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A Comparative Study on Fuel Economy and CO_2 Emissions in Passenger Cars in India, Canada and Singapore

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Abstract: The measure of Fuel Economy is important as the Carbon dioxide emission is a direct function of the fuel consumed. In India, Fuel Efficiency of the Passenger Cars is declared by the manufacturers through Society of Indian Automobile Manufacturers of India (SIAM). Unlike in the US or Europe, the testing process behind this declaration is not specifically mentioned. It can be presumed that the measured /computed value of the fuel consumed during the testing done for exhaust emissions, is noted and declared. An attempt has been made to compare the Fuel Economy of Indian Passenger Cars with reference to Fuel Economy Data available for other countries. This comparative study has analysed the Fuel Economy Data (2019) published by Canada and Singapore Governments with the Declared Fuel Economy of Indian Automobile Manufacturers. It is observed that in the case of Indian Vehicles – both Petrol and Diesel, the declared Fuel Economy of Indian Cars is higher than the Fuel Economy of cars in Canada. The fuel economy of cars in India is marginally higher compared to Singapore. There is a need for a uniform standard for testing and a standard Unit of Measurement in Automotive Industry at a global level as Fuel Economy data are important not only for the consumers but also for controlling emission.

Keywords — Fuel Economy, Fuel Efficiency, CO_2 Emission, Mileage, Passenger Car, WLTP

I. INTRODUCTION

Vehicles are one of the contributors to air pollution and there is a need to reduce vehicular emissions on a continuous basis. The emission norms have been progressively tightened, and the automotive industry responded by developing new engines, new technologies and after treatment devices such as catalysts. In the early stages, Carbon Monoxide, Hydrocarbons and Oxides of Nitrogen were identified as harmful pollutants and targeted for control. When global warming was identified as a serious issue, Carbon Dioxide was identified as one of the contributors. In the case of automobiles, be it cars or two-wheelers or any other vehicle, CO_2 is a direct function of the fuel consumed. The measure of Fuel Economy is important as the Carbon dioxide emission is a direct function of the fuel consumed. The Fuel Economy of a vehicle is inversely related to the engine capacity in a conventional design. The automobile manufacturers have to strike a balance between power and Fuel Economy and meet the customer expectations and emission norms. This analysis considers Engine Capacity for drill-down analysis.

In India, Fuel Efficiency of the Passenger Cars is declared by the manufacturers and notified by the Society of Indian Automobile Manufacturers (SIAM). The procedure adopted for arriving at Fuel Economy is not given. However, it can be derived from Carbon Emission for which Testing Procedures have been prescribed. For emission testing, India adopts the New European Driving Cycle (NEDC) with some minor modification. In Singapore, effective 1st Jan 2019, emission test results from the World-wide harmonised Light-duty vehicles Test Procedure (WLTP) for type approval of new vehicles and assessment under the Vehicular Emissions Scheme (VES) are accepted. But it has not made the complete switchover to WLTP. Emission results from the NEDC and Japanese Driving Cycle (JC08) are also accepted [1]. Manufacturers in Canada use the 5-cycle testing procedure as followed in the US. The testing procedure consists of city and highway driving conditions, testing in cold weather, the use of air conditioners, and driving at higher speeds with more rapid acceleration and

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Braking [2]. The authors have already analysed the Fuel Economy declared by Indian Passenger Car Manufacturers as per the Fuel Economy data published by the Society of Indian Automobile Manufacturers and Fuel Economy data available for the US and Europe [3 & 4]. This paper attempts to analyse the Declared Fuel Economy of Indian Passenger Vehicles with the Fuel Efficiency Data relating to Canada and Singapore.

II. PRESENT STUDY

The present study covers the specifications of Passenger cars – both Petrol and Diesel and the Fuel Economy of the vehicle models listed in the 9th SIAM FE Declaration 2017-18 [5]. Since CO_2 data is not available in the 9th SIAM FE Declaration 2017-18, we have made use of the CO_2 provided in the Declaration 2016-17 [6]. Fuel Economy of Indian vehicles has been converted to Litres per 100 KM for easier comparison. For this analysis, we have taken the data provided in 2019 CANADA Fuel Consumption Guide [2] relating to Diesel and Petrol Passenger Vehicles. Similarly, the Fuel Economy data (May 2019) published by Land Transport Authority, Singapore [7] has been considered for our analysis.

In this study, for the analysis relating to India, 238 models of Diesel Vehicles and 201 models of Petrol Vehicles have been considered. Similarly, we have considered 206 models of Diesel Vehicles and 1701 model of Petrol Vehicles relating to Singapore. For Canada, we have taken 23 models in Diesel and 491 models in Petrol categories. Overall, the present study covers 2860 models under both Petrol and Diesel categories from these 3 countries. The study covers an analysis of Fuel Economy by Engine Capacity for both Diesel and Petrol Vehicles and analysis of Carbon Dioxide emission by Engine Capacity for both Diesel and Petrol Vehicles. The study also analyses the relationship between Engine Capacity, Fuel economy and Carbon Dioxide Emissions based on the data gathered.

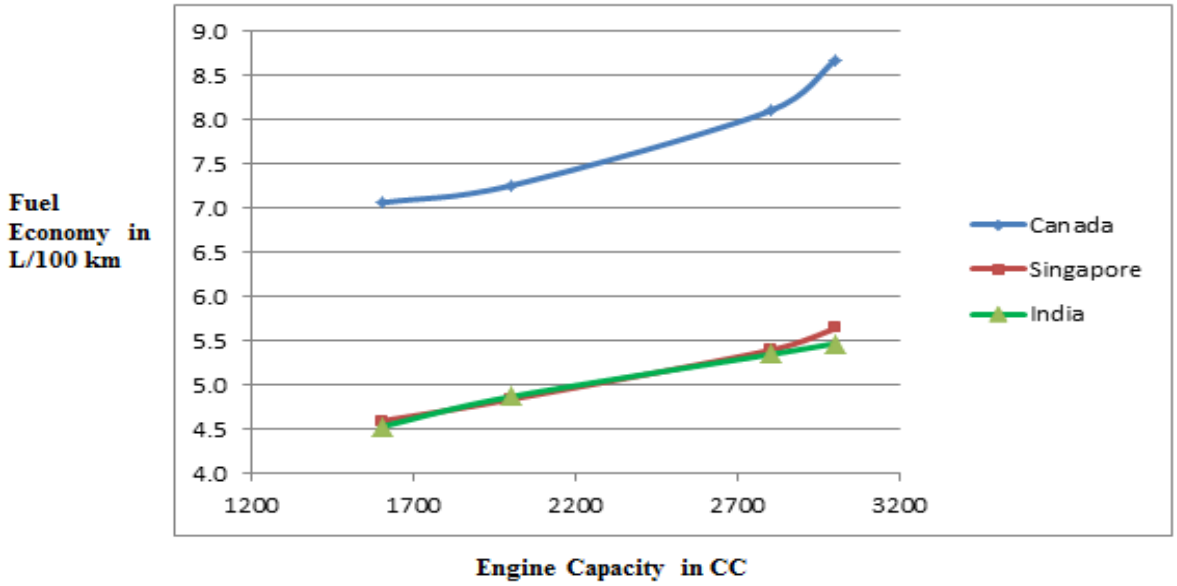
III. ANALYSIS & KEY OBSERVATIONS

Analysis of the models by Engine Capacity is given the Table 1 & 2 below:

Table 1: Analysis of Diesel Vehicles:

Engine Capacity Up to	Canada		Singapore		India	
	Cum. No of Models	Cum. Average L/100 km	Cum. No of Models	Cum. Average L/100 km	Cum. No of Model	Cum. Average L/100 km
1600 CC	6	7.1	77	4.6	104	4.5
2000 CC	10	7.3	118	4.8	147	4.9
2800 CC	15	8.1	172	5.4	213	5.3
3000 CC	23	8.7	202	5.6	234	5.5
>3000 CC	23	8.7	206	5.7	238	5.5

Figure 1: Fuel Economy of Diesel Vehicles – Canada, Singapore & India



Key Observations: (Table 1 and Figure 1)

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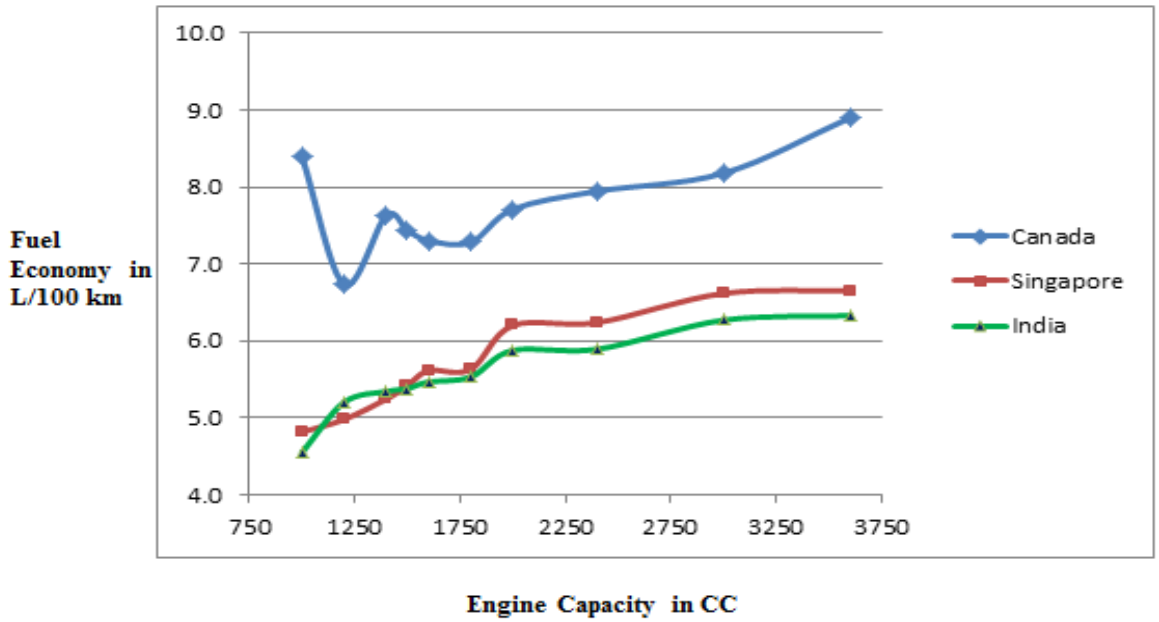
1 Number of Diesel models in Canada is negligible compared to India and Singapore.
2 Fuel Consumption in Canada is 33%-35% higher when compared to Singapore and 33%-37% higher when compared to Indian Vehicles
3 No major variation between India and Singapore.

Similar analysis done for Petrol vehicles is given below:

Table 2: Analysis of Petrol Vehicles – Canada, Singapore and India

Engine Capacity Up to	Canada		Singapore		India	
	Cum. No of Models	Cum. Average L/100 km	Cum. No of Models	Cum. Average L/100 km	Cum. No of Model	Cum. Average L/100 km
1000	1	8.4	47	4.8	19	4.5
1200	5	6.7	100	5.0	73	5.2
1400	29	7.6	196	5.2	88	5.3
1500	58	7.4	321	5.4	107	5.4
1600	84	7.3	476	5.6	120	5.5
1800	100	7.3	497	5.6	129	5.5
2000	190	7.7	1099	6.2	165	5.9
2400	222	7.9	1122	6.2	166	5.9
3000	289	8.2	1470	6.6	196	6.3
3600	409	8.9	1496	6.7	199	6.3
>3600	491	9.4	1701	7.0	201	6.4

Figure 2: Fuel Economy in Petrol Vehicles – Canada, Singapore and India



Key Observations: (Table 2 and Figure 2)

1 82% of Petrol Models in India are Engine CC 2.0 L or less. The corresponding number for Singapore is 65% and Canada, only 38%.
2 Fuel Consumption of Singapore vehicles is marginally higher (up to 6%) in most of the categories than Indian Cars.
3 Fuel Consumption in Canada is 43%-19% higher when compared to Singapore and 46%-23% higher when compared to Indian Vehicles.

Analysis of CO_2 Emission:

Table 3 and 4 provides the analysis of CO_2 emission for different Engine Capacity levels.

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Table 3: CO_2 Emission in Petrol Vehicles:

Engine Capacity Up to	Canada		Singapore		India	
	Cum. No of Models	Cum. Average CO_2 in g/km	Cum. No of Models	Cum. Average CO_2 in g/km	Cum. No of Model	Cum. Average CO_2 in g/km
1000	1	196.0	47	111.9	19	111.4
1200	5	158.2	100	115.6	73	125.9
1400	29	180.8	196	122.1	88	131.4
1500	58	178.0	321	126.1	107	132.8
1600	84	176.6	476	131.0	120	135.7
1800	100	176.8	497	131.4	129	137.6
2000	190	187.6	1099	146.2	165	142.9
2400	222	193.7	1122	147.5	166	144.7
3000	289	200.0	1470	158.1	196	150.6
3600	409	219.9	1496	159.1	199	150.9
>3600	491	236.9	1701	172.1	201	151.6

Table 4: CO_2 Emission in Diesel Vehicles:

Engine Capacity Up to	Canada		Singapore		India	
	Cum. No of Models	Cum. Average CO_2 in g/km	Cum. No of Models	Cum. Average CO_2 in g/km	Cum. No of Model	Cum. Average CO_2 in g/km
1600 CC	6	191.0	77	123.6	125	121.2
2000 CC	10	196.5	118	130.1	147	125.8
2800 CC	15	226.5	172	150.4	229	148.0
3000 CC	23	241.0	202	159.3	251	152.5
>3000 CC	23	241.0	206	160.2	253	153.3

Figure 3 and 4 provides the CO_2 emission trend for Canada, Singapore and India.

Figure 3

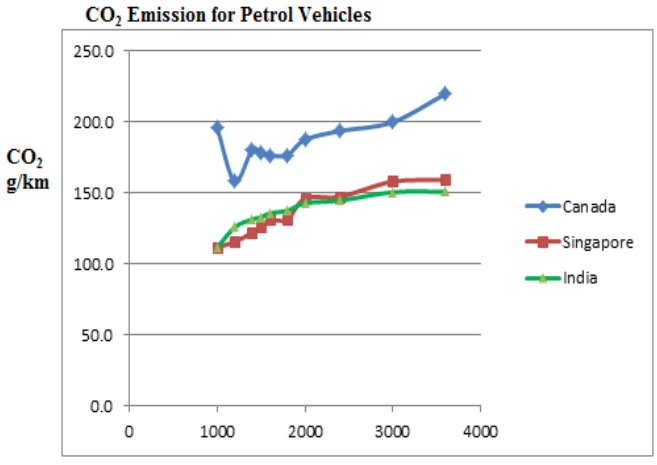
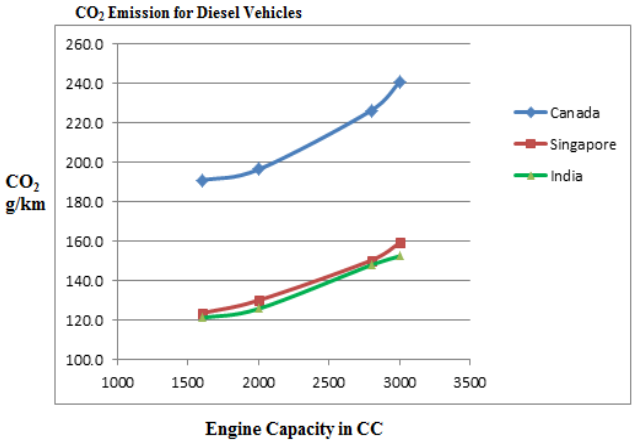


Figure 4:



Key Observations: (Table 3, Table 4, Figure 3 and Figure 4)

1 In case of Diesel models, India is marginally better (2% - 5%) than Singapore. In case of Petrol models, India is marginally better in Engine CC 2.0L or more.

2 The CO_2 emission levels shown in case of Canada vehicles are far higher than Singapore/India. It is

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more than 34-35% in case of Diesel vehicles. When compared to Singapore Petrol vehicles it is more by 21%-43% and when compared to India 20% - 43% for various Engine Capacities.

Relationship between Engine Capacity, Fuel Economy and CO_2 Emission

Linear equation for the relationship between Fuel Capacity (CC) and the Fuel Economy (L/100 KM) derived from the Fuel Economy data is given in Table 5: (x – Engine CC & y – Fuel Economy in L/100 KM)

Table 5:

Fuel Type	Canada	Singapore	India
Diesel	0.0024x+3.1772	0.0023x+1.4206	0.0019x+2.0692
Petrol	0.0017x+5.2706	0.0017x+3.3308	0.0025x+2.6021
If we apply the above equation, a 1.6L Fuel Engine car, for example, will give the following Fuel Economy (in Litres per 100 KM)			
Diesel	7.02	5.10	5.11
Petrol	7.99	6.05	6.60
CO_2 Emission conversion for the above will be as under (g/km)			
Diesel	186.0	135.2	135.4
Petrol	185.4	140.4	153.2

Key Observation: (Table 5)

For 1.6 L Diesel Vehicle, for example, Linear Equation, confirms a variation of 27% in Fuel Economy between India and Canada as well as between Singapore and Canada. Fuel consumption level in Petrol Vehicle is higher by 24% for Canada when compared and with Singapore and 17% when compared with India.

Limitations:

The analysis is limited to the Petrol/Diesel models given in the data published in the declarations. Also, this analysis has not considered the volume of vehicles produced under each model. CNG/LPG fuel model cars have not considered for this exercise.

IV. Conclusion

The above analysis shows that there are variations in the Fuel Economy/CO_2Emission values between different regions. Even the unit of measure for the Fuel Economy is not the same. Canada and the UK adopt Imperial MPG, the US follows MPG (US), and India is following Kilometres per hour and Singapore, litres per 100 Kilometres. There are differences in the method of testing for computing Fuel Economy also. In Canada, which follows the US model, testing is done as per the US test procedure, in which the test cycle consists of several modes like city, highway, aggressive driving etc. But in Europe and Singapore, where the European model is followed, there is no separate procedure for Fuel Economy testing and Fuel consumed during Emission testing Drive cycle NEDC is taken. In India also the same procedure is followed for Emission testing, with modified NEDC with max speed limited to 90kph. The fuel economy figures so obtained are generally higher because average speeds are low. It is documented that the use of two different unit systems caused the loss of the 'Mars Climate Orbiter' in 1999[8] for NASA.

Passenger Vehicles contribute to air pollution and there is a need to reduce vehicular emissions. Global warming is one of the major challenges faced in today's world and the emission of Carbon Dioxide is one of the reasons for this. The CO_2 emission is directly related to fuel economy. Automobile industry, globally, needs to have uniform measures and testing processes to effectively control the emission of CO_2. Emission control is a global issue. This research shows a lack of uniformity in testing procedures to measure the emission levels. There is a need for a uniform standard for testing and a standard Unit of Measurement in Automotive Industry at a global level as Fuel Economy data are important not only for the consumers but also for controlling Carbon Dioxide emissions.

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