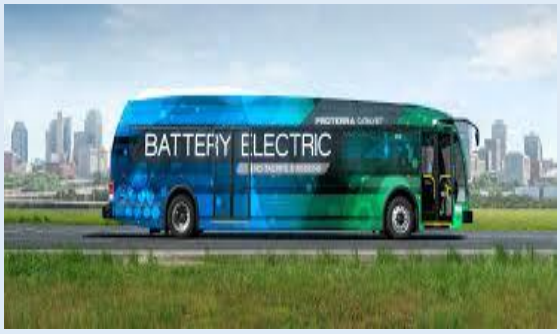
DISCUSSION PAPER

ODISHA

TRANSPORT SECTOR









ENABLING STATE LEVEL CLIMATE MITIGATION

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Draft for Review

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1 Introduction

1.1 Importance of the Transport Sector in Indian economy

One of the most important sectors in the Indian economy is the transport sector along with its available infrastructure ensures the effortless moving ability for the population and goods from one point to the other. The transport sector in India comprises of several modes which are rail, road, coastal shipping, civil aviation, pipelines and many more. It can be stated that the transport sector is responsible for the social and economic development of an economy (Jain & Dhiman, 2017). Out of all the available transport modes, the road transport mode is the most significant and commonly used. It has been observed that the percentage share of the transport sector in the GDP of the Indian economy is 5% and out of which 3.3% is directly from the road transport sector. Some of the reasons behind the preferred choice of road transport amongst all the others in the Indian economy is the ease in accessibility, minimal cost of operation & maintenance, door-to-door and reliable services.

1.2 Current Scenario in India and Odisha

As per advance estimate of 2019-20, the economic growth of Odisha is expected to grow at 6.16%of GSDP as against 7.90% in 2018-19(1st RE) due to lower agriculture production being affected by cyclone and deceleration in mining and manufacturing and at the same time the national economy is also projected to decelerate to 5.0% in 2019-20 (AE)1. India had seen a continuous growth with regards to the vehicle ownership in its transport sector and the level of penetration of passenger cars, buses and two wheelers in India is 23, 1 and 128 per 1000 people respectively. It is seen that the level of penetration for passenger cars and buses in India are significantly low in comparison with other developed and developing countries which is contrary to the case of two wheelers (MORTH, 2016). International comparison of vehicular penetration, measured by estimated number of vehicle-in-use (on-road) per 1000 persons, reveals that developed countries tend to have higher car penetration whereas in developing countries tend to have higher two-wheelers penetration (RTYB 2015-16). This can be observed from the Table 1 which shows the comparisons of India with other developed and developing countries.

Table 1: Strength and Penetration of different types of Vehicles across select countries

Country-wise Penetration per '000 people	Passenger Cars	Buses & Motor Coaches	Motorcycles & Mopeds
United States	349	3	27
China	116	2	50
Japan	479	2	88
India	**23**	**1**	**128**
United Kingdom	470	2	19
Spain	492	1	69
Indonesia	56	10	403
Korea	338	17	43

Source: Road Transport Yearbook, 2016-17

[1] Odisha Economic Survey 2019-20

It has as well been observed that the total number of registered vehicles which includes both the transport and non-transport vehicles in the country was 253 million for the year 2016. Out of the total registered vehicles, 20.9 million which is approximately 8%, belongs to the category of newly registered vehicles. Moreover, the total CAGR for registered vehicles for the time span of 2007-17 is 10.1%. The total number of registered "Transport" vehicles including both goods and passengers was 22.54 million till 31st March 2017 which is equivalent to 8.9% of the total registered vehicles. Similarly, the total "Non-Transport" vehicles accounts for the remaining balance 91.1%. The percentage share of two wheelers was 73.86 % as on 31st March 2017 in total registered motor vehicles in India. Similarly, the share of cars, jeeps and taxis combined was 13.30 % and for buses it is 0.74%. Moreover, the share of tractors, trailers and three-wheeler goods was 5.24% as on 31st March 2017. The share of three-wheeler passengers was 1.48% in total registered motor vehicles in India (MORTH, 2016). Thus, it can be concluded that the transport sector of India is exponentially growing and is mainly composed of two wheelers which comes under the category of road transport.

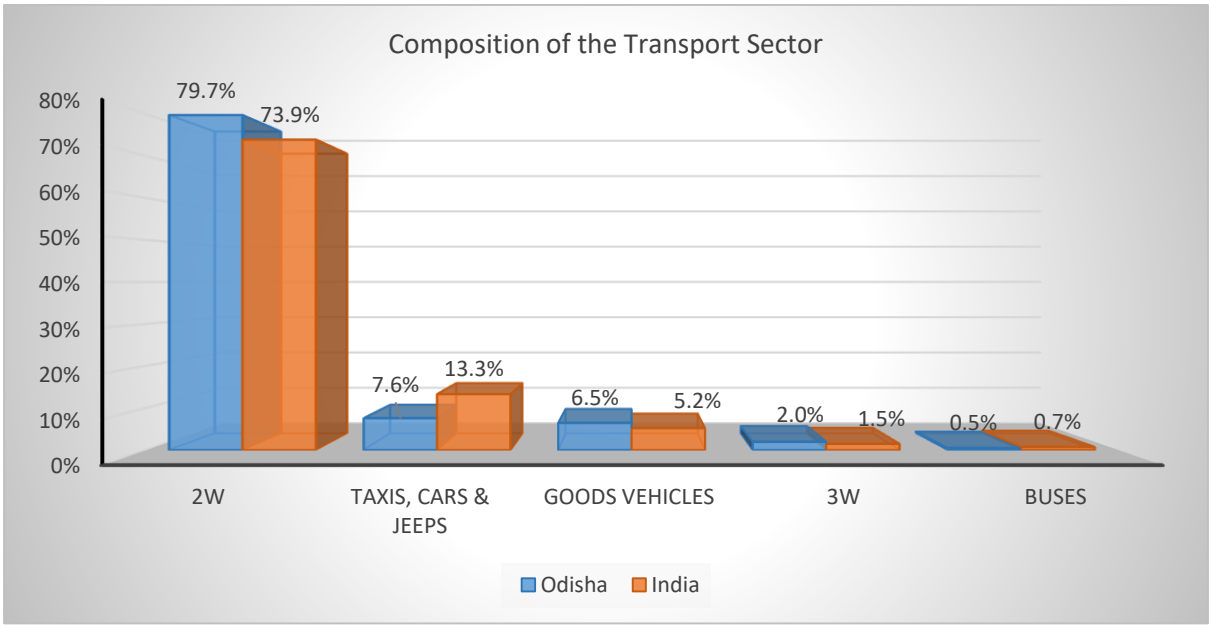

Figure 1: Composition of the Transport Sector of India

The mode-wise composition of Odisha is similar to that of India as can be seen from figure 1. The percentage share of two wheelers, three wheelers passengers, goods vehicles and buses out of the total registered motor vehicles were 78.69%, 1.96%, 6.47% and 0.48% respectively. Moreover, the share of taxis, cars and jeeps combined was 7.57% in total registered motor vehicles (MORTH, 2016). It can be stated that in both Odisha and India, the share of two wheelers is the highest which is then followed by taxis, cars and jeeps combined, goods vehicles, three wheelers and buses.

1.3 Services

Road transport maintains a dominating share over railways in both passenger and freight segments in India as well as in Odisha. In India the passenger services (BPKM) and freight

services (BTKM) are accounted at a national scale, whereas it is difficult to get at a state level. For Odisha we used our model to estimate for the period 1990-91 to 2014-15. The figure 2 shows the growth of total passenger services, which increases at an CAGR of 6.6 percent. It is also seen that only two-wheelers from private and buses from public sector holds the major of passenger services (around 88 percent) in 2015. The use of personal vehicles like two wheelers and cars is pretty high as compared to public transport services. The public transport services of Odisha have been declining and has reached 66 percent in 2015 from 85 percent in 1991. Adoption of bus services can significantly decrease the passenger load from private vehicles which can later improve the idling time and road congestion. It is said that major share of road pollution comes from vehicle standing on road rather than running. Increasing penetration of private vehicles shows the household economy is growing and the market is preferring quality of services that the private vehicles can offer. One of the major turndowns of public services (also freight) is their poorly maintained old age vehicles which consume more than required fuel and time of transport. Road transport is only appreciated in market because of its door to door services, or else railways is a much better, efficient and sustainable mode of transport.

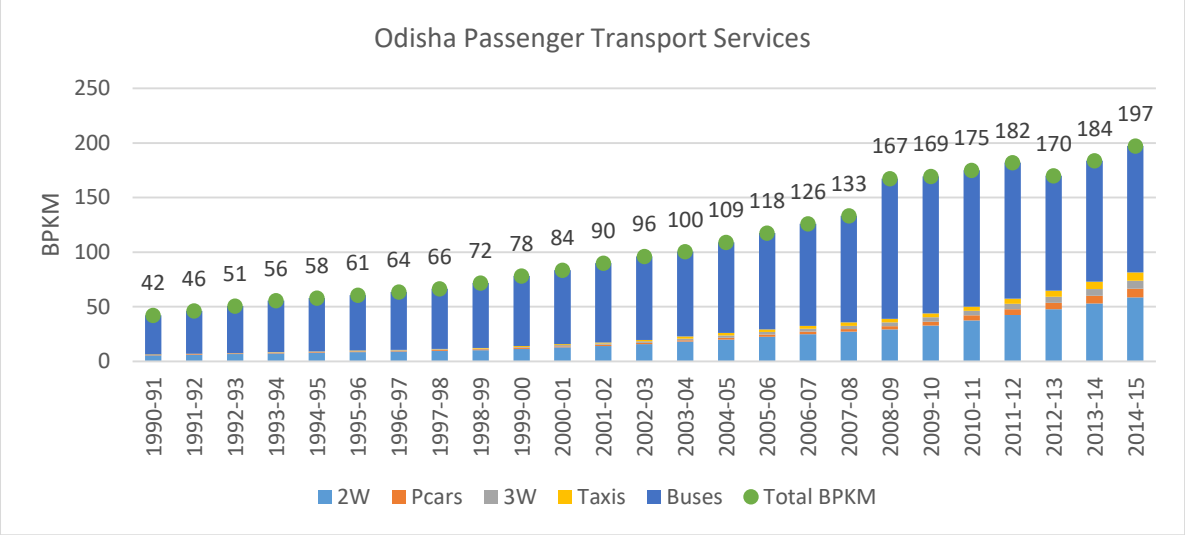

Figure 2: Road Passenger Services in BPKM-Odisha

The freight transportation sector in general is highly fragmented in terms of its operations. There are a lot of small-scale operators in trucking industry who handle local level operations in a pretty unorganised way. This results in a slow movement of goods, delays because of numerous check-posts, multiple documentations for tax and transport authorities, which thereby leads to higher logistic costs. The type of mineral industries (like Iron and steel) set up in Odisha requires heavy transportation of raw materials and finished products which is primarily responsible for the high transport sector emissions. The figure 3 shows the growth of total freight services, which increases at an CAGR of 10.5 percent from the period 1990-91 to 2014-15. It is also seen that majority of the freight is carried by Heavy Commercial/Utility Vehicles (HCV) for mineral transportation.

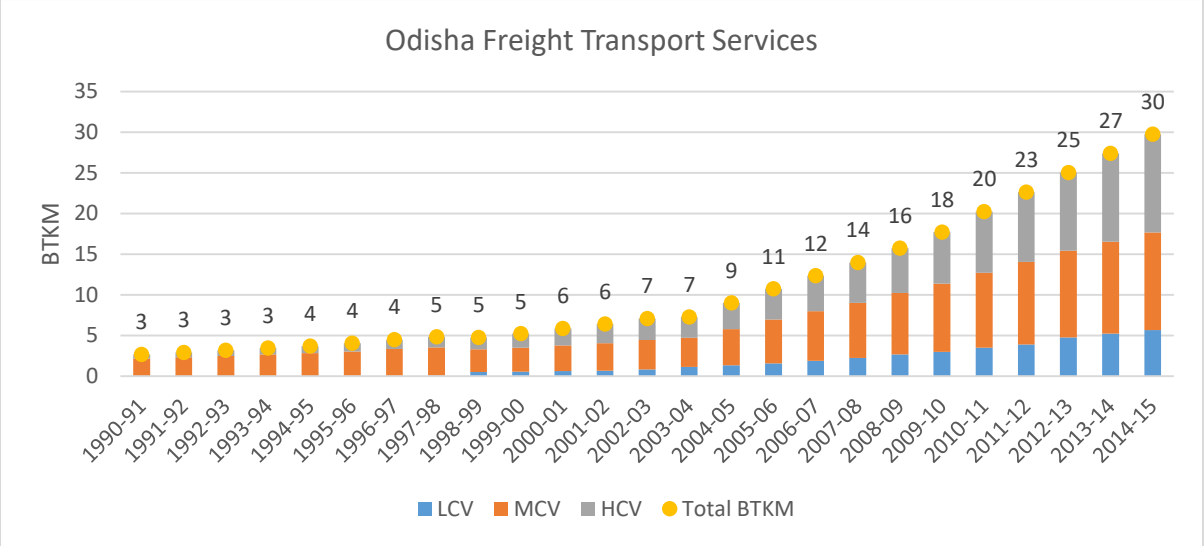

Figure 3: Road Freight Services in BPKM-Odisha

Source: Estimated by IRADe explained in Methodology Section

1.4 Fuel Consumption

The Indian transport sector consumes crude oil in the form of petrol and diesel. It has been observed that 70% of the diesel and 99.6% petrol is consumed in the transport sector alone. The percentage share of the consumption of diesel is the highest by cars, utility vehicles (UVs) and three wheelers out of the total diesel consumption, which is 28.48%. It has as well been revealed that the share of diesel consumption of private cars and UVs account for 13.15%, commercial cars and UVs account for 8.94% and for three wheelers, the share is equal to 6.39%. Petrol or motor spirit is the second highest consuming petroleum product used in the transport sector of India. Out of the total consumption, the majority share of petrol is accounted by the two wheelers which is 61.42% followed by cars with a share of 34.33% and three wheelers with 2.34% share out of the total consumption. Moreover, it has been perceived that the consumption of petrol by two wheelers exceeds by 70% in states like Odisha (82.3%), Bihar (75.2%) and Rajasthan (72.9%) (Nielsen, 2013). However, the consumption of petrol by three wheelers has significantly decreased in states like Delhi, Haryana, Gujarat and Odisha and the reason being that the consumers have shifted to compressed natural gas (CNG) and diesel.

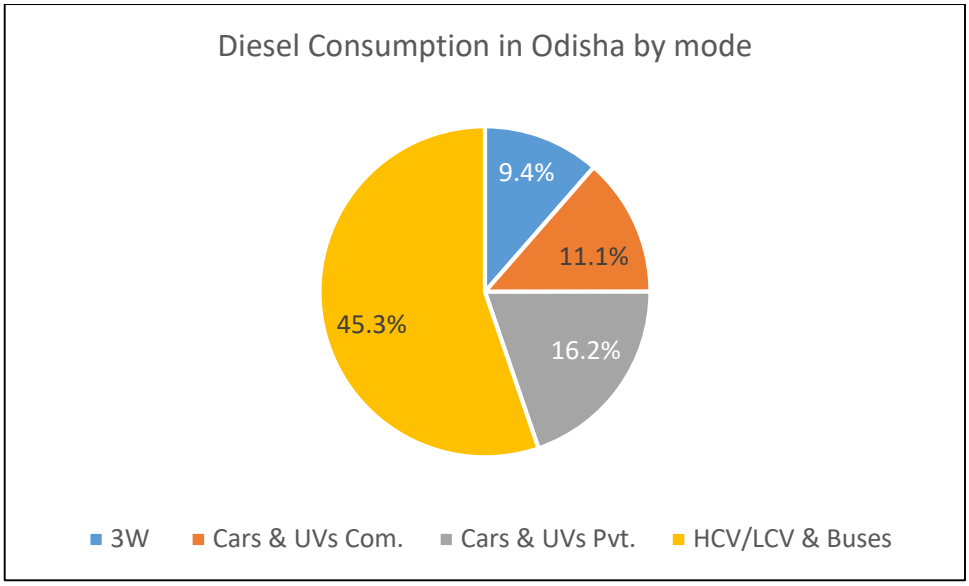

Figure 4 Diesel Consumption in the Transport Sector of Odisha by Mode

The figure 4 depicts the percentage share of diesel consumption in Odisha by different modes. It can be stated that diesel is consumed the most by Heavy/Light Commercial Vehicles (HCV/LCV) & buses with a percentage share of 45.30% in total diesel consumption in Odisha. Similarly, the share for Cars & commercial/private UVs are 12.21% and 16.21% respectively (Nielsen, 2013). Moreover, the share of diesel consumption by three wheelers in Odisha out of the total diesel consumption is 9.37%. Thus, it can be stated that diesel is consumed by different modes in the transport sector with the highest consumption being achieved by HCV/LCV & buses mode.

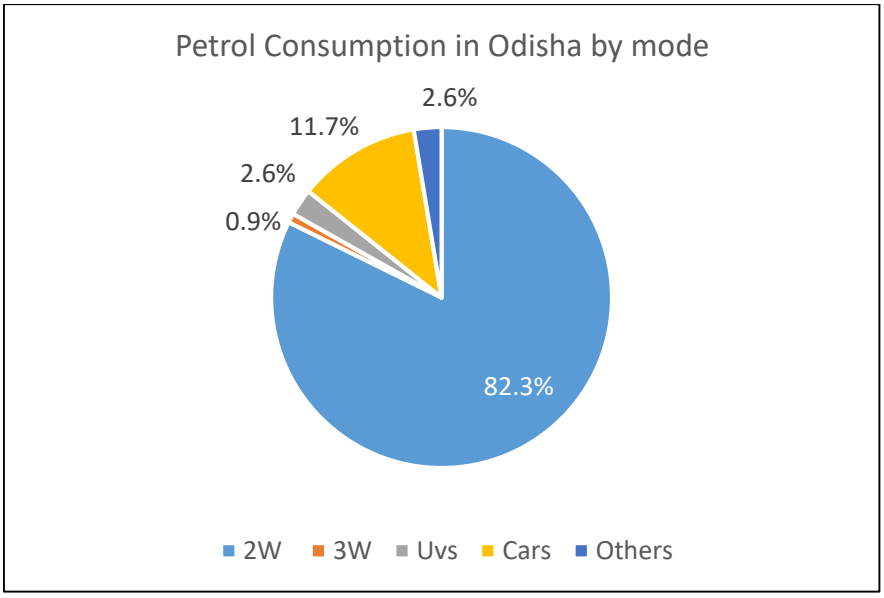

Figure 5 Petrol Consumption in the Transport Sector of Odisha by Mode

As depicted in figure 5, the percentage share of petrol consumption in the transport sector of Odisha by two wheelers, three wheelers, Utility Vehicles (UVs), Cars and other vehicles are 82.8%, 0.89%, 2.55%, 11.66% and 2.62% respectively (Nielsen, 2013). Thus, it can be stated

that petrol is consumed by different modes in the transport sector of Odisha with the most usages by the two wheelers.

1.5 Emissions

The implementation of various policies by the Government of India related to globalisation and liberalisation has resulted in an increase in economic activities which in turn resulted in higher mobility. The increase in mobility meant higher consumption of fuels which dramatically increased the level of emissions from the various modes of passenger and freight transports. The total emissions in India is 2308.91 million Tons of CO2 Equivalent with a contribution of 6.15% from the transport sector. The contribution from road transport to the total country emissions is the highest with a percentage share of 87%, followed by aviation with 7% contribution, railways with 5% and navigation sectors with 1% share (India GHG Program, 2015). Similarly, the total emissions for Odisha is 98.30 million Tons of CO2 Equivalent which suggests that Odisha contributes 4.2% of the total emissions level in India. The total emissions in 2011-12 from the transport sector of Odisha was estimated to be 6 million Tons of CO2 Equivalent. It can be stated that the transport sector of Odisha contributes 10% of the total level of emission prevalent in the state. Out of the total emissions in Odisha, 97% is contributed from road sector transport with 5.9 million Tons of CO2 Equivalent. Moreover, aviation contributes 0.1 Million Tons of CO2 Equivalent with a percentage share of 2% and railways contributes 0.06 million Tons of CO2 Equivalent in the total transport emissions with a share of 1% in total emissions in Odisha (CII, 2015). Thus, it can be concluded that the emissions from the road transport is significantly high and is responsible for a major contribution to the total level of emissions in Odisha and India as well.

1.6 Public Transport in Odisha

1.6.1 Overview

Odisha is located in the eastern region of India and has a coastline of 485 km along the Bay of Bengal. The state shares its borders with West Bengal, Jharkhand, Andhra Pradesh, Chhattisgarh and the Bay of Bengal. Bhubaneswar, Mayurbhanj, Baleshwar, Khordha and Sundargarh, Ganjam, Cuttack are some of the large cities in terms of population. The Gross State Domestic Product of Odisha was about US $30.06 million during 2019-20. The state's GSDP grew at a CAGR of 6.72%, during 2016-17 to 2020-21. Odisha has emerged as a key state in the mineral and metal-based industries. Major minerals present in the state are iron, coal, bauxite, manganese, nickel, chromite, limestone, dolomite, graphite, decorative stones, beach sand, china clay and tin ore, which has made Odisha be largest contributor of mineral production in the country. It is the first state in India to undertake reform and restricting initiatives in the power sector. As of April 2021, Odisha accounted for a total installed power generation capacity of 8,594.47 megawatts (MW). The state is amongst the top ten states accounting for the highest number of MSME enterprises.[2]

Transportation in Odisha are well connected with road, rail, airports and seaports. The state accounts for 254,845 km of the road network including 5,762 km of national highway and 4,100 km of state highways. Odisha is connected to its neighboring states and other parts of

[2] Odisha IBEF Report https://www.ibef.org/states/odisha.aspx

India through 41 national highways. [3] A railway network of 2,652 km operates within the state.[4] There are one international and one domestic airport in Odisha for the commercial purpose along with 17 airstrips and 16 helipads. Public transportation connects inter and intra city using bus and rail. Capital Regional Urban Transport (CRUT) provides city bus services along with private operators and Odisha State Road Transport Corporation (OSRTC) provides regional bus services.[5] A Bus Rapid Transit System (BRTS) is proposed for Bhubaneswar city with a 66 km network which is under implementation. The Cuttack Bhubaneswar Metro was proposed to connect twin cities Cuttack and Bhubaneswar in 2010 but the project was rejected due to infeasibility and shall be considered after 2040.[6]

1.6.2 Railways`

Odisha serves as a link between eastern and western India through the railway network of the South Eastern Railways and the East Coast Railways. The state majorly falls in the East Coast Railway region along with Chhattisgarh and Andhra Pradesh which was inaugurated in 1996 and the zonal headquarters is located at Bhubaneswar. The present East Coast railway is a truncated version of the earlier East Coast Railway which began operation in 1888. Initially, only one division namely Khurda Road was attached to this railway. Subsequently, however, when the zone became fully operational with effect from 2003, this railway was carved out of the erstwhile South Eastern Railway, comprising of three divisions Khurda Road, Waltair, and Sambalpur.[7] There are 300 railway stations in Odisha and the five main railway stations are Puri, Bhubaneswar, Khurda Road Junction, Bhadrakh and Jharsuguda Junction.[8]

Table 2: Description of the rail network in Odisha[9]

	Route kms	Running Track Kms	Total Track km
Odisha	**2,652**	4,443	5,506

Odisha has airports for commercial, private, flying schools and military purposes. The airports and airstrips are operated and owned by the Airport Authority of India (AAI), Indian Air Force (IAF), Government of Odisha and private establishments.

- The state has one international airport named Biju Patnaik Airport is located in the state capital Bhubaneswar.
- The commercial domestic airport is located at Jharsuguda and is operated by AAI.

[3] Odisha IBEF Report https://www.ibef.org/states/odisha.aspx
[4] Indian Railway Civil Engineering Portal https://ircep.gov.in/AboutUs.html
[5] Draft Bhubaneshwar LCMP
[6] Cuttack Bhubaneshwar Metro https://www.thehindu.com/news/national/other-states/metro-train-service-not-feasible-in-bhubaneswar-and-cuttack-till-2041-minister/article34197273.ece
[7] East Cost Railway https://eastcoastrail.indianrailways.gov.in/view_section.jsp?fontColor=black&backgroundColor=LIGHTSTEELBLUE&lang=0&id=0,1,261
[8] Odisha Railway Stations https://www.prokerala.com/travel/indian-railway/odisha-stations/
[9] Indian Railway Civil Engineering Portal https://ircep.gov.in/AboutUs.html

- In addition, there are 17 airstrips and 16 helipads at several places in the state which are used for dignitaries and emergency purposes.

1.6.3 Role of schemes and policies to enable public transport in India

1.6.3.1 JNNURM

In Odisha, 125 buses are approved under the Jawaharlal Nehru National Urban Renewal Mission with the Central Government's commitment of Rs 158.4 million[10]. Among which 100 buses are deployed at Bhubaneswar and the remaining 25 for Puri. The type of these buses includes mini and standard.[11]

1.6.3.2 NUTP 2006

The objective of the National Urban Transport Policy is to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and other needs within the cities. This is sought to be achieved by: incorporating urban transportation as an important parameter at the urban planning stage rather than being a consequential requirement; encouraging integrated land use and transport planning in all cities so that travel distances are minimized and access to livelihoods, education, and other social needs, especially for the marginal segments of the urban population is improved; improving access of business to markets and the various factors of production; and bringing about a more equitable allocation of road space with people, rather than vehicles, as its main focus.

The policy guided Bhubaneswar in Odisha in preparation of the following transport projects:

1. Low Carbon Mobility Plan for Bhubaneswar 2040
2. Bhubaneswar BRTS

1.6.4 Bus Transport

Annually, an average of 690 buses were registered during 2012 to 2019 and in 2020, Odisha witnessed a decline in bus registration with 403 buses.

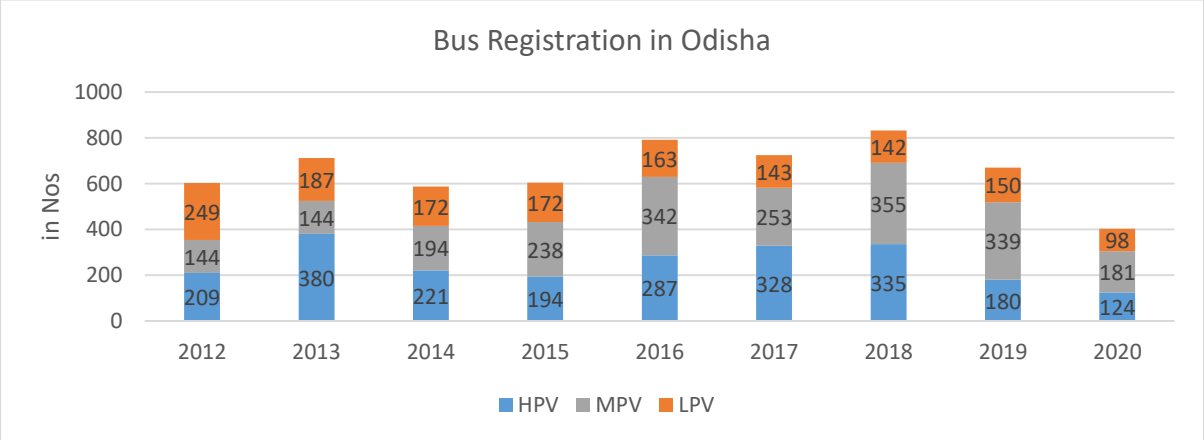

Figure 6 Registration of Bus in Odisha (2012-20) (Source: Vahan Dashboard)

[10] Buses Sanctioned under JnNURM https://www.globalmasstransit.net/archive.php?id=14533
[11] City Bus Services in Bhubaneshwar and Puri http://cdn.cseindia.org/userfiles/saurabh_garg.pdf

1.6.4.1 BRTS in Odisha

To enhance urban transport in Bhubaneswar, the Central Government had approved the proposal of the Bus Rapid Transit System in 2014. The detailed project report was prepared by CEPT University, Ahmedabad. The construction was planned for two phases: In the first phase, 30.32 km will be established to connect the Airport and Nandankanan Zoological Park and in the second phase, 36 km corridor connects Kalpana square and Mancheswar.[12] Currently, the project is under implementation.

1.6.4.2 City Transport

Bhubaneswar

For operationalizing the inter and intra city bus services (CBS) in Bhubaneswar and Puri, a special purpose vehicle called Bhubaneswar Puri Transport Services Limited (BPTSL) was set up in 2009 under the Department of Housing and Urban Development (DH&UD). A Memorandum of Understanding (MoU) was signed between Capital Region Urban Transport (CRUT) and Dream Team-Sahara (DTS) for operationalizing bus services in Bhubaneswar and Puri. A total of 100 buses are pressed into service in Bhubaneswar and 25 buses operate in Puri under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). The city bus service is initiated under the PPP mode between CRUT and DTS. The equity holders of the company are Bhubaneswar Municipal Corporation (40%), Bhubaneswar Development Authority (40%), Odisha State Road Transport Corporation (10%), Puri-Konark Development Authority (5%) and Puri Municipality (5%).[13]Over the years, BPTSL evolved into CRUT with vision to reorganize public transit services in Bhubaneswar, Cuttack and Puri. CRUT rolled out new buses under the title 'Mo Bus'. The operation of the buses is managed by CRUT under gross cost contract through two private operators Narbada travels and Travel time. The operations are supported through ITS operations from control center. Within the city, CRUT operates 200 buses on 22 routes and has average daily ridership is 91,706. Bus service comprises of 100 midi buses with 23 seating capacity and 100 standard buses with 43 seating capacity. CRUT has built 200 Bus Q shelters which are equipped with modern facilities, amenities and time tables for increasing passenger convenience. Mo-Bus App provides journey planning options to commuters.[14]

[12] Bhubaneswar: Centre's Nod for hi-tech Transport https://timesofindia.indiatimes.com/city/bhubaneswar/Bhubaneswar-Centres-nod-for-hi-tech-transport/articleshow/31049215.cms

[13] BMC City Bus Services https://www.bmc.gov.in/services/city-bus-services

[14] Draft Bhuwaneshwar LCMP

Table 3: Mo Bus services at Bhubaneswar[15]

Particulars	Details
Cities Covered	Bhubaneswar, Puri, Khurda & Cuttack
Services	Inter-city and Intra-city
No. of Routes Covered	26
Total Number of Buses Operating	310
Number of Hubs	7
Number of Stations	10
Fuel Type	CNG, Diesel, Petrol and Hybrid Electric

1.6.4.3 Regional Transport

Odisha State Road Transport Corporation (OSRTC) is a passenger transport organization providing regional bus services both within Odisha and neighboring states. OSRTC commenced its passenger transport services on 15 May 1974. OSRTC comprises of

- 3 Divisions
- 23 Depots
- 462 buses
- 264 Services

1.6.4.4 Electric Bus

Presently, 50 electric buses are sanction for Bhubaneswar City as part of the FAME-II scheme. CRUT is set to roll out e-buses in the city in two phases: 25 electric buses in the first phase and the remaining 25 electric buses in the second phase. These buses are planned to run under the Odisha Government Mo Bus scheme between Cuttack, Bhubaneswar and Puri. Two electric bus depots are planned to be set up at Patia and Patrapada for a cost of Rs 17 crore.[16]

1.6.5 Odisha Economic Corridor

East Coast Economic Corridor (ECEC) stretches about 2,500 km along the eastern coast of India that connects Kolkata to Kanyakumari and passes through four states of West Bengal, Odisha, Andhra Pradesh and Tamil Nadu. The Odisha Economic Corridor is the third phase of ECEC which covers 20 districts of the state. Based on the transport network assessment of factors including land availability, highways, large cities, existing industrial infrastructure and port, two nodes have been prioritized in the influence region which is located within 100 km on each side of NH-16. The details of the nodes are as below:[17]

- **Node-1** called the GBK node includes 6 clusters with 6,153 acres of land area in Gopalpur, Bhubaneswar, Kalinganagar industrial areas of the Ganjam, Khurda, Cuttack and Jajpur districts.

[15] Bhubaneshwar Mo Bus http://www.capitalregiontransport.in/
[16] Electric Bus in Odisha https://www.orissapost.com/odisha-government-to-launch-e-bus-next-year/
[17] Odisha Economic Corridor https://orissadiary.com/inclusion-of-odisha-economic-corridor-under-the-national-industrial-corridor-development-program-approved/

- **Node-2** called the PKDS node includes 8 clusters with 10,558 acres of land area in the Paradip, Kendrapada, Dhamra and Subarnarekha industrial areas of the Jagatsinghpur, Kendrapada, Bhadrak and Balasore districts.

2 Methodology

The State Transport Model for Odisha is developed is a Microsoft Excel spread sheet-based tool to project long term travel demand, understand trends in state transportation sector, assess impacts on emission for different low carbon policy options, and frame plans to effectively reduce emissions of both greenhouse gases and local air pollutants. The model is designed to allow user to customize parameters for estimation of transportation services, energy consumption and emissions. This will help to analyse a broad range of policy options and effectively choose the best combination for specific geographical region. It estimates total transportation activity, energy consumption and emissions from 2015 to 2030 in year-to-year increments, from on-road vehicles. To calculate the output, the model exercises various transport parameters and they are as follows:

2.1 Modes of Transportation:

The model considers all type of vehicle for which data is provided by the Road Transport Year Book published by the Transport Research Wing of the Ministry of Road Transport & Highways, Government of India. Each type of vehicle is classified under broader groups for implementation of common assumptions Table 4.

Table 4: Vehicle Categorization for analysis

Sl. No	Type of Vehicle	Vehicle Group
1	Scooters	2-Wheelers (2Ws)
2	Motor Cycles	
3	Mopeds	
4	Auto Rickshaws	3-Wheelers (3Ws)
5	Passenger Vehicles/LMVs	
6	Cars	Light Duty Vehicles Cars (LDV_C)
7	Jeeps	
8	Cars as Taxis	Light Duty Vehicles Taxis (LDV_T)
9	Buses	Buses
10	Omni Buses	
11	GVW < 7.5 Tons (including SUVs)	Light Commercial Vehicles (LCVs)
12	7.5 < GVW < 16.2 Tons (Trucks)	Medium Commercial Vehicles (MCVs)
13	GVW > 16.2 Tons (Trailers)	Heavy Commercial Vehicles (HCVs)

Vehicle Fuel Technologies:

Each vehicle is associated with a fuel technology and the model considers all kinds of fuel used in the transportation sector i.e. Gasoline, Diesel, CNG, LPG, Electric even Hydrogen. The annual sales of each mode are disaggregated into an exogenously specified mix of fuel technology available in the market in baseline scenarios or as the scenario requires.

Pollutants

The emission inventory of the model includes GHG emissions from the transport sector. The calculation does not include the whole fuel lifecycle like refining, processing, distribution, vehicle manufacturing but only the combustion during transportation.

2.2 Bottom-up Approach

The State Transport Model is a supply side simulation model that follows the "bottoms up" approach and considers details of various types of transport activities including their capital costs, operating costs fuel costs and infrastructure costs. Transport demand is exogenously given and supply options are chosen through choice of policy parameters. Figure 7 shows the framework considered in the Odisha Transport Model. The model considers all on-road vehicles, calculated by using survival rates on mode wise and technology wise annual sales of vehicles. The model also assesses the annual cost of infrastructure and vehicle stock. The annual sales are calculated from newly registered vehicles. Transport services, fuel consumption and emissions are determined using national average assumptions on on-road vehicles

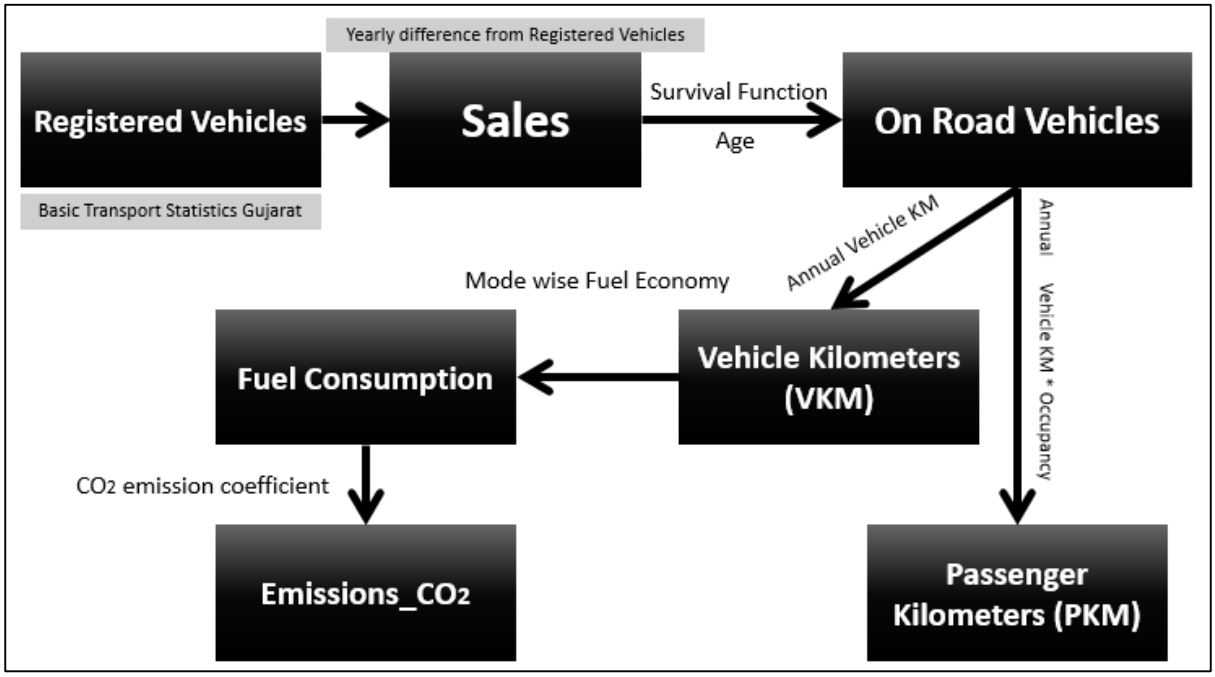

Figure 7: Methodology Flow Diagram:

3 Assumptions

To calculate the fuel consumption and emission from transport sector a number of assumptions are made. Most of the assumption are from national level exercises with inputs from Ministry of Road Transport and Highways and Niti Aayog. This is because the state specific assumptions were not available in any public domain, Hence, IRADe have used these national level assumptions for Odisha. The parameters that were assumed for the state level transport sector analysis are:

- **Annual Vehicle Kilometres (VKM)**: It is defined as the average kilometres travelled in a year by a mode of vehicle. Separate analysis has been done to estimate the VKM for Passenger and Freight Vehicles as they carry different characteristics while plying on road.
    - **For Passenger Vehicles:**
        - Mode-wise and Trip Length wise number of work trips in Odisha and India Census 2011 were compared and their difference in scale was applied to the VKT trend of IESS 2047. This gave us the VKT trend for Odisha for passengers' vehicles. The above calculation was carried out for 2Ws, Private Cars, Auto rickshaws and Taxis.
        - The VKT of Buses are adopted from the trend followed by the performance of OSRTUs from the period 2009 to 2014.
    - **For Freight Vehicles:**
        - The VKT trend for freight vehicles were considered from Gujarat and adjusted as per the consumption of diesel in Odisha. The trend also adopts the methodology from the report XXX that states the VKM for freight should increase by 400 KM each year.

Figure-8 shows the Annual Vehicle Kilometre for each mode considered in the State Transport Model from 1991-2030.

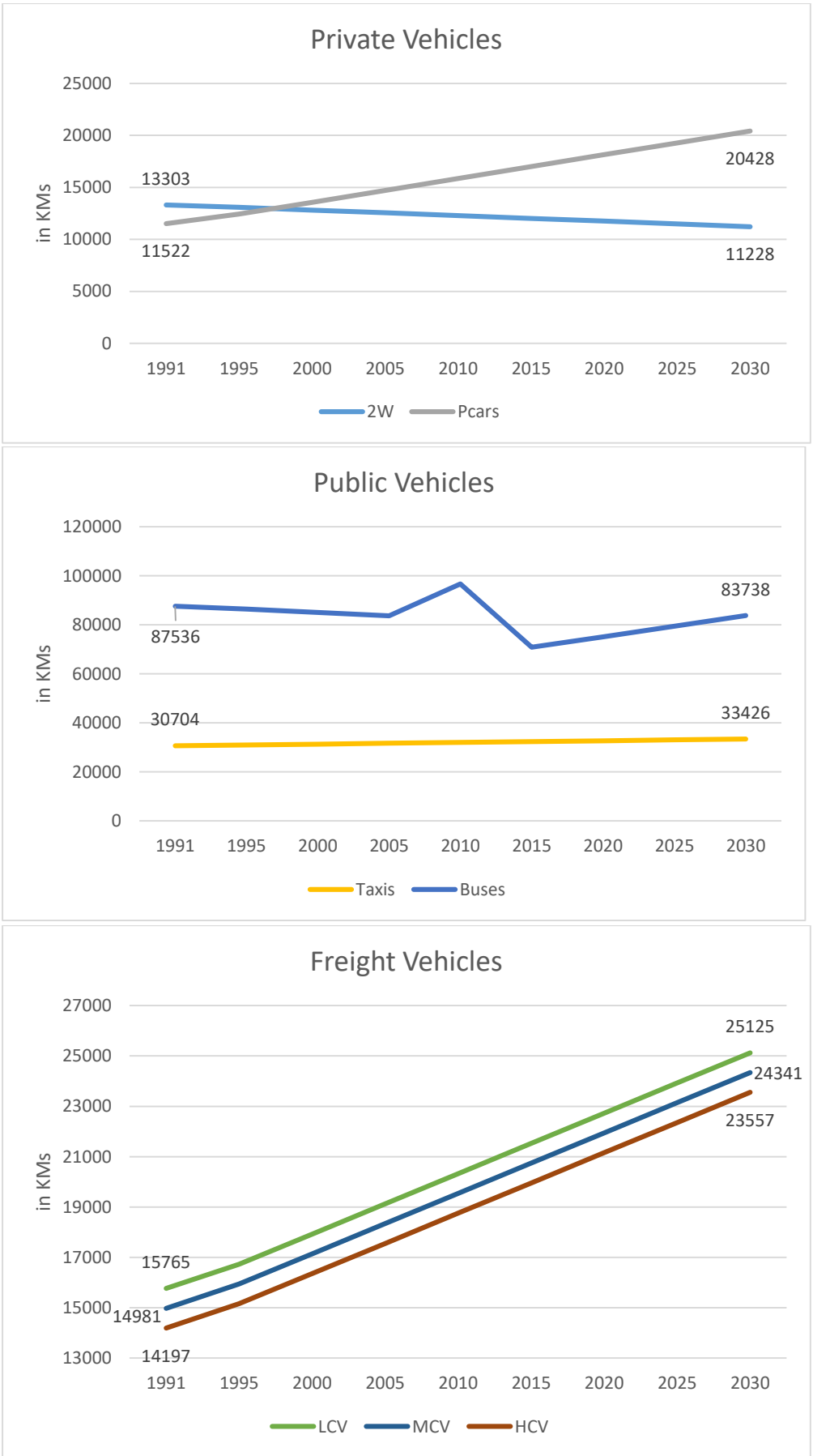

Figure 8: Annual Vehicle Kilometres for Odisha

- **Payload Quantity**: There are two types of payload quantity; one for passenger vehicles (Passengers per Vehicle) and the other one is freight vehicles (Kilometre-Tonne)
    - *Passengers per Vehicle (Occupancy)*: Movement of a passenger per kilometre on transit vehicles. Table 5 shows the assumed occupancy considered for passenger services in Odisha State Transport Model.

Table 5: Vehicle Occupancy (Passenger/Vehicle)

Modes of Vehicles	2W	3W	LDV_C	LDV_T	Buses
Occupancy	2.2	1.8	1.9	2.6	57

Source: Status of pollution generated from road transport sector, CPCB, March 2015

    - *Kilometre-Tonne (Load)*: The transportation of one tonne over one-kilometre A simple unit of freight that determines the service of moving one kilogram of payload a distance of one kilometre. Table 6 shows the assumed load considered for freight services in Odisha State Transport Model.

Table 6: Vehicle Load (Tonne/Vehicle)

Modes of Vehicles	LCV	MCV	HCV
Load	1.7	3.9	6.1

Source: Status of pollution generated from road transport sector, CPCB, March 2015

- **Fuel type and Fuel Efficiency:** It is defined as the energy or fuel required by the vehicle to travel one kilometre. The Fuel Efficiencies for all vehicles in the model is considered as per the historical trends that India had followed since 1990. This includes the CAFÉ Norms mentioned in the Auto Fuel Efficiency report and the Vehicle Manufacture Profile. The Fuel efficiency for all modes after 2020 has been estimated based on their past trends including the future norms as per the government specified targets. The following Figure-9 and 10 shows the average mileage of each mode of vehicle considered in the model for Odisha.

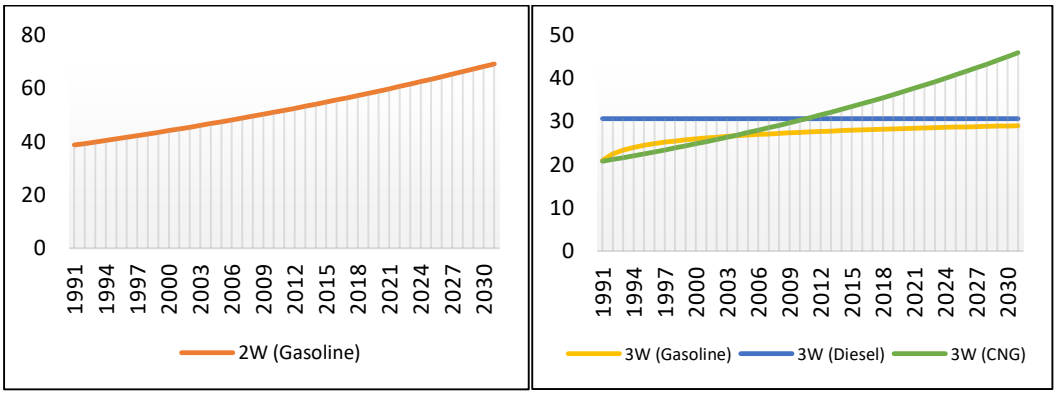

Figure 9: Fuel Efficiency (Km/Litre)-2Ws & 3Ws

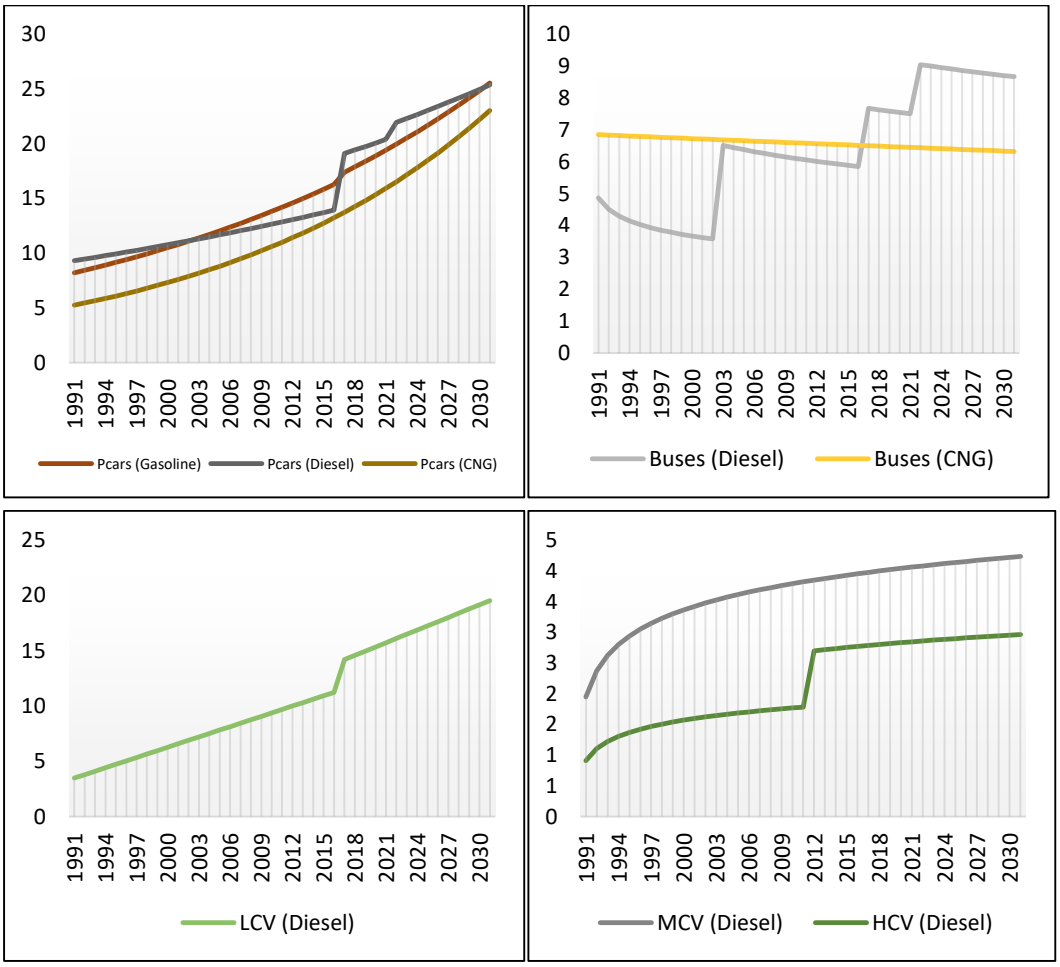

Figure 10:Fuel Efficiency (Km/Litre)-Pcars, Buses, LCVs, MCVs & HCVs

- **Fuel Technology Mix:** It is defined as the percentage share of each fuel variant in the total sales of each vehicle type. The fuel technology mix of each mode of vehicle is assumed to change over time based on past trends but also due to change in policy. Each mode uses specific type of auto fuel. Two wheelers run only on gasoline, while private cars mostly use gasoline but some use diesel also. In Odisha, three wheelers and cars operating as commercial vehicles run on gasoline and diesel. CNG has not been adopted fully in Odisha so not much private cars are running in CNG. Public/commercial transport such as buses, trucks and other light, medium and heavy-duty vehicles run mainly on diesel. Although CNG and LPG have been in use in India as alternative auto fuels for more than a decade, their share is low. The fuel technology mix of all modes of vehicle for Odisha is considered from VAHAN Database. Fuel Split from 2011-2020 for all modes are based on fuel wise newly registered vehicles from

the VAHAN Database. From the trend of each mode the fuel split from 1990-2010 back casted and from 2020-2030 is forecasted. The following Figure 11 shows the fuel split considered for each segment of vehicles.

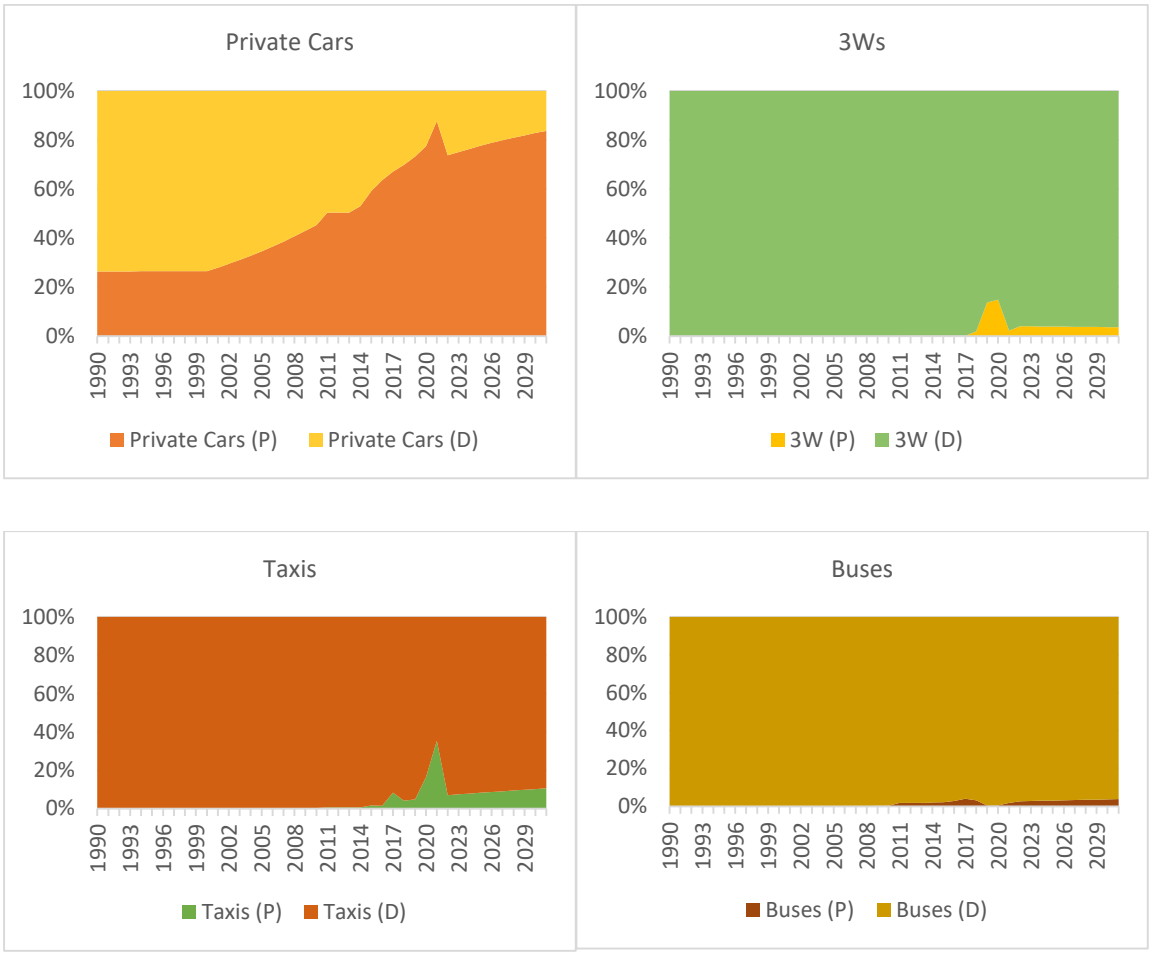

Figure 11: Fuel Split for Each Mode from 1991-2030

In Odisha it is observed that all freight vehicles run on Diesel from beginning and in passenger public vehicle category diesel variant is mostly dominated.

- **Survival Rates & Age:** This is defined as the average number of years a vehicle of a particular mode plies on the road. Survival rate accounts for gradual retirement in vehicle populations. The rate of survival of each mode or average vehicle retirement age for a given mode in Gujarat is estimated using a Weibull distribution reliability function as per literature review[18] and study conducted by CEPT. Based on the

[18] https://www.researchgate.net/figure/Figure-SI2-Vehicle-category-wise-survival-fraction-as-a-function-of-vehicle-age-836_fig2_265171098

estimated survival rate, each vehicle is assigned with a certain age of retirement or date of deregistration. In case of freight vehicles.

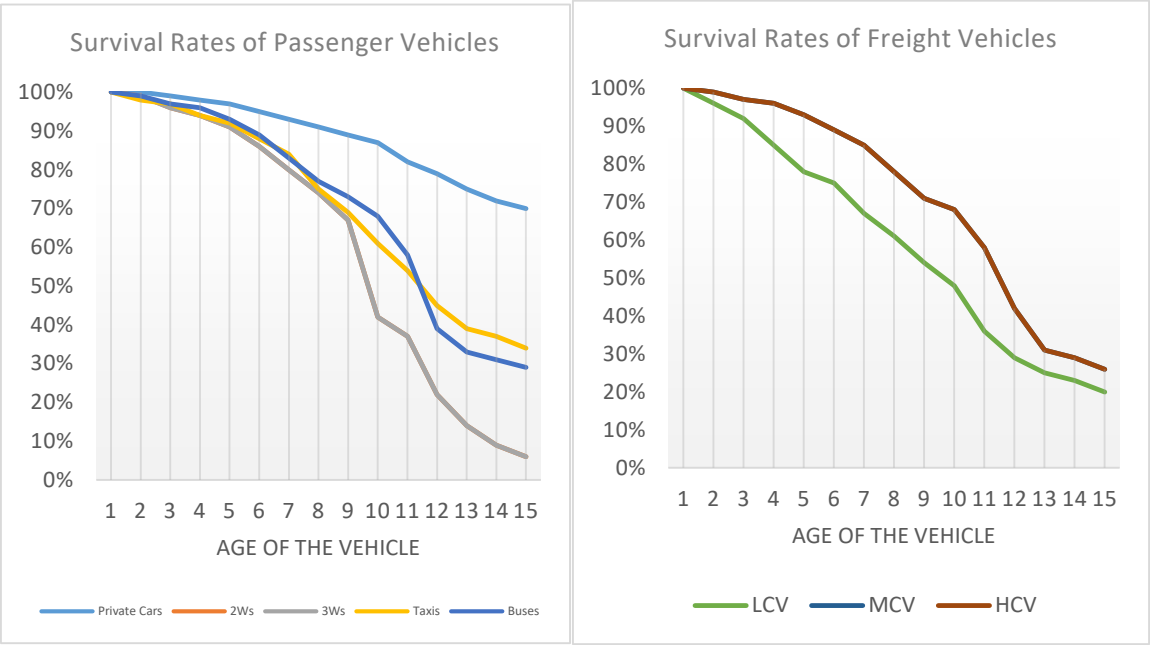

Figure 12: Survival Rate of Passenger and Freight Vehicles

4 Policies in Transport Sector and the Scenarios Considered:

For increasing productivity and enabling India to compete effectively in the world market an efficient transportation system is necessary. Adequate and reliable transport infrastructure and services are important factors for India to compete in the field of international trade and attract foreign direct investment. The Government cannot but play a role in this sphere. Even in Indian market economy, the framework that central government provide for the transport sector largely determines the level of cost and transport operations. It is, therefore, necessary to have a policy environment that encourages competitive pricing and coordination between alternative modes in order to provide an integrated transport system that assures the mobility of goods and people at maximum efficiency and minimum cost. Table 9 shows the central policies that are currently active in our country.

Table 7: Transport Policies in India

Scheme Category	Policy/Act	Description
Shift to public transport, Infrastructure development,	Strengthening of Public Transport System	The ministry will provide financial assistance to states for strengthening public transport system by GPS, GSM, Electronic ticket etc.

sustainable mobility and shared mobility	Development of Bus terminal and Multi modal transit system	The project focuses on development of large bus terminals in states/ UTs under PPP on BOT basis
	Security of women in public transport system	Installation of vehicle location device and one or more panic buttons
	AMRUT	The mission focuses on Pedestrian, non-motorized and public transport facilities, parking spaces etc.
	Smart City Mission	The mission focuses on smart solutions for efficient urban mobility and public transport
	Taxi Policy	The main focus of the policy is to have safe, secure and affordable taxi service
	Sugamya Bharat Abhiyan (Accessible India Campaign)	To make 10% of govt. owned public transport fully accessible to persons with disabilities
	Model Automated centres for checking fitness of vehicles	Inspection and certification centres for testing fitness of commercial vehicles through an automated system
	National Transport Policy	The Ministry of Transport issued the policy which is known as National Transport Policy to safeguard the rights of Transportation in India. Road Transport is vital to economic development, trade and social integration, which rely on the conveyance of both people and goods. To conduct road transport faster with integration of economy, National Transport Policy is initiated.
	Interstate connectivity scheme	The Ministry of Road Transport and Highways allocates funds to the States/ Union Territories (UTs) for development of State Roads (non-rural Roads) and Roads of Economic Importance and Inter State Connectivity (EI&ISC) as per the provisions of the Central Road Fund Act, 2000 amended by the Finance Act from time to time.
	National Mission on Sustainable Habitat (NMSH)	Promotes sustainable mobility options such as walking, and cycling and supports the development of transport infrastructure for green mobility

Electric Vehicles	National Electric Mobility Mission Plan 2020	The National Electric Mobility Mission Plan 2020 is one of the most important and ambitious initiatives undertaken by the Government of India that has the potential to bring about a transformational paradigm shift in the automotive and transportation industry in the country. This is a culmination of a comprehensive collaborative planning for promotion of hybrid and electric mobility in India through a combination of policies aimed at gradually ensuring a vehicle population of about 6-7 million electric/hybrid vehicles in India by the year 2020
	The FAME India (Faster Adoption and Manufacture of (Hybrid and) Electric Vehicles) Scheme	The scheme covers Hybrid and Electric technologies like Mild Hybrid, Strong Hybrid, Plug in Hybrid & Battery Electric Vehicles. FAME focuses on 4 areas i.e. Technology development, Demand Creation, Pilot Projects and Charging Infrastructure.
Green Transport and Standards	Green Urban Transport Scheme	The scheme focuses on taking strict actions on air pollution causing public transport system and replace conventional vehicles with eco-friendly vehicles
	Service Level Benchmarks for Urban Transport	The benchmarks provide the standards to assess the sustainability and quality of public transport
	Indian Emission Standards	Vehicular emissions standards as per the Bharat Stages
Laws	Motor Vehicles Act 1988, recently amended in 2017	The Motor Vehicles Act, 1988 is an Act of the Parliament of India which regulates all aspects of road transport vehicles. The Act came into force from 1 July 1989. It replaced Motor Vehicles Act, 1939 which earlier replaced the first such enactment Motor Vehicles Act, 1914. The Act provides in detail the legislative provisions regarding licensing of drivers/conductors, registration of motor vehicles, control of motor vehicles through permits, special provisions relating to state transport undertakings, traffic regulation, insurance, liability, offences and penalties, etc. For exercising the legislative provisions of the Act, the Government of India made the Central Motor Vehicles Rules 1989

Fuel	India Auto Fuel Policy	The policy recommends road map for auto fuel quality till 2025 for the country, taking into account the achievement under the last Auto Fuel Policy, emission reduction of in-use vehicles, growth of vehicles and supply and availability of fuels. It also recommended suitable mix of auto fuels including gas and its specifications.
	National Auto Policy	The Government of India and the Indian automotive industry articulated their objectives for the future of the industry through the Automotive Mission Plan 2016-26 (AMP 2026). The plan envisions that by the year 2026, India will be among the top three in the world in engineering, manufacturing and export of vehicles and auto components.
	National Policy on Biofuels	Government has prepared a road map to reduce the import dependency in Oil & Gas sector by adopting a five-pronged strategy which includes, Increasing Domestic Production, adopting biofuels & Renewables, Energy Efficiency Norms, improvement in Refinery Processes and Demand substitution. This envisages a strategic role for biofuels in the Indian Energy basket.

These are the central policies that are considered for analysis in our study. In addition to this, there are also some state polices for Odisha that we have considered (Table 10).

Table 8: Transport policies in Odisha

Policy/Act/Initiatives (Odisha)	**Nodal Agency**	**Description**
Odisha Motor vehicle Rules 1993	Odisha Motor Vehicle Department	focuses on vehicle registration, management, licenses etc.
Biodiesel & Ethanol blending Program	The Odisha Renewable Energy Development Agency	To reduce emissions from fuel consumption
Bus Terminal scheme	Transport Department	Development of bus transport system
Bhubaneswar E-Mobility Plan	Bhubaneswar- Puri Transport Services	sustainable mobility, cleaner technologies to minimize carbon footprint.
Govt. Equity investment through SPV in pending Railways projects	Transport Department	To increase Railway network for supporting higher passenger and freight transport

There are broadly 6 types of Low carbon policies in the transport sector 1) Electrification 2) Fuel Efficiency 3) Modal shift- Road to Rail 4) Modal shift private to public 5) alternative fuels 6) reduction in transport demand. Programs and policies in each of these 6 categories are under implementation in Odisha either by central or by state government. We develop policy scenarios for first four of these five categories incorporating targets of policies currently being implemented in Odisha:

- **Reference**: Under this scenario, no policy interventions & technological improvements are undertaken until 2020. The transport sector uses the fuel standards and the fuel mix (ratio of petrol and diesel vehicles) of each vehicle category as it existed till 2020. The fuel mix in the model behaves as per the scenario set for 2030. In the reference scenario, the share of electric vehicle is minimal in each category. The passenger segment continues to use private vehicles and the share of public vehicle decrease in line with past trends. No introduction of alternate fuel vehicles is considered in this scenario. The On Road Vehicles for Private Vehicles (2Ws and Private Cars): is estimated by applying Survival Function on the annual sales (increment in total registered vehicles per year) and for Commercial Vehicles (3Ws, Taxis, Buses, LCVs, MCVs and HCVs): is same as the total registered number of vehicles in each year. The Annual Sales for Commercial Vehicles is calculated by applying survival function on the historical sales and subtracting from the total registered vehicles. The Figure-13 shows the On Road vehicles and sales till 2030 under the reference scenario.

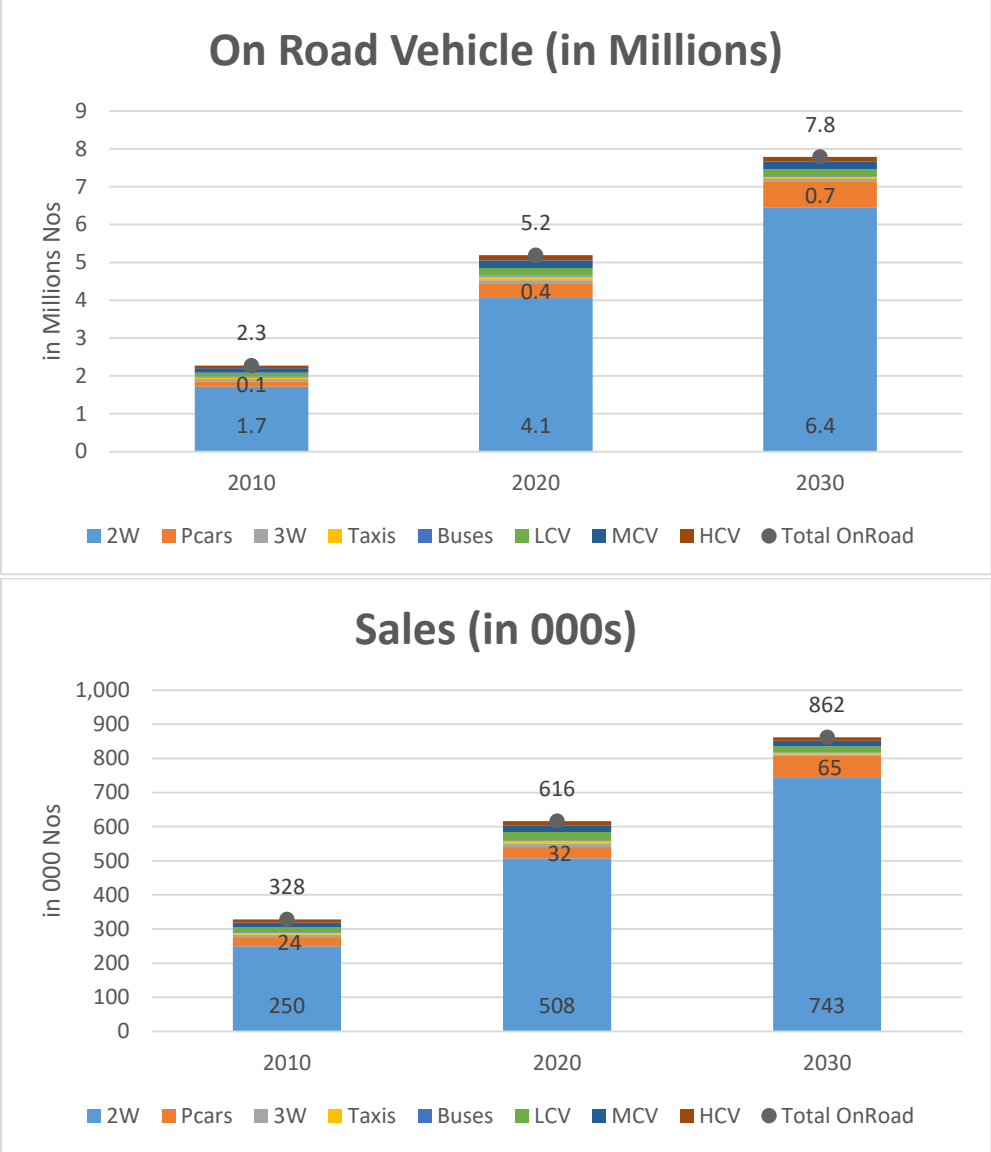

Figure 13: Reference Scenario- On road Vehicles and Sales

Figure 14 shows the sales within each fuel type for each category of vehicles in 2030.

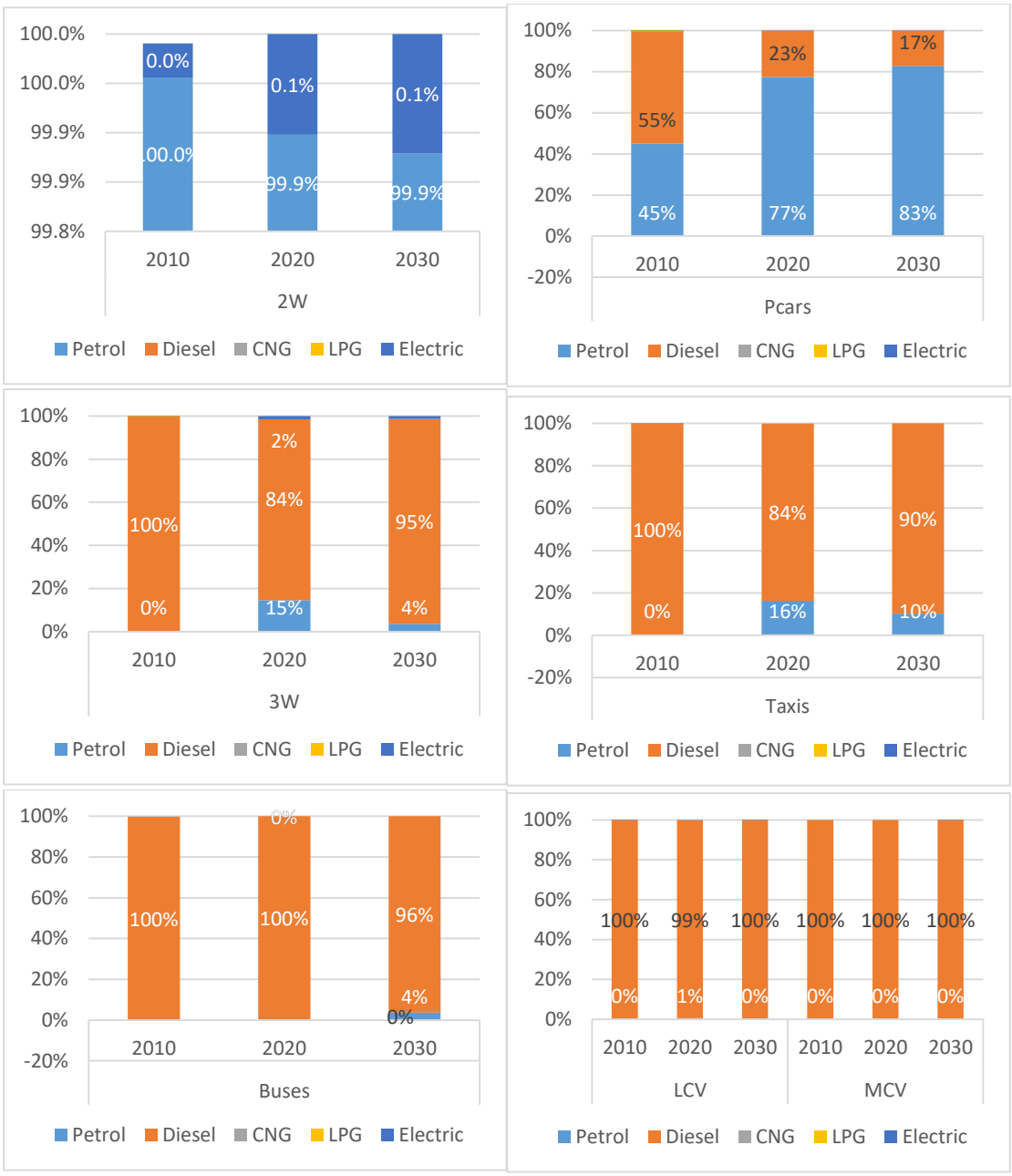

Figure 14: Percentage sale of each mode for all variants

Based on the above explained parameters like estimated on road vehicle, survival rates, fuel split, historic fuel efficiencies & assumed VKTs the Total Fuel Consumption is calculated from the Model for each mode. The consumption of all the petrol variants is summed up to get the total petrol consumption from the state in the given year. Similar Calculation was also done for all the diesel variants to get the total diesel consumption from the model. The Model Output is then compared with the Actual Consumption of Fossil Fuel in Road Transport Sector from 2004-2015 for Odisha and the following figure 15 and 16 shows that the Model Output coming approximately 10% close to the Actual Fuel Consumption.

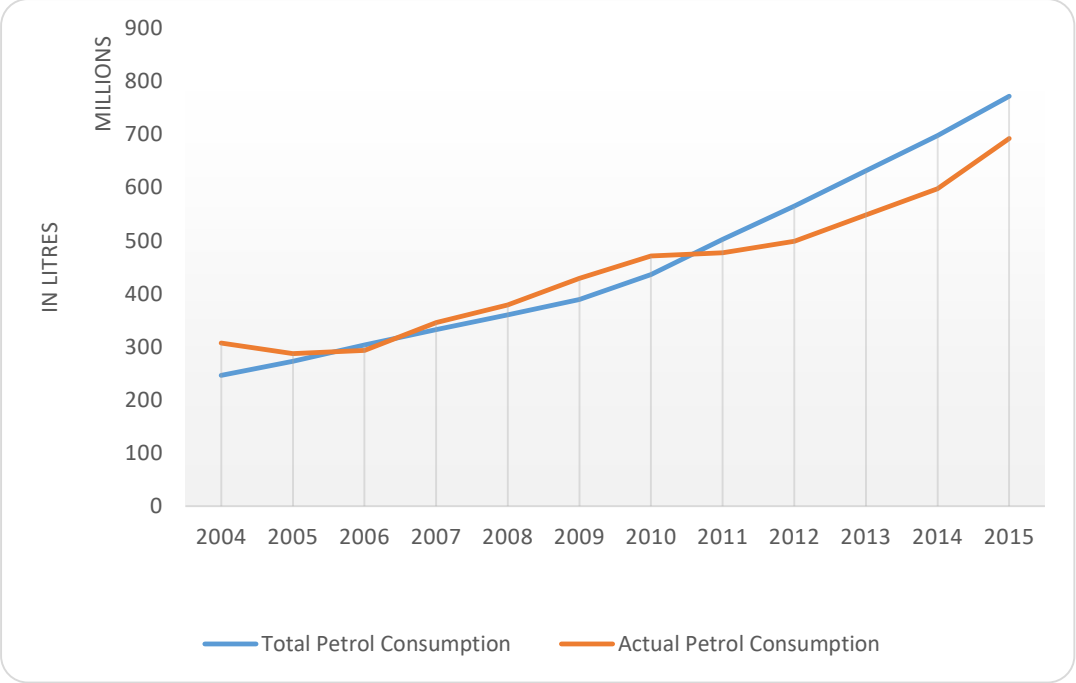

Figure 15: Comparison of Total Petrol Consumption of the Model with the Actual

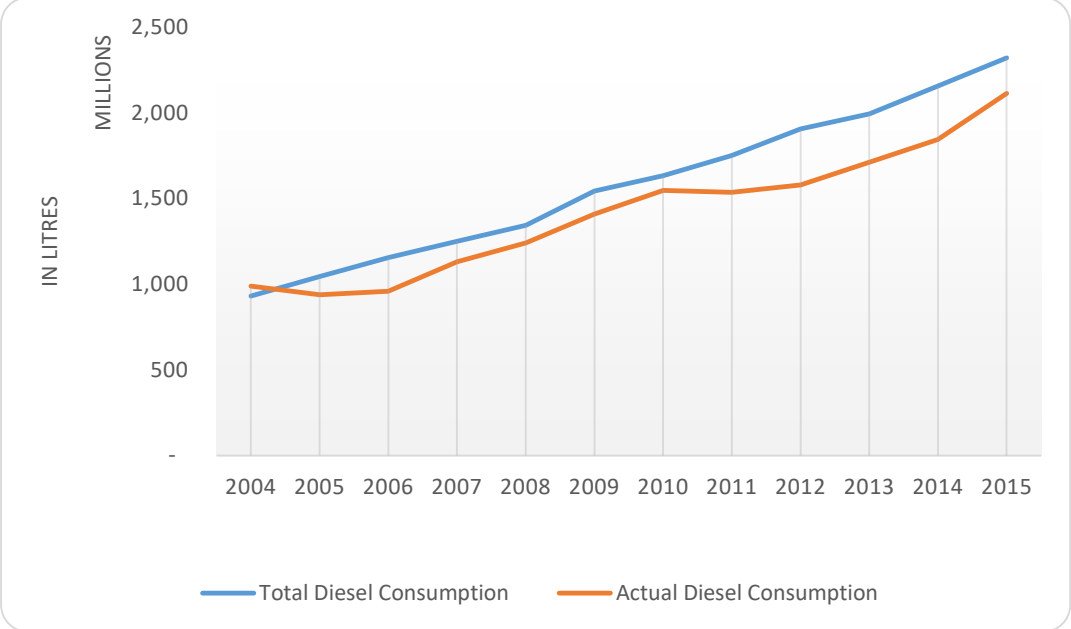

Figure 16: Comparison of Total Diesel Consumption of the Model with the Actual

The validation of fuel consumption with the actual proceed to estimate the future Passenger Travel Demand using Gompertz & Logistics Model Equation. The table 13 below shows

Table 9: Passenger Demand Estimation

Passenger Demand Estimation					
nl (pkmcap = b1/(1 + exp(-b2*(gdpcap - b3)))) in 1/45					
	b1	**b2**	**b3**	**R-squared**	**Adj R-squared**
Coef.	4660.332	0.000088	30012.18	0.9961	0.9956

t-value	21.94	7.88	21.96			
nl (pkmcap = 4900/(1+{b2}*exp(-{b3}*(gdpcap)-{b4}*(time)))) in 1/45						
	b1	**b2**	**b3**	**b4**	**R-squared**	**Adj R-squared**
Coef.	4900	8.386226	0.000051	0.048086	0.9975	0.9972
t-value		7.34	6.47	3.66		
nl (pkmcap = b1*exp(-exp(-b2*(gdpcap - b3)))) in 1/45						
	b1	**b2**	**b3**	**R-squared**	**Adj R-squared**	
Coef.	4896.906	0.000061	24820.41	0.9964	0.9959	
t-value	16.76	6.33	25.14			
nl (pkmcap = 5500*exp(-{b2}*exp(-{b3}*(gdpcap)-{b4}*(time)))) in 1/45						
	b1	**b2**	**b3**	**b4**	**R-squared**	**Adj R-squared**
Coef.	5500	2.953112	0.0000324	0.026517	0.9974	0.9971
t-value		12.7	7.1	3.47		

The figure 17 shows the estimated passenger demand we got form the above equation for each mode.

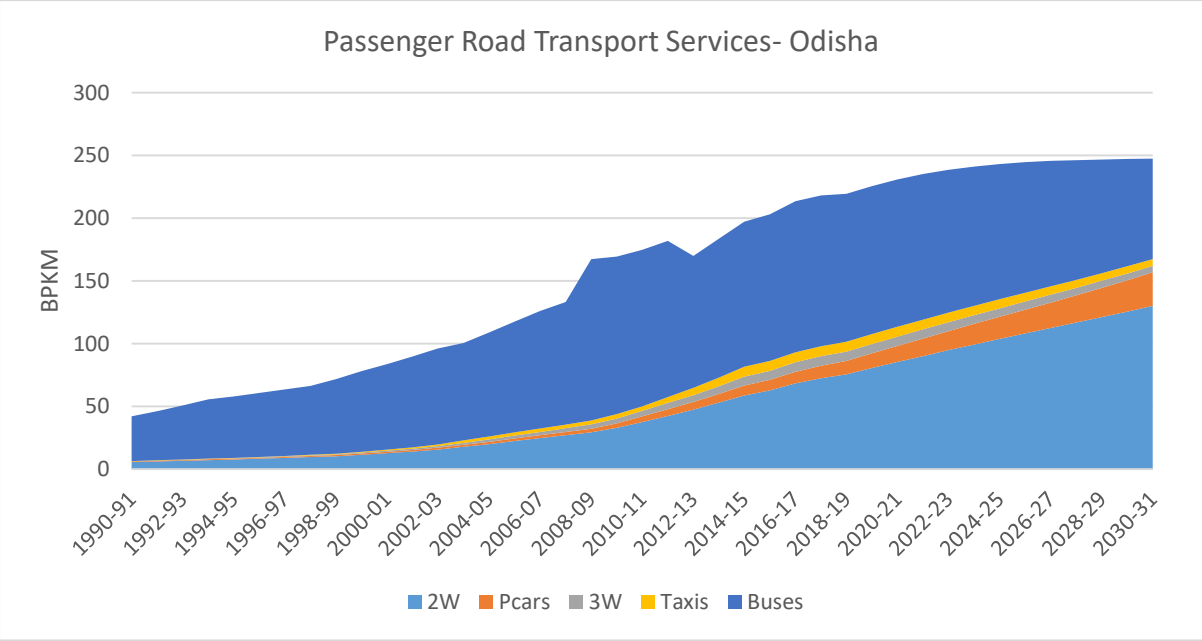

Figure 17: Passenger Transport Demand (Billion PKM)

Similar exercise was done for the future Freight Travel Demand using Gompertz & Logistics Model Equation and the table 12 below shows

Table 10: Freight Demand Estimation

Freight Demand Estimation				
nl (tkm = b1*exp(-exp(-b2*(gdp - b3)))) in 1/45				
	b1	**b2**	**b3**	**R-squared**
Coef.	90.9276	0.000005	294886.9	0.9979
t-value	4.27	7.71	7.43	0.9976
nl (tkm = b1/(1 + exp(-b2*(gdp - b3))) in 1/45				

	b1	b2	b3	R-squared
Coef.	44.05128	0.000016	228771.3	0.9975
t-value	11	17.57	18.28	0.9972

The figure 18 shows the estimated passenger demand we got form the above equation for each mode

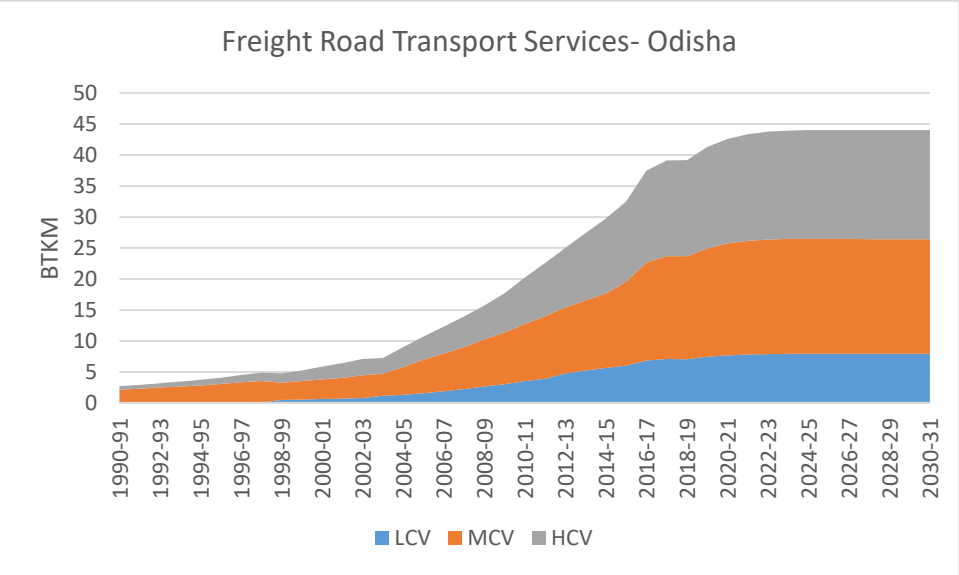

Figure 18: Freight Transport demand (billion TKM)

- **Electrification Scenario**: Electric variants for each mode in the passenger segment are introduced. Government of India does not have any definite plans for penetration of EVs for in different modes of transport though 6-7 million EVs on road was promised at national level by 2020. The Odisha EV Policy does not specify any quantifiable targets for any modes of vehicle in 2021. IRADe has assumed certain percentage in EV sales for Odisha as per NEMMP, FAME and state's EV policies. For Private Vehicles (50% by 2022 and 100% sales by 2030 in 2Ws and 25% by 2022 and 50% sales by 2030 in Privates cars segment), Public Vehicles (50% by 2022 and 100% sales by 2030 in 3Ws, 25% by 2022 and 50% sales by 2030 in Taxis and 10% by 2022 and 20% sales by 2030 in Buses) and in Freight (no sales in LCVs, MCVs and HCVs). Table 15 show the share of electric variants in sales for each mode of passenger vehicles till 2030.

Table 11: Share of Electric Vehicle in Total Vehicle Sales

Year	Two-Wheelers	Private Cars	Three-Wheelers	Buses	LCV	MCV	HCV
2022	50%	25%	50%	10%	0%	0%	0%
2030	100%	50%	100%	20%	0%	0%	0%

- **Private to Public Scenario (PvtToPub)**: modal shift scenarios have been constructed to shift private movement towards publically utilized modes of transport i.e. 3Ws, Taxis and Buses. The scenarios have been constructed based on government programs like Bus Rapid Transit System (BRTS), Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and national policy to strengthen public transport system. Public vehicles offer shared transportation at a cheaper rate is more fuel-efficient and causes less pollution compared to private vehicles on a per passenger basis. Here the shift from private to public in road sector is considered as an increase from 41:59 to 30:70 (Pub:Pvt) in 2030 and the effect in passenger services is analysed.
- **Fuel Efficiency Standards Improvements**: Based on the auto fuel policy standards that have been announced since 2005 the fuel efficiency of each mode is improved till 2020 and kept constant till 2030 in reference scenario. However, in this efficiency improvement in fuel efficiency of all modes is done by 50% till 2030.
- **Scrappage Scenario:** Survival rate & age is considered 15 years for all modes as mentioned in the above section and we assumed a policy where all vehicles above 8 years is scrapped with incentives and govt. directives. We tried to assess the benefits to Odisha in terms of emission reduction and fossil fuel consumption through the model outputs
    - **Scrappage + Electrification:** we combined the assumption of ambitious **electrification** with **Scrappage**
    - **Scrappage + PvtToPub:** we combined the assumption of modal shift to public transport with Scrappage
    - **Scrappage + Energy Efficiency:** we combined the assumption of efficient vehicle adoption with scrappage
    - **Scrappage to New Elec Veh:** we considered all scrapped vehicles to be electric
- **Integrated Policy:** The aggregate effect of all low carbon policies i.e. Electrification, PvtToPub, Energy Efficiency and Scrappage are assessed in this scenario.

5 Results and Discussion

As discussed in previous sections, the model outputs are 1) on road vehicles, 2) fuel consumption and 3) CO_2 emissions. Based on the methodology explained, all the above

scenarios were run and results in reference scenario compared with the low carbon policy scenarios. The section below reviews the results of the comparative analysis.

5.1 Vehicle in Use

On road vehicles are calculated by applying of survival rate and age over past annual sales. It is observed that the modal numbers and the modal mix of on road vehicle remains same in all scenarios except in private to public scenario, private to Bus and modal shift of integrated scrappage scenarios. The modal mix and vehicle numbers change as passengers shift from private vehicles (cars, taxis and bikes) to public vehicles (auto rickshaws and buses). As the occupancy of public vehicles is higher compared to the private vehicle so the number of vehicles on road in this scenario reduces to 7.8 from 4.2 million (46 percent reduction) in private to public, 4.0 million (49 percent reduction) in private to bus compared to reference scenario in 2030 (Figure-19).

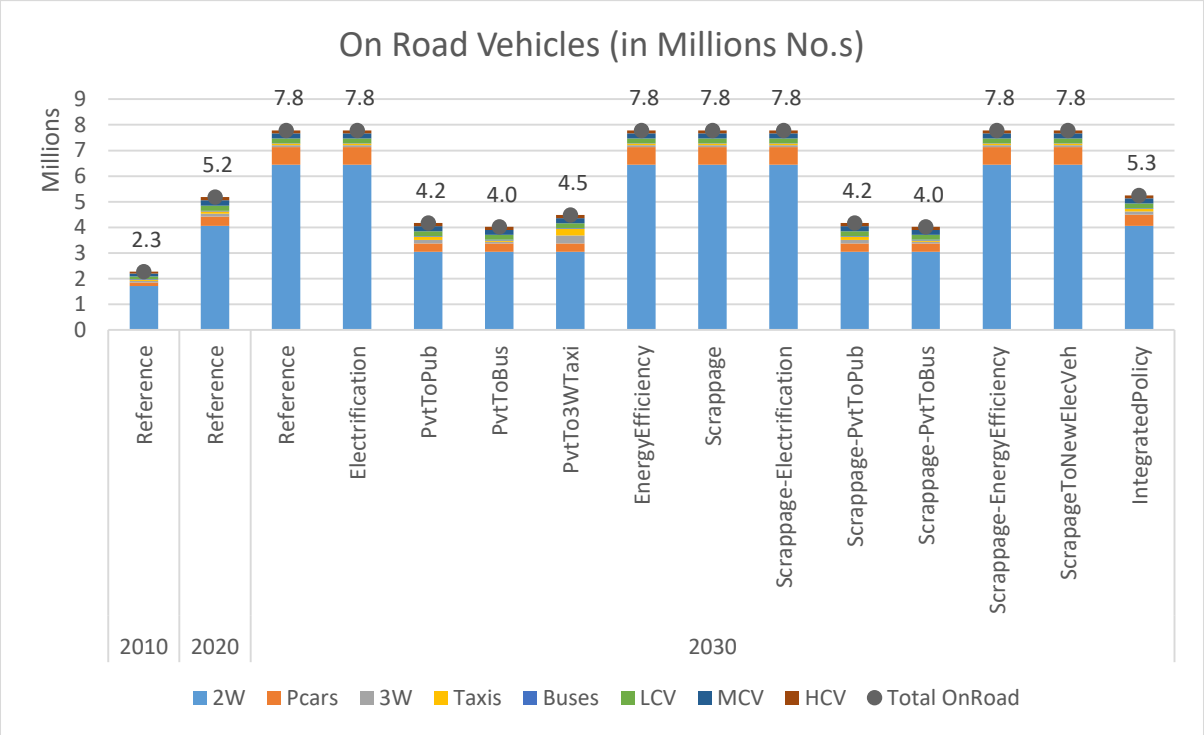

Figure 19: On Road Vehicles (in Millions)

5.2 Fuel Consumption

The road transport sector has the highest fuel consumption from among all transport sectors. Most of the petroleum products, almost 100 percent gasoline and 66 percent diesel is consumed by road transport sector. It is observed from figure-20 that in the reference scenario, the total petrol consumption from road transport sector increases at CAGR of 6.1 percent from 2010 to 2030. Compared to the reference scenario, petrol consumption in the integrated scenario is the highest (79

percent) followed by integrated scrappage scenario of introducing electric or energy efficient vehicles (around 64 percent) followed by scrappage plus private to public and electrification scenario (approx. 50 percent). This shows that integrated scrappage polices would help in reducing a higher percent of petrol consumption in the road transport sector of Odisha. Shifting to public transport also helps in reducing 48 percent of petrol consumption whereas introduction of energy efficient vehicles helps in reducing 16 percent. The scrappage policy works (only 3 percent reduction) with integrating it in electrification or with modal shift scenarios.

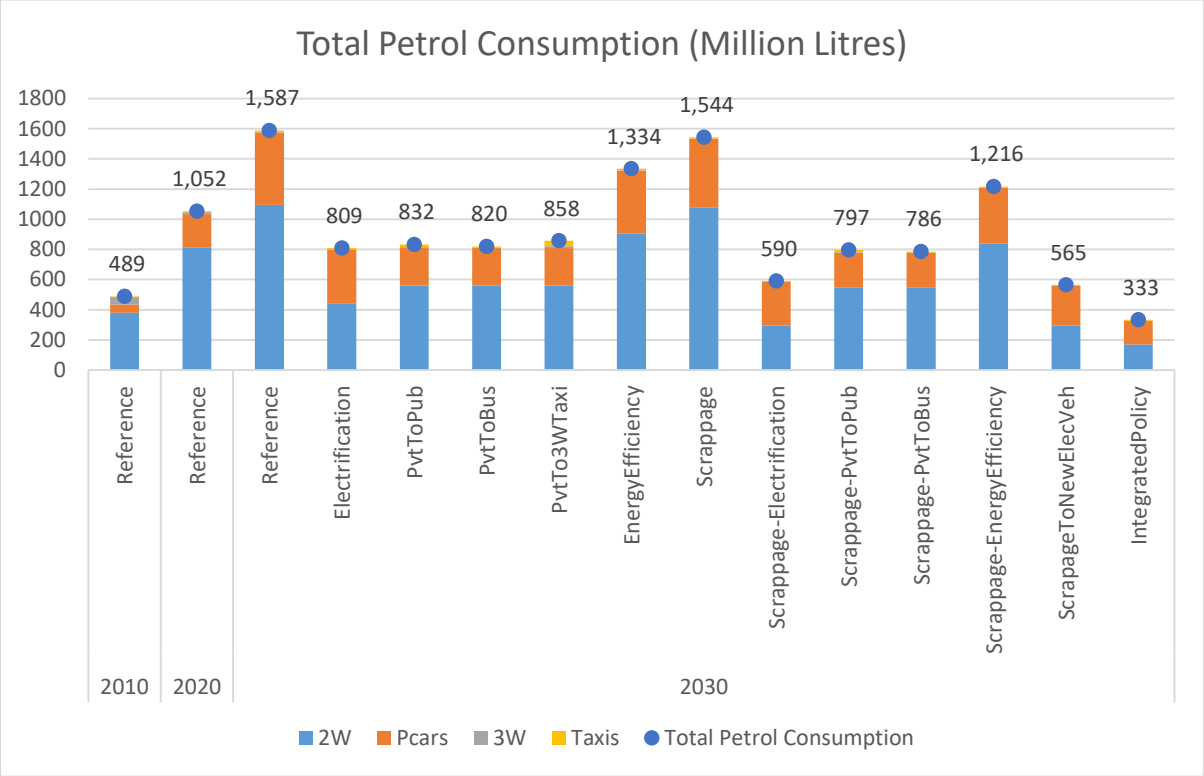

Figure 20: Petrol Consumption in Different Scenarios

It is observed from figure-21 that the total diesel consumption from road transport sector increases by 2.5 percent from 2010 to 2030. Compared to the reference scenario, the reduction in diesel consumption in integrated scenario is the highest (21 percent) followed by integrated scrappage scenario of introducing electric or energy efficient vehicles (around 18 percent) followed by energy efficiency scenario (15 percent). The modal shift scenarios show an increase in diesel consumption in the transport sector as the freight vehicles has not been electrified and shift to public transport increases the share of diesel vehicles. The figure 19 shows an 18 percent increase in diesel consumption in shift to 3Ws and Taxis scenario and 8 percent increase in shift to public transport. It also shows that integration of scrappage is effective only with new and electric vehicles but not with modal shift from private to public.

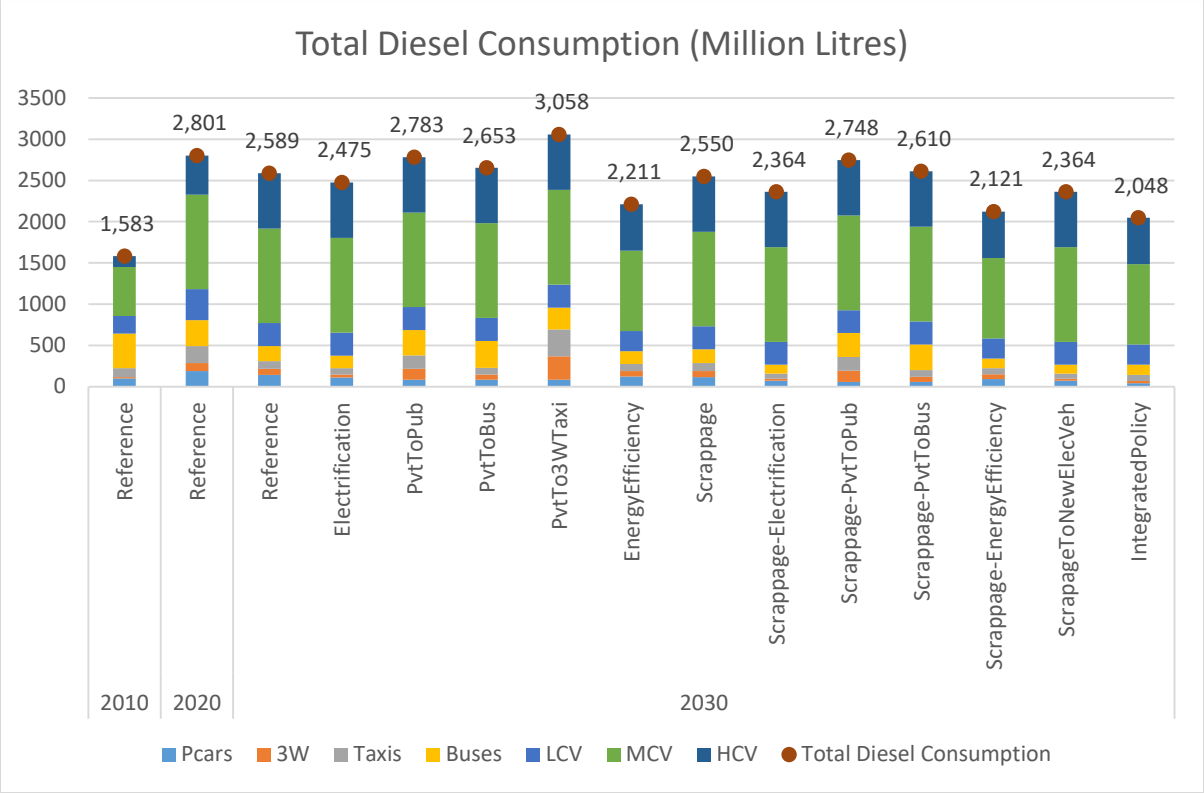

Figure 21: Petrol Consumption in Different Scenarios

5.3 Emissions

The emission from transport sector remained almost equal in the reference 2020 and 2030 as the fuel efficiencies of all modes kick in after 2021. Figure-22 shows the total CO_2 emission as per the on road vehicles in Odisha's for 2010, 2020 and 2030. It is again observed and obvious that integrated scenario shows the highest reduction (45 percent) among all the considered scenarios as because of the least fuel (petrol and diesel) consumption. In similar manner integrated scrappage scenarios as explained in the above section with introducing electric or energy efficient vehicles reduces around 30 percent followed by electrification scenario with 23 percent. The energy efficiency scenario reduces 19 percent with introduction of new energy efficient vehicles and the shift from private to public reduces around 13 percent emission compared to the reference scenario. Modal shift being the cheapest reduces the least emission compared to other low carbon scenarios.

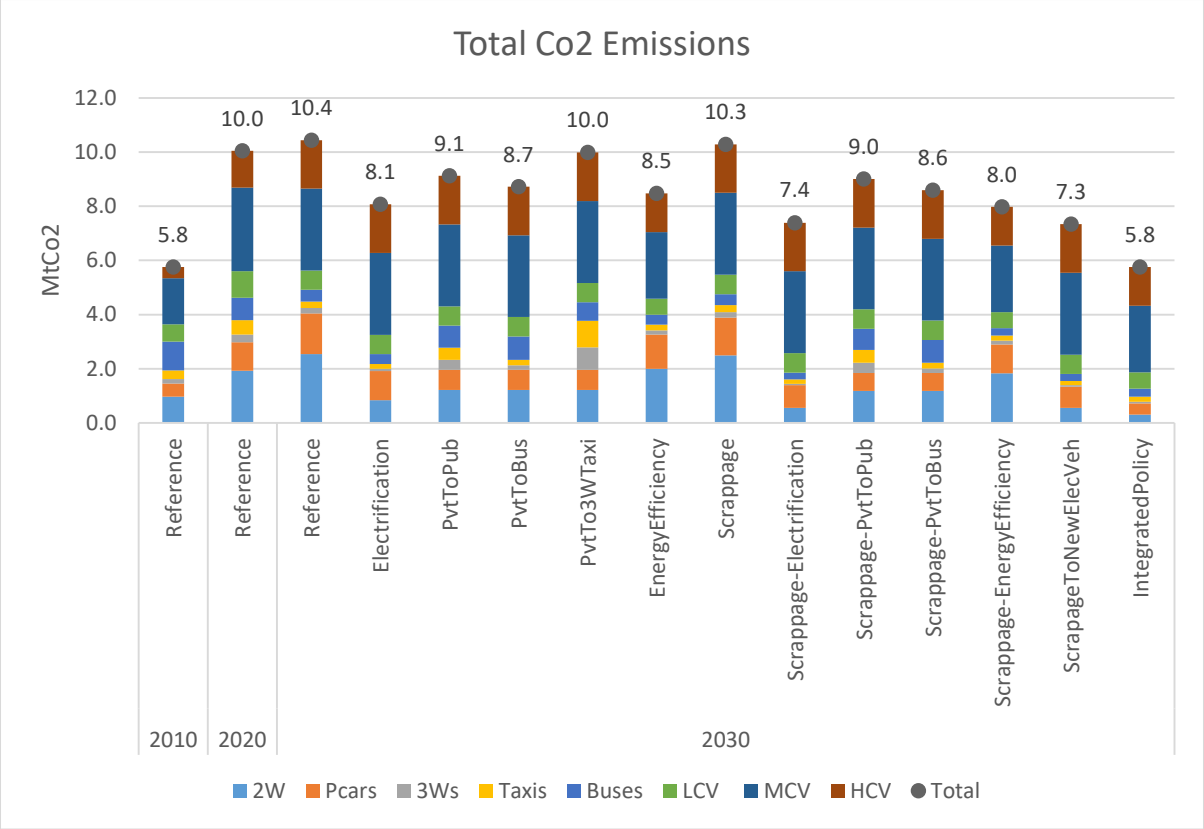

Figure 22: Total Co2 Emissions

5.4 Cost to Economy

The total cost to the economy from the Odisha transport sector is the cost of vehicle stock and investment in road infrastructure for each scenario. Figure 23 shows the cost of different scenarios for the transport sector from 2010 to 2030. It is to be noted that in 2020 there is a 12 percent cost of infrastructure (road) in each scenario. In 2030 the reference scenario cost reduces by 1 billion INR as compared to 2020 as there is no infrastructure cost. The integrated policy shows the highest cost as compared to all other scenarios and that is because of the adoption of electric, energy efficient and replacement of new vehicles in scrappage policies. As it is expected that the cost for the electric vehicles would be higher compared to new ICE vehicle across both variants (gasoline and diesel) is to be borne by the manufacturers which in turn will increase the price of the vehicle. In addition to this, scrappage and energy efficiency will also have higher cost of vehicle, as the new energy efficient vehicles will cost higher in replacing the old fleet of existing vehicles. Hence, the scenario cost is higher than the reference scenario. In 2030 we can observe that the modal shift from private to public, and scrappage with modal shift are less compared to the reference scenario. This is because public transport is cheaper and accumulated more passengers. And in scrappage and modal

shift the public would get compensated and subsidized vehicle which would be lower compared to the cost of vehicle in reference scenario. The share of new and efficient fleet on road will increase the overall cost of the economy in 10 years' time. Hence adoption of energy efficient and electric vehicles would increase the cost of electrification, energy efficiency, scrappage and even integrated scenarios. Modal shift from private to public mode of transport helps in reducing the scenario cost to 139 Billion INR compared to 160 Billion INR in reference scenario in 2030. The cost implication of this policy makes it the second best alternative for implementation in Odisha transport sector.

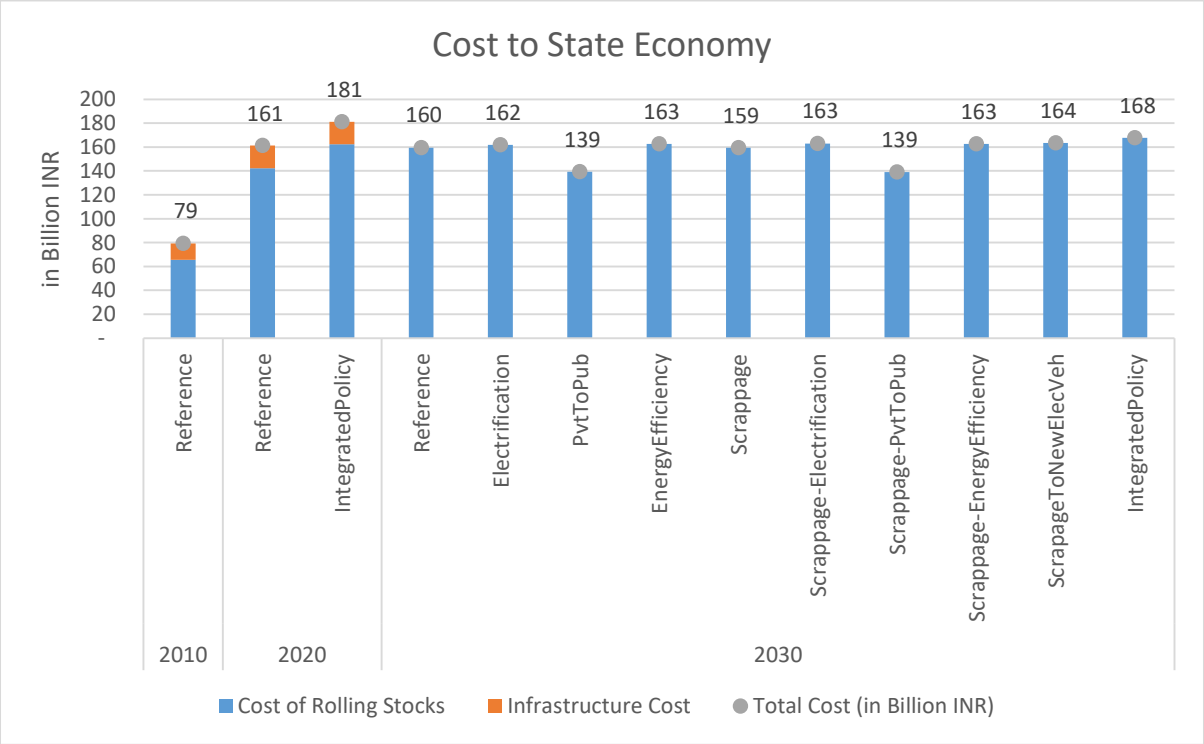

Figure 23: Cost to an economy for all scenarios

6 Findings and Recommendations