

# Bharat Stage IV to VI -Challenges and Strategies

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**ABSTRACT:** *Bharat stage VI emission norms are the sixth stage for vehicular emissions in India. The BS-VI emission norms are much needed for a country such as India to keep the pollution in check. BS-VI norms are stricter and more restrictive in terms of BS-IV norms allowing for cleaner air and also less pollution in the process. The new BSVI emission norms would require both the automobile sectors as well as oil companies to make advancements and changes to their respective products. For the best results and for the better performance of the car the BSVI based engines will have to run on BSVI fuel. The new generation modern engines which are running on low-quality fuels will emit more toxic gases compared to that generated by the BSIV engines. The modern age engine blueprints usually require low Sulphur content to maintain a strong performance. This research aims at comprehending information on a new perspective of understanding the concept and how helpful it will be in understanding the shift from BHARAT STAGE IV TO VI for various stakeholders. Followed by strategies adopted by top five Indian based car manufactures.*

**Keywords:** *Bharat Stage IV, Bharat Stage VI, Strategies, Sulphur, Car Manufacturers*

## I. INTRODUCTION

The quality of air has always been an issue of concern worldwide in the milieu of growing vehicular air pollution [1]. While pollution can usually occur from various sources, the pollution which is usually caused by vehicles and their exhaust system is usually very harmful and is considered a significant source of pollution and proper measures have to be set in place in order to curb vehicular pollution [2]. So, the Bharat stage emission standards and the basic emission standards issued by the Indian Government regulates and control the air pollution that is caused by exhaust of vehicles and Internal combustion engines these standards are usually set by the central pollution control board. The standards are based on regulations set by European countries and was first introduced to the world in 2000. The Bharat Stage IV emissions norms have been in place since April 2010, and it had been sanctioned for the entire country in April 2017. In the year 2016 the Government of India announced that the country would skip Bharat stage V norms altogether and would implement the BS-VI by 2020 [3].

The recent rule passed by the supreme court said that they would ban the sale and registration of the motor vehicles that are integrated with the BS-IV emission norms in the whole country by April 1<sup>st</sup> 2020. Primary Sources of Pollutants and Its Effects on Human Health are mainly because of internal combustion engines (ICEs) which are mainly notorious for the production of carbon monoxide, carbon dioxide (CO<sub>2</sub>), oxides of nitrogen and Hydrocarbons. Particulate matter (PM), or carbon soot, is another by-product of diesel as well as direct-injection petrol engines currently emitted by BS-IV vehicles [4].

## II. RESEARCH GAP

Currently, there are many customers who are not aware of the strategic changes got in by the government in the sector of automobiles. Also, there are many researchers who have not emphasised on how this change will affect the stakeholders related to this industry. This paper also focuses on Understanding how the fuel specifications for BSVI is different from that of Euro-VI fuel standards.

## III. RESEARCH OBJECTIVE

- 1) How the transition from BSIV fuel to BSVI fuel will impact the stakeholders
- 2) To study what are the significant changes made in the BSVI fuel and how it is different from the fuel standards of different countries
- 3) How the top 5 Indian car manufacturers are preparing themselves for the change and what strategies are they adopting to attract customers in order to improve their sales.

## IV. RESEARCH METHODOLOGY

The concept is relatively technical and subject to policy changes. The researchers have attempted to collect information from various grey literature sources such as journal articles, blogs, websites and magazines.

## V. DISCUSSION AND REVIEW

### A. Transition from BSIV To BSVI Impacting the Stakeholders

#### Customer

Most of the cities in India have started selling and implementing BS-VI fuels so the customers who are owners of the older generation cars that is the cars that conform to Bharat stage IV standards can choose to opt for BS-VI fuel at the petrol stations. This will produce a different result that is there is a direct interrelationship between the sulphur content that is present in the fuel and the emission produced by it in simple words the lesser the sulphur in the fuel the vehicle will emit lesser particulate matter (PM) which translates into cleaner combustion in the process [5].

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Petrol usually has less sulphur content in it, so it usually emits lesser carbon monoxide, NO<sub>x</sub> and other toxic hydrocarbons. Recent studies also suggest that a BSIV compatible vehicle along with BSVI fuel can reduce the particulate matter (PM) emissions into half [6]. A reduction in the sulphur content in the fuel can bring down the quality and energy content in the fuel and also bring down the efficiency in the process [7]. ULSD fuels could also reduce the efficiency of the fuel due to low sulphur content but most of these fuels are spiked with additives to address,

these concerns all this can cause a drastic increase, in the price of the fuels in the gas stations most of the companies are choosing to invest in oil companies that are implementing BS-VI fuels. Potential buyers are also planning to hold back on the idea of purchasing a new car and also most of them decided to wait and purchase the new BSVI compliant cars the next year. It is quite natural for a rational customer to wait for a few months and invest in new BSVI cars than to consider investing in BSIV compliant cars at the moment. The decisions by the customer to wait for investing in a new car has been causing much trouble for car manufacturers because the stocks of unsold BSIV cars have been piling up and they are unable to sell the BSIV cars due to low customer demand. In order to clear demand adopted attractive marketing strategies in order to attract customers.

### Effect on The Cost of The Vehicles Once BSVI Is Implemented-

India will start to implement the BSVI emission regulations from 1<sup>st</sup> April 2020 which will be in par with the Euro-VI norms. With the new emission norms coming in, the technology will also have to be upgraded in order to keep the emissions in check, Particularly the new diesel engine vehicles, it will be effortless for petrol engines to meet the BSVI emission norms with mostly upgraded Electronic control unit (ECU). The ECU is the one who controls the electrical system and the various other sub-systems in the vehicle. However, diesel cars require a massive change in their technology in order to reduce their overall emissions. The new upgrades to diesel cars are going to increase the prices of diesel cars even further. The price gap between diesel cars and petrol cars are said to be around 2.5 lakhs if it takes into consideration all the features such as a premium hatchback, premium sub-compact sedan or an entry-level compact sedan [8]. The increase in the price of the diesel cars is because diesel cars will add to several new layers into it after the treatment such as the Diesel particulate filter (DPF) and the selective catalytic reduction system (SCR). The SCR injects Diesel exhaust fluid into the exhaust gasses thus reducing the amount of Nitrogen Oxide (NO<sub>x</sub>) produced by the exhaust of the vehicles [9].

### Manufacturers

Leading car manufacturers such as Maruti Suzuki have already started announcing their plans to start manufacturing BSVI vehicles by the end of 2019 with their commitment towards a cleaner and greener environment the BSVI cars that are produced by Maruti Suzuki will have a upgraded hardware and software system along with an upgraded exhaust as well the cars which are compliant with BSIV norms can run on BSVI fuel too, and there is no operational concern in the process [10]. The leading car companies had to increase their investment to upgrade the existing available

models and make them BSVI compatible the number of new product launches by the leading automobile manufacturers have fallen over the past year. Most of the automobile firms are looking at the products that do not require much change before the new BSVI norms take effect. Two-wheelers and four-wheeler producers have pulled limit extension plans, as they anticipate that request could fall.

### How Will This Impact on The Performance and Fuel Efficiency Of The Car?

Because we are moving to more stringent emission norms, it is a more significant challenge for automakers in various ways. Since lowering the exhaust emissions generally takes a toll on fuel efficiency and performance. The car manufacturers have to make sure that they not only have to minimise the amount of pollution caused by the exhaust of the cars, but the car manufacturers also have to make sure to work with the BSVI cars in such a way that the overall performance and efficiency of the car stays intact. The new BSVI engine technology usually engages a slower combustion process. Furthermore, the exhaust system of the vehicle after treatment will increase the amount of the back pressure on the engine and some of these systems like particulate filters and the Nitrogen Oxide (NO<sub>x</sub>) traps will have to undergo a regeneration process which basically involves the exhaust material build up in the filter being combusted by using fuel [11]. The backdrop of this is that the process which involves reducing the amount of sulphur in the diesel engines can impact the quality and performance of the fuel this drastically affects the vehicles performance and efficiency. Most of the automobile manufacturers are adopting various strategies to confront challenges. Tata Motors for example has worked on the torque and power features of the car to ensure the car's performance is up to the mark. Mahindra automobile manufacturers have tweaked the powertrains of their cars to retain the driveability of the car the powertrain of the car is that component that converts the power generated by the engine into movement of the car this mainly includes the engine, the transmission, the driveshaft, axles or basically anything from the engine to the rotating wheels. Mahindra also claims to have achieved a decrease in the friction of the engine to around 30 per cent thus improving the fuel efficiency and the tweaking the performance of the car in the process [12].

### Government

The petroleum and the natural gas ministry told the court that the vehicles which are not compatible with the BSVI standards would not be allowed to run on the Indian roads. This statement had created much confusion in the minds of the auto-car makers, and the ministry has informed the auto-makers that they would get three months to exhaust their entire stock consisting of BSIV compatible vehicles after the new BSVI norms are enforced. The court also said that the car manufacturers would not be able to register for BSIV compliant vehicles after 31<sup>st</sup> March 2020.

### Environment

The place we live in that is our natural habitat is becoming a less friendly place to undertake lifestyle activities. Air pollution is a huge problem faced by our country, and proper measures have to be put in place to curb air pollution.

So, the Indian government had decided to implement a more comprehensive emission standard that is the shift from BSIV norms to BSVI emission norms. The BSVI emission standards are equivalent to Euro-VI Norms which is in place in most of the European countries the government is in the process to develop vehicles with the latest technology to make sure the vehicles emit fewer pollutants in the air and also contemplating towards improving the air quality in the metropolitan cities as well.

The Indian government has also introduced a deadline of April 2020 wherein the automobile manufacturers have to make necessary changes to their products that is making sure that the vehicles comply to the BS-VI norms which, amend the exhaust system of the vehicles in order to reduce the release of harmful gases such as Hazardous NOx and particulate matter that arises from the process of combustion. The overall objective of the BSVI norm is to reduce the release of NOx and particulate matter from both petrol as well as diesel vehicles and promote a cleaner and greener environment in the process.

**B. BS-VI Fuel Grade-Major Changes Made on Gasoline and Diesel Fuel Specifications-**

With the introduction of BSVI vehicular norms, major oil companies such as the Indian oil corporation have been advised by the government of India to develop high quality of fuel which is clean and free from harmful pollutants [13]. Most of the oil firms have spent much money to upgrade to the BSVI standard which is in par with the Euro-VI standard which is implemented by most of the European

countries the primary changes that are being made to the BS-VI fuel is the reduction the total sulphur content which has been around 50 :10 parts per million (ppm) to the amount of sulphur present in the fuel is directly proportionate to the amount of release of sulphur dioxide which is very hazardous to human beings so, a fuel with less complicated chemicals in it will be more natural to combust and also cause less air pollution in the process. The newly introduced BSVI fuel specifications mainly follow the European-VI standards regulations, the prospective limits for several gasoline fuels and diesel fuels in India vary from the European standards. The criteria mainly include the Octane number and the olefin content in the fuel for Gasoline and the density, Polycyclic aromatic hydrocarbon (PAH) and 95% distillation point content for diesel [14]. The main difference in fuel specifications between diesel fuels, commercial gasoline in India and the European standards fuel has been determined below.

**Gasoline Specification**

The prescribed BS-VI norm specifies requirements for two types of gasoline that is regular and premium. Table 1 compares the recently introduced Indian gasoline standards specifications with that of other countries, which has more stringent exhaust emission norms compared to that of India. The main parameters discussed here are the Olefin content and Octane number requirements for premium grade BS-VI Gasoline matches the quality of that of European-VI values and standards. For a regular grade, BS-VI gasoline a higher Olefin content and lower Octane number is permitted

**Table 1. Comparison of fuel specifications for select gasoline parameters**

Fuel parameter	Euro-VI	BS-VI	EPA conventional gasoline average -2005	EPA RFG AVG -2005	SOUTH KOREA	JAPAN	Worldwide Fuel Charter (Category IV)
Sulphur, ppm, max.	10	10	30ppm (Tier2) 10ppm (Tier 3)	30ppm (Tier2) 10ppm (Tier3)	10	10	10
Research Octane (RON), min.	95a	91/95	NS	NS	91/94	86/96	91/95/98
Motor Octane (MON), min.	85a	81/85	NS	NS	NS	NS	82.5/85/88
Anti-Knock Index (AKI), min.	NS	NS	87/87/91	87/87/91	NS	NS	NS
Olefins, vol%, max.	18	21/18	11.6-12.0	11.2-11.9	16-19b	NS	10

NS = Not specified / used to separate specifications for different gasoline grades; AKI = (RON+MON)/2  
 a) Member states are permitted to allow regular-grade gasoline with MON of 81 and RON of 91.  
 b) Either aromatics 24 vol.% max and olefins 16 vol.% max or aromatics 21 vol.% max and olefins 19 vol.% max  
 Table1:(2019) Retrieved 16 November 2019, from <http://egazette.nic.in/WriteReadData/2016/168300.pdf> [15]

**Octane Number**

The Octane number of gasoline fuel provides a measure of the fuel’s ability to resist the process of auto-ignition, which can mainly cause engine damage.





## Bharat Stage IV to VI -Challenges and Strategies

The Octane number can mainly be determined by testing in the laboratory and also depending on the different kinds of test methods used it is determined as Research Octane number (RON) or Motor Octane number (MON), In some states and regions the Octane rating is basically expressed using an Anti-knock Index which is abbreviated as AKI. The AKI is the average of RON and MON of the fuel. Octane number is considered to be more critical to the efficiency of the engine than air pollutant emissions. Higher the octane number in the gasoline it will allow for higher compression ratios and engines can be designed in such a way so that it can achieve thermal efficiency.

In the recent days, researchers have determined that the fuel Research Octane number (RON) and the changes in the composition of the fuel which is associated with Research octane number do not really have an impact on pollutant emissions from gasoline engines, this is because the engines are designed in a way to operate on fuel which has a specified octane rating.

As depicted in Table 1 motor octane number and research octane number specs for the regular grade BS-VI gasoline is 81 and 91 are lower compared to that of Euro-VI which is 85 and 95. While, the differences between the two might have an impact on the fuel-efficiency of that of the Indian vehicles, The Anti-knock Index (AKI) that is calculated from the motor octane number (MON) and the research octane number (RON) specs for that of regular-grade BS-VI gasoline is at 86, which is almost close to that of the AKI for regular gasoline in the United States which is at 87. Further, both South Korea and Japan where Euro-VI level of emission standards have been adopted, basically have RON specs for regular-grade gasoline at or below the level as proposed in the BS-VI emission norms. This means that regarding octane number, it will have the same requirement

as compared to that of the other countries which have world-class emission standards.

### Olefin Content in the Fuel

Olefins are a separate class of hydrocarbon compounds marked by the existence of at least one carbon-carbon double bond. The existence of the double bond makes the olefin even more reactive than various other gasoline components such as the aromatic compounds. The reactions have several conclusions for air pollutant emissions. Usually, an increase in olefin content in the fuel will help to improve the combustion efficiency, which may help to reduce the hydrocarbon emissions (HC) and increase the nitrogen oxide emissions (NO<sub>x</sub>) because of this reaction, Olefins usually tend to have high ozone formation potentials than hydrocarbon components in gasoline fuels. It is found that increasing the olefin from around 3 per cent to 15 per cent resulted in no change in emissions of primary pollutants such as hydrocarbons, Nitrogen Oxide and CO. The researchers have also noticed an increase of 26 per cent in 1,3-butadiene emissions with the increase in the olefin content in the fuel. One major takeaway from the study is that emissions from modern age vehicles which are integrating advanced exhaust after-treatment systems and combustion control usually tend to be more reactive to olefin content than vehicles working on obsolete technology. The olefin content for regular-grade gasoline is limited to 21 per cent in BS-VI specification for regular-grade gasoline. This is greater than the 18 per cent which is specified for the Euro-VI gasoline. As determined above the difference will not be expected to impact the emissions of pollutants such as Hydrocarbons (HC), Carbon oxide (CO) and Nitrogen Oxide (NO<sub>x</sub>).

### Diesel Specifications

**Table 2. Comparison of fuel specifications for select diesel parameters**

Fuel parameter	Euro-VI	BS-VI	CARB DESIGNATED EQUIVALENT LIMIT	EPA Conventional diesel	CARB designated equivalent limit	SOUTH KOREA	JAPAN	Worldwide Fuel Charter (Category IV)
Sulphur, ppm, max.	10	10	15	15	15	10	10	10
Cetane Number (CN), min	51	51	53	Cetane Index ≥ 40 Or aromatics ≤ 35 percent	Cetane index ≥ 60 or aromatics ≤ 35%	52a	45	55
Density @ 15°C, kg/m <sup>3</sup>	865(max)	820-860	NS	NS	NS	815-835	NS	820-860
95% Distillation Boiling Point (T95), °C, max.	360	370	NS	NS	NS	360b	360b	340
Polycyclic aromatic hydrocarbons (PAH), mass %, max.	8	11	35	NS	NS	5	NS	2
Flash Point, Abel, °C, min.	55	35	NS	NS	NS	40	45	55

NS= NOT SPECIFIED

FUEL DENSITY-

Density is a property of diesel fuel which is closely related to both the Cetane number and

the aromatic content as well. The fuel injection is controlled in diesel engines. The fuel density imparts the volume of the fuel that is needed to maintain constant power output in the engine. Concerning the effects on the air pollutant emissions from diesel engines a recent review by Lee.Et. Al found that by reducing the fuel density it tends to increase the Hydrocarbon emissions and it had a very minimal effect on NOx and CO emissions and had no effect on particulate matter emissions from heavy-duty engines [HDE].

A similar review said that reducing the density will tend to reduce the particulate matter, carbon oxide and hydrocarbon emission levels from light-duty vehicles (LDV) and also Nitrogen Oxide from

heavy-duty diesel engines [17]. In the above cases discussed, the authors said that the advancements in the diesel engine design like higher injection pressure and also application of after-treatment control techniques had helped to reduce the overall exhaust emissions in the vehicle.

**95 Per Cent DISTILLATION POINT-**

The 95 per cent distillation point is the temperature at which 95 per cent of specific diesel fuel will distil in a distillation test, and it is used to define the back-end volatility of the fuel. According to a recent study it was distinguished that while reducing T95 may lead to slight increase in Hydrocarbon and Carbon Oxide emissions from the exhaust of heavy-duty vehicle engines the overall effect of the variations on the back-end volatility on emissions of regulated pollutants is very small [18]. Hochhauser also found that reducing back-end volatility had little to no effect on emissions from light-duty vehicles (LDV) and tended to decrease particulate matter (PM) and increase hydrocarbons and carbon oxide emissions from heavy-duty diesel engines [19]. The BSVI norm specification for T95 in the case of commercial diesel fuel is a maximum of 370 degrees Celsius which is higher than the European specification of 360 degrees Celsius.

**Polycyclic Aromatic Hydrocarbon Content (PAH)-**

Polycyclic aromatic hydrocarbons are a class of hydrocarbons that contains two or more aromatic rings. If PAH is not entirely converted into oxide during the combustion process, the unburned fuel PAH's can be emitted into the gaseous phase which will contribute to the toxicity of the diesel exhaust. The unburned fuel PAH can also serve as forerunners for soot formation. General studies have shown that reducing the PAH content of the diesel fuels have shown to reduce the particulate matter and Nitrogen oxide emissions from diesel engines. According, to European programme on emissions fuels and engine technologies (EPEFE) had found that a decrease in the diesel fuel PAH content from 8 per cent to 1 per cent had contributed to reducing the particulate matter emissions from light-duty vehicles and heavy-duty vehicles by 5 per cent and 4 percent. According to the BSVI fuel specifications the maximum PAH content for commercial diesel fuel is around 11 per cent whereas the Euro-VI PAH content limit is 8 per cent. Since the PAH content in the fuel contributes to the toxicity of the diesel exhaust the fuel policies in both India and Europe should focus on reducing the PAH content of diesel fuels. According to worldwide fuel charter it recommends a maximum PAH limit in the fuel at 2 per cent [20].

**Summary of The Fuel Specification**

The common understanding for the above fuel specifications is that the consequence of the fuel effects on the emissions of controlled air pollutants has reduced because of the recent advancements in the engine after-treatment technologies. The modern age engines which are consolidating exhaust after-treatment and advanced combustion control systems have managed to reduce or dispose of the effects of small changes in these fuel parameters. The modern age engine blueprints usually require low sulphur content in the fuel in order to maintain a strong performance during their valuable times. One of the main reasons is because the newly introduced BS-VI regulations proposed that the sulphur content in gasoline and diesel fuels should be limited to 10 PPM. The ultra-low sulphur fuels enable the introduction of BSVI vehicles which are incorporated with the best technologies in order to control their air pollutant emissions, Concerning the emission benefits that will result from the exertion of the projected BSVI emission standards in the year 2020 the difference between the BSVI and the Euro-VI will be minimal. By the 2023-2025 timeframe India should try to match or improve on the Euro-VI or BSVI specifications none the less, the current differences in the fuel specifications should not cause any delay in the exertion of BSVI standards in the year 2020.

**C. Result and Analysis for BSVI Gasoline Specifications-**

FUEL PARAMETER	ANALYSIS
OCTANE NUMBER	<p>1) Higher the Octane number in Gasoline fuel it will allow for higher compression ratios and the engines can be designed in such a way that it can achieve thermal efficiency.</p> <p>2) Research Octane number (RON) and the changes in the composition of fuel which is associated with RON do not have a direct impact on pollutant emissions from Gasoline engines the main reason for this is that engines have been designed in such a way to operate on fuels which have specified octane rating.</p> <p>3) Regarding, The Octane number of Gasoline fuel it will have the same requirement as compared to that of other developed countries which have world class emission standards.</p>



FUEL PARAMETER	ANALYSIS
<b>OLEFIN CONTENT</b>	<p>1) Increase in the Olefin content in the fuel will help to improve the combustion efficiency which will help to reduce the overall hydrocarbon emissions (HC) and increase the nitrogen oxide emissions. Because, of this Olefins tend to have high ozone formation potentials than Hydrocarbons in Gasoline fuels.</p> <p>2) It is also found that increasing the Olefin from 3 percent to 15 percent resulted in no change in emissions of pollutants such as Hydrocarbons, Nitrogen Oxide and CO.</p> <p>3) It has also been found that there has been an increase of 26 percent in 1,3-butadiene emissions with the increase in the Olefin content in the fuel.</p> <p>4) The major takeaway from the study is that emissions from modern age vehicles which are integrating advanced after-treatment systems and combustion control are more reactive to Olefin content than vehicles operating on old technology.</p>

**C. STRATEGIES ADOPTED BY TOP 5 CAR MANUFACTURERS IN INDIA TO CONFORM TO THE BSVI NORMS-**

**1. Mahindra BSVI Diesel Engine Strategy-**

Top car manufacturer Mahindra had recently revealed its strategy for diesel engines to make sure that they meet the BSVI regulations which will be implemented by April 1<sup>st</sup> 2020. Presently, Mahindra has a total of eight diesel engines, but only one of them will be elevated to meet the regulations of BSVI. Mahindra informed that the production for the 1.2 litres, three-cylinder diesel motor that powers the KUV 100 NXT would be stopped, owing to low sales and low demand. Kicking off with the small capacity engines. Both the I00cc and the 900cc engines will be provided with turbochargers to meet the BSVI emission standards. The main job of a turbocharger is to compress more air flowing into the engine cylinder. When air has compressed the oxygen, molecules are packed close together. This increase in the air means that more fuel can be added for the same size naturally aspirated engine. This process generates increased mechanical power and also helps in overall efficiency and improvement in the combustion process which releases less harmful gases into the air [21]. The engine size can also be reduced which can lead to better packaging, weight-saving benefits and also overall fuel economy in the process. In order to conform with the BSVI

regulations, Mahindra will offer three different mills on the 1.5-litre category A 3-cylinder unit and four-cylinder motors. Currently, the 1493CC engine the one that is used in Bolero, and the TUV 300 will be elevated to meet the BSVI emission norms. From the remaining 1.5 litres, four-cylinder the 1.5 litres will be 1461CC motor that runs the Verito sedan, while the second will be the new 1497CC engine that powers the XUV300 sub-four metre. The other one will get an SCR (Selective Catalytic Reduction) **Result and Analysis for BSVI Diesel Specifications-**

FUEL PARAMETER	ANALYSIS
<b>FUEL DENSITY</b>	<p>1) It is found that reducing the fuel density tends to increase the Hydrocarbon emissions and it had a very minimal effect on Nitrogen Oxide (NOx) and CO emissions and had no effect on PM emissions from heavy duty engines (HDE).</p> <p>2) A similar research said that reducing the density will tend to reduce the PM, Carbon Oxide and Hydrocarbon emission levels from Light-duty vehicles (LDV) and also Nitrogen Oxide from Light-duty Vehicles (LDV).</p>
<b>95 PERCENT DISTILLATION POINT</b>	<p>1) It is found that reducing the amount of T95 will lead to increase in Hydrocarbon and Carbon Oxide emissions from exhaust of Heavy-duty vehicle engines the overall effect of the variations on back-end volatility on emissions of regulated pollutants is very small.</p>

system with a rear-mounted urea tank that will reduce the amount of NOx emissions to meet the BSVI regulations. Mahindra largest engine 2.5 four-litre cylinders are going through a change to be accommodated. This engine was initially introduced three years ago, and since then it had been tweaked many times to conform with the various Bharat stage emission Norms across many stages. Pawan Goenka, the Managing director had told that the prices of the new BSVI engine SUV's will increase the automobile car maker had spent over more than 1000 crore in updating from the BSIV engine to BSVI engine the BSVI conversion of Mahindra's engine fleet had resulted him over 30 patents and introducing 1482 new components across models. [23]

**Tata Motors Strategy for BSVI Emission Standards-**

Tata motors are India’s largest automobile manufacturer of utility vehicles, buses, cars, trucks and also army defence vehicles. It is not only India’s largest automobile company, but it is also a part of the 100 billion US dollar Tata group. Tata motors have operations in countries such as Korea, United Kingdom, Thailand, Indonesia and South Africa. It also has a robust global network of 76 subsidiary and various associate companies such as Jaguar, Landover in the United Kingdom and Daewoo in South Korea. Tata Motors is a market leader in cars, commercial vehicles and utility vehicles and has around approximately 9 million vehicles on the Indian roads. Tata motors have a wide variety of products which ranges from Sub-1 ton to 49 Ton gross vehicle weight (GVW) trucks, small, medium and large buses and coach to passenger cars. The company’s various segments include Information Technology, manufacturing of construction equipment, machine tools, investment business and also automotive.

FUEL PARAMETER	ANALYSIS
PAH CONTENT	2) It is also found that reducing the back-end volatility had little to no effect on emissions from Light-duty Vehicle (LDV) and tended to decrease PM and increase hydrocarbons and Carbon Oxide emissions from heavy-duty diesel engines.
	3) The BSVI norm specifications for T95 in case of commercial diesel fuel is a maximum of 370 degrees Celsius which is higher than the European specification of 360 degrees Celsius.
	1) It is found that reducing PAH content of diesel fuel have shown to reduce the particulate matter and Nitrogen Oxide emissions from diesel engines.
	2) European programme on emissions fuels and engine technologies (EPEFE) had found that a decrease in the diesel fuel PAH content from 8 per cent to 1 per cent had contributed to reducing the particulate matter emissions from light-duty vehicles and heavy-duty vehicles by 5 per cent and 4 percent.

**Strategies Adopted**

Tata motors have recently declared about is BSVI type certification that it has received BSVI type certificate of approval for its new 3.5 litres NA SGI CNG engine which is given by the automobile research association of India (ARAI). It is a massive achievement for a company like Tata because of its first Original equipment manager (OEM) in India to have achieved BSVI certification. For a Tata motor have stated the certification includes meeting the tailpipe mass emissions as well as compliance to onboard norms (OBD) which are mandated by the regulations of the Indian government. The company stated that the 3.8 NA SGI CNG engine is a naturally aspirated engine which usually does not require a turbocharger in order to function. The engine produces a power of around 85 PS at 2500 repetitions per minute which has a torque of 285 NM at 2500 repetitions per minute. This type of combustion usually happens at stoichiometric conditions in the engine. The engine also comes with the latest sequential gas injection technology. The 3.8 NA SGI CNG engine will be used to power 4T to 9T GVW buses and also famous tata trucks such as 407, 709, and 909 which are already the most popular models in the automobile sector market and which also has the best in class fuel efficiency. Rajendra Petkar who is the chief technology officer (CTO) at Tata said that the BSVI engine certification was achieved with a very intense focus on design and development as well.

**Tata Invested Rupees 1200 Crores for BSVI Transition of Tiago, Tigor, Nexon-**

The process of upgrading to BSVI engines will cost a massive sum of money for automobile

FUEL PARAMETER	ANALYSIS
	3) According to the BSVI fuel specifications the maximum PAH content for commercial diesel fuel is around 11 per cent whereas the Euro-VI PAH content limit is 8 per cent. Since the PAH content in the fuel contributes to the toxicity of the diesel exhaust the fuel policies in both India and Europe should focus on reducing the PAH content of diesel fuels.

manufacturers it is although very difficult to guess the correct estimate of how much money will be invested by a car manufacturer to meet the norms, the amount is estimated to be in crores. Not only will the car manufacturers have to spend on upgrading the engines, but they will also have to spend a considerable sum of money for adding new components to the car as well. In the recent interview with the Hindu, Tata motors Managing director and Chief Executive officer, Guenter Butschek has told that he already invested Rupees 1200 crores in the conversion of BSIV engines to BSVI engine upgrades,



as compared to that of petrol engines. Usually, the cost of upgrading a diesel BSVI is higher as compared to the cost of upgrading petrol engines to BSVI. Experts say that developing diesel engines for small vehicle is not very cost-effective because the higher they spend on converting BSIV engines to BSVI engines it will not justify the investments because it will increase the overall cost of the car and would lower the demand for that car in the process. The predictions above were also made by Tata's competitors Maruti Suzuki who also announced that the sale of diesel-powered cars and vehicles would be stopped from April 2020. However other car manufacturers such as Hyundai, Ford and Toyota had stated that they would continue the production of diesel engines to conform with the BSVI norms though they would have to invest much money on them. Tata motors plan to stop producing diesel-powered engine cars by April 2020. The company also said that they would consider reintroducing diesel cars in the market only after investigating the current market scenario and if there is sufficient demand for them in the future. Tata Motors also sells diesel variants of most of its models the new Tata Tiago hatchback gets options to choose from both diesel and petrol. The Nexon compact SUV, Zest sedan and the newly launched Tata Harrier SUV get diesel-powered engine options. Overall the share of diesel vehicles has seen a massive decline from 58 per cent in the year 2012-2013 to 36 per cent in the last year. The main reason for the decline was there was a ban on diesel engines which were more than ten years in the NCR (National capital region), and there was also a small price difference between Petrol and diesel. The diesel engines might be a cheaper and more fuel-efficient option compared to petrol but there are usually very high costs involved in making these engines to conform with the BSVI norms and if demand for that particular car decreases it might not be worth it to invest so much money on the conversion of diesel engines from BSIV to BSVI. Tata's competitors Hyundai, Toyota and Ford will be considering to invest in upgrading their petrol and diesel engines to comply with the BSVI norms. This investment might cause the price of the vehicles to increase to around 8 to 10 per cent but this is not exclusively for diesel vehicles it would include petrol vehicles as well. Hence every car manufacturer will have to decide on their own whether they would like to go ahead with their investment or not.

### **Tata Motors Launches the Tacnet 2.0 to Collaborate with Auto-Tech Start-ups-**

Tata has recently launched a new platform which helps it to collaborate with new start-ups and business models in the auto space. The Tata motors auto-mobility collaboration network 2.0 will allow the company to partner with start-up's and technology-based companies to come up with new solutions in the mobility ecosystems and explore synergies. Tata is mainly looking for business opportunities in the people and the cargo utility space, and the tac net 2.0 theme is based on the areas in which tata motors are interested. Shailesh Chandra, the president of electric mobility business and strategy recently said that, the automobile sector is undergoing a transformation phase in which there is introduction of new and advanced technologies in the manufacturing sector and also digitization of solutions to optimize the operations of the company as well and also developing innovative as well as advanced project technologies in order to engage the customer as well as the

stakeholders. The TACNET operations will also help the outside world to connect with Tata for innovation and collaboration opportunities as well. The company is also looking to develop solutions for the application of blockchain technology in the automotive industry, demand prediction algorithm and real-time monitoring of BSVI fuel quality and also to see whether the spare parts are genuine.

### **2. Maruti Suzuki Strategies to Conform with BSVI Norms-**

Maruti Suzuki recently announced in the press meet that it had received a good response from its customers for its new BSVI range of vehicles which are already available in the market now. The BSVI vehicles which are sold by Maruti Suzuki constitute around 70 per cent of the total petrol vehicles which are sold in the market. Maruti Suzuki is continuing with its commitment to launching environment-friendly vehicles, Maruti Suzuki introduced its first BSVI compliant petrol car Baleno in April in the year 2019. This was followed by the launch of BSVI compliant petrol variants of Alto 800, Wagon R (1.2 litres), Swift Dzire and Ertiga much before the given date for the implementation of BSVI regulations. The upcoming XL6 multipurpose vehicle (MPV) will also conform with the BSVI standards.

### **Maruti Suzuki Expands Its BSVI Car Line-up To 8 Models, And It Sells Over 2 Lakh Units In 2019**

Some of the main BSVI petrol models of Maruti Suzuki include Alto 800, Wagon R (1.2 Litre), Swift Dzire, Ertiga, XL6 and S-Presso. Maruti Suzuki recently sold over two lakh vehicles which are BSVI complaint [24]. This achievement was only achieved in 6 months of the launch of the first BSVI compliant vehicle. Maruti Suzuki recently launched its BSVI range with Alto 800 and Baleno in April 2019, this launch happened One year before the stipulated timeline of April 2020. The complete range of Maruti Suzuki BSVI compliant models includes Alto 800, Baleno, Wagon R (1.2 litres), Swift Dzire, Ertiga and the recently launched XL6 and S-presso.

### **3. Hyundai Motors BSVI Strategies-**

The South-Korean auto-major Hyundai plans to roll out upgraded BSVI compliant models including diesel variants from next year. The company is also planning to keep selling BSIV compliant cars till the end of March of next year but at a slightly lower price. Hyundai recently informed that it would not discontinue producing diesel cars like companies such as Ford and Honda. This means that all the current- diesel-powered Hyundai cars that are including the small ones like the venue, elite i20, Grand i10 and Xcent will get BSVI engines post-April 2020. In comparison to India's largest carmaker by volume, Maruti Suzuki recently said that it would discontinue the production of diesel cars in the BSVI era unless there is enough customer demand for diesel cars during that particular fiscal year. Upgrading the BSIV compliant cars to BSVI emission norms is likely to make them more expensive by about Rupees 1 lakh. Upgrading petrol cars to conform to the BSVI norms will not be so expensive as compared to the likes of diesel cars.



Diesel cars may also lose the edge over their petrol counterparts even for those with high average running numbers. If we consider the cost mentioned above of upgrading the petrol and the diesel engines to the BSVI standards, then the price difference between the Venue Petrol E-variant and the Venue-diesel E variant will go up from the current 1.25 Lakh to Rupees 2.05 lakh. Hyundai also offers a 1.0-litre turbocharged direct-injection petrol engine on the Hyundai venue which is very expensive compared to the 1.2-litre petrol engine. The difference in price between the Venue 1.0S petrol variant and the venue 1.4S diesel is around Rupees 24000 in the BSVI era. The difference in prices between the 1.0 litre powered venue and 1.4-litre venue might go up to Rupees 1 lakh which is the same in the current scenario. Hyundai's subsidiary Kia motors is set to enter the Indian car market with a Hyundai Creta rival soon enough it is going to power its first SUV which has a 1.5-litre diesel engine. This engine could be the only diesel engine for Hyundai small car portfolio while replacing both the 1.4 litre and 1.6 litre engines.

#### 4. Ashok Leyland BSVI Strategies-

Ashok Leyland recently announced that its entire range of heavy-duty commercial vehicles is now BSVI compliant. The heavy-duty commercial vehicle manufacturer has already received the BSVI certification. It is also the first commercial vehicle manufacturer to achieve this feat. The Indian automobile market is moving towards the deadline for the implementation of BSVI emission norms, which is equivalent to the Euro-VI emission norms. In order to update from BSIV emission norms to BSVI, all the automobile manufacturers are planning to implement significant engine changes in their product blueprint and also are putting in many efforts to redesign and upgrade specific components of their vehicles to conform with the BSVI emission norms. In some of the cases, the companies are dumping the older engines and developing and upgrading new ones. Ashok Leyland is way ahead of the rest of the automobile companies when it comes to the implementation of stricter emission regulations. BSVI norms will come into action on April 1<sup>st</sup> 2020, and Ashok Leyland is seven months early to the party [25].

#### VI. CONCLUSION AND FURTHER SCOPE-

The newly introduced BS-VI norms are going to bring a radical change in the Indian automobile sector industry. India will also get low emission producing and more fuel-efficient vehicles soon. Diesel engines will be more expensive as compared to that of petrol engines because they need more adjustment and after-treatments in order to stay clean. So, this will make sure to attract the original equipment manufacturers (OEM) towards hybrid fuels and another environment friendly alternative technology solution providing companies are also going to benefit a lot from the transition. In case of fuel specifications in terms of BSVI the main understanding is that the consequence of the fuel effects on the emission of controlled air pollutants has reduced because of the recent advancements in the engine-after treatment technologies. The modern age engines usually require very low sulphur content in the fuel in order to maintain a strong performance during their need. The efforts put in for the transition from BSIV to BSVI can incredibly help in the reduction of air pollution from

automobiles. This will bring a substantial enhancement in the air quality of highly populated cities as exhaust emission from vehicles are the primary source of air pollution in cities. The researchers could find out more on the strategies adopted by the foreign car manufacturers in order to cope up with the transition from BSIV to BSVI. Researchers can further investigate on the sale strategies adopted by top car manufacturers in order to sell their BSIV compliant vehicles existing in their inventory.

#### REFERENCES-

1. D. Vashist, N. Kumar and M. Bindra, "Technical Challenges in Shifting from BS-IV to BS-VI Automotive Emissions Norms by 2020 in India: A Review", *Archives of Current Research International*, vol. 8, no. 1, pp. 1-8, 2017. Available: 10.9734/acri/2017/33781 [Accessed 30 November 2019].
2. D. Vashist, N. Kumar and M. Bindra, "Technical Challenges in Shifting from BS-IV to BS-VI Automotive Emissions Norms by 2020 in India: A Review", *Archives of Current Research International*, vol. 8, no. 1, pp. 1-8, 2017. Available: 10.9734/acri/2017/33781 [Accessed 30 November 2019].
3. Bharat stage emission standards", *En.wikipedia.org*, 2019. [Online]. Available: [https://en.wikipedia.org/wiki/Bharat\\_stage\\_emission\\_standards](https://en.wikipedia.org/wiki/Bharat_stage_emission_standards). [Accessed: 30- Nov- 2019].
4. Clearing the air on BSVI", *Autocar India*, 2019. [Online]. Available: <https://www.autocarindia.com/car-news/bs6-emission-norms-all-you-need-to-know-413968>. [Accessed: 30- Nov- 2019].
5. R. Abraham, "Confused by the SC's BSVI ruling? Here's what it means for your existing car", *The Economic Times*, 2019. [Online]. Available: <https://economictimes.indiatimes.com/magazines/panache/confused-by-the-scs-bsvi-ruling-heres-what-it-means-for-your-existing-car/articleshow/70853624.cms?from=mdr>. [Accessed: 30- Nov- 2019].
6. Abraham, "Confused by the SC's BSVI ruling? Here's what it means for your existing car", *The Economic Times*, 2019. [Online]. Available: <https://economictimes.indiatimes.com/magazines/panache/confused-by-the-scs-bsvi-ruling-heres-what-it-means-for-your-existing-car/articleshow/70853624.cms?from=mdr>. [Accessed: 30- Nov- 2019].
7. Clearing the air on BSVI", *Autocar India*, 2019. [Online]. Available: <https://www.autocarindia.com/car-news/bsvi-emission-norms-all-you-need-to-know-413968>. [Accessed: 01- Dec- 2019].
8. [8]"BSVI Norms In 2020 Will Increase Price Gap Between New Petrol and Diesel Cars - CarandBike", *CarandBike*, 2019. [Online]. Available: <https://auto.ndtv.com/news/bsvi-norms-in-2020-will-increase-price-gap-between-new-petrol-and-diesel-cars-1965628>. [Accessed: 01- Dec- 2019].
9. C. Dhabhar, "BSVI Norms In 2020 Will Increase Price Gap Between New Petrol And Diesel Cars - CarandBike", *CarandBike*, 2019. [Online]. Available: <https://auto.ndtv.com/news/bsvi-norms-in-2020-will-increase-price-gap-between-new-petrol-and-diesel-cars-1965628>. [Accessed: 01- Dec- 2019].
10. 2019. [Online]. Available: <https://www.marutisuzuki.com/corporate/media/press-releases/2019/maruti-suzuki-goes-greener-with-environment-friendly-bsvi-compliant-vehicles>. [Accessed: 01- Dec- 2019].
11. Clearing the air on BSVI", *Autocar India*, 2019. [Online]. Available: <https://www.autocarindia.com/car-news/bsvi-emission-norms-all-you-need-to-know-413968>. [Accessed: 30- Nov- 2019].
12. Mahindra BSVI diesel engine strategy revealed", *Autocar India*, 2019. [Online]. Available: <https://www.autocarindia.com/car-news/mahindra-bsvi-diesel-engine-strategy-revealed-412965>. [Accessed: 01- Dec- 2019].
13. B. Store, "BSIV to BSVI: Understanding the Implications of Structural Changes | CarDekho Gaadi Store", *Cardekho Gaadi Store*, 2019. [Online]. Available: <https://www.gaadi.com/blog/bsiv-to-bsvi-understanding-the-implications-of-structural-changes/>. [Accessed: 01- Dec- 2019].

14. Technical background on India BS VI fuel specifications | International Council on Clean Transportation", *Theicct.org*, 2019. [Online]. Available: <https://theicct.org/publications/technical-background-india-bs-vi-fuel-specifications>. [Accessed: 01- Dec-2019].
15. *Egazette.nic.in*, 2019. [Online]. Available: <http://egazette.nic.in/WriteReadData/2016/168300.pdf>. [Accessed: 01- Dec- 2019].
16. A. Hochhauser, "Review of Prior Studies of Fuel Effects on Vehicle Emissions", *SAE International Journal of Fuels and Lubricants*, vol. 2, no. 1, pp. 541-567, 2009. Available: 10.4271/2009-01-1181.
17. J. Reijnders, M. Boot and P. de Goey, "Impact of aromaticity and cetane number on the soot-NOx trade-off in conventional and low temperature combustion", *Fuel*, vol. 186, pp. 24-34, 2016. Available: 10.1016/j.fuel.2016.08.009 [Accessed 26 November 2019].
18. J. Reijnders, M. Boot and P. de Goey, "Impact of aromaticity and cetane number on the soot-NOx trade-off in conventional and low temperature combustion", *Fuel*, vol. 186, pp. 24-36, 2016. Available: 10.1016/j.fuel.2016.08.009 [Accessed 26 November 2019].
19. A. Hochhauser, "Review of Prior Studies of Fuel Effects on Vehicle Emissions", *SAE International Journal of Fuels and Lubricants*, vol. 2, no. 1, pp. 541-567, 2009. Available: 10.4271/2009-01-1181.
20. Worldwide Fuel Charter 2019 - Gasoline and Diesel Fuel | ACEA - European Automobile Manufacturers' Association", *Acea.be*, 2019. [Online]. Available: <https://www.acea.be/publications/article/worldwide-fuel-charter-2019-gasoline-and-diesel-fuel>. [Accessed: 01- Dec- 2019].
21. How a Turbocharger Works | Cummins Inc.", *Cummins Inc.*, 2019. [Online]. Available: <https://www.cummins.com/components/turbo-technologies/turbochargers/how-a-turbocharger-works>. [Accessed: 01- Dec- 2019].
22. Mahindra BSVI diesel engine strategy revealed", *Autocar India*, 2019. [Online]. Available: <https://www.autocarindia.com/car-news/mahindra-bsVI-diesel-engine-strategy-revealed-412965>. [Accessed: 01- Dec- 2019].
23. Mahindra BSVI diesel engine strategy revealed", *Autocar India*, 2019. [Online]. Available: <https://www.autocarindia.com/car-news/mahindra-bsVI-diesel-engine-strategy-revealed-412965>. [Accessed: 01- Dec- 2019].
24. Maruti Suzuki BS-VI Car Line-up Expands to Eight Models, Sells Over 2 Lakh Units in 2019", *News18*, 2019. [Online]. Available: <https://www.news18.com/news/auto/maruti-suzuki-bs-vi-car-lineup-expands-to-eight-models-sells-over-2-lakh-units-in-2019-2333445.html>. [Accessed: 01- Dec- 2019].
25. S. Neil, "Ashok Leyland Becomes First CV Manufacturer With BS-VI Certification for Its Heavy Trucks Range", *www.drivespark.com*, 2019. [Online]. Available: <https://www.drivespark.com/four-wheelers/2019/ashok-leyland-becomes-first-commercial-vehicle-manufacturer-to-get-bsVI-certification-029294.html>. [Accessed: 01- Dec- 2019].

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