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STUDY ON VEHICULAR EMISSION IN TRIVANDRUM URBAN CENTRE

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Abstract - *Rapid urbanization, industrialization and population growth have led to an increase in number of automobiles that cause air pollution due to vehicular emissions. Several studies shows that road traffic contributes 60% of air pollution in urban areas [1]. In developing countries like India, automobile exhaust plays a vital role in causing air pollution. Specifically in Kerala, transportation is one of the most important sources of air pollution. The exponential growth of automobiles in Kerala has been considerably increased faster than the rate of population growth [2]. Hence, a case by case assessment is required to predict the air quality in urban situations [1], so as to evolve certain traffic management measures to maintain the air quality levels within the tolerable limits.*

This study mainly aims at analyzing the previous year data for air quality at locations specified by KSPCB and Vehicle kilometre travelled data (VKT) from (NATPAC) for entire Trivandrum area. The monitoring and method of analysis are according to the National Ambient Air Quality Standards (NAAQS). The estimation of Vehicular emissions for the study area under "Do nothing" and Mass Rapid Transit System (MRTS) Scenarios are considered and the Emission rates are forecasted for the horizons 2025- 2035. Based on Vehicle kilometer travelled, emission rates are found out using Fuel Consumption and Emission Factor method. Scenario analysis is done by considering five different cases of measures to reduction pollution by calculating the emissions from predicted values of VKT from NATPAC.

Key Words: Air pollution, Vehicular emissions, MRTS, Vehicle Kilometre travelled, Business As Usual, Sustainable Urban transit, Transportation.

1. INTRODUCTION

Rapid urbanization, industrialization and population growth have led to an increase in number of automobiles that cause air pollution due to vehicular emissions. Several studies shows that road traffic contributes 60% of air pollution in urban areas. Hence, a case by case assessment is required to predict the air quality in urban situations, so as to evolve certain traffic management measures to maintain the air quality levels within the tolerable limits. Exhaustive studies have been conducted on identifying the causes for excessive emissions from automobiles. Vehicular emission is considered as a line source in air dispersion models. In this study, Ambient Air Quality data's for Sulphur dioxide (SO_2), Nitrogen oxides (NOx) and Respirable Suspended Particulate Matter (below 10 micron size) (RSPM) were monitored regularly at predetermined stations (at 4 station points). The locations fall under the categories of industrial, commercial, residential and sensitive. The monitoring and method of analysis are according to the National Ambient Air Quality Standards (NAAQS).

In this paper 5 cases are considered for the reduction of vehicular emission in Trivandrum City. The estimation of Vehicular emissions for the study area under "Do nothing", Business as Usual (BAU) and Sustainable Urban Transit (SUT) Scenarios are considered and the Emission rates are forecasted for the horizons 2025- 2035. Based on Vehicle kilometre travelled (VKT), emission rates are found out using Fuel Consumption and Emission Factor method. Trip generation is used for forecasting travel demands by predicts the number of trips originating in or destined for a particular traffic analysis zone. Trip generation is forecasted using Cubes module that estimates the future travel demand and impacts of alternative transportation policies and improvements proposed [3]. Trip distribution and trip frequency data from NATPAC in the year 2015 is used for the prediction of VKT for 2025 and 2035.

2. MATERIALS AND METHODS

2.1 Materials

Thiruvananthapuram is the capital of the southern Indian state of Kerala with a Population of 9.58 lakhs and spread over an area of 214 km^2. Thiruvananthapuram is built on seven hills by the sea shore and is located at 8.5°N 76.9°E on the west coast, near the southern tip of mainland of India. The wider Thiruvananthapuram metropolitan area comprises Thiruvananthapuram Corporation, 3 municipalities and 27 panchayats, as of in 2011. The Corporation of Thiruvananthapuram or TMC oversees and manages the civic infrastructure of the city's 100 wards. The study area for the estimation of Vehicular emission is taken as 100 wards of Thiruvananthapuram and also the surrounding 8 Panchayatas and one municipality to note about vehicle fleet entering from outer corridor to Thiruvananthapuram city.

Data collected are air quality at locations specified by KSPCB and Vehicle kilometer travelled data (VKT) from (NATPAC) for entire Trivandrum area. The monitoring and method of analysis are according to the National Ambient Air Quality Standards (NAAQS).

2.2 Method

Developed three scenarios for analysis are Do Nothing, Business As Usual (BAU) and Sustainable Urban Transit (SUT). Do nothing Scenario is considered to estimate CO_2 emissions and BAU and SUT scenario for estimating Local emissions ($PM_{2.5}$, NOx, CO, VOC) .Under these scenarios five cases are studied to reduce vehicular emission and scenario giving low emissions are analyzed.

Table -1: Five cases considered.

Case I	MRTS
Case II	50% CNG
Case III	MRTS + 50% CNG
Case IV	100% CNG
Case V	MRTS + 100% CNG

Air Quality Index (AQI) is found out from monitored air quality data from KSPCB. AQI is found out by using the equation (1) given below:

$$AQI = (\text{Monitored value} / \text{Standard level}) \times 100 \quad \dots (1)$$

Where, Monitored value in $\mu g/m^3$

Table -2: Standard Air Quality Index Level

AQI	API
0-25	linear
26-50	light pollution
51-75	moderate pollution
75-100	High pollution
>100	severe pollution

Air quality data was used to compute AQI for 2005-2019 and forecast for 2035. Forecast of AQI was done using trend line method in Microsoft excel.

Table -3: Predicted AQI for 2020-2035

YEAR	AQI	API
2020	37.76	Light pollution
2021	40.85	Light pollution
2022	44.53	Light pollution
2023	48.67	Light pollution
2024	52.98	Moderate pollution
2025	58.01	Moderate pollution
2026	63.7	Moderate pollution
2027	69.6	Moderate pollution
2028	75.5	High pollution
2029	82.01	High pollution
2030	90.17	High pollution
2035	128.75	severe pollution

The vehicular emission is determined using vehicle emission factor and fuel consumption method. For the estimation of vehicular emission, Vehicle Kilometer Travelled (VKT) is to be computed for the base year. VKT is found out by following equation (2):

$$VKT = PKT / \text{Avg occupancy of vehicle (Nos)} \quad \dots (2)$$

Where, PKT is Passenger Kilometre Travelled in Kilometre, Average occupancy of vehicle classes; two-wheeler, passenger auto, car and bus.

Using Fuel Consumption method following equation (3) is used to determine the CO2 emissions:

$$Emission_{FC} = VKT \times FC \times CO_2 \text{ coefficient} \quad \dots (3)$$

Where, $Emission_{FC}$ – Emission using Fuel Consumption method, VKT – Vehicle kilometre travelled, FC - Fuel Consumption and CO_2 coefficient for fuels in CO_2 Kg/Lt.

Using Emission factor method following equation (4) is used to determine the Local emissions (PM2.5, NOx, CO, VOC):

$$Emission_{EF} = VKT \times EF \quad \dots (4)$$

Where, EF – Emission Factor (g/ km) for pollutants under Business As Usual and Sustainable Urban Transit scenarios are taken.

3. RESULT DISCUSSION

The CO_2 and local emissions for developed three scenarios (Do Nothing, Business As Usual and Sustainable Urban Transit) results are charted (1-18) below. Then total emissions for all the scenarios and cases are also tabulated.

3.1 Do nothing Scenario

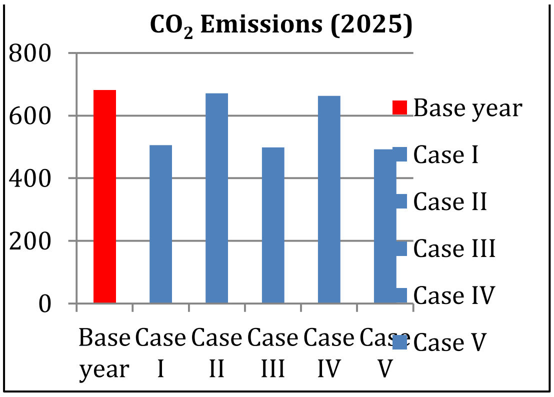

Chart -1: CO_2 emissions for Do nothing scenario and for five cases considered for 2025

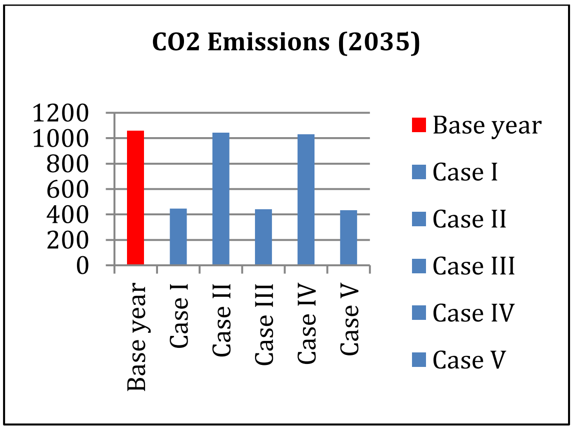

Chart -2: CO_2 emissions for Do nothing scenario and for five cases considered for 2035

3.2 Business as Usual (BAU) Scenario

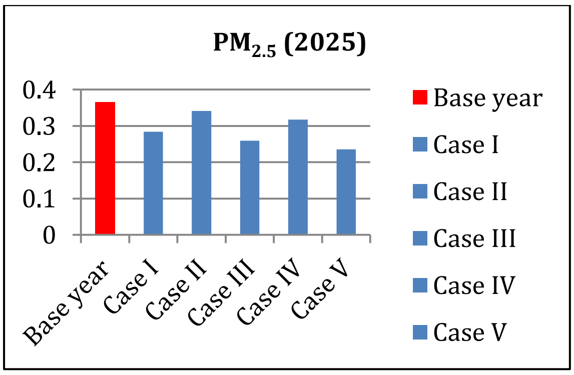

Chart -3: $PM_{2.5}$ emissions under BAU scenario for five cases considered for 2025

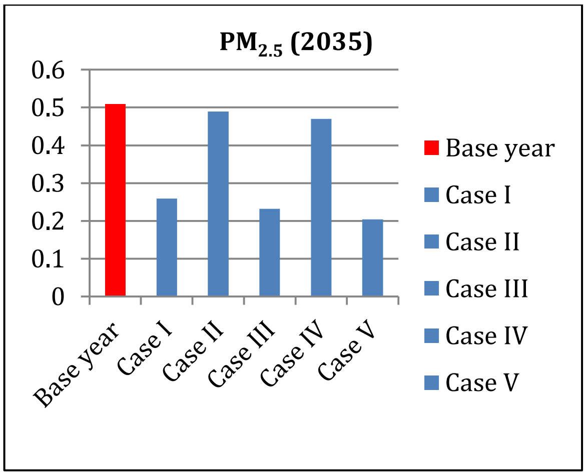

Chart -4: $PM_{2.5}$ emissions under BAU scenario for five cases considered for 2035

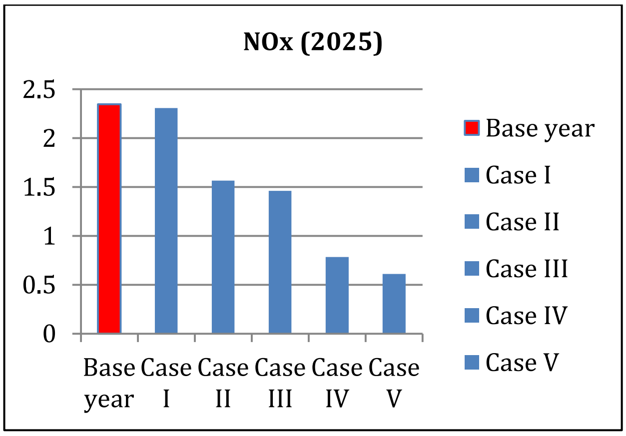

Chart -5: NOx emissions under BAU scenario for five cases considered for 2025

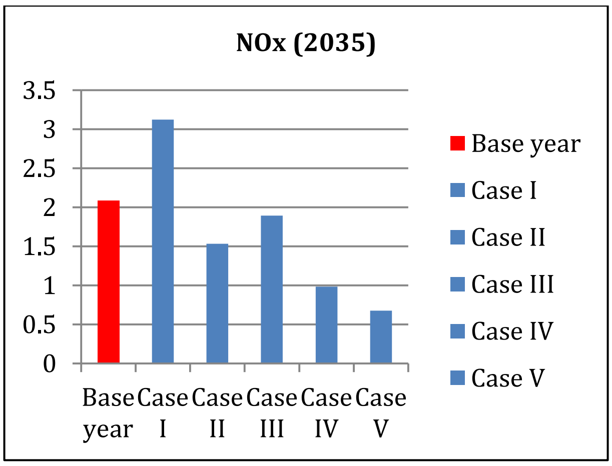

Chart -6: NOx emissions under BAU scenario for five cases considered for 2035

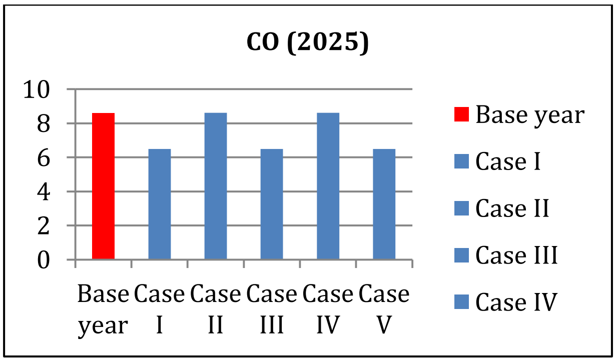

Chart -7: CO emissions under BAU scenario for five cases considered for 2025

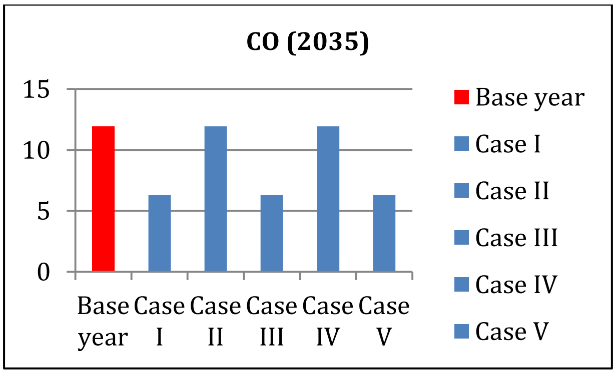

Chart -8: CO emissions under BAU scenario for five cases considered for 2035

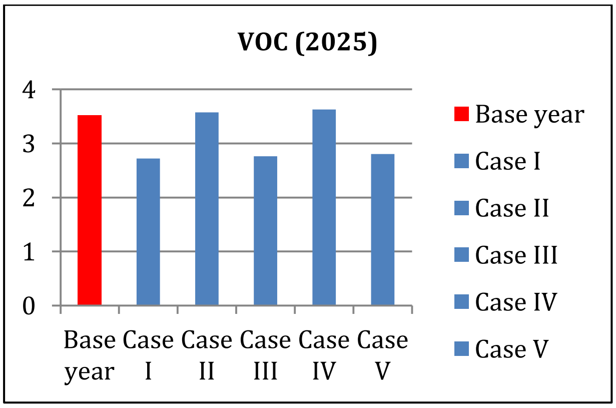

Chart -9: VOC emissions under BAU scenario for five cases considered for 2025

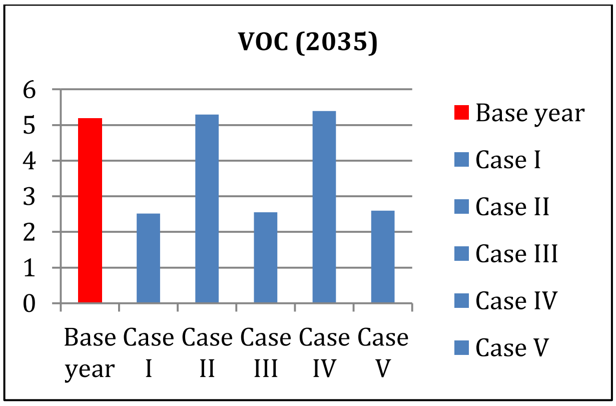

Chart -10: VOC emissions under BAU scenario for five cases considered for 2035

3.2 Sustainable Urban Transit (SUT) Scenario

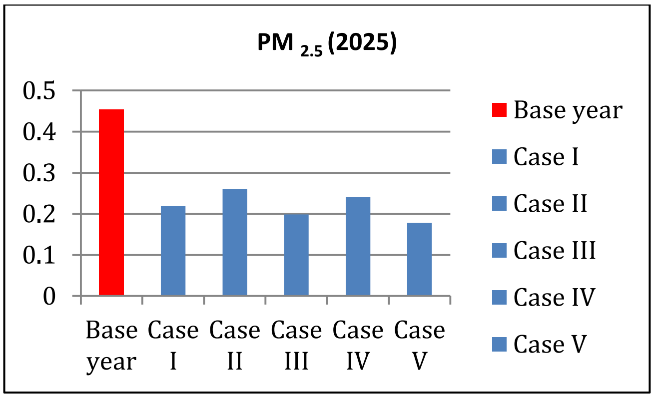

Chart -11: $PM_{2.5}$ emissions under SUT scenario for five cases considered for 2025

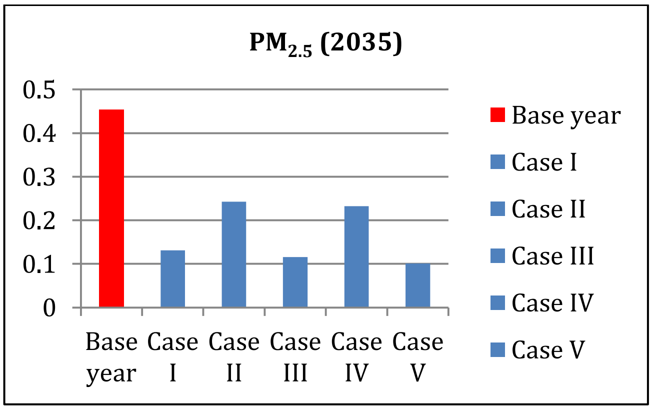

Chart -12: $PM_{2.5}$ emissions under SUT scenario for five cases considered for 2035

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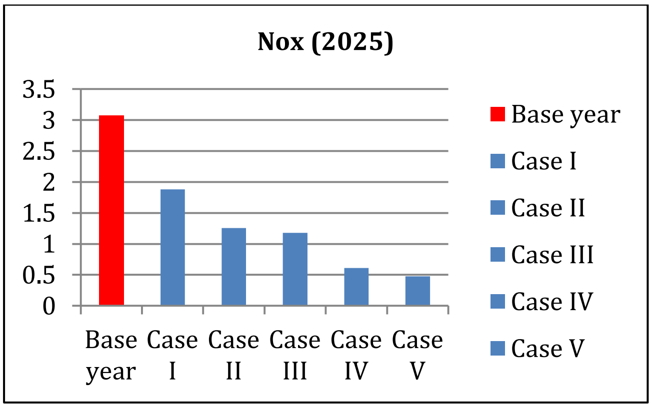

Chart -13: NOx emissions under SUT scenario for five cases considered for 2025

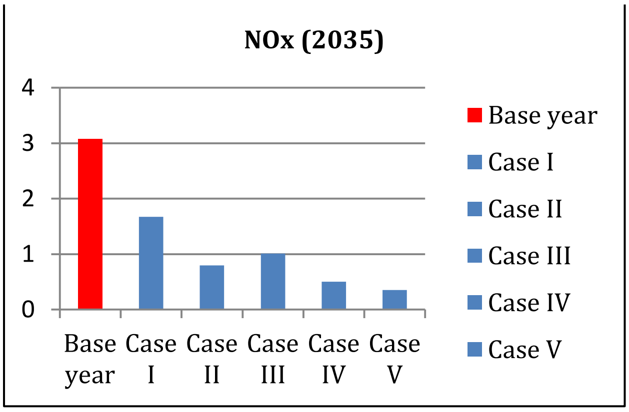

Chart -14: NOx emissions under SUT scenario for five cases considered for 2035

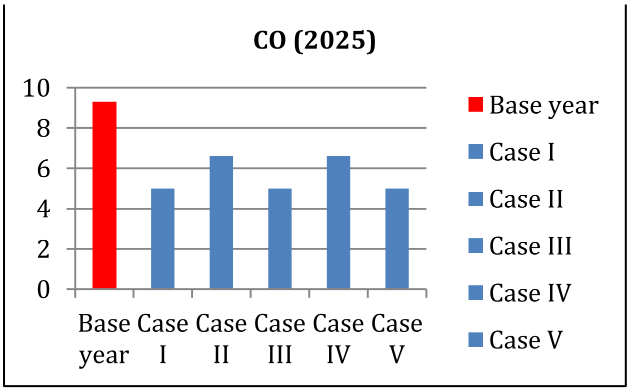

Chart -15: CO emissions under SUT scenario for five cases considered for 2025

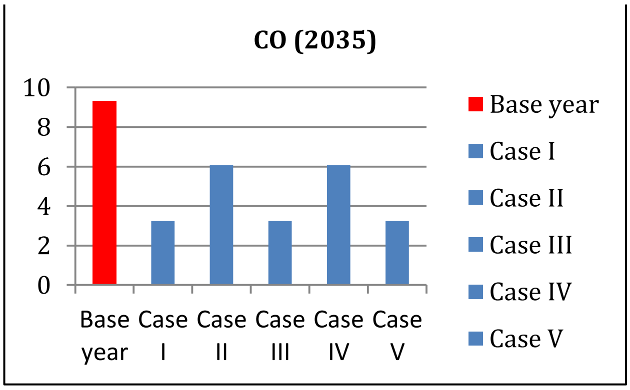

Chart -16: CO emissions under SUT scenario for five cases considered for 2035

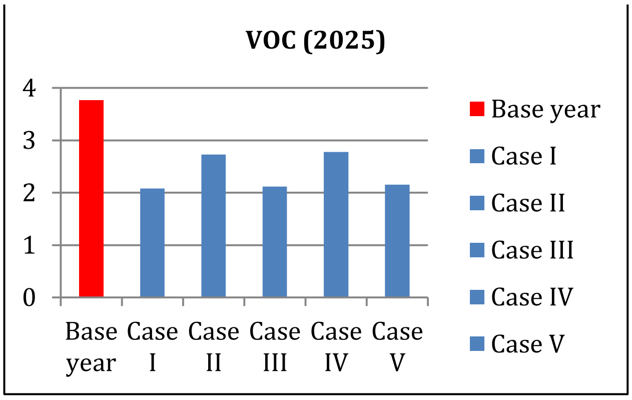

Chart -17: VOC emissions under SUT scenario for five cases considered for 2025

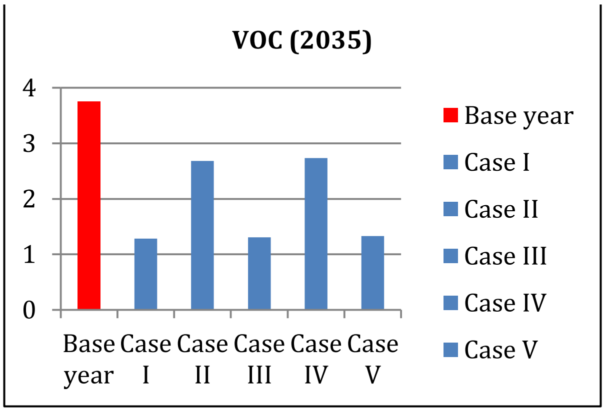

Chart -18: VOC emissions under SUT scenario for five cases considered for 2035

Table -4: Total Emissions for base year, 2025 and 2035

Scenario	Pollutant (t)	Base Year	2025	2035
Do nothing	CO_2	447031.1	492205.3	434728.1
BAU	$PM_{2.5}$	0.453258	0.23546	0.204189
	NOX	3.071398	0.610566	0.677312
	CO	9.302814	6.497181	6.305614
	VOC	3.761254	2.806931	2.59305
	TOTAL	447047.7	492215.5	434737.9
Do nothing	CO_2	447031.1	492205.3	434728.1
SUT	$PM_{2.5}$	0.453258	0.178411	0.101059
	NOX	3.071398	0.4791	0.353958
	CO	9.302814	4.999344	3.247481
	VOC	3.761254	2.151978	1.327632
	TOTAL	447047.7	492213.1	434733.1

4. CONCLUSIONS

Under do nothing scenario percentage reduction for CO2 emissions for 2025 and 2035 are 27.6% and 59%. Local emissions ($PM_{2.5}$, NOx, CO, VOC) under BAU scenario, percentage reduction for 2025 and 2035 are 35.6%, 74%, 24.5%, 20.3% and 59.87%, 67.5%, 47.2%, 50.1% .Under SUT scenario percentage reduction are 60.6%, 84.4%, 46.3%, 42.8% and 77.7%, 88.5%, 65.1%, 64.7%. Total emission able to reduce is 12314.59 T from base year to 2035. By analysing the results Case V in SUT scenario is considered adequate.

In this study percentage reduction due to shift in passenger vehicle is evaluated. Further, evaluation will be done by considering the Goods vehicle and finding the total reduced emission during the shift of both goods and passenger.

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