, 2014), which was around 7% of overall CO<sub>2</sub> from India. With the higher demand of fuels in future, it is expected that the contribution could rise to 346 TMT by 2022 in a business-as-usual case, an increase of about 150%. This can potentially result in an increased contribution to overall CO<sub>2</sub> from the transport sector which is around 7% against global averages of 20%.

This paper and strategies for different sectors of road transport, have been developed taking into consideration the **two major National Objectives** as stated below:

**Energy Security and Improvement in Environment are two National objectives**

**1. Improving India's Energy Security – Reduced dependence on Imports of crude oil**

**2. Improving Environment – Reduced impact from transport sector in terms of CO<sub>2</sub> and tailpipe emissions**

Government of India has announced fuel efficiency norms for different categories of vehicles. While the efforts to improve the fuel efficiency of all modes of transport are definitely going to help reduce the new fleet fuel consumption and in the long run will also have a positive impact on the reduction of growth rate of fuel imports, considering already enormous dependence on fuel imports, these efforts need to be substantiated with many other complementary efforts to have a significant impact on the fuel imports.

While one such major effort will come by way of electrification of fleet, India needs to work on other efforts, to not only complement this effort, considering the ultimate objective of improving India's Energy Security.

**Besides electrification of fleet, fuel diversification will be necessary to meet India's National Objectives**

One such major effort will be to diversify the fuel usage within the transport sector. This holds potential to use our indigenous resources and therefore support the "Make in India" initiative of Government of India, while at the same time reduce the CO<sub>2</sub> foot print from vehicle fleet.

The policy landscape of alternative fuels in India is still evolving and being debated particularly on enhancing and optimizing the blending of biofuels. The automobile industry is major stakeholder in policy formulation and implementation of alternative fuels. Therefore, SIAM a representative body of automobile sector through this white paper presents a possible roadmap for fuel diversification to achieve the above National objectives.

**India is world's 2<sup>nd</sup> largest 2W market, 5<sup>th</sup> largest PV market and 7<sup>th</sup> largest CV market**

The White Paper provides a status and a possible roadmap for adoption of alternative fuels and the key enablers to achieve the vision.

The diversification of fuel will also involve developing compatible vehicles, and introduction of new technologies. While there are various environmental concerns with the usage of some of the biofuels, there will be a need to overcome these challenges. Industry will commit themselves to technology development and demonstration, once clarity of sustained availability of alternative fuel is established, which would result in investments in commercialization of technology.

Some of the technologies to be developed for utilizing some fuels will be costly and may not attract customers. Specific interventions by way of fiscal incentives will be required to improve customer acceptance and hence, penetration of the technologies to achieve scale and corresponding reduction of fossil fuel usage.

In many cases, for dispensing fuels at retail outlets, infrastructure will need to be developed. Concrete steps need to be taken by Government in infrastructure development.

**E10 and B5 blended gasoline and diesel fuels are low hanging fruits enabled by availability of material compatible vehicles in fleet**

While for biofuels and some higher blends of biofuels, technology needs to be developed. Presently, gasoline & diesel vehicles are material compatible for E10 and B5 fuel, respectively. These fuels are a low hanging fruit across India is a, which needs to be assured by Government of India. Similar is the case with Compressed Natural Gas (CNG) for commercial and passenger vehicles. Today three million CNG vehicles, including 1.7 million cars, in India save 3% of fuel, which can further be enhanced by proper infrastructure, from the present level of about 1,300 stations. SIAM expects government to deploy 6,000 CNG stations by 2025 and 10,000 stations by 2030 for catering to a vehicle parc of 20 million CNG vehicles.

With a requisite policy push and infrastructure development, to be done as an enabler of fuel diversification effort by the government, the automotive industry aims to achieve substantial penetrations of alternative fuel vehicles.

**For gasoline powered two-wheelers and passenger vehicles, industry will endeavor to make vehicles material compatible with 10% ethanol (E10) and 3 % methanol (M3) blends by 2025, and by 2030 industry could make specific vehicles compatible with 20% ethanol (E20) blended gasoline depending upon sustained availability of the fuels with separately labelled dispensing at fuel stations.**

**Besides ethanol blends, four-wheeler industry would benefit from the increased reach of CNG infrastructure and CNG stations, driving sales of CNG vehicles to save CO<sub>2</sub>, as well as reduce import bill.**

**For three-wheelers, CNG penetration can be increased and by 2030 the gasoline powered vehicles could be made specifically to be compatible with E20 and diesel vehicles with B7, depending upon the sustained availability of fuels.**

**For diesel driven passenger vehicles viz. Light Commercial Vehicles (LCV's) and Heavy Commercial Vehicles (HCV's), industry could make vehicles compatible with B7 bio-diesel blends by 2020. For LCV's, and city buses, industry would push for higher penetration of CNG vehicles to reduce dependence on diesel, while for trucks, industry will also invest in R&D in the field of Liquified Natural Gas (LNG) and Di-Methyl Ether (DME) and would try to achieve 5% and 10% penetration by 2025 and 2030 respectively depending on availability and necessary roll out of fuel dispensing infrastructure.**

Government of India needs to rollout infrastructure for spread of alternative fuels to help customers accept the new technology vehicles and at the same time provide clarity to the industry to develop vehicles. A rolling plan needs to be prepared to implement the alternative fuels in the country. A firm plan for next 5 years and a tentative plan for next 10 years needs to be drawn and periodically reviewed. The progress of each phase of alternative fuel implementation needs to be reviewed by single agency under the Government of India.

**A clear roadmap is required for fuel and infrastructure availability**

**Take small but confident and concrete steps to achieve the big target**

While the policy development by government may be to aim for bigger and higher usage of alternative fuels, but considering the requirement of a roadmap by the industry to plan vehicle development, the target of the policy can be achieved by taking small but confident and concrete steps. These steps will provide enough feedback so that course corrections can be done to achieve the National Objectives.

## 2. Background

India is the one of the fastest growing economies and poised to be 5<sup>th</sup> largest economy of the world very soon. India has adopted the strategy of inclusive and human centric economic growth to raise the living standards of its masses. The availability of energy and its per capita consumption is the one of the key indicators of the living standards of the citizen. Therefore, India has been over the decades consistently striving for raising the per capita energy consumption with focus on eradication of poverty in the country. Government of India is pursuing development agenda with the strategy to meet the intent of providing electricity to all census villages by 2019, 24x7 electricity & 175 GW of renewable energy capacity by 2022 as well as reducing the energy emissions intensity by 33%-35% by 2030 as per the NDC targets and enhancing the share of non-fossil fuel-based capacity in the electricity mix is aimed at above 40% by 2030. The Government has also rolled out a roadmap for reduction of import of crude oil dependence by 10% by 2021-22 by enhancing the domestic production of oils, mineral oils and alternative fuels.

**80% of India's Energy demand is met with imported fuel – A risk on India's energy security**

India is one of the major oil importing countries to meet 80% of its total requirements. Presently, India's transport sector account for about 6.7% of India's Gross Domestic Product (GDP) and diesel is used in about 72% of transportation sector, petrol in 23% and remaining usage comprises other fuels such as CNG, LPG etc. Estimates have indicated that total requirement of petroleum products in FY 2017-18 was about 210 MMT and out of the total demand only about 17.9% was met from domestic production. There is huge gap between domestic production and the requirement which could be met only by either enhancing the crude oil production or increasing the production of alternative fuels to avert any major crisis.

**Growth of industry will put pressure on fuel imports**

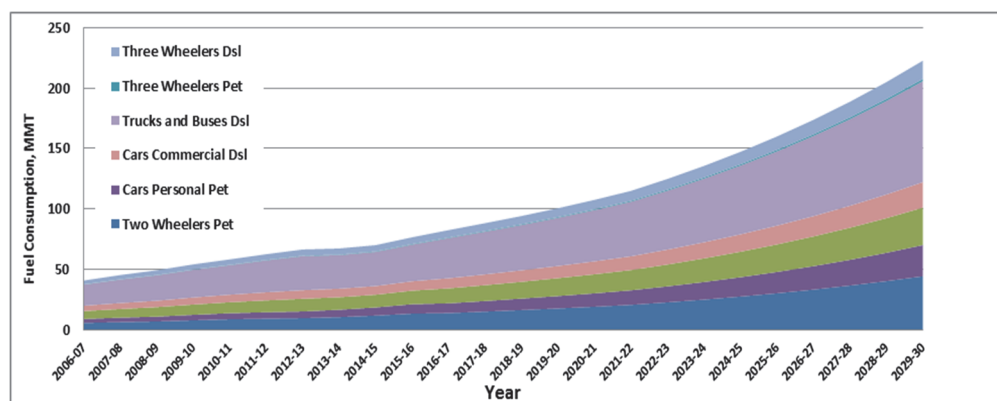


Figure 2.1: Data based on PPAC estimates and future projections at a year-on-year increase in demand by 7%.

The road transport sector, one of the major energy consumers in the country, has been growing at a steady pace and India is moving towards becoming the world's 3<sup>rd</sup> largest automobile market in the next few years, which will put

pressure on India's energy requirements to fuel this growth. At the same time this will also have an impact on the contribution of transport sector towards the CO<sub>2</sub> emitted. India's fuel consumption in road transport sector in Million Metric Tons (MMT) is as given in Figure 2.2.

Further, the emission standards for automobile industry are being made stringent to mitigate the air pollution and its adverse impact on the environment and human health. Government of India has introduced BS-IV emission norms across the country from 1<sup>st</sup> April 2017 and would leapfrog to BS-VI emission regime from 1<sup>st</sup> April 2020. This would require major changes in the vehicle technology and fuel refineries to meet the emission targets.

Based on these directions, for developing strategies for different sectors of road transport, consideration has been given to meet the **two major objectives**:

Energy security and environmental improvements are two major National Objectives

- 1. Improving India's Energy Security – Reduced dependence on imports of crude oil**
- 2. Improving Environment – Reducing impact from transport sector in terms of CO<sub>2</sub> and tailpipe emissions**

In order to meet the aforesaid objectives and targets, India is taking multi-pronged measures to expand the domestic energy production in terms of oil, gas, coal, nuclear and hydropower in the coming decade. Despite several options and opportunities, alternative fuels are struggling to occupy a significant energy space. India in 2016 achieved its highest ever ethanol market penetration, a gasoline blend rate of 3.3% but dropped to 2.3% in 2017 on average across the country.

The alternative fuels provide the best option to replace the traditional fossils and provide opportunities for reducing the import of oil bill, mitigation of pollution, and can be produced sustainably. Moreover, India with plentiful natural renewable energy resources can exploit them for achieving the economic and social development in an environmentally compatible manner.

The alternative fuels are in focus across the world due to their inherent benefits in terms of economy, high quality of energy, environmental compatibility and renewability. Therefore, several countries like USA, Brazil, Canada, Australia, China, Thailand and most European countries are in the process of transition to move over to higher share of alternative fuels to avoid the economic and environmental crisis which may emanate from depleting fossil fuels and their fluctuating prices. Off late, the Government is emphasizing on the need of a comprehensive and inclusive policy on the alternative fuels focusing on low hanging fruits like CNG, LPG/LNG, bio-diesel and biofuels with a clear road map for enhancing the

production of alternative fuels and commensurately reducing the reliance on the fossil fuels.

### Fuelling the automobile sector today

Road transportation is predominantly based on fossil fuels viz. diesel and gasoline. Other fuels like CNG, LPG, LNG are increasing their share in the present energy mix. However, the growth of alternative fuels is struggling due to several reasons which include – proper linkage upstream and downstream of life cycle of alternative fuels, assured supply of good quality of feedstock, cutting edge technology, lack of financial instruments, etc.

In 2016-17, the estimated number of vehicles in India were 257.32 million. Although the number looks staggering, the fleet comprised two-wheelers to the extent of 75%. This kind of a mix of fleet also has a peculiar demand on the liquid fuels. Also, it should be considered that such vehicles will need to be run with the conventional fuels to avoid any failures in field. Hence, a parallel dispensing of alternative fuel needs to be built into the design of the program.

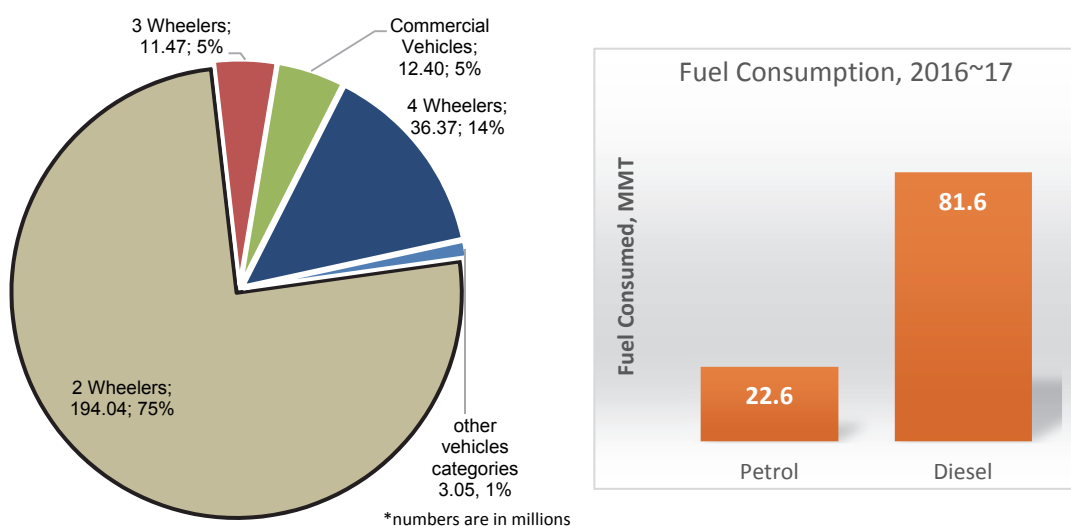


Figure 2.2: Share of various types of vehicles and fuel consumption (MMT)

The road transport sector mainly runs on two fuels viz. gasoline and diesel in addition to CNG to some extent. While transport sector consumes almost all of gasoline, 70% of diesel fuel is used up in transport sector. Two-wheelers consume more than 60% of gasoline while the rest is consumed by cars. It should be noted here that diesel consumption in the country is around 82% of the total liquid fuel consumed (gasoline and diesel combined). Therefore, any efforts to reduce diesel consumption will lead to higher benefits.

India's consumption of diesel and petrol is given below. The data indicates that about 76 MMT of diesel and about 24 MMT of gasoline is consumed by all sectors.



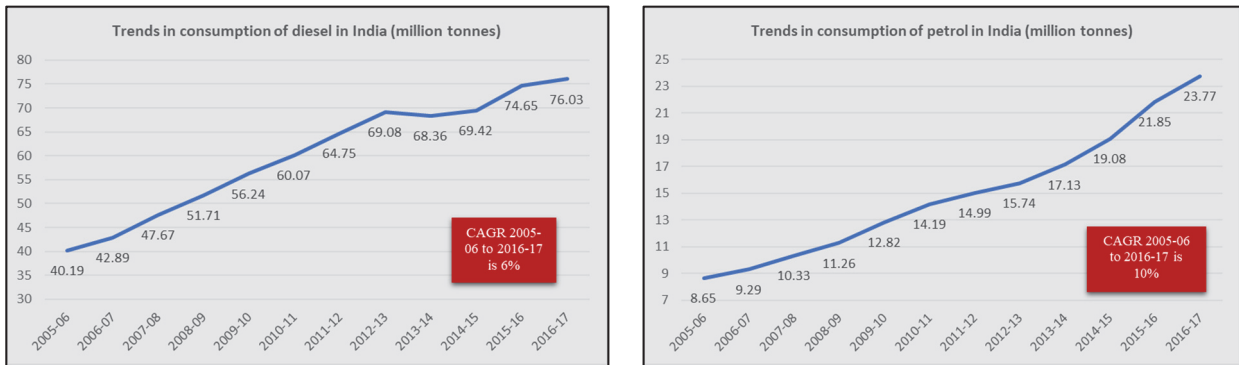


Figure 2.3: Trends in consumption of diesel and petrol in MMT (Source PPAC)

Out of this consumption, it is estimated by SIAM that about 100% of Gasoline and about 50% of the Diesel is used by the Road Transport Sector. Breakup of the consumption of Diesel by the various sectors are given in the following figure.

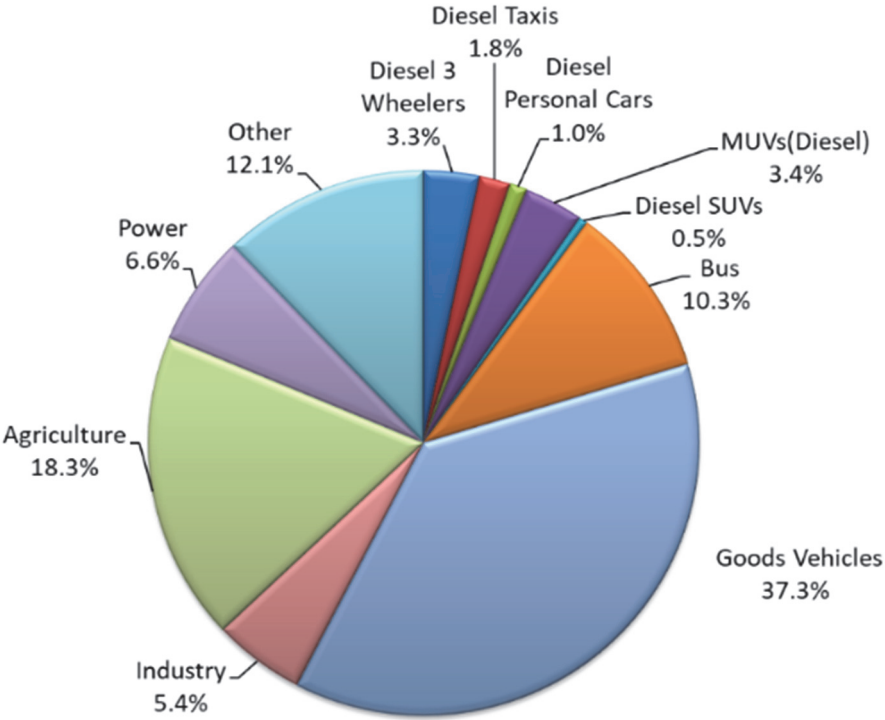


Figure 2.4: Apportionment of diesel usage in vehicle types (SIAM Estimate, 2013)

To conserve and to reduce the consumption of fossils fuels, the Government of India notified fuel economy norms for M1 category of vehicles which have come into force from April 2017. The next stage of fuel economy norms for 2022 have also been notified, which are stringent and will need a greater influx of high-end technologies to improve the efficiencies of the vehicle. The reduction of average fuel consumption from 2005 to 2022 will be as high as 26%. The fuel consumption norms for heavy commercial vehicles (trucks and buses) are also in the advanced stage of finalization. Now efforts are being

made to lay down the norms for Medium & Light Commercial Vehicles (M&LCV's) and in future similar norms may also be considered for two-wheelers.

Fuel economy norms will help reduce fuel consumption, but alternative fuels will help replace or reduce imports of fuel

While the efforts to improve the fuel efficiency of all modes of transport are definitely going to help reduce the new fleet fuel consumption and in the long run will also have a positive impact on the reduction of growth rate of fuel imports, considering already enormous dependence on fuel imports, these efforts need to be substantiated with many other complementary efforts to have a bigger impact. While one such major effort is electrification of fleet, India needs to work on other options also, to compliment this effort, considering the ultimate objective of improving India's energy security. These efforts will be to **develop engines and vehicles to run on alternative fuels, in order to diversify the fuel usage within the transport sector.**

This holds potential to use our indigenous resources and at the same time reduce the CO<sub>2</sub> from vehicle fleet. In addition, on a well to wheel (WTW) basis, CO<sub>2</sub> emission reduction will directly reduce GHG emissions from road vehicles.

### 3. Alternative Fuels options in India for Automotive Purposes

Alternative fuels like CNG / LPG / LNG / Hydrogen and biofuels like ethanol / methanol / bio-diesel would form the options of alternative fuels.

As far as biofuels are concerned, though the Government had formulated the biofuel policy in 2009, with ambitious targets of 20% biofuel blending, the actual blending was far less due to a number of reasons. There is still a possibility for achieving the targets set up under initiatives like Ethanol Blended Petrol program, National Bio-diesel Mission, Bio-diesel Blending program, etc.

Similarly, India embarked on an ambitious plan of spreading CNG across various regions of the country, which would have also enabled shifting vehicles to CNG fuel. Manufacturers developed vehicles and today most of these vehicles are made in house meeting all emission and safety norms. However, the spread of CNG did not happen as per plan and today the penetration is limited only to areas where either it is mandated by law or the gas infrastructure is developed, limiting its impact on fuel substitution.

For defining any new policies to give a fresh impetus to alternative fuel usage in automotive industry, it is important to review the current status and look at the reasons why the penetration of such fuels could not be achieved. Given below is the current status of the different biofuels and other low carbon fuels in India.

#### a. Status of Various Alternative Fuels

##### i. Bio-Ethanol

The most common biofuel, bio-ethanol, is produced from biomass containing sugar-based components, like sugar cane, sugar beet, sweet sorghum. It is also produced from starch containing materials such as corn, cassava, algae including cellulosic materials viz. bagasse, wood waste, agricultural and forestry residues or other renewable resources like industrial waste. However, in India 98% ethanol is produced from sugarcane molasses.

#### **Announced / Notified Policies of Government of India:**

1. 2003: Mandated 5% ethanol blending 13 states and UTs and made
2. 2006: 5% universal blending
3. 2008: 10% blending pan India in 2008
4. 2009: National Policy on Biofuels - 20% blending of ethanol by 2017
5. 2013: Mandated 10% mandatory blending to achieve national average of 5%
6. 2015: Notified use of flex fuel E85 and ED95 for vehicles
7. 2018: Clean Air-Better Life (Report by NITI Aayog and CII) – Achieve E10 in Delhi by 2022
8. 2019: OMCs to sell 10% EBP or any percentage as per BIS, from 1<sup>st</sup> April 2019

Government of India announced various policies from time to time regarding blending of ethanol with gasoline in various proportions, as seen in the figure below:

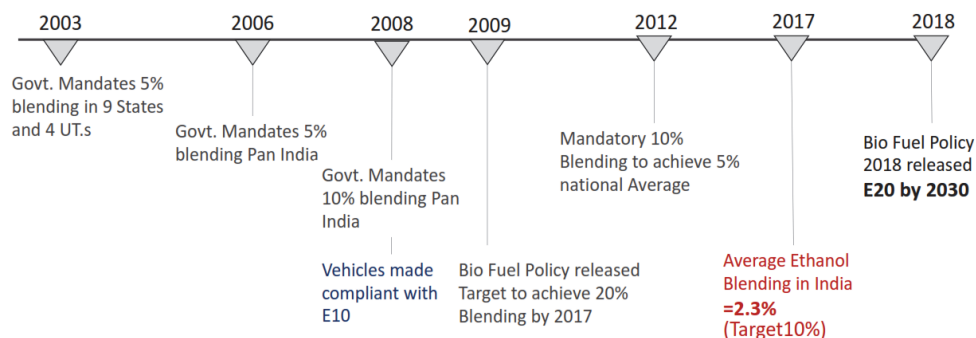


Figure 3.1: Government policies on biofuel blending

### Vehicle Compatibility

2-Wheelers and Cars are E10 material compatible today

Since 2008, two-wheelers and passenger vehicles were made material compatible with 10% ethanol blended fuel. Vehicles made prior to 2008 cannot run with such blends of fuel and hence parallel dispensing of E0/E5 is required.

### Availability

Against a target of 10%, only 2.3% average Ethanol blending was achieved in 2016

Against the target of 10% set by MoP&NG in 2013, OMC's could only achieve an all India average of 2.3% ethanol considering blends of E0, E5 or E10 at various geographical locations in 2016. In order to meet 10% ethanol blending target, about 440 crore liters of bio-ethanol would be required, the present estimated production is 300 crore liters only. Therefore, Government is emphasizing on production of bio-ethanol from lignocellulosic biomass such as corn cobs and stems, bagasse, cane trash, rice straw, wheat straw or other non-food biomass feedstocks.

To bridge the yawning gap between production and demand, the Government has given go-ahead to establish the country's first Second-Generation (2G) ethanol plant at Kashipur in Uttrakhand in 2016 to convert all types of agricultural residues to ethanol in less than 24 hours, with optimum product yields. The plant, which has a capacity to consume 10 tons of biomass per day, is based on the globally-competitive indigenous technology. Another new advanced bio-refinery plant, set up in 2017 in Pune, boasts of integrated production capability of one million liters of ethanol a year, from a variety of biomass. This plant, located in Pune allows manufacture of ethanol from a range of agricultural waste.

## Transportation and Storage

Currently major transport of ethanol and blended fuel happens through road and rail, through which ethanol producers supply ethanol to storage depots of Oil Marketing Companies (OMC's). Major challenge in fuel ethanol downstream is limited ethanol storage capacity at depots and therefore OMCs are trying to build more and more storages to match the supply & demand. In future, with 10% or higher ethanol blending in gasoline and 2G ethanol production becoming reality, it would be necessary to move beyond the ad-hoc strategy of augmentation of storage capacity at depots.

Global experiences have confirmed that biofuels, including ethanol, and gasoline blends can be transported in liquid pipelines, rail, truck, barge, and marine transport. Physical and chemical properties of cellulosic ethanol, especially its affinity to water and resultant corrosivity, present operational challenges. Although in India pipelines are not used for ethanol transportation, pipelines are considered to be the safest, most reliable, economical and environmentally favorable way to transport liquid fuels. This would require higher ethanol production volumes or technological interventions/innovations to allow using mixed product pipeline.

## Cost

At present, given the strong linkage of the Ethanol Blended Petrol (EBP) Programme to the domestic sugar industry, the price of ethanol is impacted by the price of sugarcane and the demand for sugar. Due to the inconsistency of ethanol supply in most States, Inter-State movement of ethanol plays an important role in ensuring its availability across different States in the country. One of the major problems being faced by OMCs and ethanol suppliers is the varying structure of taxes and duties levied by the states. For the Inter-State movement of ethanol, dispatching States levy an export fee while the receiving State levies an import fee. The extent of these duties varies from State to State, thus leading to further difficulties for OMCs and the suppliers. The absence of standardization in tax rates for Inter-State movement of ethanol, makes ethanol availability uneven across different States, resulting in difficulties in implementing the blending mandate. Moreover, since ethanol is not available in all States, the implementation of these duties discourages seamless Inter-State movement of ethanol for blending purposes and the creation of a unified national market.

The price of production of sugarcane varies from State to State owing to variation in soil quality, climate, fertilizer requirement, water availability and productivity level, based on which the State governing bodies decide on the State Advised Price (SAP). This results in high difference in the price demanded by sugar mills and the benchmark price set by OMCs which discourages sugar mill owners from diverting ethanol produced by them for fuel blending. In December 2014, the Government of India adopted a fixed

pricing policy for bio-ethanol where the price range was set between INR 48.5-49.5 per liter. Additionally, on October 13, 2016, the CCEA revised ethanol prices at INR 39/liter from December 1, 2016 to November 30, 2017 for supply to OMCs to carry out the EBP (Source: PIB Press release).

## ii. Bio-Diesel

Bio-diesel is a methyl or ethyl ester of fatty acids (fatty acid methyl ester, FAME) produced from non-edible vegetable oils, acid oil, used cooking oil or animal fat and bio-oil. Government of India notified policies for blending bio-diesel as given in the figure below:

### Announced / Notified Policies of Government of India:

1. 2005: National Biodiesel Mission (NBM): Biodiesel blend of 20% with conventional diesel by 2017
2. 2009: National Policy on Biofuels - 20% blending of Bio-Diesel by 2017

The Government of India had initiated a Bio-Diesel Purchase Policy in October 2005 and permitted the sale of bio-diesel (B100) by private manufacturers to bulk consumers. Retailing of bio-diesel blended diesel by Public Sector Oil Marketing Companies (OMCs) has started on 10<sup>th</sup> August 2015 for blending with High Speed Diesel (HSD) to the extent of 5% at identified 20 purchase centers across the country.

### Vehicle Compatibility

Passenger vehicles and commercial vehicles today are material compatible with 5% bio-diesel blended diesel.

### Availability

Despite the blending targets outlined in the previous biofuels policy of the Government, the percentage blending of biofuels was not encouraging enough. The bio-diesel blending so far is approximately 0.001%.

The lower bio-diesel blending is attributed to inadequate feedstock availability due to lack of proper provision of incentives to farmers or producers of feedstock.

Although vehicles are compatible with B5 fuel, availability of fuel is constrained

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)

Bio-diesel used for the blending programme is presently being manufactured from imported sources like palm stearin. Presently, India has five to six plants with capacity to produce 10,000 metric ton to 250,000 metric tons (MT) of bio-diesel per year, although the actual capacity utilization is not more than 32% which accounts for only 0.001% average bio-diesel blending possible in India. Large scale blending of B100 and releasing B5 is achieved mainly in Tamil Nadu (Korukkupet), Telangana (Hyderabad) and West Bengal (Mourigram) and few other states. As per IOCL 5% bio-diesel (B5) is being sold from almost 5,400 outlets.

### **Storage**

The storage of bio-diesel for long durations is a problem especially in winters. Stability of bio-diesel is one of the important factors which determines the duration for which bio-diesel can be stored.

Bio-diesel is generally more susceptible than petroleum diesel to microbial degradation. Microbial contamination of fuel storage tanks can plug dispensers and vehicle fuel filters and cause vehicles to stall. The best way to deal with this issue is adequate fuel storage tank maintenance and monitoring, especially minimizing water in contact with the fuel. Water bottoms must be removed from tanks and standing tanks should be sampled and tested for microbial contamination.

If the bio-diesel will be stored prior to blending, the induction time and acid number should be monitored at regular intervals to ensure the bio-diesel is not oxidizing.

### **Cost**

Government of India has deregulated diesel fuel price in line with gasoline. Following up, the Union Cabinet has also allowed private bio-diesel manufacturers, their authorized dealers and joint ventures (JVs) of OMCs authorized by the MoPNG to sell bio-diesel directly to consumers subject to their product meeting prescribed BIS standards.

Presently the procurement price is Rs.48.5 in pre-GST and Rs.54.0 with GST of 18%. This is because in India most of the bio-diesel (or bio-diesel feedstock which is mainly palm stearin) is imported from countries like Germany, UAE, France, China, Indonesia, Japan, and Netherlands which includes import duty. For achieving the long-term goals of bio-diesel blending, the locally produced/available raw material like waste/ used cooking oil, oils non-edible seeds which otherwise are automatically ousted from the economic streams, would be vital.

### **Dispensing**

Pumps are required to be labeled to inform consumers about the percentage of bio-diesel being offered for sale. Pumps selling up to B5 blends require no

separate labeling, however, blends higher than B5 are required to be labeled with the exact blend percentage.

### iii. Methanol

Methanol (CH<sub>3</sub>OH) is an alcohol fuel which is clear and colorless being produced by variety of sources like biomass, natural gas, coal and cellulose. methanol can also be transformed into di-methyl ether (DME). The production of methanol is highly economical from natural gas, biomass and coal.

Government of India (NITI Aayog) is planning usage of methanol in automotive purpose.

#### **Announced / Notified Policies of Government of India:**

1. NITI Aayog, the think tank of Government of India has started plans for transition to Methanol Economy in India
2. Union Minister for Transport has announced that India will leapfrog to 'Methanol Economy' to reduce the import oil bills as well as to reduce the emissions.

### **Vehicle Compatibility**

Two-Wheelers and Passenger Vehicles running on gasoline are not compatible with methanol blended fuels. Though E10 material compatible vehicles may be also material compatible with M3 blends, which needs to be verified though, for any higher blends of methanol, vehicles and engine components will need material changes and specific calibration. Methanol has been found to be a much more aggressive material. Corrosion of metallic parts and degradation of rubber / plastics are the main development challenges. Vehicle cold startability and hot re-startability are the operational challenges.

Hence, methanol blending would necessitate material changes and specific calibration in the vehicles along with a separate dispensing infrastructure at the fueling stations for methanol compatible vehicles while normal gasoline (as per BIS specifications of BS-VI commercial fuel) shall be supplied parallelly for old vehicles not compliant to methanol and ethanol blends.

### **Availability**

India is at a nascent stage in methanol production and usage, but the Government of India is of the view that India has a large potential given its wide applications. Presently methanol is produced only as a chemical and there are 5 main producers of methanol in India – Gujarat Narmada Valley Fertilizer & Chemicals Limited, Deepak Fertilizers, Rashtriya Chemicals and



Fertilizers, Assam Petrochemicals and National Fertilizers Limited. The following figures would give an overview of the methanol industry in India.

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%

Table 3.3: Methanol production and imports

**Methanol fuel usage tradeoffs with environment need elaborate studies**

Presently most of the methanol produced in India is from natural gas. This is not a favorable source of raw material as natural gas is not abundantly available. NITI Aayog is making a plan to use methanol as a fuel and they are looking forward to producing methanol from coal, however, Indian coal is becoming difficult to use directly due to environmental issues.

The tailpipe emissions from methanol usage (i.e. at the consumption end) are quite low in comparison with conventional fuels like gasoline and diesel, however, the Well-to-Wheel (WTW) emissions for coal to methanol production is 190 grams of CO<sub>2</sub> e/MJ of fuel, whereas the same number for gasoline production is in the range of 95-100 e/MJ.

### Transportation

As per the current practice totes, drums (55 gallon), and cans (5 gallon, and 1 gallon) are used to transport, store, and dispense methanol in a wide variety of circumstances by low volume users. For long distance transport specially designed rail tankers are used while for short distances such tankers are moved on haulage trucks. These tankers should be equipped with provisions for pressure relief in order to accommodate thermal expansion during transit, short-term (less than 30 days) side-lining during switching and temporary holding. Rail transport is considered to be safe, as long as methanol is contained within an upright tanker car. Considering the corrosive nature of methanol, special material will be required for holding methanol safely.

### Storage

Methanol is more corrosive than gasoline and may require new equipment for storage. Methanol is routinely stored in tanks farms consisting of above-ground, floating roof tanks and smaller, internally baffled floating baffle tanks. Tanks must be grounded to avoid hazards associated with static discharge. Because methanol is commonly stored with other solvents and

feed stocks, all piping and valves subject to carrying methanol should be consistently labeled, and direction of flow should be indicated. All storage materials, including totes and drums, require berming and adequate ventilation. Berming should be stabilized by compacting, by use of suitable methanol resistant fabric, or with concrete.

#### iv. Compressed Natural Gas (CNG)

India embarked on an ambitious plan of spreading CNG across various regions of the country, which would have also enabled shifting vehicles to CNG fuel.

##### Vehicle Compatibility

Slow growth of CNG infrastructure is preventing large scale use of CNG vehicles

Manufacturers developed vehicles to run on CNG and today most of these vehicles are made in-house, meeting all emission and safety norms. Currently there are 30 lakh CNG vehicles in India. These CNG vehicle are able to substitute 3% of the oil imports. Further potential is immense.

CNG vehicles have seen huge customer acceptance wherever there is widespread availability of CNG infrastructure. However, the overall potential is significantly limited due limited availability of CNG infrastructure.

##### Availability

The spread of CNG today is restricted to areas where the usage of fuel in commercial vehicles is mandated by law or the areas close to CNG pipelines. The table below gives the status of the fuel availability and sale of CNG in various states.

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
<b>All India</b>	<b>1273</b>	<b>2,937,995</b>	<b>21</b>	<b>2037.2</b>	<b>2155.4</b>	<b>2365.5</b>	<b>1293.7</b>

Table 3.4: CNG vehicle sales (Source: PPAC)

There is an increase in sale of CNG over the last four years with CAGR of 9%. However, the growth is mainly coming from areas with established CNG infrastructure. The infrastructure will help in increasing vehicle penetration.

It needs to be understood that currently there are 55,000 liquid fuel stations, whereas there exist only about 1,300 CNG stations. Hence, SIAM would request clarity and commitment on the CNG road map as the single most important suggestion for expansion of CNG. For SIAM to achieve the targeted penetration of CNG in vehicles, as mentioned in the Objectives and Vision section of this paper, infrastructure needs to be developed by Government as given in table below:

Year	2017	2020	2025	2030
Number of CNG stations (Recommendation by SIAM)	1300	3,000	6,000	10,000

Table 3.5: Recommendation for number of CNG stations

### Transportation

Transportation of CNG is done via pipelines and the gas is pressurized at the retail stations to be filled into vehicle CNG tanks at excess of 200bar. The present gas trunk pipeline grid is about 17,658 kms in length.

This is a low hanging fruit which needs concrete steps to be taken in infrastructure development. It is also important as CNG can also be retrofitted and can result in improvements from existing fleet of vehicles as well.

### v. Liquefied Natural Gas (LNG)

LNG is the fuel of choice for long haul trucks.

Liquefied Natural Gas (LNG) is a low carbon fuel formed by liquefying methane at low temperature of around -160°C. Being stored in liquid state increases its energy density and can be stored at moderate pressure in smaller fuel tanks.

The LNG is the most benign fuel with least emission of pollutants like SO<sub>2</sub>, NO<sub>2</sub>, CO etc. gets substantially reduced using LNG. The emission factor of LNG is only 56,100 Kg/TJ as compared to emission factor of 74,100 kg/TJ of diesel. There is estimation about the reduction of carbon emission of about 0.7 ton per 1,000 liters if diesel is replaced with LNG.

LNG can reduce CO<sub>2</sub> by around 30% from diesel run vehicles.

LNG is gaining popularity in China with 300,000 heavy commercial vehicles running on this fuel, which is provided through 2,600 fuel stations. Europe is planning a 'blue corridor' for LNG distribution.

### Vehicle Compatibility

LNG Vehicles will need major changes in fuel storage and handling. A CNG compatible engine may not need major modifications.

Liquefied Natural Gas (LNG) is a low carbon fuel and **most suitable for heavy duty engines involved in long haul freight transport across long distances.** The liquefied fuel is stored in cryogenic tanks on board the vehicle. Since it is stored in liquid state, the size of tanks is substantially lower than that required for CNG. This is a major benefit for such long-haul vehicles with a range of around 600-700kms, which is three times that of CNG. The system allows 50-200% faster filling as compared to CNG. LNG helps in overcoming the shortfalls of CNG, especially for long haul trucks.

The fuel handling system on vehicle needs exhaustive changes with cryogenic tank being the major part of the system, while on the engine side, a CNG compatible engine would be compatible and may not need major changes. Dry gas has issues with injector wear and life of the other engine parts like spark plug regulator, LP hose & connections after LNG vaporiser may vary on LNG vehicles w.r.t CNG engines.

There are various systems required on board the vehicle like auto venting system for tanks, heating of LNG for conversion to gas state before injecting to the engine. Mono-fuel application of LNG engine is popular where the availability of the LNG is good. More expensive dual fuel engines i.e. LNG + Diesel can be used where LNG availability is less, and long range of vehicle operation is required.

Since the cryogenic tanks are not cooled on board, the fuel warms up and there is an increase in pressure if the vehicle is not used for approximately 5 days, making auto venting system mandatory. Vehicle needs to be kept in open and cannot be parked in closed spaces to prevent fuel vapor build up around the vehicle.

### Availability

Network of LNG stations along National Highways being planned will ignite the movement towards LNG transportation

India is the 4th largest LNG importer – 19 BCM (~51 MMSCMD). India's LNG demand has the potential to touch 30 MMT by FY20. Presently, India's LNG import capacity is around 30.0 MMTPA through 4 terminals & meeting more than 35% of total gas supply of the Country. These four LNG terminals are: Dahej and Hazira in Gujarat, Dabhol in Maharashtra and Kochi in Kerala with nearly 30 million tonnes capacity that is expected to become 47.5 MT by 2022. The existing capacity of these terminal is given below:

Existing Terminals	Capacity (MMTPA)
Dahej	15
Hazira	5
Dabhol	5
Kochi	5
<b>Total Capacity</b>	<b>30</b>

Table 3 6: LNG availability in India

The network of supply of LNG is required for the vehicles to shift to LNG. Some plans have been announced like, Petronet is setting up 20 LNG stations at petrol pumps on highways along the west coast that connect Delhi with Thiruvananthapuram covering a total distance of 4,500 km via Mumbai and Bengaluru. Likewise, there are plans to commission stations along the Mumbai-Delhi corridor and also along National Highways to connecting Ahmedabad, Mumbai, Mundra, Chennai, Bengaluru, Salem and Coimbatore.

### Transportation and Storage

LNG is transported across the world in dedicated sea vessels, which are unloaded at specially designed dedicated ports terminal of LNG bulk storage and re-gas facilities. These LNG terminals are connected to the consumer locations for distribution through a gas pipeline network or in cryogenic storage road tankers. Using this network not only LNG, but also CNG can be dispensed to vehicles.

### Cost

LNG trucks are expected to be costlier than their diesel counterparts. Major contribution coming from the expensive onboard cryogenic tanks. This could act as a dampener for promotion of such vehicles, among the cost conscious freight operators. Suitable incentives may have to be built-in to help better acceptance by customers to increase penetration.

High cost of cryogenic tanks is a major cost addition to the vehicle

## vi. Other Alternative Fuels

The Government is supporting and fostering R&D and innovation in developing the new and emerging alternative fuels which are derived directly from biological materials and also from non-biological sources like plastics, industrial waste including Municipal Solid Waste (MSW) are getting attention from all stakeholders. These new categories of alternative fuels can supplement the alternative fuel economy which is at the nascent stage in the country. Noteworthy measures are being taken across the world in the clean technology space for conversion of domestic and industrial waste into alternative fuels such as Hydrogen & Fuel Cell, Bio-CNG, Drop-In fuels, Bio-Hydrogen. These alternative fuels can be produced with the support of

Government and later could be scaled up in a public and private partnership as commercial and profitable venture.

**'Hydrogen'** is a next generation fuel for powering low carbon transportation. Hydrogen is an excellent energy carrier with great potential for clean, efficient transport applications. Hydrogen and fuel cell are best suited for a balanced energy mix for decarbonized transport that will enhance energy security, reduce oil dependency, greenhouse gas emissions and air pollution. Hydrogen fuel is best positioned for wide diversification of energy sources which can contribute effectively in mitigation of climate change when produced by renewable primary energy sources. Hydrogen and Fuel Cell technologies could achieve a 33-35 % reduction in greenhouse gases by 2030 of its 2005 level apart from co-benefits in terms of lower levels of air pollution, affordability, sustainable transportation. India has promised to generate 40% of its electricity from alternative fuel-based energy resources by 2030 with the help of transfer of technology and low-cost international finance including from Green Climate Fund.

Hydrogen is having high energy content and contains 120.7 kilojoules/gram- the highest energy content per unit mass among known fuels. However, the energy content per unit volume is rather low and storage of hydrogen is a challenge, as compared to storage of liquid fossil fuels. On combustion, hydrogen produces water as a by-product and is therefore not only an efficient energy carrier but a clean, environmentally benign fuel as well. Hydrogen can be used in transport applications and can easily be used in internal combustion (IC) engines, either directly or by blending with diesel and compressed natural gas (CNG). For commercial production of hydrogen fuel and fuel cell vehicles, considerable research, technology innovations and cost reductions, mainly in fuel cell technology is in focus. Over 95% of hydrogen produced globally is from hydrocarbons and only about 4% is produced through electrolysis of water. The other methods which are being explored include biomass and biological route, photo electrochemical route, thermo-chemical decomposition of water using nuclear energy or solar energy, and electrolysis using renewable energy (solar, wind).

India has developed and demonstrated the hydrogen-operated motorcycles, three-wheelers and other vehicles. The Banaras Hindu University (BHU) has modified a commercially available motorcycle (100 cc, four strokes) and a three-wheeler (175 cc, four strokes) to operate on hydrogen as a fuel. The Banaras Hindu University (BHU); Murugappa Chettiar Research Centre (MCRC), Chennai; and IIT, Kharagpur are among the leading research groups working on biological, biomass, and other renewable energy routes to produce hydrogen. With R&D support from the Ministry of New and Renewable Energy (MNRE), the MCRC has demonstrated hydrogen production in batch-scale from distillery waste. A couple of prominent automobile companies have already taken lead and demonstrated the hydrogen fuel cell bus, and some have developed a hydrogen fuel-based four wheelers. However, there is a need of support from the Government in

infrastructure creation, R&D, technology development and fiscal & financial arrangement to promote hydrogen economy in the country.

**'Bio-CNG'** a purified form of biogas whose composition & energy potential is similar to that of fossil based natural gas (CNG, LPG, LNG etc.) and is produced from agricultural residues, animal dung, food waste, MSW and sewage water. The production of bio-CNG has the immense potential in meeting the energy demand in rural areas and address the environmental issues. Bio-CNG standards by BIS have been made equivalent to CNG standards, hence it can be supplied along with normal CNG supply outlets and that can be used in normal CNG vehicles & cylinders.

Among the other biofuels, **'Drop-in Fuels'** is highly promising liquid fuel produced from biomass, agricultural residues, wastes such as Municipal Solid Waste (MSW), industrial wastes etc. The drop-in-fuels are directly mixed with petrol/diesel through the petroleum supply network and as such no alteration or any modification is needed either in engine or in distribution systems, till it is within the BIS specification. The drop-in fuels have promising future and are getting attention due to their easier implementation. However, it is an emerging technology which is yet to mature, and it has the risk of being high in WTW CO<sub>2</sub> emission depending on the technology option used.

**LPG** is a potential alternative fuel and had seen some momentum in early 2000's. Many manufacturers launched vehicle to be able to run on LPG, however apart from initial spurt in customer acceptance, the same has not seen much acceptance lately due to high fuel price & lower return on investment. Also, since LPG is being imported for automotive purposes, it does not help much in achieving India's national objective of energy security.

**Dimethyl Ether (DME)** is a potential and promising energy alternative for petroleum fuels due to its good burning characteristics, and to its high cetane content which is superior even to that of diesel with low emission of particulate matter and NO<sub>x</sub>. DME can be produced by dehydration reaction of methanol by using solid catalysts in catalytic reactions. The production of Di-Methyl Ether (DME) by dehydration of methanol for substituting the use of propane in domestic LPG is being studied at present. DME blending with diesel can enable replacing the use of diesel and therefore providing opportunity to reduce our dependence on imported crude oil.

There are several other alternative fuels that can be extracted from the MSW with appropriate technology at a commercial scale with support measures provided by the Government through various incentives and buying assurance of biofuels.

Another emerging and promising area of biofuel production is biofuels from algae which are categorized as **3<sup>rd</sup> Generation (3G) biofuels**. The 3G biofuels are high quality fuels with high energy content oil and their production is

characterized by the no or low waste generated in the process, thereby leaving insignificant environment impact. The commercial algal biofuels are in its infancy and need R&D and support from the Government for transforming the laboratory level production of algal biofuels to commercial level by employing the techno-economic viable options.

**b. Summary of relative assessment on National Objectives**

There are various options to diversify the fuels beyond gasoline and diesel used in different categories. A relative assessment of the fuels is presented in the table:









Criteria	CNG	LPG	LNG	Ethanol	Bio-Diesel	Methanol	DME	Hydrogen
Reduction of CO2 from Base fuel (Gasoline /Diesel)	+++	++	+++	+	+	+	+	++++
WTW CO2 emission	++	+	+	++	+++	+ (coal) ++ (biomass)	+	++++
Local Sourcing Possibility	+++	-	-	+++	++	+++	++	+
Replace / Reduce								

Figure 3.7: Relative assessment of alternative fuels

As is very clear from above, different types of alternative fuels have varied level of benefits in terms of CO<sub>2</sub> reduction. Some of the fuels will need to be blended with and reduce the usage of the fossil fuels, however there are other fuels which completely replace the fossil fuels. A careful selection of fuel has to be done considering these aspects.

**c. Possibility of alternative fuels in different segments of automobiles**

Different vehicle types use different fuels and incorporate different technologies to suit the usage and duty cycles. The possibilities of usage of different fuels in different vehicle categories is given in the matrix below. There are fuels for which technology has already been developed and usage of fuel can be easily implemented, while for some other, technology needs to be developed before the fuels can be used. There are technologies which may not be feasible for certain vehicle types due to technology constraints, vehicle usage duty cycle and customer concerns. The ‘OO’ marked areas are the low hanging fruits which can be implemented, and benefits realized ahead of time.



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
<b>Legend:</b>												
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											

Figure 3.8: Technologies and alternative fuel feasibilities

#### d. Trade Off's and how these can be reduced

Higher ethanol and methanol blends can have a potential impact on the environment. Due to higher Reid Vapour Pressure (RVP), resulting in higher evaporative emissions can impact ambient ozone. Tailpipe aldehyde emissions can also increase which are not regulated. Similarly, higher evaporative emissions could lead to higher Volatile Organic Compounds (VOC's) and possibly higher secondary particulates formation which can negate the efforts being taken to reduce the particulate emission load from vehicles.

If such issues are not taken into account, the benefits of using such blends of fuel for reducing the crude oil will have a trade off with environmental concerns, which is not desirable.

Vehicle technologies and infrastructure need to be designed and fuel specifications need to be defined appropriately to reduce this trade off. However, it is highly recommended to do detailed studies to check the environmental and safety concerns before any concrete plans are made for higher blends of ethanol and especially methanol.

## 4. Vision - Diversifying fuel usage in India

It is felt that the adoption of xEV's would continue to exist and grow with growing acceptance and feasible Total Cost of Ownership (TCO) for such technologies. Internal Combustion Engines (ICE) vehicles adapted to use biofuels and low carbon gaseous fuels will co-exist and supplement the efforts to reduce dependence on imported fossil fuels thus improving India's energy security and lower emissions. Adoption of alternative fuels however is mainly dependent on the consistent availability of fuel and infrastructure development for spread of such fuels across the country. Notwithstanding the same, the following section gives a macro overview of segment wise roadmap proposal for diversification of alternative fuels.

Following is the indicative roadmap for phasing in of various alternative fuel vehicles in the country.

### a. Gasoline Vehicles based on Spark Ignition Engine Technology: -

Two wheelers consume 60% of gasoline, which is around 15% of the total liquid fuel consumed. Most of the two wheelers today are based on 4-stroke with carburetor fuel systems. In 2020 with the mandating of BS-VI, most of the two wheelers will shift to electronic fuel injection system with closed loop control. Four wheelers today already run on electronic fuel injection systems with advanced closed loop control system. With BS-VI the vehicle control system will become more advanced with high level of On-Board Diagnostics (OBD).

Both the two-wheelers and four-wheelers produced after the year 2008 have been made material compatible with E10 fuel. The compatibility has been ensured from a material compatibility and durability perspective. However, the vehicles have been tuned for E0 fuel specifications which would be the worst-case fuel available in the field. Moving to higher blends of ethanol or methanol will need radical changes in design and material compatibility. Also considering the drop in fuel calorific value, tuning will have to be done with blended fuel to avoid decline in drivability performance and fuel efficiency. Any such change will mean consistent supply of fuel across the country has to be guaranteed as these engines cannot be run on regular fuels.

As far as CNG is concerned the penetration of vehicles is entirely dependent on customer acceptance, which majorly hinges on ease of availability of fuel.

#### Two-Wheelers:

- Phase 1 (by 2020): **E10 material complaint** two wheelers would be continued to be made available across India and oil companies would be requested to gradually increase supply of E10 fuel so as to achieve 100%

E10 gasoline fuel by the year 2020, in all dispensing stations. These dispensing units should also be clearly labelled for only supply of E10 fuel, while the normal gasoline would continue to be made available for older vehicles not designed for E10.



- Phase 2 (by 2025): All new two wheelers would be E10 material compliant and in addition would also be tuned for **fuel efficiency** by utilizing the benefits of higher RON of E10. This would be done by the manufacturers provided there is consistent year-round supply of standalone E10 gasoline fuel across all dispensing stations in the country. In addition, vehicles will be made **material compliant** to gasoline fuel with **3% methanol (M3)**.



- Phase 3 (by 2030): Based on availability of fuel and its infrastructure and outcome of review of previous phase, SIAM proposes that two wheelers **specifically compliant to E20** to be produced which will also be compatible for M3 across India. Hence, oil companies need to ensure availability of E20 fuel dispensing stations gradually from 2025 and have large number of E20 dispensing units by 2030 across the country. The standard gasoline fuel (E10) should continue to be made available for large number of only E10 material compliant vehicles. From 2030, oil companies can **stop supply of E5 gasoline fuel** as these vehicles would have practically reached the end of life since the manufacturing of only E5 material compliant vehicles has been stopped by 2010.
- Phase 4 (Beyond 2030 and upto 2047): Share of **electric two wheelers** are also expected to grow significantly especially in urban areas by this time. **Hybridization** of two-wheelers may be considered by two-wheeler manufacturers and specific two-wheeled vehicles could be developed to use E20 fuel, along with compliance to M3, across India as **large scale E20** fuel dispensing units are made available along with E10 units.

Industry will work continuously with the other stake holders to adopt other alternative fuels as per requirement.

### Three-Wheelers:



- Phase 1 (by 2020): All S.I. engine three wheelers would be **E10 material complaint vehicles** across India and out of these three-wheelers, **50% sales** of new S.I. Engine three wheelers could be of **CNG or LPG Vehicles**. It is expected that large scale CNG and LPG infrastructure would come up across India as mentioned above. All C.I. engine three wheelers will be material compliant to **7% Bio-Diesel**.
- Phase 2 (by 2025): Share of sales of **CNG or LPG vehicles** could also be increased to upto **75% of the sales** of new S.I. engine three wheelers.

However, all S.I. engine three wheelers vehicles will be E10 material compliant along with the **improvements in fuel efficiency**, assuming consistent supply of E10 gasoline fuel across the country. In addition, vehicles will be compliant to gasoline fuel with **3% methanol (M3)** blended at the refinery level, across India. All C.I. engine three wheelers will be compliant with 7% bio-diesel.

- Phase 3 (by 2030): S.I. engine three wheelers with **E20 specific compliant will be introduced**, in addition to 3% methanol (M3) blended gasoline. **All S.I. three wheelers** will be either on **CNG or LPG** and it is expected that such vehicles are also expected to be made available in the rural areas, where sufficient dispensation of CNG or LPG is made available. During this phase significant penetration of electric three wheelers is expected.
- Phase 4 (Beyond 2030 and upto 2047): **Hybridization** of three-wheelers may be considered by manufacturers, however largely **CNG and LPG three wheelers** are expected to cater to the **rural market** requirement. However, **all new SI engine vehicles will be specifically developed for E20**, even if it is on dual fuel. Share of **electric three wheelers** is also expected to grow significantly driven by the demand in urban areas.

#### Four-Wheeler Segment (Cars, Vans and Utility Vehicles):

- Phase 1 (by 2020): **E10 material complaint** vehicles would be continued to be made available across India and oil companies would be requested to gradually increase supply of E10 fuel so as to achieve 100% E10 gasoline fuel by the year 2020, available in all dispensing stations. These dispensing units should also be clearly labelled for only supply of E10 fuel, while the normal gasoline would continue to be made available for older vehicles not designed for E10. In addition, with the desired number of CNG station going to 3,000, the population of CNG vehicles could increase from 1.7 million vehicles to around 2.2 million, substituting liquid fuel consumed by transport sector, saving 2.0 MT/year of liquid fuels & 1.5 billion \$/year of forex outgo.
- Phase 2 (by 2025): All new vehicles would be E10 material compliant and would also be tuned for **fuel efficiency** by utilizing the benefits of higher RON of E10. This would be done by the manufacturers provided there is consistent year-round supply of standalone E10 gasoline fuel across all dispensing stations in the country. In addition, vehicles will be **material compliant** to gasoline fuel with **3% methanol (M3)**. If the CNG infrastructure is further doubled from the 2020 level as per the table 3.5 then penetration of CNG vehicles is likely to increase to more than 5.2



million vehicles, displacing liquid fuel consumed by transport sector, saving 4.3 MT/Year of Liquid fuels & 3.3 Bn \$/Year of forex outgo.



- Phase 3 (by 2030): Based on availability of fuel and its infrastructure and outcome of review of previous phase, SIAM proposes **specifically E20 compliant** SI cars to be produced which will also be compatible for M3 across India. Hence, oil companies need to ensure availability of E20 fuel dispensing stations gradually from 2025 and have large number of E20 dispensing units by 2030 across the country. The standard gasoline fuel (E10) should continue to be made available for large number of only E10 compliant vehicles. From 2030 oil companies can **stop supply of E5 gasoline fuel** as these vehicles would have practically reach the end of life since the manufacturing of only E5 compliant vehicles have been stopped prior to 2010. Further, if the CNG dispensing is augmented to **10,000 CNG stations** especially in urban areas, CNG vehicle population may increase to around 13 Million, which will displace Liquid fuel demand of Transport sector, saving 10 MT/Yr of Liquid fuels & 7.7 Bn\$/Yr of forex outgo.
- Phase 4 (Beyond 2030 and up to 2047): Besides Electric and Hybrid cars, **E20 specific vehicles and CNG** vehicles would **continue to support** the overall objective of Government of India to reduce the dependency on crude.

#### **b. Diesel Vehicles based on Compression Ignition Engine Technology:**

Four wheeled Diesel Vehicles (Cars) today already run on Electronic fuel injection systems employing Diesel Oxidation Catalysts (DOCs) and Exhaust Gas Re-Circulation (EGR) for emission reduction. With BSVI the vehicle emission control system could become more advanced with Diesel Particulate filters and Selective Catalyst Reduction (SCR) technology making the emissions at par with Gasoline vehicles, while still retaining the Fuel Efficiency (lower CO<sub>2</sub>) advantage.

Heavy commercial vehicles use Diesel as a fuel of choice. Industry has already made material of vehicles compatible with 5% Bio-Diesel blends. This is a low hanging fruit and needs to be harnessed to lower the crude oil by similar proportions. Current blending is of the order of 0.001%. Hoping that fuel with higher blends will be made available, Industry will target to make the complete new vehicles compatible with 7% Bio-Diesel blend from 2020 for all forms of Diesel run engines. Considering the high share of fuel used by Buses and Trucks (consuming around 50% of the total fuel (Petrol and Diesel)), additional efforts would be required for supply of atleast upto 5% Bio-Diesel blend at a National level.

#### Four-Wheeler Segment (Cars Vans and Utility Vehicles):

- Phase 1 (by2020): **B7 complaint** C.I. Engine Passenger Cars and Utility Vehicles would be made available across India in phases. The **oil companies** may be encouraged to increase availability of bio-diesel from present 0.001% to **atleast upto 5% bio-diesel** in a phased manner.
- Phase 2 (by2025): From 2020 onwards, **all new BS-VI vehicles will be compliant to B7** and efforts should be made by the oil industry to make 5% bio-diesel be made available uniformly across the country. During this phase, oil industry should also **commence phasing in of B7 fuel**.
- Phase 3 (by2030): **All diesel fuel** that would be supplied would become **B7**. However, during this phase, **hybrid** and **electric** vehicles would gain momentum.
- Phase 4 (Beyond 2030 and upto 2047): **Large scale electric cars** are expected from the year 2030 in urban transport mobility. However, B7 compliant vehicles would continue to support the government initiative of reducing crude import.

#### LCV Segment:

Auto Industry to offer the following compliant vehicles schedule in the market:

- Phase 1 (by 2020): Upto **2% of vehicles sold in cities to be CNG** provided suitable infrastructure in CNG is made available, while vehicles sold in rural areas will be compatible to **B7 Diesel** in phases.
- Phase 2 (by 2025): If the dispensing infrastructure is doubled as stated in the Table 3.5 above then about **5-10% of new vehicles sold in this category could be in CNG**. Rest of the vehicles would be compatible to running on B7 diesel. During this phase certain pockets of the country where bio-diesel is abundantly available, vehicle manufacturers would manufacture and sell B100 vehicles provided the oil industry sets up separate dispensing units for B100 in a large scale in those areas.
- Phase 3 (by 2030): Further augmenting the CNG infrastructure to atleast **10,000 CNG stations**, vehicle manufacturers may consider selling upto **10% CNG vehicles**. Rest of the vehicles would continue to operate on **B7**, however electric and hybrid options are expected to gain momentum.
- Phase 4 (Beyond 2030 and up to 2047): Level of hybridization would be increased, in other than Electric vehicles, with an aim to save more fossil fuel and lower emissions. CNG would continue to have a fixed market presence.



### Heavy Vehicles for Public transport – Buses:

There are buses employed for city bus services and also as Inter-City buses. It is proposed to shift City Buses to CNG technology, which is already developed and replace Diesel fuel and also reduce emissions. Once the CNG infrastructure is developed along highway corridors, even such buses can be shifted to CNG operation with following roadmap:

- Phase 1 (by 2020): Upto **2 % of all city buses sold is proposed to be in CNG, once commensurate dispensing stations for CNG are available**, and rest all the new buses would be compatible to B7 Diesel.
- Phase 2 (by 2025): **5-10% of new buses sold can be on CNG** and rest of the **70% vehicles could be compliant to B7 fuel**. Use of DME and ED95 fueled Buses could also be introduced for niche applications, if the fuel infrastructure is made available for such fuels.
- Phase 3 (by 2030): **10% of all the new buses can be on CNG** and rest of the new Buses running in inter-state routes could be operating on **B7 biodiesel fuel**. Major proportion of the city buses to shift to Electric, there will be a sizeable CNG and Diesel run buses running on intercity routes. Many of these may also be hybridized for fuel saving. DME and ED95 fuel could be seen in significant proportions in areas where such fuel is made available.
- Phase 4 (Beyond 2030 and up to 2047): Level of Electrification & Hybridization in Diesel and CNG run buses could also be increased to achieve overall savings of fuel.

### Medium & Heavy Commercial Vehicles:



Heavy commercial vehicles use Diesel as a fuel of choice. Industry has already made vehicles compatible with 5% Bio-Diesel blends. This is a low hanging fruit and needs to be harnessed to lower the crude oil by similar proportions. Current blending is of the order of 0.001%. Hoping that fuel with higher blends will be made available, Industry to target to make the complete new vehicles compatible with 7% Bio-Diesel blend from 2020 for all forms of Diesel run engines. Besides the above efforts, considering the high share of fuel used by Medium and Heavy Duty Trucks, consuming around 40% of the diesel fuel, additional efforts to be made to make Bio-Diesel fuel available

widely. Considering duty cycles and Long-distance haulage and running along highways, besides shift to B7 for diesel run vehicles, LNG and DME technologies would also hold promise if Fuel is available. Based on the development of fuel infrastructure, Industry may focus on either both or one of the potential fuels in future. Auto Industry would offer the following compliant vehicles schedule in the market:

- Phase 1 (by 2020): All new vehicles to be compatible to **B7 bio-diesel** in phases.
- Phase 2 (by 2025): **5-7% of the new fleet to be operating on LNG or DME**, depending upon the geographical locations and the availability of LNG and DME, Medium and Heavy duty with different fuels will be sold in areas where such fuels are available and energy suppliers also have sufficient dispensing units in these areas and balance new vehicles will be operating on B7 Bio-Diesel.
- Phase 3 (by 2030): **10-15% of the new fleet to be operating on LNG or DME** and rest of the new fleet is expected to compatible to B7 Bio Diesel.

## 5. The Key Enablers to Fuel Diversification

Although there has been a consistent urge to shift to Alternative fuels, however the actual implementation on ground has not seen major progress so far. There have been many reasons for this gap. Industry viewpoint on the enablers to see more infusion of alternative fuels is provided below:

### a. One Nation, One Fuel Specification

“One Nation, One Fuel, Consistent Supply” would be the new paradigm to propel the fuel diversification drive

Auto Industry has always been recommending One Country One Fuel one Emission Norms and after lot of deliberations now in April 2017 India has moved to follow “One Nation, One Fuel” One emission norm. It is not possible to develop vehicles specifically for different areas of the country due to development requirements and efficiencies, besides considering India as one big nation with free flow of people (and with them their vehicles). “One Nation, One Fuel” leads to better customer acceptance of technologies, portability of vehicles, synergies of development both at vehicle manufacturers end as well as fuel supply logistics front. Going forward industry would like to continue the philosophy of “One Nation, One Fuel Norm”.

Identification and removal of artificial barriers in achieving “One Nation One Fuel” to be demolished.

This norm is well understood when it comes to gasoline and diesel fuels. For clarity purpose, for alternative fuels the norms would mean that the fuel of a particular type would need to have same specifications across the nation. In addition to above owing to specific development of vehicles to make them compatible with the alternative fuels, the availability and specifications of such fuels must be maintained throughout the year, for such vehicles to be able to be used by customers without any functional and safety issues.



## **“One Nation, One Fuel, Consistent Supply” would be the new paradigm.**

However, there are certain hurdles in achieving the objective of “One Nation, One Fuel, Consistent Supply” which are State specific law overruling the Centre Government laws, Inter-State movement of blend stock, seasonal and annual variations including flexibility allowed by law for not mandating a consistent blend throughout the year. Such artificial limitations need to be removed and have the same fuel specifications across the country and to ensure a consistent supply of such a fuel.

Besides the above hurdles, the flexibilities provided in the blending of fuels (as provided for E10 Blending program) today need to be addressed. This will enable all stake holders to focus on achieving the targeted blend of the fuel.

### **b. Supportive Institutional Mechanisms**

**A single agency which can define a roadmap and ensure its implementation is necessary**

India has a well evolved institutional framework both at Centre and State level for governance. Presently, there are several Ministries, Department and State Agencies involved in the formulation of policies, regulation and economic instruments for the development of alternative fuels in the country. There is an apprehension that alternative fuels could be hampered by the multiplicity of agencies handling the alternative fuels. Therefore, there is an urgent need for right coherence, coordination and synchronization necessary to develop policies and their implementation. A single Agency which can define a roadmap and ensure its implementation is necessary.

**Automotive Industry will work on Vehicle application, while Academia will have to work on basic research and environmental impact assessment**

The implementation of policy and regulations should be supported by a robust and responsive and institutional mechanism.

Adoption of alternative fuels needs coordination and proper planning of:

- a. Fuel Production and Supply,**
- b. Development of vehicles to run on such fuels**
- c. Support structure for the program especially in the initial phases, to drive customer acceptance.**
- d. Studying the impact of usage of alternative fuels on growth of industry, employment and most importantly environment.**

### **c. Research and Development:**

The alternative fuels, especially the biofuels are being encouraged and developed commercially across the world. Countries like USA, Canada and Brazil have advanced technological background and commercial production of biofuels. Production of biofuels is still evolving in India, therefore technological collaboration from these countries would be relevant in

biofuels programme in India. Government should encourage and facilitate transfer of clean technology under the bilateral and multi-lateral cooperation for sharing best practices, best available technologies and co-funding, etc. for the promotion and production of alternative fuels.

Besides production of Fuels, research will be required in the areas of combustion development, compatible material development, etc. While Industry will focus on the Application development of vehicles, material compatibility studies etc., Academia will be required to work on combustion research, emission development, besides studies to check the environmental impact of fuels, especially biofuels like methanol, known for their toxicity issues, impact on ambient air quality, etc.

Competence centers both in testing institutes and academia will be required to be developed with Government funding to do research in production of fuels, environmental impacts, basic research on combustion etc. auto industry at the same time to work on demonstration projects of alternative fuels.

Research will also be required to define the specifications of blended fuels so that the impact of the blend is benign to the ambient air quality and at the same time is possible to use in larger population of vehicles.

#### **d. Periodic Review of Progress and any course correction**

The periodic review to modify the policies to be responsive to changing needs is vital to succeed in its objectives and intentions envisaged. The White Paper provides a statement on the historic background, present status, and futuristic perspective about the alternative fuels from the angle of automotive industry. Since the landscape of alternative fuels, technology, environmental impact etc. is rapidly evolving and developing and so are the policies of the government, therefore, automotive industry believes that it is necessary to have a periodic review of the policy in consultation with key stakeholders.

A frequency of three yearly review is necessary for studying the progress of fuel production and distribution infrastructure and environmental benefits studies & technology development and take suitable measures in the roadmap. It is necessary that the policies are consistent, predictable and reliable with clear roadmaps for their effective implementation and for achieving the objectives envisioned.

#### **e. Incentivization**

Production & distribution network of alternative fuels, customer acceptance for such fuels will be the key to achieve higher penetration of these fuels to meet India's National objectives.

A few proposals to achieve the targets as below are proposed

- a. **Lower taxation on production and distribution infrastructure** of alternative fuels, besides advance depreciation on plant expenditure.
- b. **Lower taxation on sales of alternative fuels.** At present the GST rate on biofuels is 18% which are at higher side and it is suggested that GST rate of 5% should be implemented for the promotion of biofuels.
- c. **Viability Gap Funding (VGF)** should be provided to reduce high cost of technologies like LNG Fuel system and Cryogenic Fuel Tanks for heavy duty application.
- d. **CO<sub>2</sub> reduction potential** on Green House Gases (GHG) measured as per WTW basis should be considered for each alternative fuel and vehicle should incentivized based on the GHG benefit.

The above proposals are not comprehensive but need to be looked at by a **nodal central institute** for driving customer acceptance.

## 6. The Way Forward

While electrification and hybridization of fleet will be required to lower the usage of fuel for automotive purposes, the National Objectives of Energy Security, lowering emissions can be supported by the augmentation and promotion of alternative fuels. Strategic positioning of the biofuels in the overall energy basket is crucial for India considering the huge increase in demand not just from the automotive sector but also from other energy consumers.

A roadmap, built on concrete foundations of micro detailing of steps, is required for all stake holders, fuel producers, automotive companies to define their individual strategies, however aligned at grassroots.

A single agency, which can define this roadmap based on sound engineering and scientific debate, and ensure its implementation is necessary for successful implementation. Although international experiences could be used for learning, while deciding the fuel diversification for India, it is important to consider:

- i. Diverse segments within road transport running on different fuels and having different duty cycles,
- ii. Consumption of fuels by different segments and priority of implementation
- iii. Geographical enormity of India, resource origins and logistic issues

Most importantly, customer acceptance of alternative fuels and vehicle technologies will be the key to achieve sizeable penetration and to have a

significant impact on the reduction of fossil fuel imports. Following “One Country, One Fuel Specification” norm, to ensure portability of vehicles and efficiencies of development of fuels and vehicles, subsidizing fuel production and distribution besides funding the viability gap in case of high acquisition cost of technologies like LNG etc. would be the key.

CNG, E10 blends for gasoline and B5 blends for diesel are low hanging fruits for India. Consistent supply of such E10 and B5 fuels can reduce fuel imports in a very short time frame provided fuel is made available, on a sustained basis since the vehicles are already material compliant. For CNG, even with a lack of infrastructure today, there are estimated to be around 3 million vehicles running in various parts of India. These vehicles would be displacing roughly 2,000 Million liters of gasoline fuel every year. With the growth of CNG infrastructure the savings can be significant.

Lastly while aim and vision should be high, the same can be done by taking small but concrete steps. This allows for the ecosystem to grow while ensuring penetration of fuel and technologies. A classic example could be aiming for a high level of usage of a fuel, while it could be started with a lower blend of fuel to allow easy penetration in vehicles and customer acceptance with lower tradeoffs with environmental concerns. This would provide direction and scales for fuel producers to invest in production facilities which will be required for achieving higher blends.

While automotive industry can focus on engineering and vehicular application, a clear roadmap with well-defined steps is crucial for all stakeholders to come together and achieve the National Objectives.

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