

# Fuel shifting towards fuel of future for Transportation in India

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**Abstract** - Fuel shifting of vehicles in India is the idea or initiative or need that insists on switching the dependency on fossil /conventional fuels for transportation into an appropriate alternative that may have the potential to become the primary fuel of almost all vehicles of Road Transport from passenger to commercial segment. Here, the scenario and background for this idea are considered, followed by selective alternatives of conventional fuel and their comparison on various parameters, including the government's interest and people towards adopting a suitable option. Then, it results in the most appropriate fuel that can swap itself from conventional fuels. With all due consideration and analysis, electric energy is the most suitable fuel which can be shifted from traditional fuels in transportation systems.

**Key Words:** India Electric Vehicle (EV) Policy, Fuel Change, Sustainable fuel for Transport, Best Fuel for Future, alternative fuel vehicle

## 1. INTRODUCTION

The shifting of fuel is the case of 'change' which shows the changing needs and demands for both Environment and People to change the fuel for the transportation systems with time and population and Urban growth of Indian cities.

The change in vehicles' fuel significantly impacts existing transportation systems because people, technology and infrastructure, and economy and policies are adapted accordingly to conventional fuels. So, shifting fuel is a macro subject and has high consequences on the abovementioned domains. Therefore, focusing primarily on the topic 'fuel' would get changed, and the engine to pull the dependent fields accordingly.

This research aims to find out the most appropriate 'fuel of the future' for transportation in India. It proves itself at par over the other fuel of the future, simultaneously maintaining the advantages of conventional fuels.

Here, the subject of shifting of fuel is discussed, followed by its need, with due consideration of the scenario of India. Then, list out the potential alternate fuels that can replace fossil fuels and thoroughly discuss their scope and limitations. Then compare these fuels on exclusively selected parameters for the research and finally find out the most suitable energy that can be switched from conventional fuels.

## 2. LITERATURE REVIEW

### 2.1 Fuel shifting for transport machines is the subject of continuous change of requirements

Every physical-mechanical machine requires some energy to work. Our human body needs food that is ultimately a raw source of energy that our body processes and converts into Glucose or Energy in the form of Processed energy that our body uses. Here in mechanical machines, the need is for processed energy in the form of fuel as present-day machines are not designed to convert or process the raw source of energy from where they can get Processed power.

These machines are of various characteristics and are designed for multiple purposes. Similarly, the Machines meant as transport are utilized to shift people or goods from one place to another. Like any other machine, these transportation machines also need fuel to run; ultimately, the energy source of these machines creates the bigger picture because the need for transportation is increasing day by day in the present way of living.

Earlier, these machines get the raw fuel like coal and ultimately convert it into energy to heat, which produces steam that generates the pressure and the engine runs. Things had changed from the industrial era and soon after the invention of internal combustion engines (ICE) commercially. There was a need for liquid fuel, so ultimately, the shifting of fuel happened from Solid fuel to liquid fuel, i.e., coal to petroleum. Then several types of research occurred, which led to bringing the fuel in the form of gas that is Natural gas and its storage.

The conventional forms of transport fuels like Petroleum/Natural Gas have been provided for more than five decades or maybe more and are also being used today. Soon after, Researchers and environmentalists analyzed that due to emissions from these fuels, there is a significant rise in Global Warming (Romm, 2005), because of the generation of greenhouse gases (WOODS, 2020). Moreover, these fuels are non-renewable sources of energy. Therefore, the need arose again to change the power of transportation.

## 2.2. Scenario of India

In India, some people still use ancient transportation like Bullock Carts, Horse Carts, and others. Similarly with fuel, in India, every type of fuel is used in some or other way for transportation systems. Here, what is meant by this is that whatever shift happens in vehicles' fuel, some people will still use the predecessor fuel or both. It is evident from the socio-cultural behavior of Indian societies that bringing out a 'change' and its adoption in India is not a simple task.

Presently, the primary fuel dominating in India is Petrol or Diesel and Compressed Natural Gas (CNG) as transportation fuels in Urban contexts and Petrol and Diesel in Rural India. CNG still is not a charm in Rural India because that had come later. This is what happens when a 'change happens.' Some may change, some might not change.

Soon after decades, again, the same situation aroused to shift (O'DELL, 2022) from Fossil fuels to green fuels like Electric or Hydrogen or even Liquified Natural Gas (LNG) in commercial applications or Petrol mixed with Ethanol or Bio-ethanol or any Hybrid Combination.

Another primary task is to provide infrastructure to facilitate and adopt the shift in fuel which is again a tedious task. This is also why the objective of Fuel shifting of vehicles won't get fully implemented in every corner of India.

## 2.3. Types of Fuels available for shifting (Alternative Fuels and Advanced Vehicles, 2022)

### 2.3.1. Electric Energy

It is a form of widely available energy and can be stored in batteries. These batteries are thus can be recharged or swapped to 're-fuel' the vehicles. There are two significant concerns with Electric energy as an option of fuel. The first is the capacity of batteries, which determines the time Range for vehicles to Run. The second is the method by which that electricity is produced.

Electric energy is the only energy available at best in comparison with other fuels, so somewhat the fuel shifting of vehicles may get a better extent if electric energy is adopted.

The one-time run distance when the vehicle is recharged to its total capacity pushes the users or buyers to switch to electric cars. Limited battery capacities give a little one-time run distance, thus creating fear or disability for the vehicle to cover long distances without recharging. Also, the time needs to recharge the battery makes it more nuisance. Presently, it just takes a few seconds for the vehicle to get re-fuel; however, in the case of battery restoring, it takes half an hour or one hour or more to get it fully recharged.

Here, what matters is the loss of time in recharging the vehicles. Research is happening to develop mast methods of recharging, but still, it is way behind the speed of re-fueling the cars. Somehow the charging infrastructure can be created at every corner, but to extend the battery capacities and reduction in time of recharging is solely dependent on the extent of research and developing new technologies.

Another primary concern is the source of electric energy to recharge the batteries. If renewable sources of energy produce electrical power, then it is feasible for people and the Environment and justifies the objective of shifting fuel. However, if Non-renewable sources make the electrical power, then there would be no meaning left to change from conventional (Logan, Nelson, & Hastings, 2020) petroleum fuels.

### 2.3.2. Bio-Fuels

This category of fuels is mainly produced as a by-product of Agricultural (Zhang, 2015) waste or Bio-waste Human waste, or precisely any biodegradable waste. There is always a natural benefit in these types of waste; i.e., they contain carbon element, a fuel followed by oxygen, the promoter of burning, which is widely available. So due to this exothermic chemical reaction, there is always a release of energy/heat which can be utilized as fuel for vehicular needs.

This is the most suitable fuel as it is a 'waste consumer', but on the other side, it creates pollution similarly to other petroleum fuels that are not desirable in the present context.

Other than that, it may be used as an additive to Petrol and decrease the consumption of raw Petrol, a Non-renewable source; it also generates revenue employment and eats waste as a healthy diet.

### **2.3.3. Liquefied Natural Gas (LNG)**

Liquefied Natural Gas (LNG) is a non-polluting natural gas; however, it is a non-renewable source of energy. It is better than Compressed Natural Gas (CNG) because it provides a more extended range once re-filled, which significantly benefits commercial applications. It also creates less pollution and more mileage, so running costs are a relatively low economic benefit.

This LNG is suitable as an alternative fuel, but still, it does not fulfill all the criteria of Future demand, as it is a non-renewable source of energy.

### **2.3.4. Hydrogen**

Hydrogen is a very well-tested non-polluting fuel because, ultimately, the smoke from vehicles is nothing but water vapor. Though Hydrogen (Mansuri, Saxena, & Mishra, 2021) is much better than all other options, it has a significant flaw: the extraction of commercial Hydrogen is quite an expensive process. It does prove to be extravagant for the ordinary person to buy and fill it in vehicles.

Somehow, if researchers evolve and can produce commercial hydrogen is feasible rates, then it would be a Gem. Any alternative fuel must be selected to get a 'shift' in vehicles' fuel until then.

## **2.4. Future Demand**

The demand for future fuel depends upon several parameters that power needs to qualify. For instance, to list down parameters, it is essential to figure out the probable demands of the future that energy must fulfill. Fuel for future needs to be like green fuel, the vital need, then readily available to the user end in large amounts, easy to produce in large quantities for unlimited time, under the purchasable limit for an ordinary person, able to generate revenue for service providers, ability to run every kind of vehicles whether in passenger segment or logistics.

On this basis, the parameters can be derived for comparative analysis for various fuels, like:

- Eco-friendly
- Convenient
- Renewable
- Cost-effective/feasible
- Financial Generator
- Suitable for all vehicles
- Adequate for prolonged use
- Technology available
- Government's Interest
- People's Interest

## **2.5. Behavior of Government**

Government plays a crucial role in making final decisions or policies that license a particular fuel and its vehicles to legally run-on streets. The government of India has accepted multiple enterprises to promote the manufacturing and relinquishment of electric cars in India. Electric cars have begun weaving the Indian market with encouragement from the government side.

However, the dream of electric mobility in India won't become a reality unless the charging infrastructure for electric vehicles fulfills its adequacy.

The Ministry of Power has made specific laws and guidelines to lay out charging infrastructure for electric vehicles. The Ministry has allotted the central Nodal Agency to the Bureau of Energy Efficiency (BEE) as the National body for guiding the development and laying of charging infrastructure.

**2.5.1. Central government incentives to Electric Vehicle owners (Bureau of Energy Efficiency, 2022)**

Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India, (FAME India) Scheme Phase II –

**2.5.2. National / State Electric Vehicle Policies and Regulations (Bureau of Energy Efficiency, 2022)**

- Regulations issued by Ministry of Power, Government of India
- Charging Infrastructure for Electric Vehicles - Revised Guidelines and Standards October 2019
- Amendment in the revised Guidelines and Standards for Charging Infrastructure for Electric Vehicles June 2020
- Regulation regarding delicensing the sale of electricity at charging stations April 2018
- Central Electricity Authority (Measures relating to the Safety and Electric Supply) Regulations June 2019

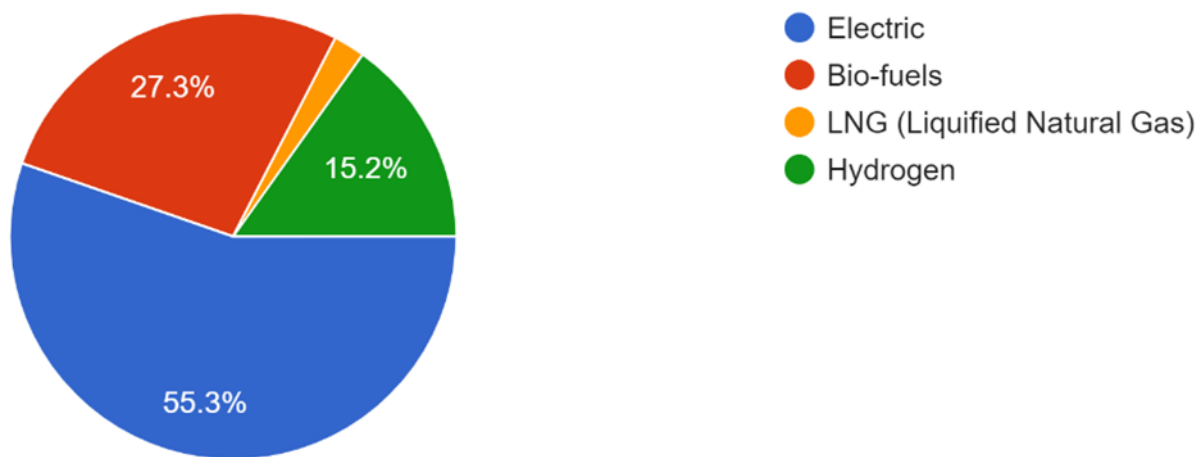
**2.5.3 Regulations issued by other Ministries (Bureau of Energy Efficiency, 2022)**

- Guidelines issued by the Ministry of Housing and Urban Affairs (MoHUA), 2016

Apart from this, various state policies on EV and incentive policies on EV push EV into the Indian scenario.

**2.6. Choice of People**

Choice of people is highly significant as the ordinary person would be the largest user, simultaneously will have a substantial impact on them and their daily rides, expenses, maintenance, and others. Another concern is social acceptance. No one can dare force people to accept the fuel they don't want to buy. Also, participatory planning is a must method that needs to be followed. This is stakeholders' Consultation.



**Chart -1<sup>1</sup>:** Pie-chart showing the interest of people towards a particular fuel to be adopted for future transport systems

More than 50% weightage, even highest goes to Electric energy as the choice of appropriate fuel which can take place the conventional fuels.

<sup>1</sup>Source: Author; To figure out the choice of People, a Primary survey was carried out through online survey with Google Forms, where choice-based selection is recorded which people can select their interests. Limitation in this survey was imposed to record the data from random 100 people irrespective of Qualification/experience/technical expertise/region/caste/age/profession/etc.

## 2.7 Change In Cost of Fuel

The costs are different for different types of fuels; comparing each alternative fuel with conventional fuel, it can be considered as electric vehicles running cost is about 60% less (SHAH, 2021) than traditional fossil fuels. Moreover, Liquefied Natural Gas (LNG) costs less than conventional fuels like Petrol or Diesel but is More Expensive than Compressed Natural Gas (CNG).

Similarly, Bio-fuels are sometimes cost-free or negligible if in-house production occurs or less than fossil fuels as transportation cost for Bio-fuels is less.

Hydrogen production is expensive, so the running cost is almost double the price of petroleum fuels. With this comparison, Bio-fuels or Electric is a leftover economical option to reduce fuel expenses. At the same time, LNG for a commercial purpose is also suitable because its running cost is less than Diesel. However, cheap hydrogen is still behind in the race.

## 2.8. Towards Green Fuel

There are, of course, specific parameters on which the fuel for the future needs to qualify. However, among them, the most important one to be considered to mitigate Environmental impacts (Khurana, Ravi Kumar, & Sidhpuria, 2019) or reduce the Air Quality Index (AQI) of Urban Cities or Prevent the ozone depletion and its consequences is to follow to adopt 'Green Fuel.'

Here, except for the biofuels, the rest can be considered green fuels. Electric will be a highly green fuel when produced from renewable sources of energy.

## 3. COMPARATIVE ANALYSIS ON VARIOUS FUELS AVAILABLE TO BE CONSIDERED

**Table -1<sup>2</sup>:** Comparison of the various parameters for the 'fuel of the future.

	<b>Electric Energy</b>	<b>Bio-Fuels</b>	<b>LNG</b>	<b>Hydrogen</b>
<b>Eco friendly</b>	Yes	No	Yes	Yes
<b>Convenient</b>	Yes	Yes	Yes	Yes
<b>Renewable</b>	Yes	Yes	No	Yes
<b>Cost-effective/feasible</b>	Yes	Yes	Yes	No
<b>Financial Generator</b>	Yes	Yes	Yes	Yes
<b>Suitable for all vehicles</b>	Yes	Yes	No	No
<b>Adequate for prolonged use</b>	Yes	No	No	Yes
<b>Technology available</b>	Yes	Yes	Yes	No
<b>Government's Interest</b>	Yes	Yes	Yes	No
<b>People's Interest</b>	High	Medium	Very low	Low

## 4. FINDINGS FROM COMPARATIVE ANALYSIS

Based on Comparative analysis, it is found that only electric energy is the fuel that satisfies the needs for 'fuel of future.'

## 5. CONCLUSIONS

Considering all factors of future demand and maintaining overall sustainability, the selection is left to adopt 'Electric energy' as an appropriate alternative for 'fuel shifting of Vehicles.'

<sup>2</sup> Source: Author; The comparative analysis to mark the potentials and cons of various fuels available to be adopted. The parameters are exclusively selected to thoroughly compare the fuels with each other and figure out the number of 'Yes' as accepted and 'No' to be rejected. The fuel which gets the highest Number of 'Yes' would be considered as most appropriate fuel to be selected for future transport systems.

Through this research, it has also been found out that, apart from electric energy, the second most fuel which can be considered for fuel shifting are Bio-fuels. However, the only concerns are developing pollution-free/negligible types of Bio-fuels, which somewhat fulfill all the criterial requirements of the fuel that would replace the conventional power. Another significant outcome from this research is that although electric energy is the most suitable fuel, other fuels like Biofuels, Hydrogen, or even LNG cannot be neglected or discouraged. These fuels are behind in the race, but not so far, to be disqualified in the selection of 'Fuel of Future' in India.

Electric energy has proven itself superior to other fuels in the overall improvements in achieving Eco-friendly, Convenient, Renewable, Cost-effective/feasible, Financial Generator, Suitable for all vehicles, Adequate for prolonged use, Technology available, Government's Interest, and People's Interest requirements of Modern India Transport. Electric energy would have an overall positive impact on all these parameters.

Among all parameters, the Cost-effective parameter for Electric Energy proven to provide large economic benefits from 60% savings if electricity is purchased, to 100% savings if electricity is generated from renewable sources at premises like solar energy or Wind energy. This is dominating benefit of adopting electric energy over other fuels.

Efforts can be made to promote fuel shifting and subsequent planning of its infrastructure, simultaneously locking the estimated timeline to achieve the aim of 'fuel shifting in India.'

This research is limited to only 100 people in the primary survey, which is also based on random selection. This can be further be extended to take the primary study from the whole population of India, making it more justifiable for inclusive planning.

## GLOSSARY

**Electric Vehicle (EV):** Vehicle which uses electrical energy as its fuel to run

**Internal Combustion engine:** Engine which runs on Gas/fuel with internal combustion process inside engine cylinders

**Liquified Natural Gas (LNG):** Natural Gas in the form of Liquid state stored in Cylinders

**Waste Consumer:** Bio-fuels are mainly produced from Biodegradable waste, hence regarded as waste consumers

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