**Role of Renewable Energy in Decarbonisation of Indian Road Transport Sector : Emobility, Biofuels and Beyond**

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# 1.0 Introduction

India has a population of nearly 1.2 billion people spread over a vast & diverse geography. To connect its people it has one of the largest and most complex transport networks in the world. The transport sector is and will continue to remain a critical enabler of development and would have to grow in a sustained manner for the country to meet its developmental objectives. The Indian transport sector is growing rapidly and as per the estimates of the National Transport Planning and Development Committee (NTDPC) (Committee, 2014), it is expected that the overall passenger traffic will increase by 15% per annum and freight traffic will increase by 12% and 8% per annum for rail and road, respectively. As per a study conducted by (Dhar, Shukla, & Pathak, 2017) transport sector accounted for 13 % of India’s energy-related CO2 emissions. As per the Global Carbon Project Report (https://www.globalcarbonproject.org/, 2018), though India’s road transport emissions are small in global comparison, they are increasing exponentially, two times as fast as the Global rise in 2018. India’s Intended Nationally Determined Contributions (INDC) specify an economy wide decarbonisation target of 33 to 35 % between 2005 and 2030 and includes announcements for road transport, urban transport, intercity transportation infrastructures, sustainable logistics and inland waterways to achieve these reductions (https://pib.gov.in, 2015).

# 2.0 Research Objective

The main purpose of the research study is develop decarbonisation pathways for Indian road transport sector with a focus on the role of renewable energy. This will involve

* Analysis of the trends in Road Transport sector
* Identification of Main stakeholders for Road transport sector
* Analysis of current government targets , policies & strategies for decarbonisation of road transport sector
* Review of current status of Renewable energy, E- Mobility and Biofuels w.r.t to Indian road transport sector
* Review of technologies and strategies apart from current focus on E-Mobility and Bio Fuels
* Review of International models for Road sector decarbonisation and learnings from their experience
* Interpretation and interpolation of data into various scenarios and pathways for decarbonisation through to 2050.

# 3.0 Literature Review

## 3.1 Indian Road Transport Sector

India has the one of largest road network across the world, spanning over a total of 5.5 million km. Road Transport accounts for about 90 % total passenger and nearly 65 % of good/freight traffic of the country (https://www.ibef.org, 2019). Transport policies in India have historically favoured motorised transport compared to non-motorised transport (Arora, 2013). Implementation of projects focussing on non-motorised transport designs has been piecemeal & symbolic (Mahadevia, Joshi, & Datey, 2012) Along with economic development and urbanization there has been a tremendous growth of automobile industry in the country. The Indian auto industry is fourth largest in the world with a growth rate of 9 per cent year-on-year based on 2018 statistics. Based on the same India is the seventh largest manufacturer of commercial vehicles. The industry accounts for 7 % of the country's Gross Domestic Product (GDP) with around 40 OEM’s, operating through either a manufacturing unit or assembly set up. India is also a prominent auto exporter & its exports grew 14.5 per cent during FY 2019 (Mukhtyar, et al., 2019).

Factors favouring the industry include availability of skilled labour at low cost, multiple R&D facilities & low-cost steel production. The industry provides great opportunities for investment & employment to skilled and unskilled labour.

Government statistics show that domestic automobiles sales increased at nearly 7 % between FY13-19 with 26.27 million vehicles being sold over last year. Year-on-year growth in domestic sales among all the categories was recorded in commercial vehicles at 17.55 per cent followed by 10.27 per cent year-on-year growth in the sales of three-wheelers.

India’s currently has more than 210 million cars, motorcycles, 3-wheelers, and trucks. Over the past five years, the number of vehicles grew by as much as 23% cumulatively. By the year 2030, an estimated 600 million vehicles will be on Indian roads - thrice the current number. Two-wheelers dominate the sector accounting for 75% of total vehicles sold in the country and trends point to a continued dominance the same in terms of volume owing to a growing middle class and a young population, the growing interest of the companies in exploring the rural markets leading to increased access and affordability.

This sheer volume means road transport becomes a major contributor to energy vulnerability and growing pollution.

Road transport sector accounts for nearly half the consumption of petroleum products in India. Fuel demand is expected to grow at 6–8 per cent over the coming years in tandem with the rapidly expanding vehicle ownership (Committee, 2014). India’s energy security would remain vulnerable until there is a steep decline in dependence on imported fossil fuels.

Road transport sector is also a major contributor to air pollution in India. India is currently the world’s fourth largest emitter of greenhouse gases (GHG), and road transport accounts for 13 percent of the country’s energy-related CO2 emissions ((MoEF), 2010,) . In an assessment carried out by the Central Pollution Control Board, half of the 164 cities studied had high or critical levels of PM10 while more than half had moderate or critical levels of NOx ( (Dhar, Shukla, & Pathak, 2017). Increasing motorisation has also contributed to impacts on human health and increasing accidents (Dhar, Pathak, & Shukla, 2017). India has some of the most polluted cities in the world and as per multiple newspaper reports air pollution kills an average of 8.5 out of every 10,000 children in India before they turn five. Exhaust emissions from diesel vehicles are responsible for about two thirds of deaths from air pollution in India. (https://www.cseindia.org, n.d.)

Several policies over last two decades have been implemented to try reducing dependence of road transport in India from fossil fuels. Early 2000’s saw a focus on bio fuels and recent emphasis has been on E-mobility. In spite of several initiatives the penetration of bio fuels remains negligible and sales of electric cars in India decreased during majority of last 5 years (https://www.autocarindia.com, n.d.)

Rising energy demands, fuel insecurity and unprecedented levels of pollution have made it essential that India successfully decarbonises its road transport sector in coming decades.

## 3.2 Biofuels and road Transport in India

Among the portfolio of renewable energy alternatives that are available, biofuels, especially ethanol and biodiesel have been promoted in India since turn of the millennium. A recent study on lifecycle for biodiesel in India (Kumar, Jasvinder, Nanoti, & Garg, 2012) observed that the GHG emissions reduction varied between 40-70 % depending upon the methodology used.

India took the initiative on biofuels with the aim of reducing the country’s dependence on oil imports, improving energy security and achieving environmental commitments. In 2001, the country began a five percent ethanol blending pilot program, and in 2003, formulated a National Biodiesel Mission (NBM) with a goal of 20 percent biodiesel blends by 2011–2012. In December 2009, in order to strengthen and formalize the country’s commitment to promoting a sustainable biofuels industry, India adopted the National Policy on Biofuels (NPB). The policy proposed a 20 percent biofuel (ethanol and biodiesel) mandate by the end of 2017 (MNRE, 2009). In order to improve the availability of ethanol and eliminate uncertainty regarding both pricing and supply, in December 2014 the Indian government fixed price ranges for ethanol. Further, ethanol produced from non-food feed stocks, such as cellulosic and lignocellulosic materials (including those derived from petrochemicals) are allowed, as long as they meet Bureau of Indian Standards (BIS) specifications.

The targets in the national plan have not been met. Currently ethanol blends are only available in 13 states and the average blend is two percent) (Comittee, 2014). There are concerns over the long-term sustainability & commercial viability of the current ethanol programme. Factors like low plant capacities, use of batch process technology, inefficient by-product and effluent management practices have impeded growth within the sector.

Manufacture of Bio diesel in India focusses on use of non-edible seed oils and use of “wastelands”. It does not involve established methods of using vegetable oils derived from palm oil, soyabean etc for the production of biodiesel, as India is not self-sufficient in edible oils production. Food security is a national priority for India due to its one billion plus population rising domestic demand for food, stagnating agricultural productivity, and limited scope for expansion in area under crop cultivation. Currently, Jatropha occupies around 0.5 million hectares of wastelands across the country, of which 65-70 per cent are new plantations of under three years. Most Indian-produced biodiesel is used locally by the informal sector for irrigation and electricity generation, or by automobile and transportation companies for experimental projects. (Raju, et al., 2012)

The environmental impacts of Jatropha in Andhra Pradesh have been studied and it is found that the biofuels produced from the Jatropha seeds can be a viable alternative to fossil fuel thereby reducing the GHG emissions. Studies also find that cultivation of Jatropha on arid and unusable lands prevents desertification. Research also showed that Jatropha cultivation can be used for carbon sequestration. (Simon, Singh, Pfister, Adheloya, & Zah, 2012)

Research and pilots for second generation biofuels are ongoing.. Evaluation of strategies involving a mix of 2nd generation plus waste vegetable oils (WVO) which are cheaper and produce equivalent yield have shown some promise. (Purohit & Dhar, 2015). The success of the same will depend on factors like annual generation, usage levels, and the surplus available. Several other options like Pongamia, Simaruba, Neem, Mahua, etc. have also been found suitable and are being promoted but are less favoured than Jatropha owing mainly to their long gestation periods

As of now, the consumers of biodiesel in the country include Indian Railways, Defence Research and Development Organization (DRDO), some private companies, etc. Other than this, the local consumption in heavy vehicles, tractors, diesel pump sets, etc. is also prevalent. (Raju, et al., 2012)

Like many other countries, India has endured barriers to a successful implementation in form of supply shortages, fluctuations in oil prices, and global concerns about food security. Weak policy further acts as a decelerator to meet the targets. Policy prevents private biofuel manufacturers from marketing directly with the responsibility of storage, distribution and marketing vested in oil marketing companies (OMCs). Price and minimum quality requirements are also laid out in the NPB and may not necessarily reflect market conditions. Even though the central government is involved in the strategic decisions on biofuel policies, the actual implementation rests on the state governments. Presently, there seems to be a disconnect between the state policies and the priorities of the centre, especially with respect to tax and pricing policies, transfer of land title rights, etc. Similarly, in several aspects, divergence between the policies and approaches pursued by various state governments is apparent. The public private partnership with buy-back arrangements, and with need - based support from NGOs seem to work well in most of the state. (Raju, et al., 2012)

Bio-fuels have potential to create new value chains, generate employment, markets for agricultural products and stimulate rural development hence holding enormous potential for farmers.

Biofuels could have positive implications for national energy security, local air quality and GHG mitigation, employment generation and rural development. There are however several such un-tackled issues as economic viability and long-term sustainability of the bio ethanol programmes, commercial feasibility of Jatropha-based biodiesel, technological challenges constraining the development of second-generation biofuels industry, loose ends in the national and state biofuel policies, etc.

It is essential to close these gaps to enable biofuels to play their part in improving energy security and decarbonising road transport sector in the country. The current focus of the government though is primarily on E-Mobility.

## 3.3 E-Mobility and Road Transport in India

India's Intended Nationally Determined Contribution (INDC) enlists electric vehicles as a focus area under transport mitigation actions. Part of the country's National Electric Mobility Mission Plan 2020, the Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME India) is aimed at accelerating the diffusion of hybrid and electric vehicles through financial incentives Indian government has set ambitious targets for the country under the national mobility program. The initial target of having 100 % of EV vehicles on road by 2030 was toned down to a 100 per cent electric vehicle (EV) fleet in public transport by 2030, and aims for 40 per cent electrification in personal transport. A preliminary proposal to meet these targets has been tabled and it includes phasing out fossil-fuel-based three-wheelers by 2023 and two-wheelers (up to 150 cc) by 2025. (https://www.thehindubusinessline.com, 2019)

Several incentives including tax concessions and subsidies for the EV sector in various areas such as creating demand incentives, developing a charging infrastructure, and building IEC (Information, Education & Communication) efforts. Automotive majors are already anticipating potential EV growth and coming up with plan to capitalise on the market opportunities. Concrete steps being taken to help spur EV growth. Energy Efficiency Services Limited (EESL) launched a tender for 10,000 4-wheeler EVs in 2017 followed by another in 2018 (https://economictimes.indiatimes.com, 2018), the world’s largest single EV procurement to date. In the 3-wheeler and bus segments, the government is looking to introduce battery swapping to decouple battery costs from vehicle costs and ease the re-charging process. Standards for the first generation of public EV chargers have been set, and a second generation is in the pipeline. (Electric vehicles in India : Prospects and challenges, 2017)

Inspite of all the government push, policy changes and hype the India EV story has been underwhelming so far. Absence of charging infrastructure, inconsistent government support and early product failures have all resulted in stagnant growth in recent years. Other factors for the tepid response include high battery costs, insufficiently attractive financial incentives, lack of charging infrastructure, and local production consumers in India perceive charging time, driving range, battery replacement costs, top speed and acceleration as key barriers for EVs.

A point to note is that while introduction of EV’s is to curb emissions, the primary source of power for these e-vehicles for near future will come from fossil fuels. Even now, with a total contribution of 60% to total power, coal is the major source of power generation in India (https://www.export.gov, 2019). The Bharat Standard-VI (BS-VI) emission norms will be implemented across India by 2020; this is another potential EV growth decelerator with manufacturers having made significant investments for recalibrating vehicles to meet the new standard. From a consumer’s point of view, the cost of EVs is a major barrier in a price-conscious market like India.

While a lot has been spoken about the challenges with respect to the network of charging infrastructure solutions aren’t yet forthcoming. A small network of 4,230 public charging

stations in 53 cities with a million plus population has been planned under FAME-II, but that is around 1% of requirement.

A successful transition of the road transport sector to meet the ambitious EV targets will involve building of shared infrastructure for more efficient utilization by mobility service providers, smart grids that enable bi-directional charging, allowing vehicles to charge themselves using the grid, manufacturing of EV and its key components in India , E highways etc.

## 3.4 E-Mobility , Bio Fuels & Beyond

Multiple studies have focussed on the choice of emission reduction methods. According to a recent study electricity is the most efficient and cheapest technology and hence the best option (Connolly, Mathiesen, & & Ridjan, 2019). Another one concludes that while new generation biofuels will be in certain regions, the limited availability of their feedstock will limit their global application (Aro, 2016). Majority of the current research supports the idea that that E-mobility will be the future due to limited ability (resource scarcity/food security) to meet the entire energy need of the transport sector via biofuels. For large and diverse countries like India, bio fuels will still have a role to play short/medium term and possibly long term. Current study proposes to analyse scenarios with different proportion of E-mobility successes and role biofuels will have to play in the same to help achieve decarbonisation targets for the country’s road transport sector.

A short insight into alternative technologies which might develop into game changers (e.g fuel cells) for the sector along with strategies focusing on demand side management will be part of the final thesis.

Further, strategies to reduce dependence on fossil fuels and increase the share of renewable energy to drive decarbonisation of the road sector in medium and long term (~2050) will be presented and pathways showing business as usual, Ideal and median cases will be proposed.

# 4.0 Research Methodology and Timeline

The proposal is to conduct an interpretative study mainly qualitative in nature along with some quantitative inputs as existing market statistics, trends and interpolations. The study will focus on India, its drive to meet it emission targets and the role decarbonisation of road transport sector in the same.

## 4.1 Data Collection, Analysis & Confidentiality

The data of this study will be obtained from Indian government (Niti Ayog, MNRE, DBT etc) , Society of Indian Automobile Manufacturers , publicly available papers strategy roadmaps, scholarly literature, newspaper articles, websites, social media etc. There is a plan to collect data/material based on official/unofficial interviews from experts (Indian/Global) to add depth and pragmatism to results. Based on the stakeholder involved a small set of questions will be emailed/communicated and additional questions if any will be provided as a follow up email or during one on one discussion. Data collected at the interviews will be kept confidential and secure, and not disclosed to anyone without explicit

approval of the interviewees with the option of anonymous contribution being available to them.

## 4.2 Research Timeline

* It is proposed to conduct the study over a period of 16 weeks starting from November 2019 with following Major Milestones:
* Detailed Analysis of Indian road Transport Sector and its future : Week 1-2
* Detailed Literature review on Biofuels , E-mobility, Renewable energy in reference to Indian Road Transport Sector: Week 3- 6.
* Interviews with Identified Experts : Week 4-8
* Review of learnings from Alternate technologies , examples from other countries and various strategies for Road sector decarburization : Week 6-10
* Data Analysis , Interpretation and pathway proposals: Week 10-13
* Draft Paper: Week 15
* Finalisation of Paper: Week 16

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