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Market Evaluation for Resource Efficiency and Re-use of Secondary Raw Materials in the Automotive Sector

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Final Report

Market Evaluation for Resource Efficiency and Re-use of Secondary Raw Materials in the Automotive Sector

August 2015

Abbreviations

ACMA	Automotive Component Manufacturers Association of India
ASEAN	Association of South East Asian Nations
AISI	American Iron and Steel Institute
BIW	Body In White
Bn	Billion
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
B2B	Business To Business
B2C	Business To Customer
CAGR	Compound Annual Growth Rate
Capex	Capital Expenditure
CENVAT	Central Value Added Tax
CII	Confederation of Indian Industry
CV	Commercial Vehicles
DHI	Department of Heavy Industries
DIFM	Do-It-For-Me
DIY	Do-It-Yourself
DSIR	Department of Scientific and Industrial Research
EIS	Electric Ignition Systems
ERP	Enterprise Resource Planning
EVs	Electric Vehicles
EY	Ernst & Young
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
Govt.	Government
HSS	High Strength Steel
HSLA	High Strength Low Alloy
IFEU	Institut für Energie und Umweltforschung
ISO	International Standards Organization
INR/Rs.	Indian National Rupee/Rupees
JV	Joint Venture

LCV	Light Commercial Vehicle
M&HCV	Medium & Heavy Commercial Vehicle
MNC	Multi-National Corporation
MoEFCC	Ministry of Environment and Forests and Climate Change
MoU	Memorandum of Understanding
MSME	Micro, Small and Medium Enterprises
MUV	Multi Utility Vehicle
NCR	National Capital Region (Comprising of urban areas around the capital city of Delhi)
OOE	Overall Equipment Effectiveness
OEMs	Original Equipment Manufacturers
OES	Original Equipment Suppliers
OE	Original Equipment
PMP	Phased Manufacturing Programme
PV	Passenger Vehicles (4 wheeler passenger cars)
RE	Resource Efficiency
RFID	Radio Frequency Identification
R&D	Research and Development
SCM	Supply Chain Management
SEZ	Special Economic Zone
SIAM	Society of Indian Automobile Manufacturers
SIDBI	Small Industries Development Bank of India
SMEs	Small and Medium-Sized Enterprises
TERI	The Energy and Resources Institute
UHSS	Ultra High Strength Steel
ULSAB	Ultralight Steel Auto Body
USAB	Ultralight Steel Auto Body
USD	U.S. Dollar (Conversion factor assumed 1 USD = INR 60)
VDIZRE	VDI Centre For Resource Efficiency
FY	Financial Year (April-March)
2W	Two wheelers
3W	Three wheelers

Executive Summary

India, over the last few decades, has witnessed significant growth in population, increased industrial production and income, rising middle class population and rapid urbanization. With the growing future demand of resources in India, resource efficient production processes and consumption patterns need to be adopted along with the increased use of secondary materials. The resource-efficiency enhancement will result in immediate costs reduction and improve competitiveness of India's industrial sector while tackling environmental and social issues.

In India, automotive industry is one of the main pillars of the economy; with strong backward and forward linkages, it is a key driver of growth. The contribution of this sector to the National GDP rose from 2.77% in 1992-93 to about 7.1% in 2014. It provides direct and indirect employment to over 19 million people. The automotive sector is marked by a sharp rise in vehicle (Passenger car and two wheelers) ownership and will be a main consumer of key industrial metals. As part of the Resource efficiency project, the Indian automotive sector (majorly auto-component sector) has been identified as a potential sector focusing on the entry points for resource efficient production processes. This study focusses on the raw material consumption (mainly ferrous and non-ferrous metals) and the current practices of increasing the resource efficiency in the auto component sector.

The Indian automobile industry produced close to 18 million 2 wheelers and about 3 million passenger vehicles in FY 2014. The total market size of the Indian auto component industry is close to USD 35 billion out of which USD 10.2 billion are the direct exports of components. India is estimated to have the potential to become one of the top five auto component economies by 2025. Presently the Auto component Industry manufactures a wide range of products in India for both domestic consumption and exports. The Indian auto component industry is balanced in its contribution at components level like engine parts (20%), drive transmission and steering parts (10%), body and structural (40%), suspension and braking parts (10%), interior (10%) and electrical parts (10%) (by revenue).

Automotive sector is one of the biggest metal product consumers. Steel, Aluminium, Copper, Magnesium and Zinc are widely used in the automobile industry. Apart from these metals, fibre, plastics and glass are also used to manufacture vehicles. The sector consumes about 12% of global steel production and 15% of aluminium production. In spite of tremendous efforts being made to develop vehicles made of all aluminium auto body (because of its light-weight nature), most light weight cars today are composed of 57% steel, 7% iron, 8% plastic, 8% aluminium. Other materials account for the remaining 20%.

Major Findings - Top 10 components, raw materials and resource efficiency practices:

The findings of the study are based on the facts and views shared by auto component companies having a manufacturing base in Delhi/NCR region and secondary analysis of auto components sector across India. The study included face to face discussions and telephonic interviews with auto component manufacturers (OES, Tier-1, Tier-2), automotive manufacturers (OEMs), industry associations (ACMA, SIAM) and industry experts to understand the major factors affecting the resource efficiency in auto component manufacturing sector to understand the challenges faced by the Indian auto component industry with respect to raw material consumption, production processes (percentage yield and waste generated), input cost, quality, delivery schedule, scaling up operations and government policies. Many of the top executive of the companies are increasingly buoyant about India's prospects for the growth in coming years both in terms of manufacturing growth, technology advancement, domestic consumption, exports and investments etc.

Below are the identified top 10 auto components in a vehicle by their resource intensity specified below. These components consume about 60-70% of total raw material required in a vehicle (combined for 2 wheeler and 4 wheeler).

1. Frame
2. Axle
3. Cylinder Block
4. Gearbox
5. Flywheel
6. Wheel Rims
7. Disc Brake
8. Clutch
9. Connecting Rod
10. Piston

The major raw materials consumed in these components – iron, steel, aluminium, silicon etc. have been estimated along with production of these components based on secondary research as well as interviews with component manufacturers.

The increasing requirement of key industrial metals (Steel, Aluminium etc.) can be fulfilled to a great extent by recycling because these key metals do not lose most of the inherent physical properties during the lifetime, which can be repeated ad infinitum. Heat treatment and surface modification are the key technologies available today, to enhance the effective use of materials, to achieve the desired properties of the components used in the automotive industries.

Metal recycling sector is one of the neglected sectors in India because of lack of awareness within the metals ecosystem and lack of incentive programs, and policies in the sector.

Current practices in resource efficiency in the auto component sector in India:

- Most of the waste scrap metal generated from the auto component manufacturing gets recycled by selling it to the recyclers or back to the material suppliers through buy back agreements.
- The vehicles OEMs keep full control over the raw materials for most of the components as well as their sourcing.
- The vehicle OEM approval is required to introduce any changes in the material or processes in component manufacturing which leads to inflexibility.
- The component manufacturers in India do not have much design capabilities which generally are taken care by OEM; this makes it difficult to introduce changes in the processes or materials which may lead to better efficiencies.
- The incentive for taking up of resource efficiency initiatives is not too high for the auto component manufacturers, since the cost savings gets passed to the vehicle OEM directly.
- There is a good scope of technology up gradation in forging as well as training requirements, in the absence of which about 20% of material gets wasted. The forging units are generally very small and do not get soft loans or financing at low interest rate which hinders the technology up gradation.
- As per an estimate from SIAM, with efficient recycling, India can hope to recover by the year 2020 over 1.5 million tons of steel scrap, 180,000 tons of Aluminium scrap and 75,000 tons each of recoverable plastic and rubber from scrapped automobiles.

Challenges and support required for enhancing resource efficiency:

- Lower production efficiency and low-end technology in production systems
- Lack of Support for innovation (R&D Centres) and testing facilities to attain global standards of operational efficiency and productivity, build R& D competence of Auto Component Sector.
- Recycling in India is carried out mostly manually in the un-organized sector without any consideration for the environment and safety of the people.
- Import duty on secondary raw materials import resulted in cost and uncompetitive in both domestic and export markets
- Non-availability of easy access to Capital (funds / soft loans) for expansion and up-gradation
- Inadequate availability of skilled labour (Training and skill development centre network), interaction between institutes and the industry to minimizing the gap between skill requirement and the availability.
- Rationalization of labour laws to ensure availability of human resources with the requisite skill and competence
- Up-gradation and debottlenecking of rail, road, port and power infrastructure
- No specific policy on ELV, Vehicles and recyclability of the materials or material reduction used in the vehicles

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1. Introduction

1.1 Background

India, over the last few decades, has witnessed significant growth in population, increased industrial production and income, rising middle class population and rapid urbanization. This has substantially impacted India's resource consumption patterns. Natural resources provide essential inputs to production in India. Apart from production, the extraction, processing and ultimate disposal of materials are an important source of income and jobs in the country. These activities also impact the environment to a greater or lesser extent. Natural resources are also part of the ecosystems that support the provision of services such as climate regulation, flood control, natural habitats, amenities and cultural services that are necessary to develop man-made, human and social capital.

The use of materials from natural resources in production and consumption processes has many environmental, economic and social consequences that extend beyond borders and affect future generations. Although India's per capita materials consumption is among the lowest in the world, the absolute material consumption has increased sharply. The main features of current and future dimensions of India's resource requirements[1] are as follows:

- India has become a net importer of raw materials dominated by fossil fuels and metal
- Demand for materials is expected to be 45 billion tonnes by 2050
- Per capita consumption expected to increase from 4 tons to 16 or even 28 tons
- Higher extraction and consumption of natural resources are strongly linked to global and regional environmental problems including climate change, deforestation, biodiversity loss and pollution.
- Negative health effects and vulnerability to natural hazards are increasing.
- Sharp increase in demand for finite raw materials that have only limited substitutes.
- Supply shortages and price volatility could endanger economic development.

With the growing future demand of resources in India, resource efficient production processes and consumption patterns need to be adopted along with the increased use of secondary materials. The

[1] Current and future dimensions of India's resource requirements, Indo – German Environment Partnership, Nov. 2013

resource-efficiency enhancement will result in immediate costs reduction and improve competitiveness of India's industrial sector while tackling environmental and social issues.

Box 1: The Resource Efficiency Project

The Resource Efficiency project has been commissioned for 3 years (05/2014 – 04/2017). Its objective is to enable Indian institutions responsible for the formulation of environment, climate, industry and resources policy to provide incentives and establish institutional frameworks that improve resource efficiency and the management of secondary materials as a vital contribution to environment and climate protection.

Resource Efficiency Project Design (work packages) includes following:

Analysis of Potential & Constraints
Common understanding of the concepts of resource efficiency and use of secondary materials and their meaning for sustainable and inclusive economic development, the project assesses potential and constrains, policy framework, existing and potential incentives to identify specific support areas and potential interventions.

Agenda Setting & Policy Dialogue
With a solid understanding of the ground realities, the project seeks to firmly establish the topic of resource efficiency amongst private and public institutions in order to design an enabling environment for resource-efficient production and to form incentives for creating a market for secondary materials. To do so a "resource panel" will be established.

Advisory Services for Corporations (Especially SMEs) & Pilot Projects
Specific demonstration projects in the construction and mobility sectors will be undertaken to illustrate how to enhance resource efficiency through process innovation and use of secondary materials. Resource efficiency trainings will complement this process.

The sectors identified for relevant resource efficiency enhancement potential are as follows:

- **Construction and the demolition waste**
- **Mobility (Automotive) Sector**

The outcomes of the Resource Efficiency Project will help to develop a larger policy framework in India for addressing the key environmental related challenges arising from material production and use as identified in the National Environmental Policy. The project will also demonstrate how primary material demand can be minimized through reuse of waste materials at different stages of the materials life cycle. It will contribute to existing knowhow and practices by collaborating with and engaging various stakeholders

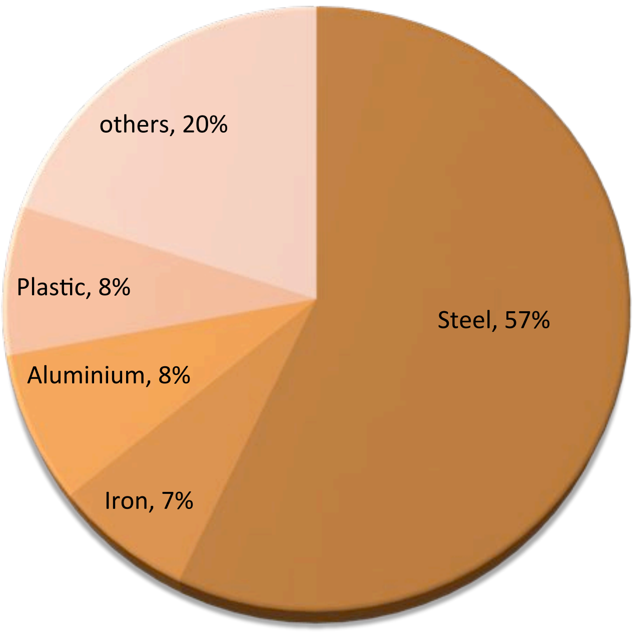
The implementation of the activities under the three working packages is being supported through various implementing partners: the Development Alternatives Group and The Energy and Resources Institute (TERI) in India, jointly with the Institut für Energie und Umweltforschung (IFEU) and the VDI Centre for Resource Efficiency (VDI ZRE) from Germany. The project will moreover work with intermediaries like industrial associations (e.g. Automotive Component Manufacturers Association of India (ACMA),Society of Indian Automotive Manufactures (SIAM)).

The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has commissioned GIZ to implement the Indo-German Project on Resource Efficiency jointly with the Indian political partner, the Indian Ministry of Environment and Forests and Climate Change (MoEFCC). The title of this large umbrella project is **"Fostering Resource Efficiency and Sustainable Management of Secondary Raw Materials" (in short: Resource Efficiency).** Its objective is to enable Indian institutions responsible for the formulation of environment, climate, industry and resources policy to provide incentives and establish institutional frameworks that improve resource efficiency and the management of secondary materials as a vital contribution to environment and climate protection.

1.2 About the Study

The automotive sector is a major segment of developed and developing economy, a large amount of GDP of economies is directly or indirectly dependent on this sector. In India, automotive industry one of the main pillars of the economy, with strong backward and forward linkages, it is a key driver of growth. The contribution of this sector to the National GDP rose from 2.77% in 1992-93 to about 7.1% in 2014[2]. It provides direct and indirect employment to over 19 million people[3]. India is fast turning into a global automotive hub.

Figure 1: Typical Raw Material Consumption In Passenger Car (By Weight)[4]



[2] Review of automotive mission plan 2006-2016, Department of Heavy Industries , Govt. Of India
[3] Review of automotive mission plan 2006-2016, Department of Heavy Industries (GoI) , Govt. Of India
[4] Velury Vijay Bhasker(2013), Indian Auto Component Industry: A Decade of Growth and Way Forward , Research Journal Of Management Sciences

Automotive sector is one of the biggest metal product consumers. Steel, Aluminium, Copper, Magnesium and Zinc are widely used in the automobile industry. Apart from these metals, fiber, plastics and glass are also used to manufacture vehicles. The automotive sector is the second largest steel consumer with about 12% of global steel consumption[5]; however the aluminum intensity is increasing with improvement in technology and demand of high efficient vehicles. Typical material consumption in passenger cars (by weight) is presented in the figure below, steel is a major raw material for manufacturing passenger car, it forms 50-60% of Car by weight and 80% by cost of raw material.

The automotive sector is marked by a sharp rise in vehicle (Passenger car and two wheelers) ownership and will be a main consumer of key industrial metals. However the increasing requirement of key industrial metals (Steel, Aluminium etc.) can be fulfilled by the great extent by recycling because these key metals do not lose any of its most of the inherent physical properties during the lifetime, which can be repeated ad infinitum. Steel and aluminium are 100% recyclable and therefore, recycled metals can be used for the same applications as steel produced from virgin material. As part of the Resource efficiency project, the Indian automotive sector has been identified as a potential sector focusing on the entry points for resource efficient production processes. Increasing the use of secondary metals will reduce the currently high input of primary materials, thus easing the stress on the environment while saving cost and reducing supply dependencies.

1.3 Scope of the Study

The present study focussed on the Indian automotive market, specifically on component industry and comprehensive data collection and analysis. The objective of the study is to identify the major characteristics and processes, key product categories, challenges and opportunities of the auto component production processes for resource efficient production and design capacities. The study covers and delineates the following:

1. A macro level overview of the Indian automotive market
2. Resource efficient practices of the automotive component manufacturers
3. General production in-efficiencies and potentials for improvement in the processes
4. Status for the use of secondary raw materials from internal sources as well as other markets (import)
5. Case studies on some successful demonstration of the resource efficient and environmentally sustainable auto component manufacturing and possible linkages for the by-products and end-products for the closed loop economy
6. Identification of potential companies/ stakeholders for implementing pilots related to resource efficiency and secondary resource usage in production

[5] World Steel Association

This study has focus on the raw material consumption (mainly ferrous and non-ferrous metals) and the current practices of increasing the resource efficiency in the auto component sector. The specified geographic preference for conducting the study was specified as Delhi/NCR (as a hub of automotive industry) region, however a macro level data for other auto hubs have also been reviewed and analysed. The study report includes the following:

- **Market Overview (Indian Auto Industry) on the resource efficiency and sustainability at product's life cycle including production to operation to recycling;**
  - General Market conditions, trends of OEMs (Macro Level) and supply chain linkages
  - General Market conditions, trends of Component Industry and supply chain linkages
  - Extent of the duplicate/ non-OES market and effects on the industry
  - List of most important components by volume of raw material use (Top 10)
  - List of most important components by volume of sales (Top 10)
  - Future forecasts (demand and supply side) for the volumes of sales and raw material usage
- **Issues affecting the technological process chains of the automotive sector (both OEMs and Component Suppliers)**
  - Indian regulatory issues
  - International trade
- **Resource use and supply for the auto component sector (including identification of constraints)**
  - Most important/ widely used materials and sources (raw vs secondary & domestic vs imports) for the most important components
- **Resource Efficiency practices adopted by the automotive component industry in India (including best practices examples)**
  - Degree of secondary material use (and related constraints)
  - Process changes/ improvements and product design incorporating Resource Efficiency
- **Potential for Resource Efficiency improvements and innovation in the component industry**
  - Use of secondary material
  - Process changes/ improvements and product design incorporating Resource Efficiency
- **Identification of potential candidates (companies/ industry sub-sectors) for implementing pilots for resource efficiency based on but not limited to the following specified criteria:**
  - The selected organisation must have ready investment to complete the project (max. 2 years)
  - Must have technical competence
  - Must have a strong interest and initiative to jointly develop a demonstrable plan

This study is mainly focused on the Indian auto components industry (mainly Tier-1 and tier-2 suppliers) special focus on passenger vehicles (two wheelers and four wheelers) and light commercial vehicles. The study provides extensive information and analysis on OEMs and OES in the country, overview of auto component sector across India (superficially covers the secondary/duplicate market). Sales, growth rate, market share, forecasts for the auto component sector, provide detailed information and list of major auto component manufacturers in Delhi and NCR region. The mapping of secondary market has also been conducted with detailed supply chain analysis.

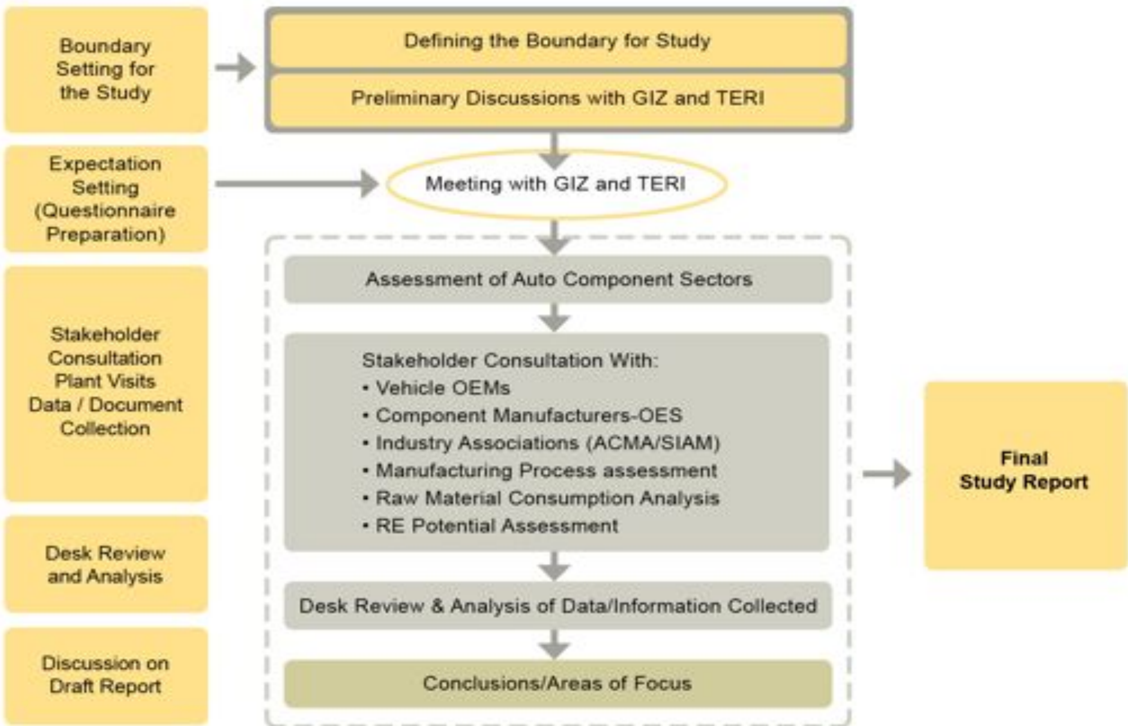
The study also identifies the top 10 auto components (parts) by maximum resource consumption (weight of material per unit component) and by sales volume (no of units sold per year) based on the mix of stakeholder interviews conducted and the secondary research. The overview of Resource Efficiency in the auto component industry in India, current practices, approaches; best practices and obstacles (technical and financial) have also been discussed in the report.

As a part of this study the regulatory and policy environment and framework including the relevant policies/standards/guidelines from government, industry associations and private sector has also been reviewed. The detailed approach and methodology adopted for conducting study has been discussed in the following section of the report.

1.4 Approach and Methodology

The approach and methodology adopted for conducting this study is depicted in the figure below:

Figure 2: Approach and Methodology for the Study



Interviews & Questionnaires:

Questionnaire has been designed for OEMs and OES to collect the qualitative and quantitative information on auto component industry. The core set of qualitative questions and quantitative questions (to create substance of comparative data) has been developed. The questionnaire has been used to Identifying constraints faced by stakeholders; the questionnaire was focused on following:

- Raw Material Consumption, production capacity and growth plans
- Resistance to technology advancement adoption for RE
- Market competition and uncertainty for raw material and product
- Government support systems for production efficiency and improvement in RE
- Ability to implement resource efficiency practices
- Cost implications and availability of financial resources
- Level of top management commitment and organizational encouragement

The questionnaires from the stakeholder consultation meetings have been annexed to this report.

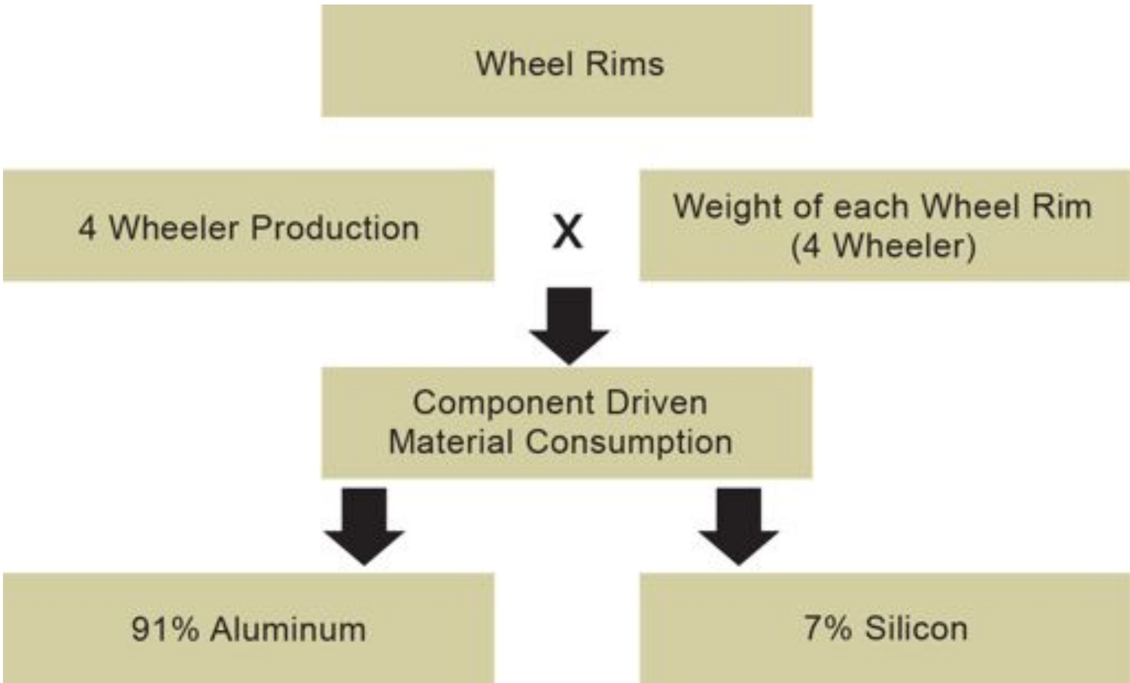
Methodology for Calculations:

The methodology for creating data pertaining to the material flows in the auto market was designed with the view that no such information exists formally. The market reports and other desk top research revealed that information concerning only the financial implications was available. Therefore, while designing the survey questionnaire, specific questions were incorporated to access general information which would be used in building data combined with secondary and market research. Also, it must be understood that aforementioned questions were deliberately made to look general in order to appear non-threatening to the perceptually secretive interviewee companies.

As a first step, point number 8 from the Questionnaire's General Information, provided a rough idea of an interviewee company's annual production. This snapshot was further elaborated by the Question 1 (a) and (b) of "Resource Use for Products" which provided the estimated consumption of type and quantity of raw materials in the production processes. In the "Major Output" section, the overall rough demand of a particular sub component is recorded and later forecasted in Questions 2(a) and (b). Once these estimated data were collected from the survey and secondary sources, the backward calculation method was envisioned to be the most effective in assessing the findings and their archiving.

As an example, in the case of sub component, "Wheel Rims", we found the weight of 4 wheeler's Rim to be 6 kg through the survey and secondary research. The distribution of materials used were also estimated from the survey and secondary research; in this case Aluminium was estimated to comprise 91% of the total material consumed whereas Silicon was estimated to be 7%. From SIAM and other such sources, the overall sales of 4 wheelers in the year 2014 was already known and from here the estimated demand for Wheel Rims was predictable (Assumption: Each 4 wheeler will have 4 wheels hence 4 wheel rims). These findings were later collated with the overall demand estimates in the industry and collated accordingly to find macro level data. Forecasts were then estimated using GDP and industry growth numbers over the time horizon.

Further descriptions are provided in the annexure section comprising of top 10 identified components. The following figure illustrates the calculation in action and is applicable to all sub components. Sample calculation is as follows:

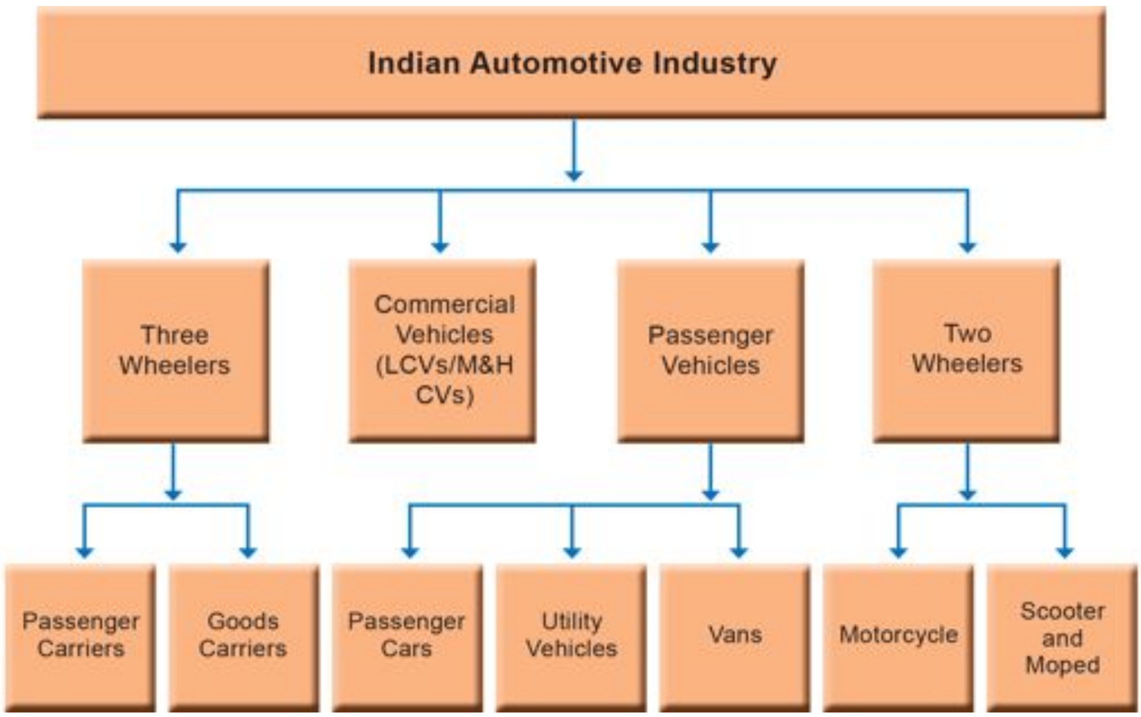


2. Overview of Indian Automotive Industry

The automotive industry in India is one of the largest automotive markets in the world. India has one of the world's fastest growing passenger car markets and second largest two wheeler manufacturer[6]. The Indian Automotive Industry embarked on a new journey in 1991 with de-licensing of the sector and subsequent opening up for 100% FDI through automatic route. Since then almost all the global majors have set up their facilities in India taking the level of production of vehicle from 2 million in 1991 to 29.4 million estimated in 2015. Aptly, the sector was christened as the 'Sunrise Sector' of the economy.

The growth of Indian middle class with increasing purchasing power along with strong growth of economy over a past few years have attracted the major auto manufacturers to Indian market. The market linked exchange rate and availability of trained manpower at competitive cost have further added to the attraction of Indian domestic market.

Figure 3: Genre of Indian Automotive Industry[7]



[6] Automotive Mission Plan 2006-2016, Department of Heavy Industries, Government Of India
[7] Classification as per SIAM

2.1 Market Study Of Indian Automotive Sector

The Indian economy has grown at an average rate of around 9 % over the past five years[8] and is expected to continue this growth in the medium term. This is predicted to drive an increase in the percentage of the Indian population able to afford vehicles. India's car per capita ratio (expressed in cars per 1,000 populations) is currently among the lowest in the world's top 10 auto markets. The turnover of automotive industry was more than 45% of the manufacturing GDP of India during FY2014.

The importance of this industry to the national economy can be seen by way of the size of its turnover compared to India's GDP and contribution across several other parameters[9]:

- 7.1% of India's GDP
- 27% of India's industrial GDP
- 4.3% of overall exports (second only to textiles & handicrafts)
- 13% of excise revenues
- Incremental employment generation in excess of 19 million since FY06
- Total investment in excess of US$ 35 bn of which US$ 24 bn is contributed by automobile companies while US$ 11 bn is contributed by automotive component companies
- 8% of the country's R&D expenditure

The domestic automotive industry has been growing at impressive rates and is expected to witness strong growth in vehicle production till 2020 across all segments (major growth in passenger vehicles i.e. Cars and Two Wheelers). Achievement of these production volumes will position India as one of top 5 vehicle producing country in the world. However, the sector displays an uneven growth trajectory, barring the scooter segment, each and every other vehicle segment showed negative growth in the last financial year (2013-14). Some of the areas causing distress in the automotive sector are: slowdown in economic growth, high cost of vehicle finance, high interest rates, high fuel prices, high inflation and negative market sentiments, increase in the commodity prices, high customs duty on Alloy Steel, Aluminium Alloy and Secondary Aluminium Alloy, high rate of service tax and excise duty, high and varied rate of road taxes in the States, low growth of export markets etc.

Government has taken some fiscal and other measures to put the industry back on track. As a result, reduction in excise duty in case of cars, two wheelers and truck chassis was announced. Further, some other measures are urgently required to be taken, such as, removal of customs duty on raw materials such as steel and aluminium, revisit of CENVAT rules, review of import policy, duty draw back schemes, excise and customs rules, direct tax benefit to promote automotive R&D, and , above all, containing inflation and control of interest rates to make loans more affordable to the people etc.

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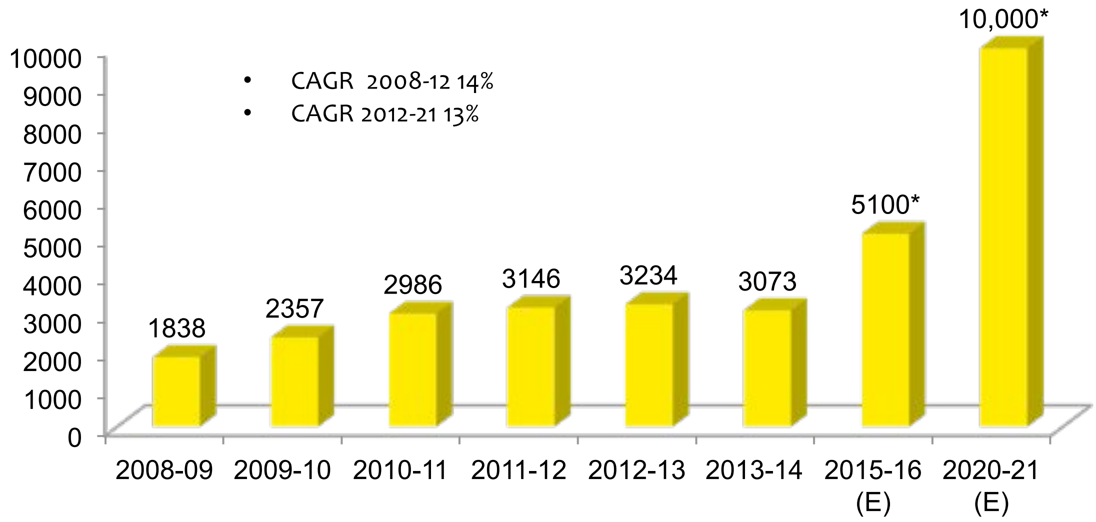
[8] CRISIL
[9]Review of automotive mission plan 2006-2016, Department of Heavy Industries , Govt. Of India

The growth trend and projection of major segment of automotive sector depicted in the following graphs:

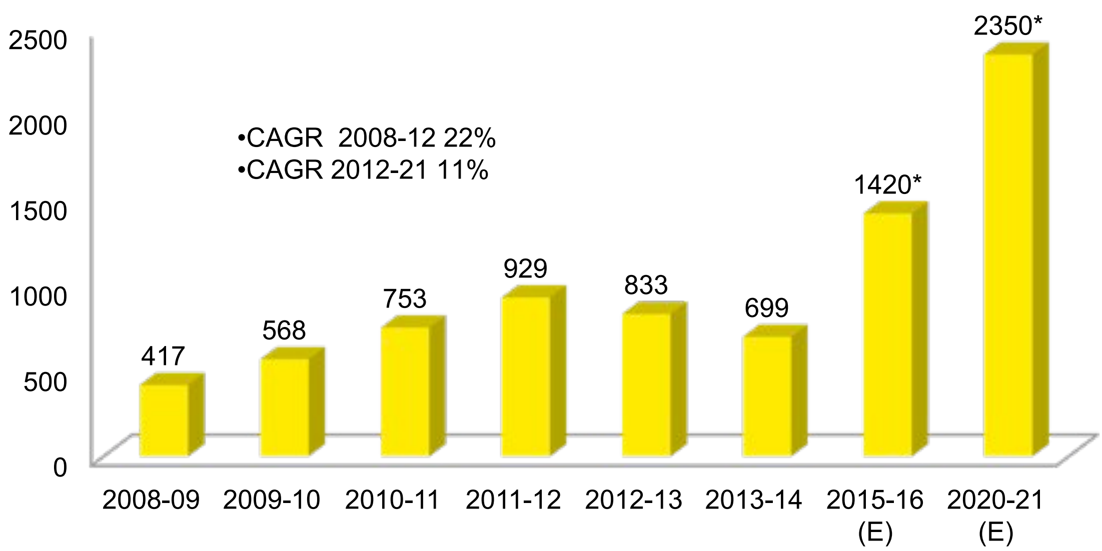
Figure 4: Production of Passenger Vehicles in India (Number in Thousands)



Source: SIAM, EY Analysis
Figures for financial year *(E)estimates

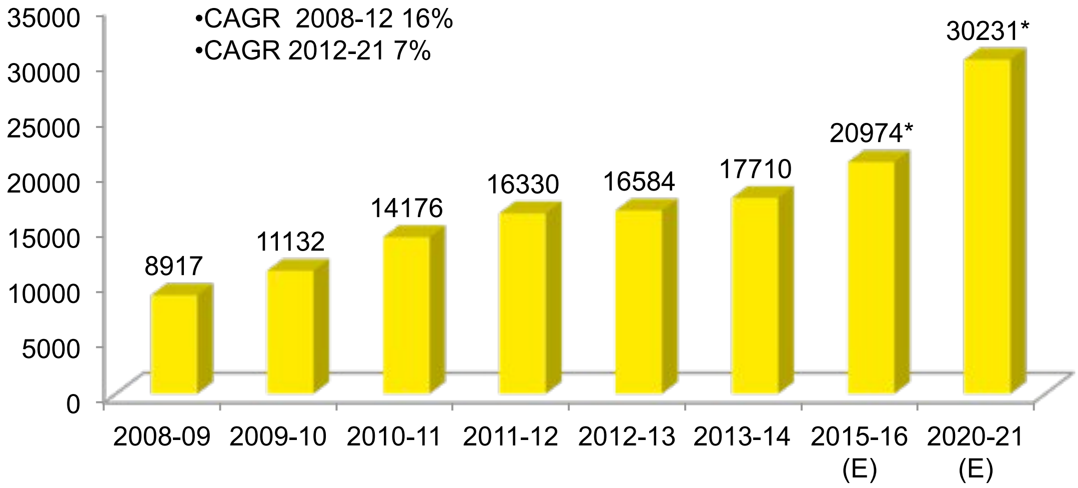
The growth of the auto sector has slowed down post 2012 owing to a combination of factors like service term changes, tax hikes and slowing auto sales. This is also attributed to the less demand of vehicles due to rising petrol prices, economic slowdown leading to negative customer's sentiments.

Figure 5: Production of Commercial Vehicles in India (Number in Thousands)



Source: SIAM, EY Analysis Figures for financial year *(E) estimates

Figure 6: Production of Two and Three Wheelers in India (Number in Thousands)



Source: SIAM, EY Analysis   Figures for financial year *(E) estimates

2.2 Market Size of Indian Automobile Industry

The automobile industry accounts for 22 % of the country's manufacturing gross domestic product (GDP)[10]. An expanding middle class, a young population, and an increasing interest of the companies in exploring the rural markets have made the two wheelers segment (with 80 % market share) the leader of the Indian automobile market. The overall passenger vehicle segment has 14 % market share[11]. India is also a substantial auto exporter, with solid export growth expectations for the near future.

Various initiatives by the Government of India and the major automobile players in the Indian market is expected to make India a leader in the Two Wheeler and Four Wheeler market in the world by 2020. The following graph presents the market size (domestic sales and export) of two wheelers and passenger car segments:

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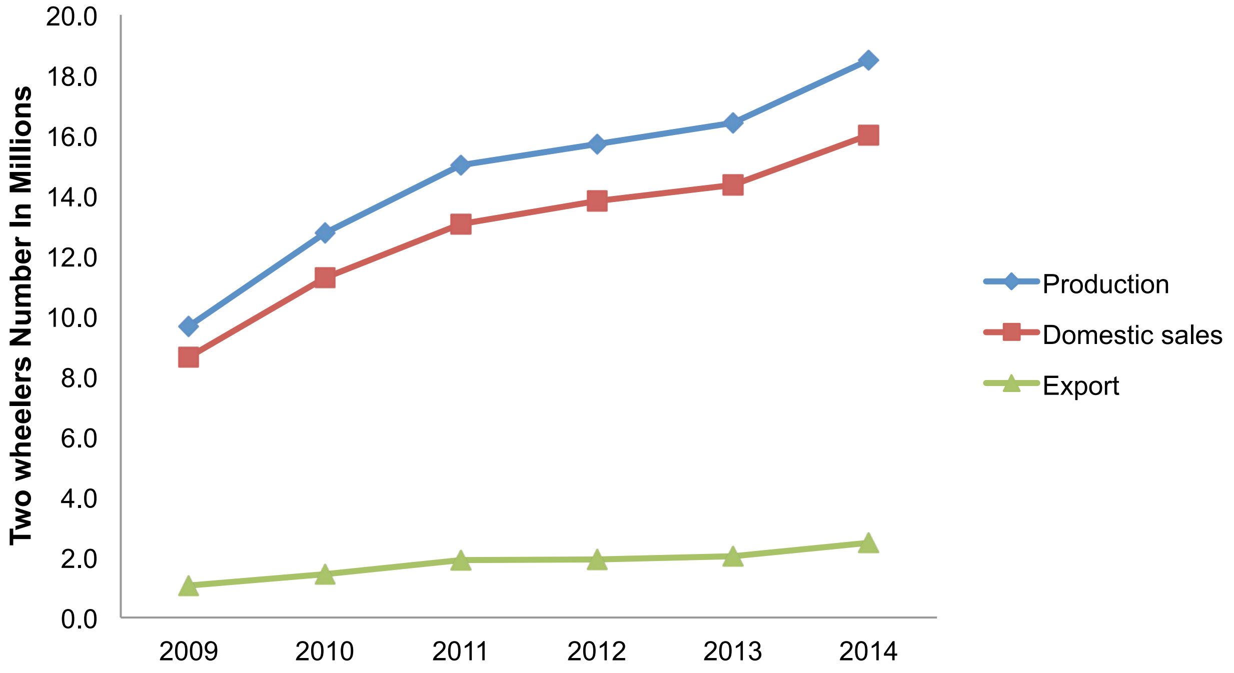
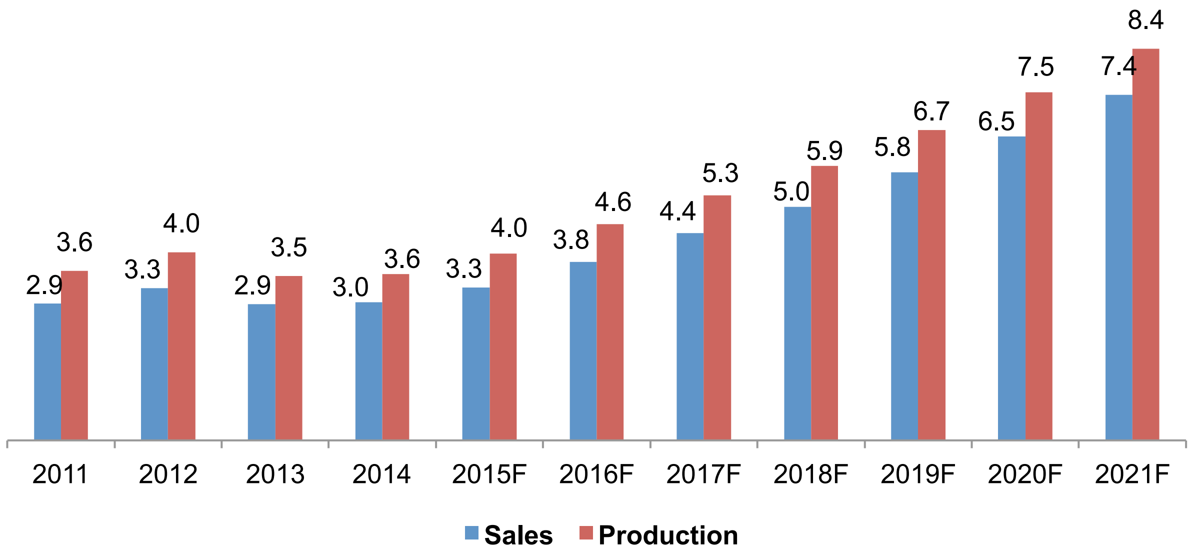
[10] India Brand Equity Foundation (IBEF), March 2015 sectoral report
[11] India Brand Equity Foundation (IBEF), March 2015 sectoral report

Figure 7: Market Trend Two Wheelers (Production, Domestic and Export)



Source: SIAM, EY Analysis

Figure 8: Market Trend Passenger Vehicle (Production, Domestic Sales – Million Numbers)



Source: SIAM, EY Analysis

2.3 Major Automotive Clusters In India

The majority of India's automotive manufacturing industry is evenly divided into three "clusters" namely South, West and north. The Indian auto industry has evolved around these three major clusters; however there are other small clusters in east and central part of India.

Figure 9: Major Automotive Clusters In India

- South Cluster: The southern cluster is developed around Chennai. It is the southernmost and largest, with a 35% revenue share, accounting for 60% of the country's automotive exports, and home of the India operations of Ford, Hyundai, Renault, Mitsubishi, Nissan, BMW, Hindustan Motors, Daimler, Caparo, Mini, and Datsun etc.

- West Cluster: The western cluster is developed around , Pune, Aurangabad, Nashik (Maharastra) . Audi, Volkswagen, and Skoda are located in Aurangabad. Mahindra and Mahindra has an SUV and engine assembly plant at Nashik. General Motors, Tata Motors, Mercedes Benz, Land Rover, Jaguar Cars, Fiat, and Force Motors have assembly plants in the area.

- North Cluster: The northern cluster is developed around the New Delhi and National Capital Region, and contributes 32%. Gurgaon and Manesar, in Haryana, are where the country's largest car and two wheeler manufacturers are based like Maruti Suzuki, Hero, Honda etc.

- East and Center Cluster: The east and center cluster is quite small compared to the other clusters and has presence of Tata (east), Mahindra & Mahindra, Eicher, Hindustan Motors, Force Motors etc.

There are some emerging clusters in the state of Gujarat, with a manufacturing facility of General Motors in Halol, Ford in Sanand, and a facility for Tata Nano in Sanand

The Suzuki group will set up three plants at Hansalpur(Gujarat) with a total annual capacity of 750,000 vehicles. Another automobile manufacturer, Peugeot-Citroen, has plans to set up a facility in Gujarat.

Other small clusters and automotive manufacturing regions around the country includes east cluster near Kolkata with Hindustan Motors, Pithampur with Eicher, Force and M&M, Noida with Honda, and Bangalore with Toyota are other automotive manufacturing regions around the country.

The state wise presence of major automotive manufacturers is presented in the table below:

Table 1: State Wise Presence of Major Automotive Manufacturers In India

State	Automotive Manufacturing
Gujarat	Passenger vehicles: General Motors India Private Limited, Chevrolet Sales India Private Limited – Halol, Tata Motors – Sanand Commercial vehicles: Asia Motor Works AMW – Bhuj
Haryana	Two wheelers: Honda Motorcycle & Scooter India – Manesar, Hero MotoCorp – Dharuhera, Gurgaon, India Yamaha Motor – Faridabad, Manesar, Suzuki – Gurgaon. Passenger vehicles: Maruti Suzuki – Gurgaon, Manesar
Himachal Pradesh	Two wheelers: TVS Motors – Nalagarh Passenger vehicles: ICML motors – Amb Commercial vehicles: TAFE Tractors – Parwanoo
Jharkhand	Commercial vehicles: Tata Motors – Jamshedpur
Karnataka	Two wheelers: TVS Motor – Mysore, Honda Motorcycle & Scooter India Pvt. Ltd. – Narsapura, Passenger vehicles: Mahindra REVA Electric Vehicles – Bangalore, Toyota Kirloskar Motor Private Limited – Bidadi Commercial vehicles: Bharat Earth Movers – Bangalore, Scania Commercial Vehicles India Private Limited – Bangalore, TAFE Tractors – Doddaballapur, Tata Motors – Dharwad, Bharat Earth Movers – Mysore, Volvo India Volvo Buses India – Hosakote, Volvo Trucks India – Hosakote, Volvo Construction Equipment India – Hosakote
Kerala	Commercial vehicles: Bharat Earth Movers Defense Products - produces Tatra Trucks 12x12, 10x10,8x8, 6x6, 4x4 & Variants, Kerala Automobiles Limited

Madhya Pradesh	Two wheelers: Mahindra & Mahindra – Pithampur Commercial vehicles: Eicher Motors – Pithampur, Hindustan Motors – Pithampur, Force Motors Private Limited – Pithampur, TAFE Tractors – Mandideep, John Deere Tractors – Dewas
Maharashtra	Two wheelers: Bajaj Auto – Chakan (Pune), Waluj Aurangabad, KTM Sportmotorcycles – Chakan (Pune), Vespa Scooters – Baramati (Pune), Kinetic Engineering – Pune, Ahmednagar Passenger vehicles: Mahindra & Mahindra Automotive Division – Nashik, Chakan (Pune), Ssangyong Motor Company – Chakan (Pune), Tata Motors Limited,Tata Motors – Pimpri Chinchwad (Pune), Jaguar Cars and Land Rover – Pune, Mercedes-Benz Passenger Cars – Chakan (Pune), Fiat Automobiles – Ranjangaon (Pune), General Motors India – Chakan (Pune), Volkswagen Group Sales India Private Limited Volkswagen – Chakan (Pune), Audi AG – Aurangabad, Škoda Auto – Aurangabad, Chinkara Motors – Karlekhind Alibag, Premier Automobiles Limited – Pimpri Chinchwad (Pune), Commercial vehicles: Ashok Leyland – Bhandara, Bajaj Auto – Waluj Aurangabad, Force Motors – Pune, Mahindra Navistar – Chakan (Pune), MAN Trucks India – Akurdi, Mercedes-Benz Buses India – Chakan (Pune), Piaggio Vehicles – Baramati (Pune), Premier Automobiles Limited – Pimpri Chinchwad (Pune),
Punjab	Commercial vehicles: SML Isuzu Limited – Nawanshahar (originally a Swaraj Mazda plant),
Rajasthan	Two Wheelers: Honda Motorcycle & Scooter India – Tapukara Passenger vehicles: Honda Cars India Ltd. – Tapukara Commercial vehicles: Ashok Leyland – Alwar, TAFE Tractors – Alwar
Tamil Nadu	Two wheelers: TVS Motor – Hosur, Royal Enfield – Chennai, India Yamaha Motor – Oragadam Passenger vehicles: BMW India – Chengalpattu, Ford India Private Limited – Maraimalai Nagar, Hyundai Motor India Limited – Sriperumbudur, Mitsubishi – Tiruvallur, Renault Nissan Automotive India Private Limited, Nissan Motor India Private Limited – Oragadam, Renault India Private Limited – Oragadam Commercial vehicles: Ashok Leyland – Ennore, Hosur, BharatBenz – Oragadam, Kamaz Vectra Motors – Hosur, SAME Deutz-Fahr Tractors – Ranipet, Vellore, TAFE Tractors – Chennai, TVS Motors – Hosur
Uttar Pradesh	Two wheelers: India Yamaha Motor – Greater Noida, LML – Kanpur Passenger vehicles: Honda Cars India Ltd. – Greater Noida, J.S. Auto (P) LTD. – Kanpur Commercial vehicles:Tata Motors – Lucknow
Uttarakhand	Commercial vehicles: Ashok Leyland – Pantnagar, Tata Motors – Pantnagar, Mahindra & Mahindra – Haridwar, Hero MotoCorp – Haridwar, Bajaj Auto – Pantnagar
West Bengal	Passenger vehicles: Hindustan Motors Limited - Kolkata

3. Overview of Indian Automotive Industry

3.1 Introduction

The Indian auto component industry is one of the few sectors in the economy that has a distinct global competitive advantage in terms of cost and quality. It is also one of the fastest growing industries in India. This industry had gradually transformed from being a domestic market supplier to becoming one of the essential auto parts suppliers in the world, with the components being widely demanded by major global automobile companies.-

3.2 Brief Background

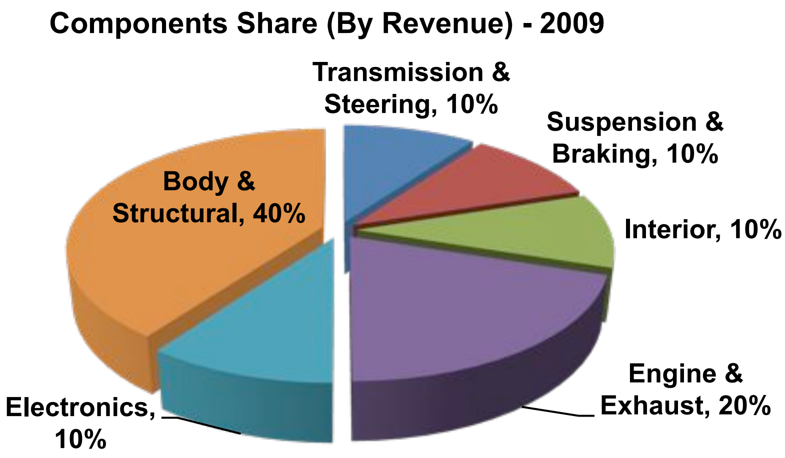
In 1953, the Tariff Commission in its report to Government had stressed the need for a balanced and integrated development of the Automotive Industry by promoting the emergence of a strong auto-component sector. As a result of this recommendation the leading entrepreneurs were invited by Government to establish an auto-component manufacturing industry. In the pre-1985 era, the auto component sector was a protected market with high import tariffs. The market was oriented primarily towards supply of components to domestic manufacturers. In the 1980s, encouraged by the establishment of many Japanese OEMs in the passenger car, two wheeler and LCV industry in the country, a number of Indian companies entered into joint ventures with Japanese companies and exports also commenced.

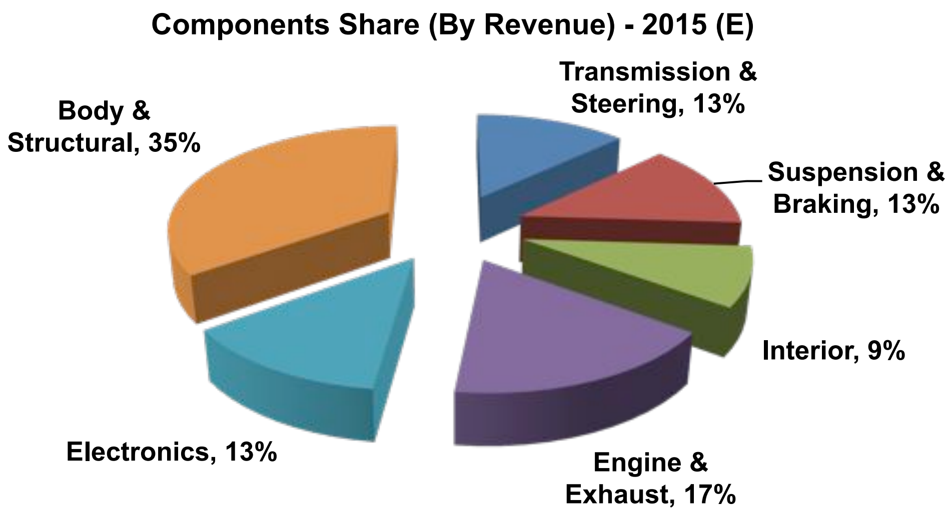
The Phased Manufacturing Programme (PMP) introduced in Indian automotive sector in the 1980s for localization had laid the foundation for the development of auto component industry. This programme enabled the auto-component industry to modernize its technology, improve quality and to imbibe good manufacturing and shop-floor practices and to transform itself into a highly capable sector of the industry, while at the same time contribute to localizing the component base. In 1990s global OEMs and Tier 1 suppliers started operations in India. This paved the way for a large number of new Joint Ventures in the component industry with European and American component manufacturers and gave the Indian component industry an all-round expertise to manufacture components for applications in Japanese, European as well as American vehicles.

After the PMP programme came to an end in 1991, Government introduced the MOU system that continued to place emphasis on the aspect of localization of components. With support from this policy, the component industry developed further capability to manufacture the new breed of auto-components required for the new generation vehicles. As a result of successful localization of these components, Vehicle manufacturers started outsourcing more and more components rather than manufacturing in-house. Entrepreneurs were encouraged to develop components and set up facilities. Whenever required, OEMs supported component manufacturers through equity participation, technical collaboration, etc.

The Indian auto-components industry can be broadly classified into the organized and unorganized sectors. The organized sector caters to the original equipment manufacturers (OEMs) and consists of high-value precision instruments while the unorganized sector comprises low-valued products and caters mostly to the aftermarket category. In the Indian auto component manufacturing segment a significant number of players are from the unorganized sector. However, the organized sector contributes more than 85% of the country's total production of auto components. Of the total production large Indian players contribute around 43%, while global majors such as Bosch, Magna, Visteon, Federal-Mogul corporation and Denso contributes around 15%.

Figure 10: The Indian Auto-Components Industry Product Range (By Revenue)





Source: Vision 2020, Indian Auto Component Industry, 2010, ACMA-EY

Presently the Auto component Industry manufactures a wide range of products in India for both domestic consumption and exports. The Indian auto component industry is balanced in its contribution at components level like engine parts (20%), drive transmission and steering parts (10%), body and structural (40%), suspension and braking parts (10%), interior (10%) and electrical parts (10%) as depicted in the figure. High quality and global standards are helping the highly competitive Indian auto component manufacturers to blend into the global industry for sourcing of auto components. A substantial percentage of auto component manufacturers have opted for quality certifications and recognition like ISO 9000, TS-16949, QS-9000. The industry is also rapidly adopting modern shop floor practices such as 5-S, 7-W, TQM, TPM, 6 Sigma and Lean manufacturing.

The Indian auto component manufacturers have made their presence felt in all product categories. Pro-industry policies like manufacturing and imports free from licensing and approvals, 100% FDI in auto sector and no local content regulation of the Government has helped the auto component sector to grow in the past. In order to give further fillip to the sector and move to next phase of rapid growth, timely policy decisions and support from the Government is required.

3.3 Market Size of Indian Auto-Component Industry

Currently the Auto component Industry manufactures a wide range of products in India for both domestic consumption and exports. The total market size of the component industry is close to USD 35 billion out of which USD 10.2 billion are the direct exports of components. More than 60% of the exports of auto-components are to Europe and USA. More than 70% of the exports go to the OEMs and Tier I suppliers and only 30% to the global aftermarket, indicating the high level of maturity in quality and technology that has been achieved by the component industry[12].

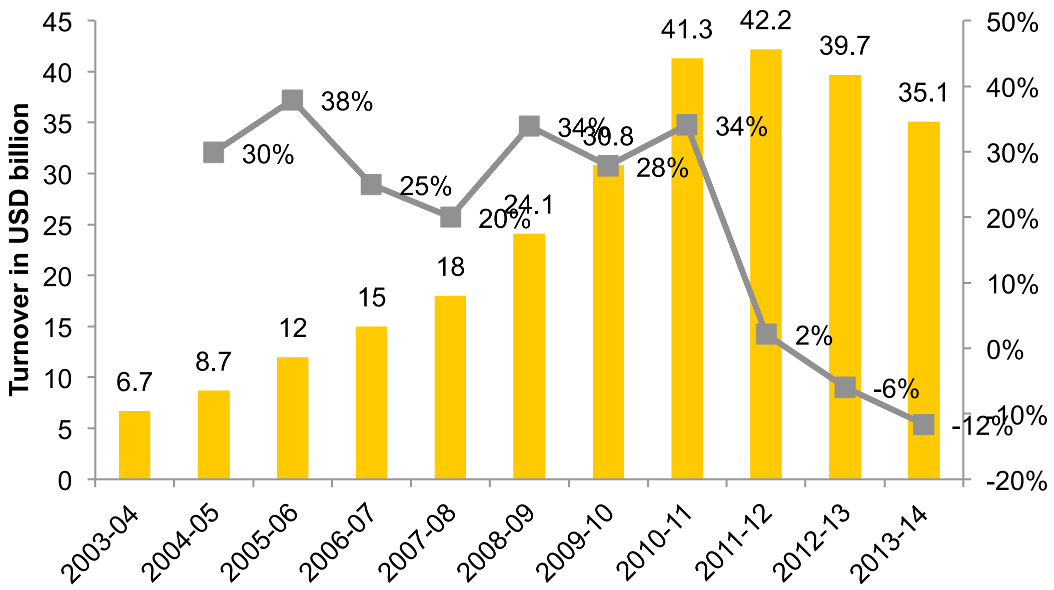
According to the ACMA[13], the auto components industry is likely to grow to US$ 115 billion by 2020, with the domestic market at around US$ 84 billion. Revenues for the auto industry in 2014-15 are expected to grow by 11-12 per cent supported by healthy recovery by major original equipment manufacturers (OEMs) in the medium and heavy commercial vehicles (M&HCV) and passenger vehicle (PV) segment.

Going forward, the Indian auto components industry is well poised to achieve strong growth, owing to rising domestic demand in the OEM market and the expanding replacement market, which will give India a strong platform to gain a stand in the global market. The export market for auto

[12] Indian Automotive Aftermarket Industry Study, 2012, ACMA
[13] Indian Automotive Aftermarket Industry Study, 2012, ACMA
ACMA is the apex body representing the interest of the Indian Auto Component Industry. Its active involvement in trade promotion, technology up-gradation, quality enhancement and collection & dissemination of information has made it a vital catalyst for this industry's development. ACMA's charter is to develop a globally competitive Indian auto component Industry and strengthen its role in national economic development as also promote business through international alliances.

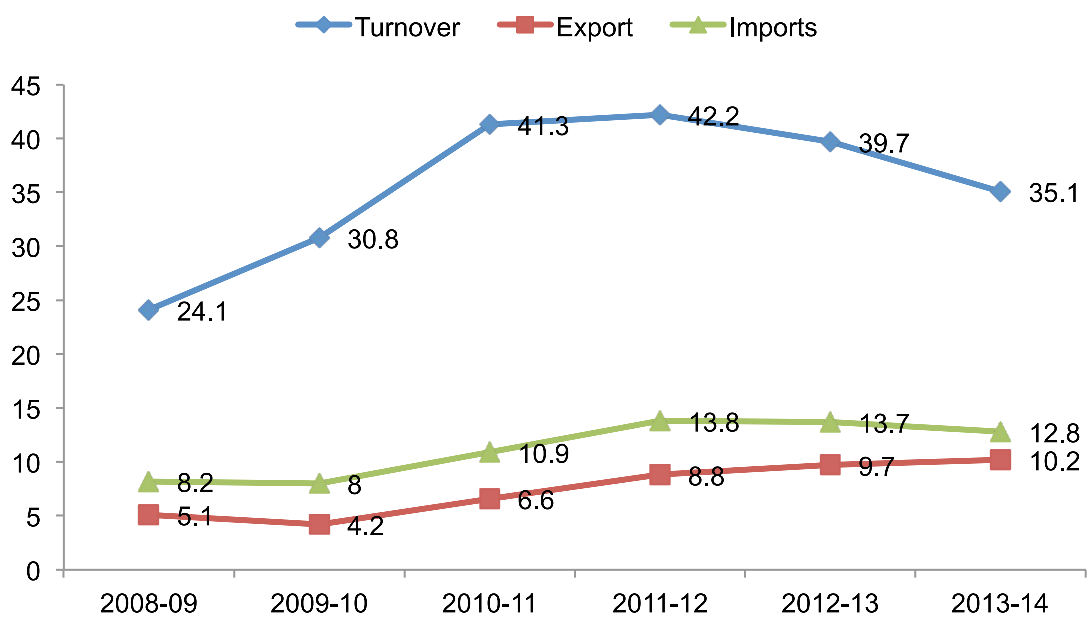
components is also likely to see strong traction once the global market stabilizes and the economic uncertainty fades away. The cooling off of raw material prices and the expected rate cut to revive the decelerating economic growth is likely have a favorable impact on the margin of industry players. In the long run, auto component industry's outlook remains robust on the back of various government initiatives initiated to make India an Auto Hub of the world by 2020.

Figure 11: Indian Auto Component Market Turnover and Growth Rate (2003-2011)



Source: Auto Component Industry in India: Capabilities & Growing Opportunities , ACMA

Figure 12: Indian Auto Component Industry Performance, USD Billions (2008-2014)



Source: Auto Component Industry in India : Capabilities & Growing Opportunities , ACMA

Unfortunately, given the prolonged demand slump, the auto-component sector in India witnessed a reduction in total turnover during 2013-14. However, exports grew by 5.4% to USD 10.2 billion in 2013-14 helping offset some of the drop in domestic demand. The ability to steadily grow exports at a time when market conditions are not very supportive is a reflection of the growing position of the Indian auto-component industry in global terms. It is now becoming even more imperative for domestic companies to become an integral part of global supply chains, not only to grow, but also to hedge against market downturn in any specific region. Key findings of the auto component industry performance for year 2013-14 are as follows.

- **Exports**[14]: Exports of auto components grew by 16.7 % to INR 614.87 billion (USD 10.2 billion) from Rs 526.9billion (USD 9.7 billion) in 2012-13. Europe accounted for 38 % of exports followed by Asia at 25 % and North America at 21 %. Exports to Europe increased by 14.5 % over the previous fiscal, while exports to Latin America and Asia registered a growth of 16.5 % and 5.4 % respectively. The key export items include engine parts, transmission parts, brake system & components, body parts, exhaust systems, turbochargers etc.

- **Imports**[15]: Imports of auto components grew by 3.6 % to INR 771.6 billion (USD 12.8 billion) in 2013-14 from INR 744.63 billion (USD 13.7 billion) in 2012-13; Asia and Europe contributed to 57 % and 34 % of the imports respectively. Within Asia - China, Japan, South Korea and Thailand contributed to maximum imports while from Europe the key contributors were Germany, France, UK, Italy and Spain.

- **Aftermarket**[16]: With increasing *vehicle parc*[17] in the country, the aftermarket in 2013-14 grew by 12 % to INR 356.03billion (USD 5.93 billion) from INR 317.88 billion (USD 5.23 billion) in the previous fiscal.

- **Capacity Addition**[18]: For the fiscal 2013-14 an estimated investment of around USD 0.5-0.7 billion was witnessed in the auto component sector. Due to moderation in vehicle sales and depressed market sentiments, the investment in 2013-14 declined compared to the previous year. Capex in 2012-13 stood at around USD 1.2-1.7 billion.

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[14] Indian Automotive Aftermarket Study, ACMA, 2012
[15] Indian Automotive Aftermarket Study, ACMA, 2012
[16] Indian Automotive Aftermarket Study, ACMA, 2012
[17] Vehicle parc refers to the number of vehicles in a region or market. It is typically used to gauge the capacity within a market or region for aftersales

[18] Indian Automotive Aftermarket Study, ACMA, 2012

3.4 Auto Component Manufacturers In India

The Indian auto component manufacturers can be broadly divided into organized and unorganized sector, with about 700 organized manufacturers accounting for about 85% of the total production(by volume)[19]. While the forte of the organized sector is the high value added precision engineering products (like transmission gears, engine casings etc.), the lower value-added segments of the industry are characterized by the presence of a large unorganized sector (more than 6000 in number[20]) like filters, rubber rings etc.

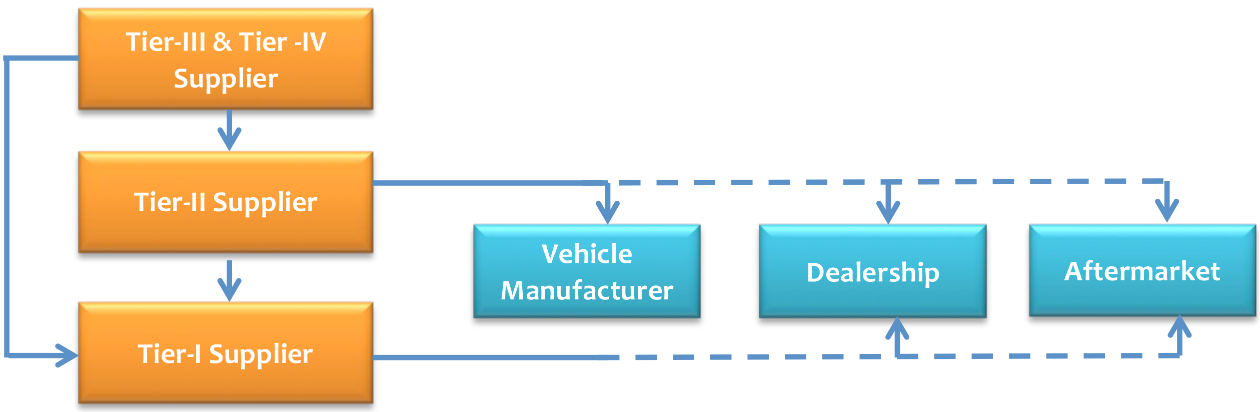
The automotive components industry is divided into several tiers based on their position in the supply chain[21]:

Tier 1: These manufacturers supply assemblies and sub-assemblies to OEMs. These companies are large organized players with high quality products, strong technological base and large production facilities. Many of the Tier -1 component manufacturers also supply to international OEMs. These companies are progressive and work in the area of arresting environmental degradation due to their activities and are proactive in choosing recycled or secondary materials for their processes, but are driven strongly by vehicle manufacturers' specifications.

Tier 2: These component manufacturers, relatively small compared to Tier -1 players, have limited access to technology. Such manufacturers often supply to Tier-1 component manufacturers. These players are generally driven by cost rather than focusing on secondary raw material use.

Tier 3 & Tier 4: Other tier players are smaller in size and usually have significantly poorer technological skills and manufacturing strengths. They mostly manufacture non-critical parts. These manufacturers generally end up using most of the secondary or rejected material from larger players or other industries as these materials are auctioned at very low cost.

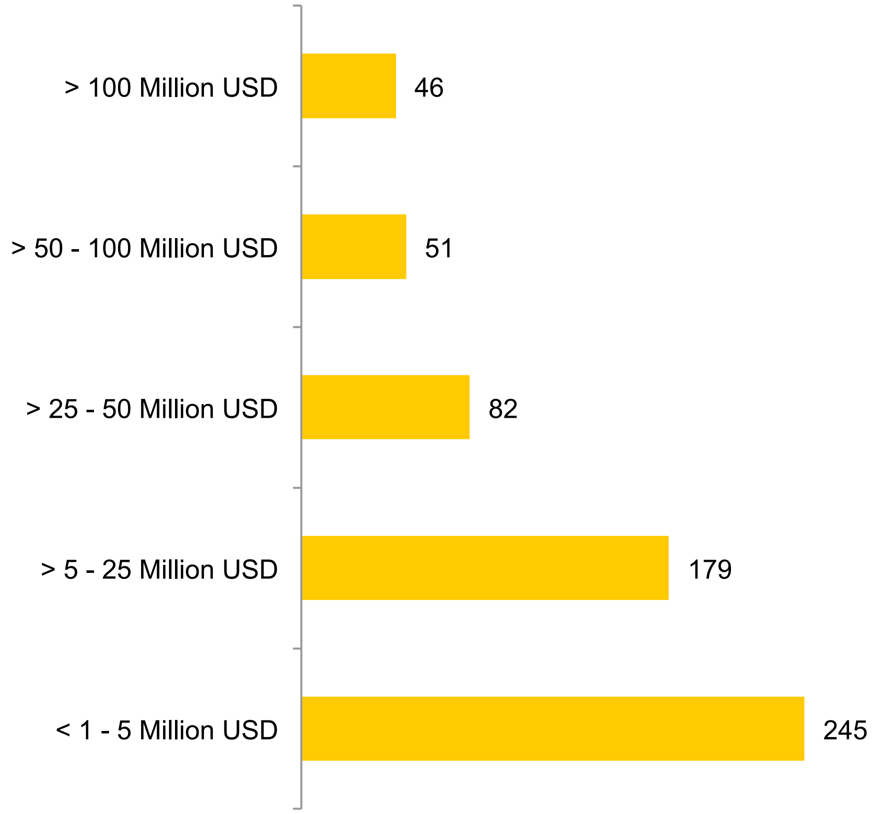
Figure 13: Automotive Supply Chain



[19] Indian Automotive Aftermarket Study, ACMA, 2012
[20] http://india.smetoolkit.org/india/en/file/content/43677/en/Indian_Auto_Components_Industry_Snippet.pdf
[21] Indian Automotive Aftermarket Study, ACMA, 2012

Below is a snapshot of the size of the Indian auto component manufacturers in terms of revenue as provided by ACMA for its member companies, which are mostly from organized sector.

Figure 14: Annual Turnover of Auto Component Manufacturers 2012 (ACMA Members)



Source: ACMA

The industry's initiative in setting up world class shop floor practices and quality practices have helped them to be recognized as a force to reckon with in the auto component suppliers' league. Major automobile companies all over the world are sourcing products from Indian auto component manufacturers.

The reference of quality certifications & recognition and Best shop-floor practices adopted by the major Indian auto component manufacturing industry is important, since it's been observed that number of waste reduction and efficient productivity interventions have been implemented in order to achieve these standards and practices; same has been confirmed by the stakeholder during consultation. However, penetration of these quality certifications & recognition and Best shop-floor practices are limited to the major players only (Tier-1 and some Tier-2; since these practices are mostly OEM driven). The wide spread adoption/implementation of these practices across the auto-component supply chain may further improve the efficiency and productivity in the sector; and ultimately would result in resource efficiency in auto-component manufacturing process.

Table 2: Significant Number of Companies with Quality Certifications & Recognition

Quality Certification	No of Units	Brief Description
ISO 9000	552	ISO 9000 is a series of standards, developed and published by the International Organization for Standardization (ISO), that define, establish, and maintain an effective quality assurance system for manufacturing and service industries
TS 16949	438	The ISO/TS16949 is an ISO technical specification aimed at the development of a quality management system that provides for continual improvement, emphasizing defect prevention and the reduction of variation and waste in the supply chain.
QS 9000	33	QS 9000 is a company level certification based on quality system requirements related specifically to the automotive industry. These standards were developed by the larger automotive companies including Ford, General Motors and Daimler Chrysler.
ISO 14001	204	It is a series of environmental management standards developed to provide a guideline or framework for organizations that need to systematize and improve their environmental management efforts.
OHSAS 18001	95	OHSAS 18001 is an Occupation Health and Safety Assessment Series for health and safety management systems. It is intended to help organizations to control occupational health and safety risks.
JIPM	3	Japan Institute of Plant Maintenance: This is a system which assesses Total Productivity maintenance and functioning and life of equipment.
Deming Award	11	The Deming Award is a global quality award that recognizes both individuals for their contributions to the field of Total Quality Management (TQM) and businesses that have successfully implemented TQM.
TPM Award	15	Total Productivity maintenance awards: These awards are given to acknowledge the contribution of companies to "strengthen the improvement of enterprise constitutions and contribute to the development of industry, by promoting the modernization of plant maintenance and the development of plant maintenance technologies."
Japan Quality Medal	1	Japan Quality Medal is one of the coveted awards awarded globally to recognize the contribution to the field of quality
Shingo Silver Medallion	1	The Shingo Silver Medallion recognizes companies that demonstrate operational excellence. This includes tools, techniques, systems and behaviors and excellent lean manufacturing practices.

(*As on 2014, Source: Indian Auto Component Industry an Overview, ACMA, accessed in May 2015)

Table 3: Best Shop-Floor Practices Adopted By The Industry

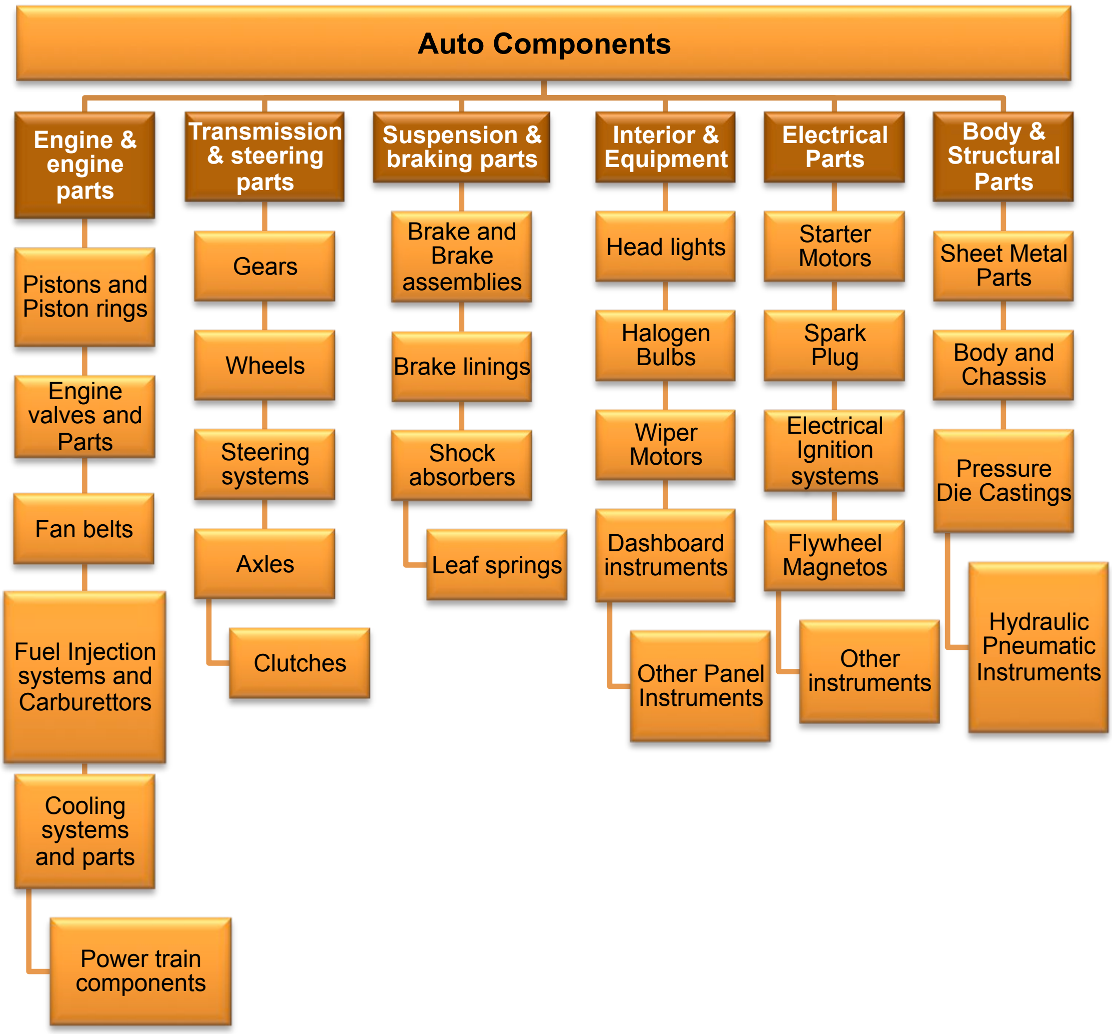
Best Practices	Brief Description
5-S	5S is the name of a workplace organization method that uses a list of five Japanese words: ***seiri, seiton, seiso, seiketsu, and shitsuke***. Translit erated into English, they all start with the letter "S". The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.
7-W	7-W system is focussed around eliminating 7 types of waste to increase the productivity. The seven types of waste are: ▶ Waste from overproduction ▶ Waste from waiting times ▶ Waste from transportation and handling ▶ Waste related to useless and excess inventories ▶ Waste in production process ▶ Useless motions ▶ Waste from scrap and defects
Kaizen	Kaizen is the practice of continuous improvement. Kaizen was originally introduced to the West by Masaaki Imai in his book Kaizen: The Key to Japan's Competitive Success in 1986. Today Kaizen is recognized worldwide as an important pillar of an organization's long-term competitive strategy.
TQM	Total Quality Management (TQM) is a management approach that originated in the 1950s and has steadily become more popular since the early 1980s. Total quality is a description of the culture, attitude and organization of a company that strives to provide customers with products and services that satisfy their needs.
TPM	In industry, total productive maintenance (TPM) is a system of maintaining and improving the integrity of production and quality systems through the machines, equipment, processes, and employees that add business value to an organization.
6 Sigma	6 Sigma Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process – from manufacturing to transactional and from product to service.
Lean Manufacturing	Lean manufacturing or lean production, often simply "lean", is a systematic method for the elimination of waste (*"Muda"*) within a manufacturing process. Lean also takes into account waste created through overburden *("Muri")* and waste created through unevenness in workloads *("Mura").*

3.5 Major Auto Component Segments (Product Group)

In India, the auto components are categorized into six major segments or product group (by ACMA). The subdivisions of auto-component are based on the use of component in the vehicle assembly/production assembly line (like Engine and Engine Parts, Transmission & Steering parts, Suspension & Braking Parts, Interior & Equipment, Electrical Parts and Others – including body and chassis).

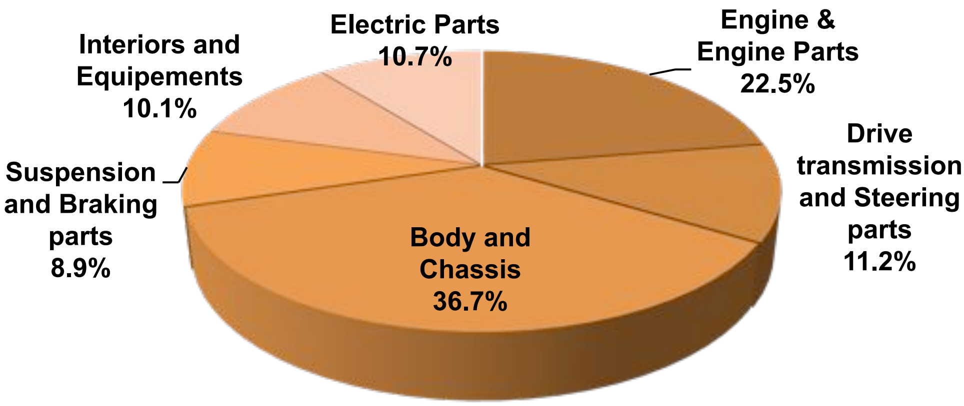
The major auto component segments along with the constituent components are listed in the figure below:

Figure 15: Major Auto Component Segments (Product Group)



Source: Indian Automotive Aftermarket Study, ACMA, 2012

Figure 16: Major Auto-Components / Product Group-2011 (By Production (Number of Components))



Source: Indian Automotive Aftermarket Study, ACMA, 2012

- **Engine and Engine Parts:** Engine and Engine parts including exhaust contributes about 22.5 % to component production in India. The sub-assembly includes pistons, piston rings, engine valves, carburettors, fuel delivery and cooling system, power train and exhaust components. This segment is technology, capital and material intensive and led by existing major auto component manufacturers (tier 1 supplier). Some new technology change in this segment includes the introduction of turbo chargers and common rail system. Due to better technology life of the engine increasing, this may have negative impact on after market[22] and replacement cycle.

- **Transmission and Steering Parts:** Transmission and Steering Parts that includes gears, wheels, steering system, axles and clutches form another major product group, with 11.2 % share in production. The technology and capital required for this sub-assembly is comparable to that of engine and engine components. This segment is also dominated by organized sector mainly existing major players (tier 1 suppliers). Aftermarket / replacement of this segment is increasing rapidly due to raise in traffic density, lack of good road infrastructure. Competition is expected to intensify this sub-segment (gears and clutches), with the entry of global players. OEMs source complex axel assemblies from one or two vendors' rather than individual components from different vendors.

- **Suspension and Braking Parts:** At a production share of about 8.9%, suspension and braking parts includes brakes, brake assemblies, brake linings, shock absorbers and leaf springs. The demand share of the replacement market in this segment varies from 30% to 70%, depending on the product. With challenging road infrastructure, utilization pattern of

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[22] Auto aftermarket refers to the sale of parts, accessories and reconditioned equipment or the services rendered for an automobile after its sale by the OEM

vehicle and driving habits, this sub-segment is a very important contributor of replacement/aftermarket. The segment is estimated to witness high replacement demand, with manufacturers maintaining a diversified customer base in the replacement and OEM segment, apart from export market. With the entry of global manufacturing players, competition in this segment has been intensified like in shock absorber manufacturing.

- **Interior and Equipment:** At 10.1% share in production of components, the key constitute of this segment include lights, bulbs, wiper motors, dashboard instruments, switches, electric horns and other panel instruments. The demand share of the replacement/aftermarket in this segment varies from 30% to 70%. Major manufacturers are targeting on replacement market and has developed own distribution network.

- **Electric Parts:** With the key component comprising of starter motors, generators, distributors, spark plugs, ignition coils, flywheel magnetos, voltage regulation and electric ignition systems (EIS), electric parts constitutes approximately 10.7% production share or auto components in India. The demand share of replacement/aftermarket and export markets is low at about 25%, while that of the OEM segment is about 75%[23]. This segment offers a growing opportunity as electric parts are increasing (like EIS in two wheelers etc.). Competition is expected to intensify in the electric part segment serving four-wheeler due to increasing presence of multinational companies (MNCs) in India.

- **Body & Structural Parts:** This is one of the fastest growing segments within the automotive components industry, with up to 36.7% production share and includes body and chassis, sheet metal parts, plastic moulded components, and hydraulic pneumatic equipment. The sheet metal parts sub-segment is expected to grow at a fast clip in next five years. Companies in this segment are likely to reduce the cost and improve performance.

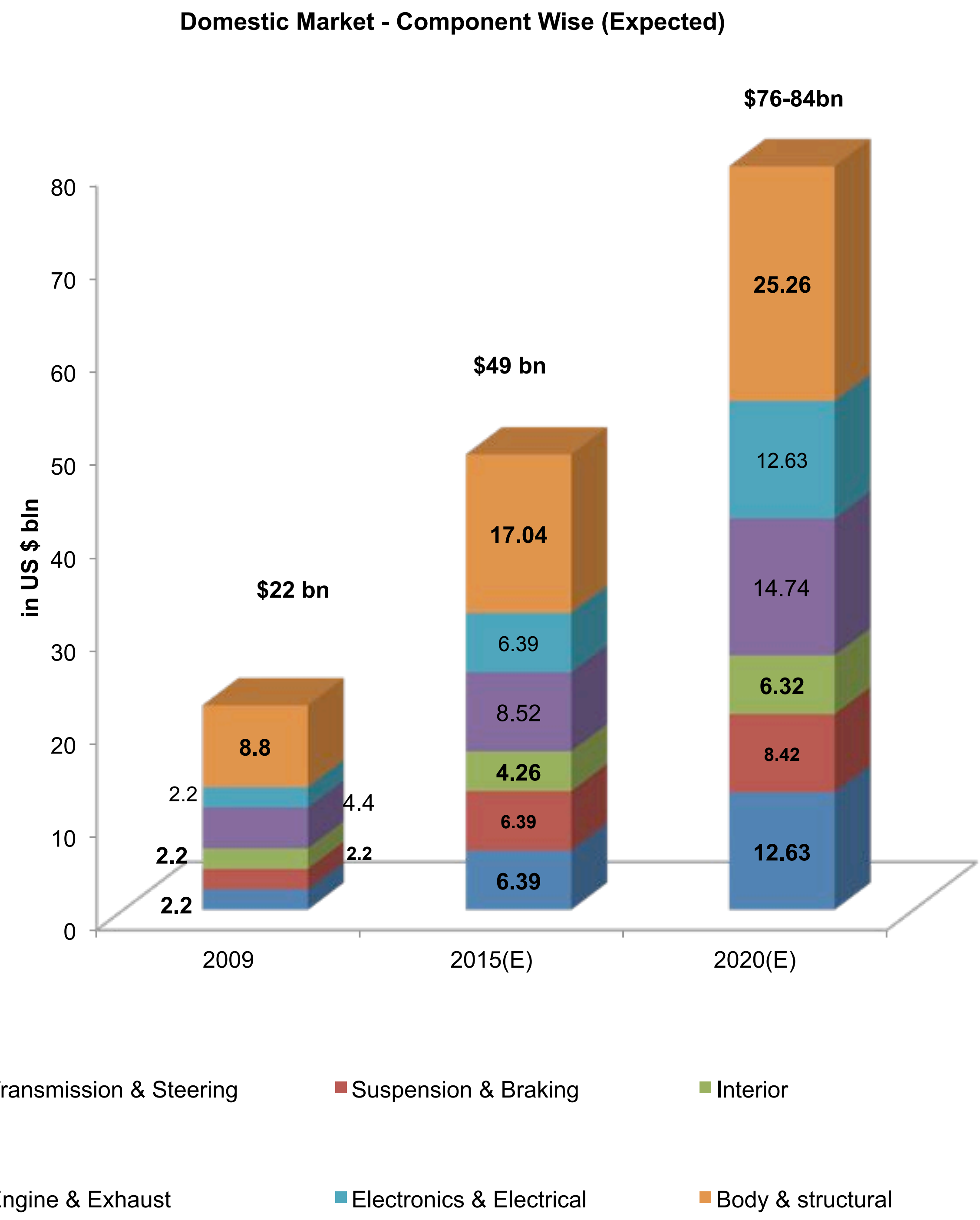
  Average vehicle uses about 150 Kg[24] of plastics and plastic composites, which is about 10-15% of the total weight of the car. Although up to 13 different polymers may be used in a single car model, just three types of plastics make up some 66 % of the total plastics used in a car, which are:

  - Polypropylene (32 %)
  - Polyurethane (17 %)
  - PVC (16 %)

[23] Vision 2020, Indian Auto Component Industry, 2010
[24] Automotive Materials Plastics In Automotive Markets Today (By Katarína SZETEIOVÁ)

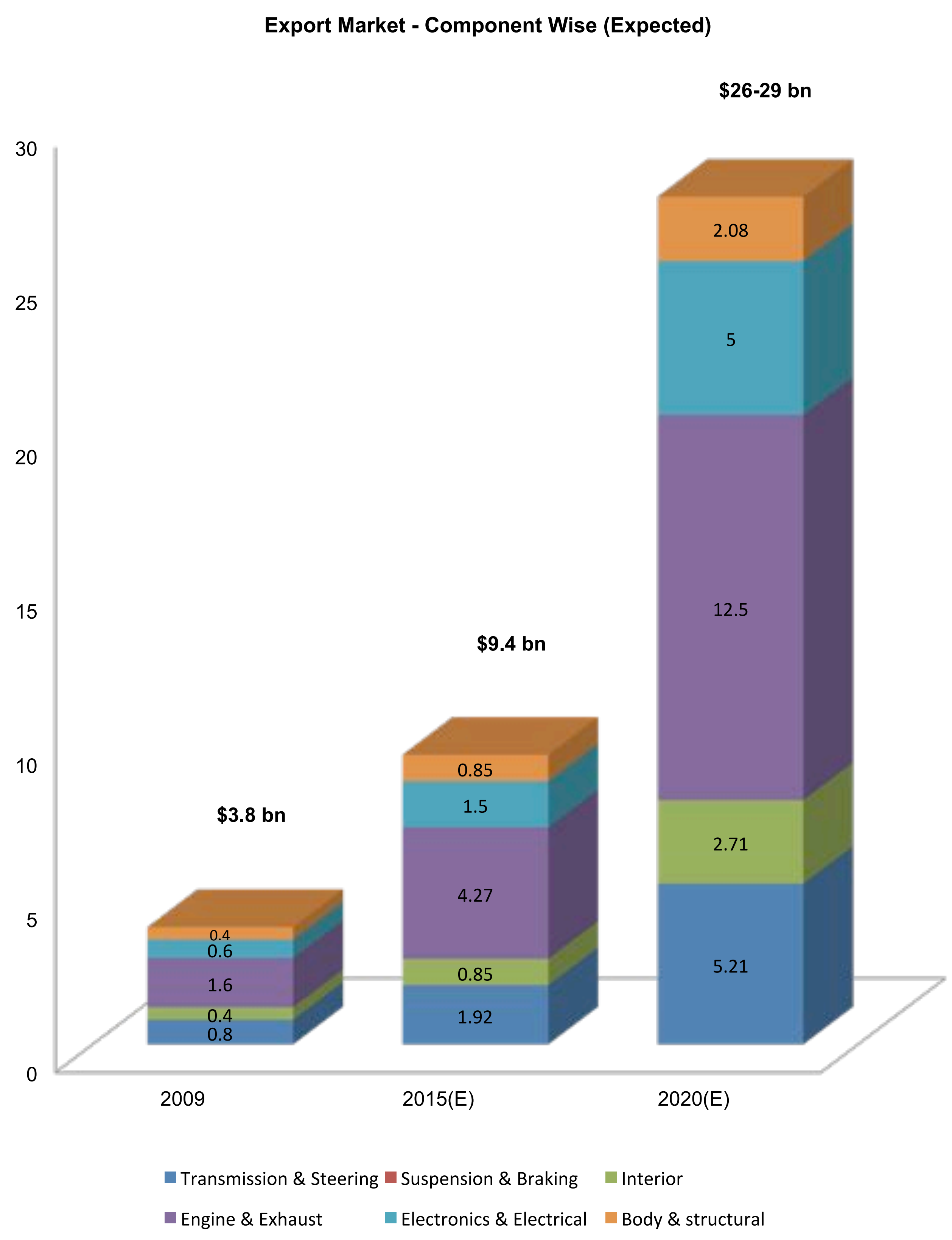
Below are the market sizes for each component segment and forecasted growth till 2020 in domestic as well as export markets.

Figure 17: Component Wise Market Size – Domestic (Billion USD)



Source: Vision 2020, Indian Auto Component Industry, ACMA-EY

Figure 18: Component Wise Market Size – Exports (Billion USD)



Source: Vision 2020, Indian Auto Component Industry, ACMA-EY

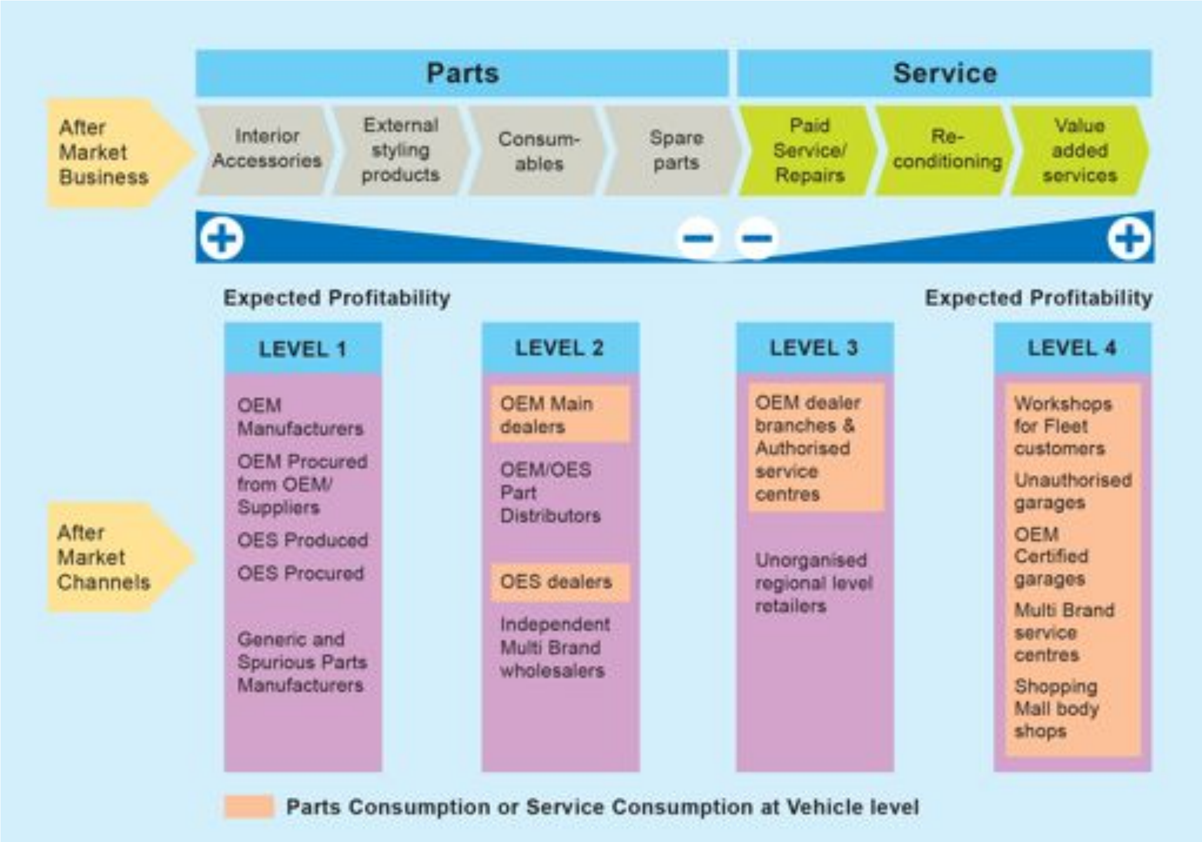
3.6 After Market and Duplicate Market Size (Overview)

Auto aftermarket refers to the sale of parts, accessories and reconditioned equipment or the services rendered for an automobile after its sale by the OEM. When OEMs manufacture the parts or accessories or reconditioned equipment themselves, the aftermarket is referred to as Captive Market for the OEM and when it does not manufacture them, the aftermarket is a Non-captive Market for the OEM. Consumers (B2B or B2C) have the option of repairing their vehicles themselves (known as the DIY- Do-It-Yourself segment) or taking the vehicle to a repair facility for repair (known as the DIFM - Do-It-For-Me segment).

Table 4: DIFM (Do-It-For-Me) Segment In India

DIFM Segment Constitutes the Majority of the Aftermarket and Comprises:	
Parts	▸ Replacement/spare parts ▸ Interior accessories (for e.g. infotainment systems) ▸ Exterior styling products (for e.g. parking sensors) ▸ Consumables (for example, tyre/battery/lubricants)
Services	▸ Vehicle reconditioning ▸ Aggregate reconditioning (for e.g. engine reconditioning, gear box reconditioning) ▸ Service repairs (for e.g., warranty claims, body shop repairs) ▸ Value added Services (for e.g. fleet management for B2B customers)

Figure 19: Representation of Distribution Structure of The Indian Auto Aftermarket With 4 Levels of Possible Consumption[25]



3.7 Indian Component Aftermarket – Size

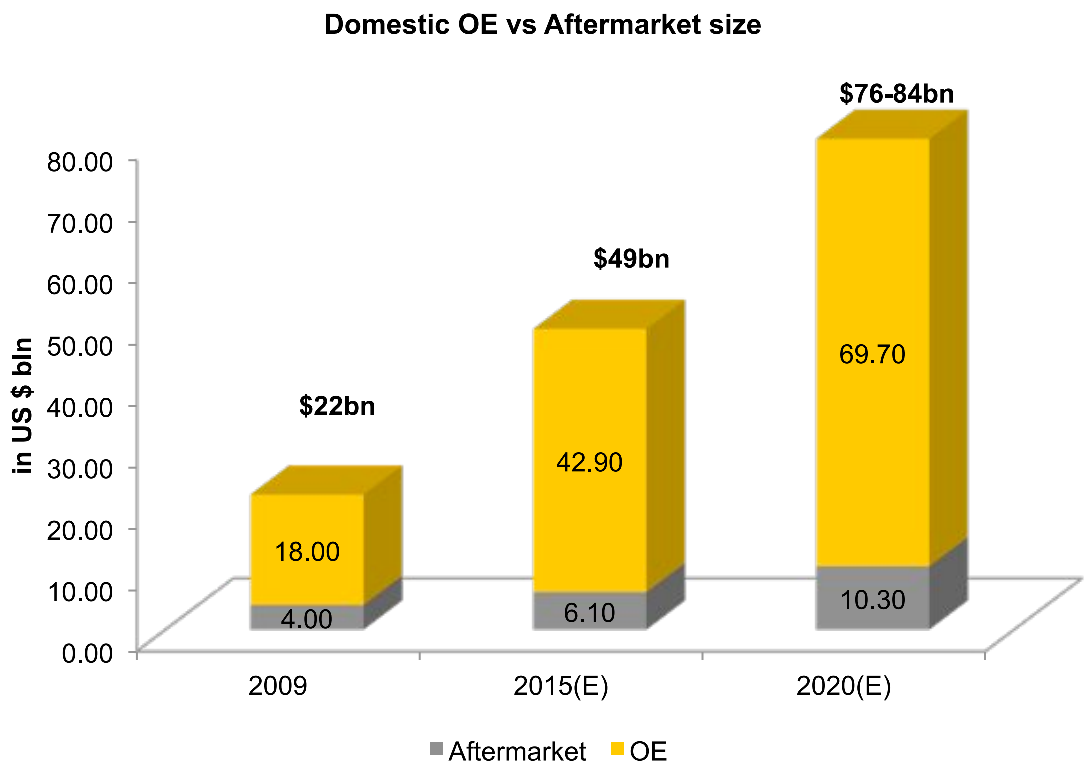
- Indian automotive aftermarket industry is valued at ~INR 350 billion (6 billion USD)[26] in 2015 led by two wheelers
- Total aftermarket around the world is expected to cross US$1 trillion within 2012, growing at over 5%

The figure below gives the share of the aftermarket in USD billion in the domestic auto component market compared to Original equipment (OE) sales.

As can be seen the aftermarket size was about 22% of the OE market size, and in 2020 it is expected to grow by more than 150%.

[25] Indian automotive aftermarket growth – ten commandments for capturing the potential, white paper by TCS, 2012
[26] Indian Automotive Aftermarket Study 2012, ACMA

Figure 20: Aftermarket Size Compared to OE In Auto Component Market (USD)



Source: Indian Automotive Aftermarket Study 2012, ACMA

- Comprising labour and components market, total aftermarket industry is dominated by two wheelers (2Ws)

- 2Ws contribute around 50% to the total vehicle components' aftermarket and around 33% to total labour aftermarket

Figure 21: Share of Vehicle Segments In Aftermarket

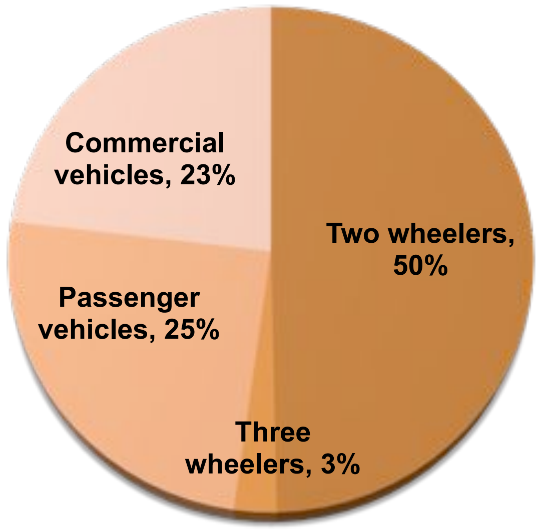
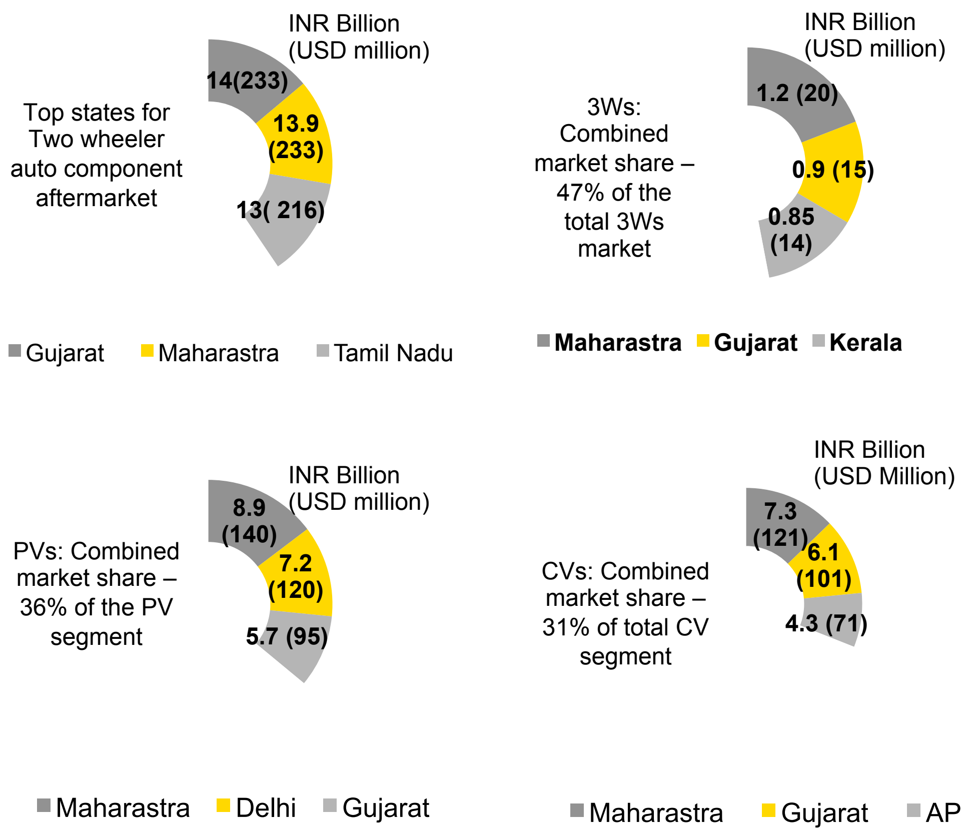


Figure 22: State-Wise Distribution of Automotive Components Sale In Aftermarket In India[27]



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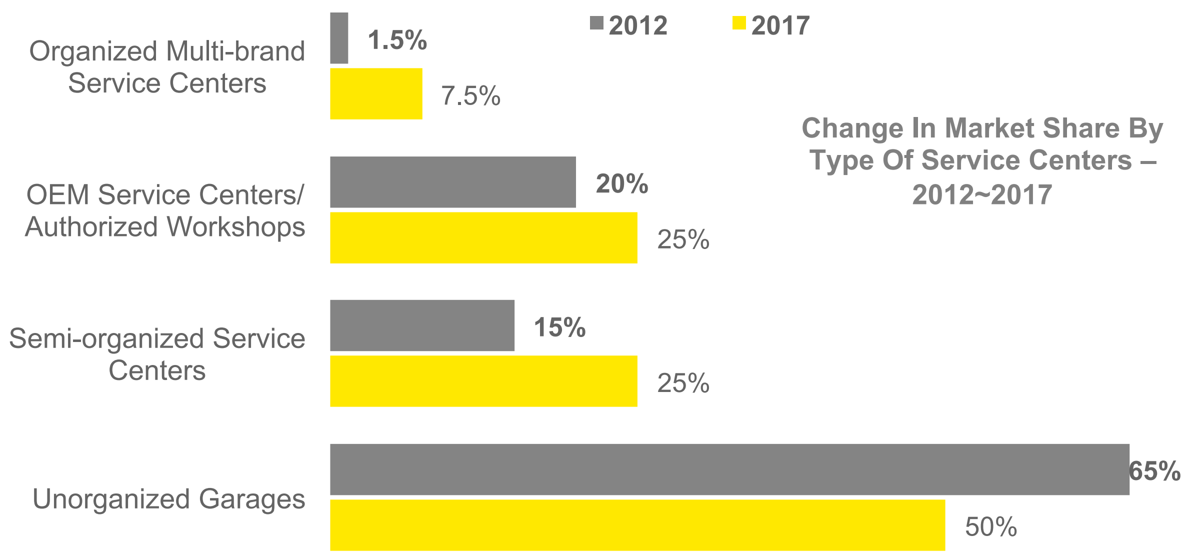
[27] EY research – Indian Aftermarket Mega Trends, 2012

- Large part of aftermarket component market in India resides in the states of Maharashtra and Gujarat

The graph below shows the type of service centers share in vehicle service segment.

Figure 23: Indian Aftermarket – Vehicle Service[28]



- Increase in the number of multi-brand service centres with brands like Bosch, Carnation etc. coming in and setting up shops in tier I and tier II cities, more organized aftermarket options available to customers
- Movement from unorganized garages/ roadside shops to organized service outlets – also a function of better vehicle built quality and thereby lesser unforeseen breakdowns
- Semi-organized service centres like those at petrol pumps, body-shops etc. also see a surge in footfall

3.8 Duplicate (Spurious) Market

Duplicate, fake, counterfeit or spurious parts refer to the aftermarket parts which are either non-branded or copied from the original equipment but are manufactured with low standards and their manufacturers normally do not follow the requisite regulations. Duplicate parts use rejected / used spares or acquire low quality spares and package them quite similarly to original ones.

The most common among these fake parts include clutch, filters, lamps wipers, bearings, steering arms, brakes and brake linings and are available for a range of vehicles including two-wheelers, cars,

[28] EY research – Indian Aftermarket Mega Trends, 2012

SUVs and commercial vehicles (trucks and buses). Some of the parts in this list are critical for the safe operation of vehicles. ACMA has claimed that about 20% of the total road accidents in the country could be caused by the use of counterfeit parts.

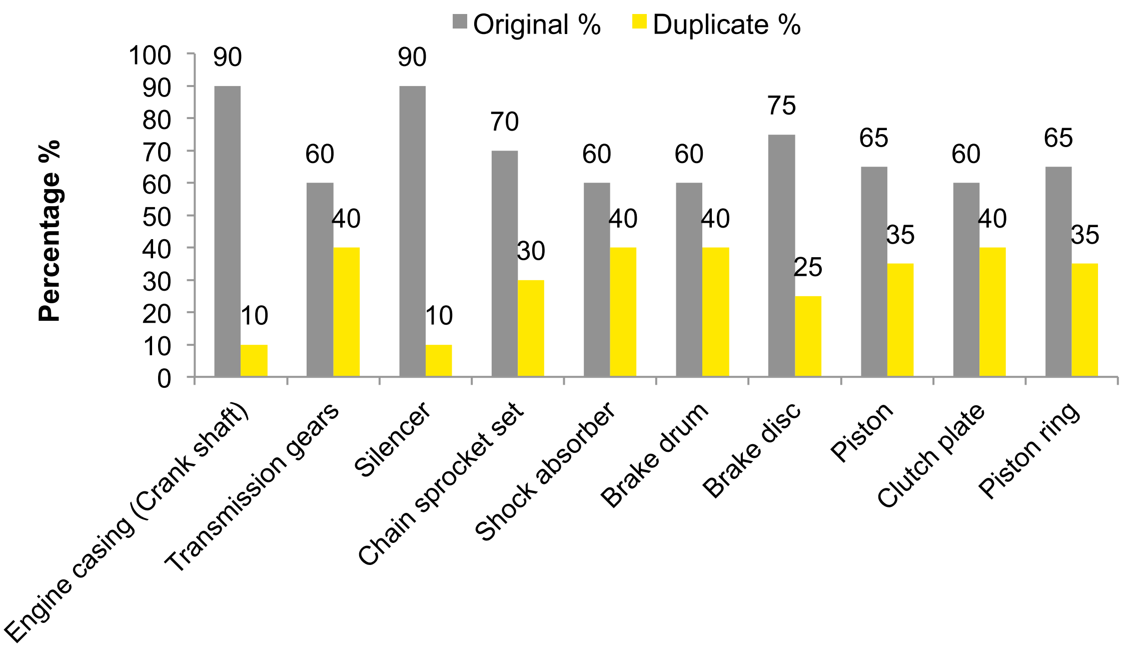
> As per "Automotive Components Manufacturer's Association Study, January 2012", it is estimated that almost 36% of the components in the aftermarket are duplicate or fake.

Table 5: Estimation of Duplicate (Spurious) Market (FY 2015)

Case Illustration (FY2015)	Value
▶ Value of aftermarket	▶ INR 350 billion (USD 5.83 billion) (expected)
▶ Share of duplicate components	▶ 36%
▶ Value of counterfeits	▶ INR 126 billion (USD 2.1 billion)
▶ Excise duty and other taxes	▶ 25%
▶ Loss to government	▶ INR 31 billion (USD 0.52 billion)

Source: EY Calculations

Figure 24: Duplicate (Spurious) Market % Share In The Aftermarket – Major Component Wise



Source: Indian Automotive Aftermarket Study 2012, ACMA, 2012

4. Supply Chain, Materials and Major Components

4.1 Supply Chain Mapping

Supply Chains have been aptly defined as a "network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer" and is therefore the sum total of efforts in integrating a network of firms and coordination as regards information, material and financial flows. Interestingly, the top two supply chain goals have shifted, from reducing operating costs and overall inventory levels, to concerns of how to improve customer service and speed of product delivery to markets[29]. The complexity of the automotive supply chain may be gauged from the fact that a typical vehicle comprises approximately 20,000 components with about 1,000 sub-assemblies or modules.

Figure 25: Linkages In Supply Chain In Indian Auto Component Industry[30]

	Past		Present	
OEMs	R&D Purchase Assembly	Cost Pressure	System integration Testing Assembly Supplier management	Risk Sharing
Tier-I Supplier	Component Manufacturing		System Supply R&D on System Module Assembly Sub-Suppliers Management	Cost Pressure
Tier-II Supplier			Sub-Component Manufacturing	

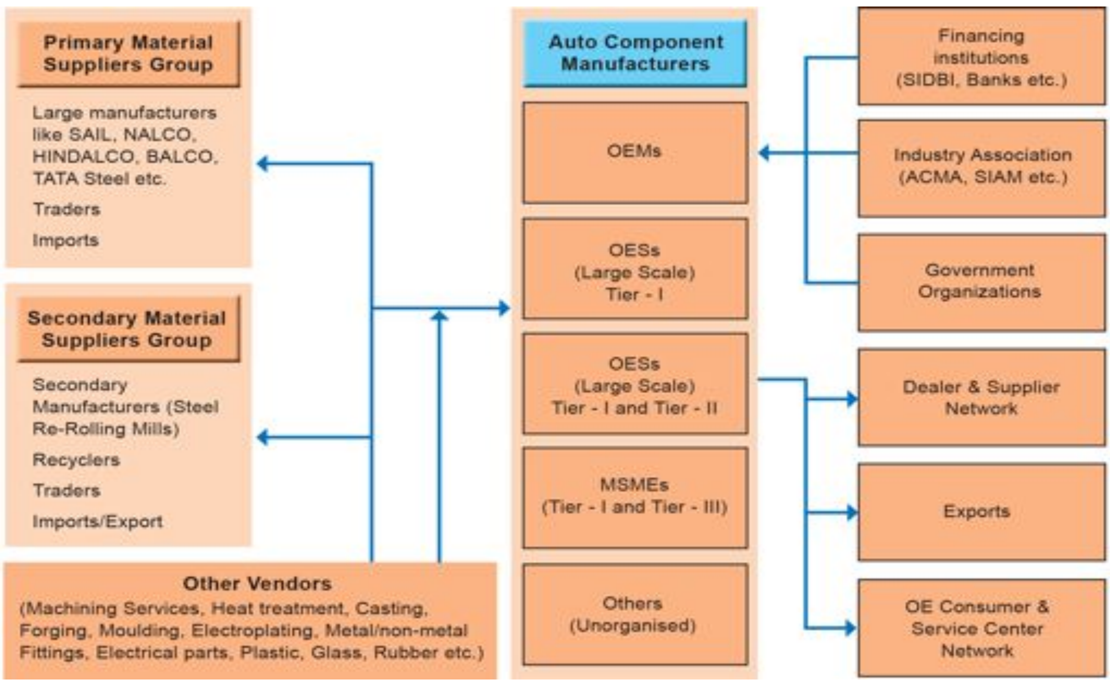
[29] Supply Chain Management In Indian Automotive Industry : Complexities, Challenges And Way Ahead, International Journal Of Managing Value And Supply Chains, June 2014
[30] Defining the Role of the Government in the Transnationalisation Efforts of the Indian SMEs in the Auto Components Sector, DSIR(Govt. Of India), 2012

The automotive supply chain includes multitude of Tier 1, 2 and Tier 3 suppliers or manufacturers with many assembly operations and a number of dealerships. Customer demand for varied specific configurations and features add to the high level of response needed from automobile supply chains. The order lead time required by a customer is averaged at 4-6 weeks in the automobile industry and there is a definite correlation between implementation of Supply Chain Management (SCM) practices and quality and conformance of design[31]. Figure 25 shows the linkages in supply chain in Indian auto component industry:

The supply chain of the auto industry has completely changed over the years. Major OEM players are increasingly focusing on basic design and assembly operations as well as servicing the aftersales market and they prefer to deal with a smaller number of large suppliers. Consequently, the supply chain is morphing into sub-system integrators, component makers, and commodity players. The segregation is increasingly defined by "risk sharing," which was earlier defined by only cost pressure. Tier-I suppliers (concentrating on system supply, module assembly and sub-supplier management) are taking increasing risk from major players, shifting the cost pressure to tier-II suppliers who concentrate only on the production of sub-components.

In the Asia-Pacific region, the growth of component manufacturers has taken a different route. Most of the Japanese producers follow a tight relationship with their suppliers (Independent or quasi-independent). The existence of the keiretsu system (business affiliation) in Japan greatly facilitated such an arrangement. But other manufacturers like Korean, Chinese and Indians give a lot of importance to price and quality while buying from a number of trusted suppliers. As a result of this, indigenous auto- component sectors are thriving in many Asian countries.

Figure 26: Mapping of Auto Component Supply Chain Matrix and Material Flow



[31] Supply Chain Management In Indian Automotive Industry : Complexities, Challenges And Way Ahead, International Journal Of Managing Value And Supply Chains, June 2014

4.2 Challenges In the Supply Chain

The top five global supply chain challenges[32] are:

- Visibility
- Cost containment
- Risk management
- Increasing customer demands
- Globalization

It is interesting to note that automotive supply chains, globally, lag behind other supply chains (such as retail, pharmaceutical etc.) in these five parameters clearly indicating the need for and scope of considerable improvements to make them more effective and responsive. The surge in demand in the last decade has put sudden pressure on the existing Indian auto and auto component manufacturers, with hardly any integration, to quickly adopt global standards and practices and introduce or vitalize supply chain processes thus posing challenges in technological preparation and transition management almost dynamically without impacting the brand image.

Supply chains in the automotive sector have to contend with peculiarities in the Indian context which are distinctly different from those in developed countries. Preference for small cars and two wheelers, lack of visibility at the customer end especially in rural markets, packaging complexities due to language and cultural diversity, quality challenges due to resource shortcomings, large number of fragmented suppliers which impede effective collaborations, complex tariffs and duties, lack of infrastructure (off highway transit is difficult) and a multilevel distribution system impacting price of products are some of the significant supply chain challenges[33].

The biggest challenge being integration of end-to-end supply chain followed by managing in-bound logistics, product and part proliferation. The auto component industry, a major contributor to export and growth, is beset with frequent changes in costs of raw materials, customer demand for product quality, timely deliveries and sourcing of raw materials[34].

Skill development is being undertaken by some major Tier-1 auto-component manufacturers and a good example is that of Bosch Ltd which has the Bosch Vocational Center (BVC) to impart training on quality, safety, problem solving techniques etc[35]. A survey has revealed that the main strategies for overcoming SCM challenges in Indian auto industry are - increasing investment in Information

[32] Supply Chain Management In Indian Automotive Industry : Complexities, Challenges And Way Ahead, International Journal Of Managing Value And Supply Chains, June 2014
[33] Supply Chain Management In Indian Automotive Industry : Complexities, Challenges And Way Ahead, International Journal Of Managing Value And Supply Chains, June 2014
[34] Supply Chain Management In Indian Automotive Industry : Complexities, Challenges And Way Ahead, International Journal Of Managing Value And Supply Chains, June 2014
[35] Sahoo, T., Banwet, D.K., Mamaya,K., (2011), "Strategic technology management in the auto component industry in India", Journal of Advances in Management Research, Vol. 8, No.1 pp 9-29

Technology and process improvements (38%), vendor/dealer consolidation (31%) and improving internal infrastructure (8%)[36].

OEM-Supplier Synergy:

The major aspect of the 'OEM-auto component manufacturers' linkage relates to concerns regarding responsibility for design and quality besides location, cost and module design capabilities. It is evident that 'on-site' suppliers contribute substantially in achieving overall supply chain efficiency through standardization of parts and cost effectiveness. Outsourcing by OEMs has also resulted in suppliers assuming greater responsibilities in assembly and sub-assembly design and development necessitating widespread technological advancement. Global suppliers, particularly, face challenges of logistics, local content and quality, innovative ability of suppliers, reliability and cost.

Leveraging Technology:

A survey conducted among top auto makers in India highlighted the fact that technology is widely seen to be a supply chain enabler, reducing inventory levels and stocking, shortening lead times and fostering a spirit of collaboration with suppliers and dealers[37]. IT managers indicate a 'lack of alignment' between business goals and IT implementation plans in majority of the companies. Although there is a high awareness among Indian Tier-1 companies, the usage of productive-enhancing tools such as data analytics, ERP, RFID etc are still at low levels specially among Tier 2 suppliers due to challenges such as cultural, financial, organizational and technological barriers to be overcome[38].

4.3 Major Raw Materials In Auto Components

An automobile is composed of various material components which are produced by utilizing a wide variety of technologies and which satisfy customer needs and environmental norms. Heat treatment and surface modification are the key technologies available today, to enhance the effective use of materials, to achieve the desired properties of the components used in the automotive industries, to save energy and conserve natural resources. In spite of tremendous efforts being made to develop vehicles made of all aluminium auto body, most automobiles today are composed of 57% steel, 7% iron, 8% plastic, 8% aluminium. Other materials account for the remaining 20%. To fulfil the fuel economy targets, it is necessary to reduce vehicle body weight while also improving engine and rolling energy losses. These improvements are being achieved through the use of high strength steel sheets and/or in conjunction with even greater increased usage of aluminium, magnesium and titanium alloys having lower specific weights compared with iron and steels. Approximately 22% of

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[36] Supply Chain Management In Indian Automotive Industry : Complexities, Challenges And Way Ahead, International Journal Of Managing Value And Supply Chains, June 2014

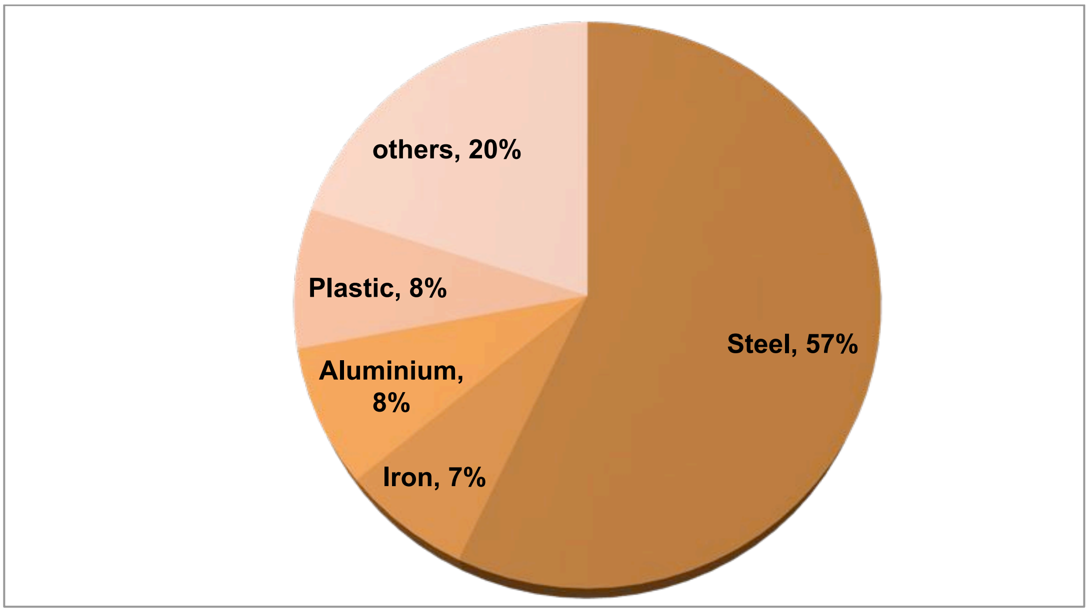
[37] Khare,A., (2006), "Supply Chain Collaborations changing the face of Indian Automobile", The International Journal of Applied Management and Technology, Vol. 6, No. 1.

[38] Childerhouse,P.,Heriz,R,,Mason-Jones,R,Popp,A.,Towill,DR.,(2003), "Information Flow in automotive supply chains – identifying and learning to overcome barriers to change", Industrial Management & Data System,

an automaker's operational costs depend on steel. So, any fluctuation in global steel prices has a direct impact on profitability.[39]

In India traditionally, automakers only used aluminium for wheels, cylinder blocks, and other engine parts. Aluminium is twice as expensive as steel. However, this trend is changing in response to stringent fuel economy standards. Although it's more expensive than steel, aluminium is much lighter. It has a similar strength. Every 10% reduction in weight improves the fuel economy by 5–7%[40]. In recent years, there has been an increased use of aluminium, magnesium and carbon fibre composite in the raw materials for manufacturing of automobiles. For example: During the stakeholder consultation with Anand group, it came to notice that Anand group is making more use of polyurethane and plastic in the filters in place of metal.

Figure 27: Raw Material Constituent of A Small Car By Weight[41]



Steel:

Advanced iron and steel technologies have seen considerable development over the past decade and are frequently included into new designs and redesigns by all automakers. The steel industry and component suppliers are investing heavily in innovation. The result of the investment is numerous examples of successful, cost-effective use of stainless steel, new formulations of iron, high-strength steels, and an associated variety of new design, fabrication, and assembly techniques. Applications include not only vehicle bodies, but also engine, chassis, wheels and many other parts. The usages commonly demonstrate weight reduction plus simultaneous improvements in strength, stiffness, and other structural performance characteristics. Thus, a clear potential exists to affordably make vehicles

[39] http://marketrealist.com/2015/02/raw-materials-biggest-cost-driver-auto-industry/
[40] http://marketrealist.com/2015/02/raw-materials-biggest-cost-driver-auto-industry/
[41] Indian Auto Component Industry: A Decade of Growth and Way Forward, Velury Vijay Bhasker, 2013

lighter and safer at the same time. [DeCicco, 2005] While body, chassis, engine and other powertrain components made of ferrous materials comprise the largest part of a vehicle by mass, lightweight steel and iron technologies compete with potential substitutes in all of these applications.

The past several years have seen steady increases in the use of high-strength steels (HSS), many versions of which are referred to as high-strength, low-alloy (HSLA) steels. These materials plus their associated advanced design and fabrication techniques (as well as improved design and fabrication using traditional steels) formed the basis of the American Iron and Steel Institute (AISI) Ultra-Light Steel Auto Body (ULSAB) series of studies and demonstration projects. The ULSAB car body demonstrated a 19% mass reduction in a body structure that had superior strength and structural performance (including crashworthiness) along with a reduced parts count and net manufacturing cost savings compared to a conventional steel body[42]. Comparable mass reductions and other benefits were achieved for doors, hoods, decklids, and hatchbacks[43]. Improved steel materials and forming processes allow a significant optimization of vehicle body structures and components[44]. The prime reason for using steel in the body structure of an automotive is its inherent capability to absorb impact energy in a crash situation[45]. This, in combination with the good formability and joining capability, makes these materials often a first choice for the designer of the body-in-white (BIW) structure[46].

New Grades of Steel and Alloys:

Materials are often described by properties such as yield- and tensile strength, elongation to fracture, anisotropy and Young's modulus but shape is not a material property. A sheet metal component is a material made into a certain shape through a forming process. Depending on loading condition, a material-and-shape combination resists the applied load best. Components in a BIW structure should also be able to absorb or transmit impact energy in a crash situation.

High-strength steel (HSS) is based on alloys that are categorized on the basis of yield strength. Standard HSS has a yield strength between 210 MPa and 550 MPa; ultra-high strength steel (UHSS) has a yield strength higher than 550 MPa [47]

Stainless steel is a material of choice due to passivity and resistance to corrosion. The specific stiffness of Stainless Steel is very similar to that of aluminium alloy and the HSLA steel, which means that the three materials can all be considered as "light materials". Austenitic Stainless Steels i.e. Fe – Cr – Ni containing alloys have the advantage over aluminium alloys and carbon steels of being highly strain rate sensitive.

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[42] USAB, 1998
[43] Opbroek & Weissert, 1998
[44] DeCicco, 2005
[45] Marsh, 2000
[46] Magnusson et al, 2001
[47] Materials in Automotive Application, State of the Art and Prospects, New Trends and Developments in Automotive Industry (By Elaheh Ghassemieh), 2011

Aluminium and Aluminium Alloys

Typical products made of aluminium alloys include cases for transmission, differential and steering gear boxes. In order to reduce the weight of the vehicle, aluminium sheets are being used for panels such as engine hood, body panels and suspension components. There are a broad range of opportunities for employing aluminium in automotive powertrain, chassis, and body structures. Aluminium usage in automotive applications has grown substantially within past years. A total of about 110 kg of aluminium: vehicle in 1996 is predicted to rise to 250 or 340 kg, with or without taking body panel or structure applications into account, by 2015[48]. There are strong predictions for aluminium applications in hoods, trunk lids and doors hanging on a steel frame. Recent examples of aluminium applications in vehicles cover power trains, chassis, body structure and air conditioning. Aluminium castings have been applied to various automobile parts for a long period. As a key trend, the material for engine blocks, which is one of the heavier parts, is being switched from cast iron to aluminium resulting in significant weight reduction. Aluminium castings find the most widespread use in automobile. In automotive power train, aluminium castings have been used for almost 100% of pistons, about 75% of cylinder heads, 85% of intake manifolds and transmission (other parts-rear axle, differential housings and drive shafts etc.)[49]. For chassis applications, aluminium castings are used for about 40% of wheels, and for brackets, brake components, suspension (control arms, supports), steering components (air bag supports, steering shafts, knuckles, housings, wheels) and instrument panels.

Top components identified by resource intensity and corresponding raw material consumption:

Table 6: Top 10 Components By Resource Intensity

Auto Components Selected For Analysis	
1.	Frame
2.	Axle
3.	Cylinder Block
4.	Gearbox
5.	Flywheel
6.	Wheel Rims
7.	Disc Brake
8.	Clutch
9.	Connecting Rod
10.	Piston

[48] Sears, 1997
[49] Materials in Automotive Application, State of the Art and Prospects, New Trends and Developments in Automotive Industry,(By Elaheh Ghassemieh),2011

Table 6 shows the top 10 auto components in a vehicle by their resource intensity. These components have been identified on the basis of secondary research and industry stakeholder consultation and consume about 60-70% of total raw material consumption (considering weight of these 10 components) of the light weight car.

Following table shows the current production of these top 10 components and the weight per component of each of these 10 components for two and four wheelers.

Table 7: Top 10 Components By Resource Intensity and their Weights

Auto Components	Current Production	Weight Per Component in Kg (4 Wheelers)	Weight Per Component in Kg (2 Wheelers)	Assumptions (If Any)
Frame	2,04,30,000	385.46	18	-
Axle	35,30,000	80	-	All four wheelers are of two wheel drive type
Cylinder Block	3,10,20,000	37.5	5.5	-
Gearbox	2,04,30,000	25	10	-
Flywheel	2,04,30,000	6.8	3.3	-
Wheel Rims	4,79,20,000	6	1.5	1) All tyres of four wheelers has wheel rims 2) Two wheelers have wheel rims in front tyres.
Disc Brake	2,39,60,000	6	2	1) All 4 Wheelers have two disc brakes. 2) All 2 wheelers have one disc brake
Clutch Disc	2,04,30,000	3.8	1.5	-
Connecting Rod	3,10,20,000	0.75	0.40	-
Piston	3,10,20,000	0.350	0.200	-

Below are the detailed findings for all the 10 selected components for the study:

1) Frame[50]

It is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. It gives strength and stability to the vehicle under different conditions.

Raw Material Composition: On the basis of our secondary research, we found that automotive frames are manufactured mostly from steel in India, though aluminium is another raw material that has increasingly become popular for manufacturing these auto frames. To know more about the raw materials used for the construction of frame, we also conducted a stakeholder interaction with one of the leading manufacturer of the two wheeler frames in India.

Weight of the component: The weight of the frame is around 385.46 Kg for a four wheeler and around 18 Kg for a two wheeler.

Following table shows the composition of the structural steel used for manufacturing of the frame.

Table 8: Material Composition of the Frame

Raw Material	Percentage Composition
Iron (Fe)	96.8%
Carbon (C)	0.60%
Silicon (si)	1.80%
Manganese (Mn)	0.70%
Phosphorus (P)	0.05%
Sulphur (S)	0.05%

50 Source: Industry Sources, Modelling and Structural Analysis of Ladder Type Heavy Vehicle Frame , 2014

The analysis of total raw material consumption (tonnes) for frames in various categories of vehicles for the year 2013- 2014 is as follows:

Table 9: Material Consumption in Tonnes for the Frame (2014)

Categories	2 Wheelers	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Frame Production	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Total Raw Material Consumption in Tonnes	3,03,926	11,93,851	1,65,599	16,63,375
Iron (Tonnes)	2,94,602	11,57,226	1,60,518	16,12,347
Carbon (Tonnes)	1,719	6,751	936	9,407
Silicon (Tonnes)	5,476	21,509	2,983	29,968
Manganese (Tonnes)	2,129	8,364	1,160	11,654

2) Axle[51]

An axle is a central shaft for a rotating wheel or gear. In a live-axle suspension system, the axles serve to transmit driving torque to the wheel, as well as to maintain the position of the wheels relative to each other and to the vehicle body.

Raw Material Composition: There are a number of different materials used to make axles. Most OEM axles are made from carbon steel (typically SAE 1055 or 1541). It mainly consists of

[51] **Sources:** http://www.markwilliams.com/axle-txt.aspx , Industry Sources

Iron. Following table shows the composition of the raw material used to manufacture this subcomponent.

Table 10: Material Composition of Axle

Raw Material	Percentage Composition
Iron (Fe)	96.41%
Carbon (C)	0.50%
Silicon (si), Manganese (Mn) and others	1.09%

Weight of an Axle: As per the industry sources, axle weight for most of the 4 wheelers is around 80 Kg.

Assumption: Analysis has been conducted for two wheel drive only, as most of the 4 wheelers are of two wheel drive type in India.

The analysis of total raw material consumption (tonnes) for Axle in various categories of vehicles for the year 2013- 2014 is as follows:

Table 11: Raw Material Consumption In Tonnes for the Axle (2014)

Categories	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	3100000	430000	3530000
Axle Production	3100000	430000	3530000
Raw Material Consumption in Tonnes	248000	34400	282400
Iron (Tonnes)	244057	33853	277910
Silicon &Manganese &Others (Tonnes)	2703	375	3078
Carbon (Tonnes)	1240	172	1412

3) Cylinder/Engine Blocks[52]

Cylinder/Engine block is an integrated structure comprising the cylinder(s) of an engine and often some or all of their associated surrounding structures (coolant passages, intake and exhaust passages and ports, and crankcase).

Raw Material Composition: Engine blocks are a critical component of an engine, and it must satisfy a number of functional requirements. These requirements include lasting the life of the vehicle, housing internal moving parts and fluids, ease of service and maintenance, and withstand pressures created by the combustion process. In order for an engine block to meet the functional requirements listed above, the engineering material (s) used to manufacture the product must possess high strength, modulus of elasticity, abrasion resistance, and corrosion resistance. Aluminium alloys are widely used in engine blocks and they give advantage over cast iron in terms of strength to weight ratio.

Following table represents the two most commonly used alloys for the construction of an engine block. For the calculation of the raw material consumption, we have taken average of both these alloys.

Table 12: Aluminium Alloy for Cylinder/Engine Block

Alloy	Aluminium	Silicon	Copper
Alloy 319	85.8%	5.5%	3.0%
Alloy A356	91.1%	6.8%	0.25%
Average	88.5%	6.1%	1.6%

Weight of the Component: The cylinder block (popularly known as the engine block) is the strongest component of an engine that provides much of the housing for the hundreds of parts found in a modern engine. Since it is also a relatively large component, it constitutes 20-25% of the total weight of an engine.

[52] **Sources:** Engine block composition (Manufacturing Processes and Engineering Materials Used in Automotive Engine Blocks) ,2005, Industry Sources

The analysis of total raw material consumption (tonnes) for Cylinder in various categories of vehicles for the year 2013- 2014 is as follows:

Table 13: Raw Material Consumption In Tonnes for the Cylinder Blocks (2014)

Categories	2 Wheelers Production	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	16900000	3100000	430000	20430000
Cylinder Production	1,69,00,000	1,24,00,000	17,20,000	3,10,20,000
Total Raw Material Consumption in Tonnes	89,418	4,47,330	62,049	5,98,797
Aluminium (Tonnes)	82,214	4,11,293	57,050	5,50,557
Silicon (Tonnes)	5,693	28,481	3,951	38,125
Copper (Tonnes)	1,510	7,556	1,048	10,115

4) Gearbox[53] (Transmission System)

The gearbox or Transmission System uses gears and gear trains to provide speed and torque conversions from a rotating power source to another device. There are two type of transmission system designed in vehicles Manual and Automatic.

Raw Material Composition: Gearbox is made from the cast iron. Gearbox materials selection depends upon the large number of factors such as mechanical properties, physical and electrical properties, corrosion resistance and economy.

[53] Sources: Industry Sources, www.castingquality.com

Optimal design of gears requires the consideration of the two type parameters:

- Material Parameters
- Geometrical parameters: The choice of stronger material parameters may allow the choice of finer geometrical parameters and vice versa.

Following table shows the composition of cast iron used for manufacturing of the gearbox:

Table 14: Material Composition For The Gear Box

Raw Material	Percentage Composition
Iron (Fe)	92%
Carbon (C)	3%
Silicon (Si) & Manganese (Mn) and Others	5%

Weight of Gearbox: As per our interaction with the auto industry sources, weight of gearbox is around 25 Kgs for a four Wheelers vehicle and around 10 Kgs for a two wheelers vehicle.

The analysis of total raw material consumption (tonnes) for gear box/transmission system in various categories of vehicles for the year 2013- 2014 is as follows:

Table 15: Raw Material Consumption In Tonnes for the Gearbox (2014)

Categories	2 Wheelers Production	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	16900000	3100000	430000	20430000
Gearbox Production	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Total Raw Material Consumption in Tonnes	1,69,000	77,500	10,750	2,57,250
Iron (Tonnes)	1,55,480	71,300	9,890	2,36,670
Carbon (Tonnes)	5,070	2,325	323	7,718
Silicon & Manganese & Other	8,450	3,875	538	12,863

5) Connecting Rod[54]

The connecting rod or conrod connects the piston to the crank or crankshaft. Together with the crank, they form a simple mechanism that converts reciprocating motion into rotating motion.

The connecting rod is the intermediate member between the piston and the Crankshaft. Its primary function is to transmit the push and pull from the piston pin to the crank pin, thus converting the reciprocating motion of the piston into rotary motion of the crank.

Raw Material Composition: It could be made from aluminium alloy or carbon steel. But most of the existing rods are manufactured by using carbon steel. Micro alloyed high carbon steels (such as C70S6, SMA40 and FRACTIM) have been considered to be economic alternatives to powder metal and conventional steel, having been used as main crackable con-rod materials in recent years. Compared with powder metal and conventional steel, these micro alloyed high carbon steels have many advantages such as:-

- Fracture-splitting connecting rods exhibit 30% higher fatigue strength and 13% less weight than conventional connecting rods
- Lower cost for the whole manufacturing process

Following table shows the composition of the carbon steel used to manufacture the connecting rod.

Table 16: Material Composition of the Connecting Rod

Raw Material	Percentage Composition
Iron (Fe)	98.48%
Carbon (C)	0.69%
Silicon (Si)	0.18%
Manganese (Mn)	0.50%
Phosphorus (P)	0.02%
Sulphur (S)	0.06%
Nickle (Ni)	0.06%

Assumptions: Four wheeler has been considered to have four cylinder engines and a two wheeler has been considered to have one cylinder engine.

[54] **Source:** Industry Source; A metallographic examination of fracture splitting C70S6 steel used in connecting rods (Ziya AKSOY, Zafer ÖZDEMİR, Tekin ÖZDEMİR), 2012

Weight: Connecting rod weight varies slightly from one vehicle manufacturer to another. However, from industry sources and secondary research we have found weight of the connecting rod is around 400 grams for 2 Wheelers and around 750 grams for a 4 wheelers.

The analysis of total raw material consumption (tonnes) for connecting rods in various categories of vehicles for the year 2013-2014 is as follows:

Table 17: Raw Material Consumption In Tonnes for the Connecting Rod (2014)

Categories	2 Wheelers	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Connecting Rod Production	1,69,00,000	1,24,00,000	17,20,000	3,10,20,000
Raw Material Consumption in Tonnes	6,760	9,300	1,290	17,350
Iron (Tonnes)	6,658	9,159	1,270	17,087
Silicon & Manganese & Others (Tonnes)	56	77	11	143
Carbon (Tonnes)	47	64	9	120

6) Piston[55]

Piston is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod.

Raw Material Composition: Raw material composition of piston can vary from one manufacturer to another. But variation in the composition is not huge and raw material mainly consists of aluminium and silicon.

[55] Source: Effect of Alloying Elements on High Temperature Mechanical Properties for Piston Alloy (Express Regular Article), Industry Sources

To arrive at the raw material composition of the pistons, we have taken the average of three types of alloys which are used for manufacturing pistons. Out of this, we have focussed on the top components, aluminium and silicon, which makes around 92% of the total raw material composition of the piston. Following table shows the percentage of the top resources used in the raw material.

Table 18: Material Composition of the Piston

Raw Material	Percentage Composition
Aluminium (Al)	81.4%
Silicon (si)	12%
Others	Rest

We have also conducted a stakeholder interaction with an auto component manufacturer. Above percentages of aluminium and silicon are in sync with the composition of raw material used by auto component manufacturer in India.

Weight: Piston weight varies from one vehicle manufacturer to another. However, from industry stakeholder consultation we found out that piston weight is around 200 grams for a two wheeler and it is around 350 grams for four wheelers.

Assumption: Four wheelers have been considered to have four cylinder engines and a two wheeler has been considered to have one cylinder engine.

The analysis of total raw material consumption (tonnes) for Pistons in various categories of vehicles for the year 2013- 2014 is as follows:

Table 19: Raw Material Consumption In Tonnes for the Piston (2014)

Categories	2 Wheelers Production	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 to Dec 2014	1,69,00,000	3,100,000	4,30,000	20,430,000
Pistons Production	1,69,00,000	1,24,00,000	17,20,000	3,10,20,000
Total Raw Material Consumption in Tonnes	3,159	4,056	563	7,777
Aluminium (Tonnes)	2,752	3,534	490	6,776
Silicon (Tonnes)	407	522	72	1,001

7) Clutch Discs[56]

A clutch is a mechanical device that engages and disengages the power transmission, especially from driving shaft to drive shaft. Clutches connect and disconnect two rotating shafts (drive shafts or line shafts).

Raw Material Composition: Clutches are manufactured from grey cast iron. Grey cast iron constitutes Fe-C- Si alloy with unavoidable impurities Mn, P, and S. Grey cast iron is used because of its low cost, excellent machinability, good wear resistance and excellent damping capacity. Following table shows the percentage of the top resource used for the manufacturing of clutch discs.

Table 20: Material Composition of Clutches

Raw Material	Percentage Composition
Iron (Fe)	94%
Silicon (Si)	2%
Carbon (C)	3%

Weight: Clutch disc weight varies slightly from one vehicle manufacturer to another. However, from industry sources we have found that weight of a clutch disc is around 3.8 Kg for a four wheeler and around 1.5 Kg for a two wheeler.

The analysis of total raw material consumption (tonnes) for Clutches in various categories of vehicles for the year 2013-2014 is as follows (Table 21 on next page):

[56] **Source:** Industry Sources, Microstructure and mechanical properties of pearlitic gray cast iron (By L. Collini a,∗, G. Nicoletto a, R. Koneˇcn´a b), Basic Mechanical Engineering (By Mohan Sen), 2006

Table 21: Raw Material Consumption In Tonnes for a Clutch Disc (2014)

Categories	2 Wheelers	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Clutch Production	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Raw Material Consumption in Tonnes	25,097	11,662	1,618	38,376
Iron (Tonnes)	23,829	11,073	1,536	36,438
Carbon (Tonnes)	761	353	49	1,163
Silicon (Tonnes)	507	236	33	775

8) Brake Rotor Disc[57]

A disc brake is a type of brake that uses calipers to squeeze pairs of pads against a disc in order to create friction that retards the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. Hydraulic disc brakes are the most commonly used form of brake for motor vehicles.

Raw Material Composition: Disc brake is a device for slowing or stopping the rotation of a wheel while it is in motion. A disc brake (or rotor) is usually made of cast iron, but in some cases it can be made of composites such as reinforced carbon-carbon or ceramic-matrix composites. For calculation of the raw material consumption, we have assumed all disc rotors to be made of cast iron. The front braking system of most modern cars is based on brake discs, which uses gray cast iron brake discs as the braking surfaces. The metallurgical properties of the gray cast iron determine the

[57] **Sources:** Microstructure and mechanical properties of pearlitic gray cast iron (By L. Collini a,∗, G. Nicoletto a, R. Koneˇcn´a b), Research Paper on Manufacturing of Gray Cast Iron Automotive Disc Brake, 2014

strength, noise, wear and braking characteristics of the brake discs. Following table shows the percentage of the top resource used for the manufacturing of brake rotor disc.

Table 22: Material Composition of the Brake Rotor Disc

Raw Material	Percentage Composition
Iron (Fe)	94%
Silicon (Si)	2%
Carbon (C)	3%

Weight: Brake rotor disc weight varies from one vehicle manufacturer to another. However, from the industry sources and secondary research we have found that the braking band or ring in the disc rotor weighs around 6 kg for a four wheelers and around 1.5 -2 kg for a two wheelers.

Assumption: Only front braking system of four wheelers and two wheelers has disc brake.

The analysis of total raw material consumption (tonnes) for Brake Rotor Disk in various categories of vehicles for the year 2013- 2014 is as follows:

Table 23: Raw Material Consumption In Tonnes for the Brake Rotor Disc (2014)

Categories	2 Wheelers Production	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Disc Brake Production	1,69,00,000	62,00,000	8,60,000	2,39,60,000
Raw Material Consumption in Tonnes	33,462	36,828	5,108	75,398
Iron (Tonnes)	31,772	34,968	4,850	71,590
Carbon (Tonnes)	1,014	1,116	155	2,285
Silicon (Tonnes)	676	744	103	1,523

9) Flywheel[58]

A flywheel is a rotating mechanical device that is used to store rotational energy. Flywheels have a significant moment of inertia and thus resist changes in rotational speed. Flywheel provides continuous energy when the energy source is discontinuous and controls the orientation of a mechanical system.

Raw Material Composition: Most factory or OE flywheels are made from cast iron (gray iron) to keep costs down. Cast iron is a very heavy and porous material and can be brittle when subjected to high stress loads. However, steel and aluminium can also be used to make this auto subcomponent. Steel has higher strength than cast iron and it is used where extreme strength is the issue and not increased performance. Following table shows the composition of the cast iron used to manufacture this subcomponent.

Table 24: Material Composition Of The Flywheel

Raw Material	Percentage Composition
Iron (Fe)	94%
Silicon (Si)	2%
Carbon (C)	3%

Weight of Flywheel: It varies slightly from one type of manufacturer to another. However, from industry sources and secondary research we found out that for two wheelers it is around 3.3 kg and for four wheelers it is around 6.5 Kg.

The analysis of total raw material consumption (tonnes) for flywheel in various categories of vehicles for the year 2013- 2014 is as follows (Table 25 on next page):

[58] **Sources:** Microstructure and mechanical properties of pearlitic gray cast iron (By L. Collini a,∗, G. Nicoletto a, R. Koneˇcn´a b), Research Paper on Manufacturing of Gray Cast Iron Automotive Disc Brake

Table 25: Raw Material Consumption In Tonnes for the Flywheel (2014)

Categories	2 Wheelers	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Flywheel Production	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Raw Material Consumption in Tonnes	55,212	20,925	2,903	79,040
Iron (Tonnes)	52,424	19,868	2,756	75,048
Carbon (Tonnes)	1,673	634	88	2,395
Silicon (Tonnes)	1,115	423	59	1,597

10) Wheel Rim[59]

The rim is the "outer edge of a wheel, holding the tire". It makes up the outer circular design of the wheel on which the inside edge of the tire is mounted on vehicles such as automobiles.

Alloy wheels are wheels that are made from an alloy of Aluminium or Magnesium.

Raw Material Composition: On the basis of secondary research and our consultation with the industry sources, we found out that mostly rim wheels are made from the aluminium based alloy. A356 is one of the widely used alloy for making rim wheels. A356 belongs to a group of hypo eutectic Al-Si alloys and has a wide field of application in the automotive industries. It is used in the heat treated condition in which a optimal ratio of physical and mechanical properties is obtained.

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[59] **Sources:** Microstructure and mechanical properties of pearlitic gray cast iron (By L. Collini a,∗, G. Nicoletto a, R. Koneˇcn´a b), Research Paper on Manufacturing of Gray Cast Iron Automotive Disc Brake, 2008

Following table represents the percentage of aluminium and silicon in the alloy A356.

Table 26: Material Composition of the Wheel Rim

Raw Material	Percentage Composition
Aluminium (Al)	91%
Silicon (si)	7%
Others	2%

Weight of the component: Weight of the aluminium wheel rim is around 6 Kg for four wheelers and around 1.5 Kg for two wheelers. The analysis of total raw material consumption (tonnes) for wheel rim in various categories of vehicles for the year 2013- 2014 is as follows:

Table 27: Raw Material Consumption In Tonnes for the Wheel Rims (2014)

Categories	2 Wheelers	Passenger Vehicles	Light Commercial Vehicles	Total
Vehicles Production from Jan 2014 till Dec 2014	1,69,00,000	31,00,000	4,30,000	2,04,30,000
Wheels Rims Production	3,38,00,000	1,24,00,000	17,20,000	4,79,20,000
Total Raw Material Consumption (Tonnes)	49,686	72,912	10,114	1,32,712
Aluminium (Tonnes)	46,137	67,704	9,391	1,23,232
Silicon (Tonnes)	3,549	5,208	722	9,479

Below table shows the aggregate raw material consumption in tonnes for various categories of auto components (selected 10 auto components) of the vehicles for the year 2013-2014.

Table 28: Raw Material Consumption Aggregated at the Component Segment Level

Raw Material Consumption At The Auto Component Segment Level (2014)				
Categories	2 Wheelers	Passenger Vehicles	Light Commercial Vehicles	Total
Engine & Engine Parts (Piston, Engine Casing, Connecting Rod)				
Iron (Includes Steel) (Tonnes)	6,658	9,159	1,270	17,087
Aluminium (Tonnes)	84,966	4,14,826	57,540	5,57,333
Silicon & Manganese & Other (Tonnes)	6,156	29,080	4,034	39,269
Cabon (Tonnes)	47	64	9	120
Suspension and Braking Parts (Wheel Rims, Brake Disc)				
Aluminium (Tonnes)	77,909	1,02,672	14,242	1,94,823
Carbon (Tonnes)	1,014	1,116	155	2,285
Silicon (Tonnes)	4,225	5,952	826	11,003
Transmission and Steering Parts (Gearbox, Axle, Clutch Disc, Flywheel)				
Iron (Includes Steel) (Tonnes)	4,75,790	1,36,094	2,92,092	9,03,976
Carbon (Tonnes)	8,744	3,484	1,871	14,100
Silicon & Manganese& Other (Tonnes)	12,776	4,908	3,707	21,391
Others (Frame)				
Iron (Includes Steel) (Tonnes)	2,94,602	11,57,226	1,60,518	16,12,347
Carbon (Tonnes)	1,719	6,751	936	9,407
Silicon (Tonnes)	5,476	21,509	2,983	29,968
Manganese (Tonnes)	2,129	8,364	1,160	11,654

Following table shows the aggregate raw material consumption for the selected 10 auto components for the study.

Table 29: Total Raw Material Consumption In Million Tonnes for All the 10 Auto Components (2014)

Categories	2 Wheelers	Passenger Vehicles	Light Commercial Vehicles	Total
Iron (Includes Steel) (Million Tonnes)	0.78	1.30	0.45	2.53
Aluminium (Million Tonnes)	0.16	0.52	0.07	0.75
Silicon & Manganese & Others (Million Tonnes)	0.03	0.07	0.01	0.11
Carbon (Million Tonnes)	0.01	0.01	0.00	0.03
Total Raw Material Consumption (Million Tonnes)	0.98	1.90	0.54	3.42

Figure 28: Raw Material Projections For Top 10 Components Till 2030

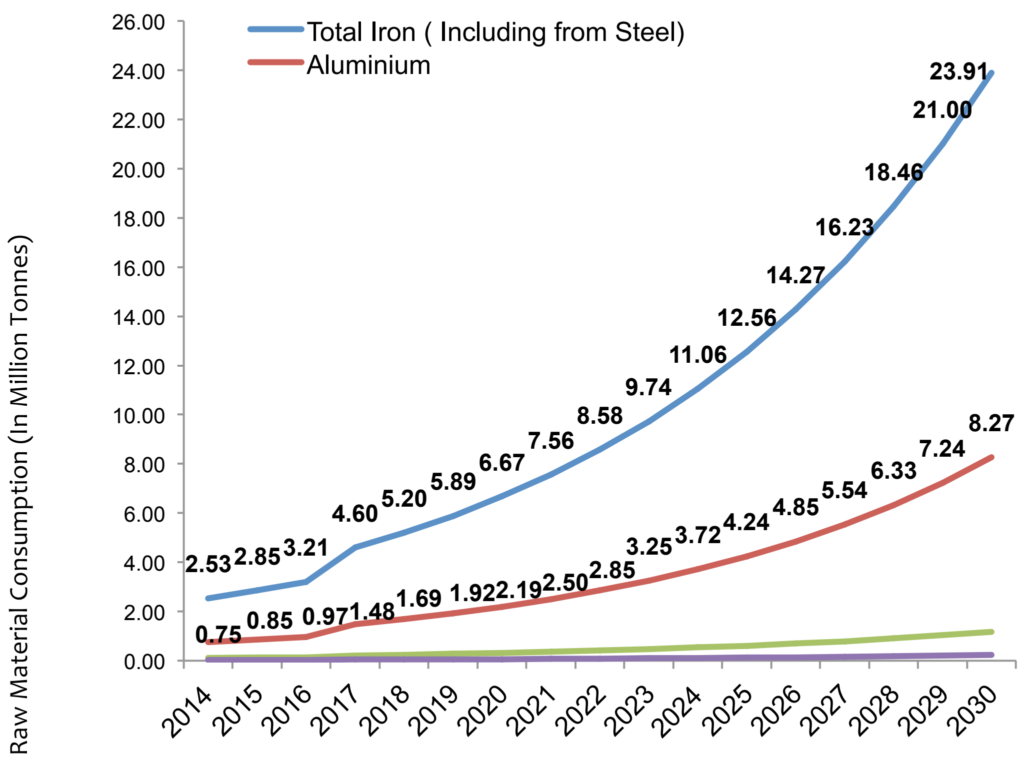


Figure 28 shows the projection for raw material consumption till 2030 for the top 10 components considered for the study. As per this study there would be a requirement of 23.91 Million tonnes of Iron (Including Steel) in 2030 and a total requirement of around 8.27 million tonnes of Aluminium in India. This would mean an increase of more than 800% in Iron (Including steel) and an increase of around 1000% in Aluminium requirement for the manufacturing of these 10 auto components by 2030.

Aluminium, steel and iron forms about 70% of the total raw material consumption in a normal passenger car. As per Indian Minerals (Part- II: Metals & Alloys) document, the normal demand for steel in the transport sector is around 12% of the total demand for various sectors in India. Below table shows the current production of the finished steel in India.

Table 30: Finished Steel Production In India

Finished Steel Production (In Million Tonnes)[60]		
2010-2011	**2011-2012**	**2012-2013**
68.62	75.69	81.68

As per our analysis there would be a requirement of 20.96 million tonnes of steel (57% of the total raw material) in 2030 for the 10 auto components selected.

Table 31: Finished Steel Requirement for the 10 Selected Auto Components

Finished Steel Requirement (Million Tonnes) For the 10 Auto Components Selected	
Year 2020	**Year 2030**
5.85	20.97

Assuming current level of resource efficiency in 2030 and also that transport sector demand will remain at the current level of 12% of the total finished steel production in 2030 in India (not changing the other industrial sector demand percentage), we can estimate that this 20.96 million tonnes of steel will require around 175 million tonnes[61] of finished steel production set up.

[60] Source: Indian Minerals (Part- II : Metals & Alloys), Iron and steel and scrap
[61] Assumption : Same level of import and export as now

Table 32: Finished Steel Production Set Up Requirement (In Million Tonnes)

Finished Steel Production Set Up Requirement (In Million Tonnes)	
Year 2020	**Year 2030**
49	**175**

Similarly, there is a production of around 1.65 million tonnes of aluminium in India and around 15% of this goes in to the transport sector at present.

Table 33: Aluminium Production In India (In Million Tonnes)

Aluminium Production (In Million Tonnes)[62]	
2010- 2011	2011-2012
1.62	1.65

Table 34: Aluminium Consumption for the Transport Sector (In Million Tonnes)

Aluminium Consumption for the transport sector (In Million Tonnes)	
2010-2011	2011- 2012
0.24	0.25

Assuming current level of resource efficiency in 2030 and also that transport sector demand will remain at the current level of 15% of the total aluminium production in 2030 (not changing the other industrial sector demand percentage), we can estimate that this 0.25 million tonnes of aluminium will require around 55.1 million tonnes[63] of aluminium production set up.

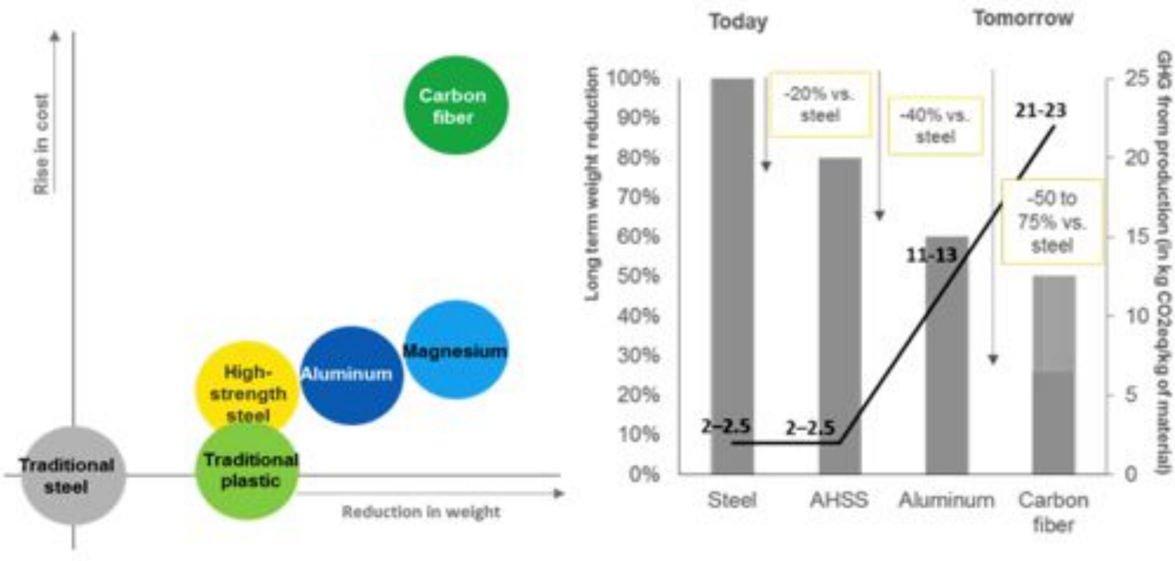
Table 35: Aluminium Production Setup Requirement (In Million Tonnes)

Aluminium Production Set Up Requirement (In Million Tonnes)	
Year 2020	**Year 2030**
14.6	**55.1**

[62] Source: Indian Minerals (Part- II : Metals & Alloys) , Aluminium and alumina
[63] Assumption : Same level of import and export as now

The automotive and auto component manufacturing industry is one of the highly material intensive industries in India and growth of this industry will further increase the requirement of virgin material (since the resource efficiency practices are very nascent stage in India). The Automotive industry across the globe is exploring new opportunity to reduce the high cost of raw material (high-strength, low-density materials) and emission norms. The figure presents Comparison of traditional steel with alternate materials:

Figure 29: Comparison of Traditional Steel with Alternate Materials



Source: US Department of Energy

5. Resource Efficiency: Current Practices and Scope In India

5.1 Resource Efficiency – Need and Drivers

Manufacturing is currently undergoing a radical transformation. Greater purchasing power in the emerging economies and expanded global markets are boosting opportunities for trade. However, this growth is triggering greater demand for resources and energy that are increasingly scarce and more and more costly to exploit. Decisive action to use our resources efficiently is the only response, not only to political demands for environmental and social sustainability but also to the need for initiative on the part of industry.

Per capita consumption of materials in India has changed during the past few decades. According to Singh et al. [2012,] per capita consumption of materials remained at a low level of less than 3 tonnes per capita a year, and even fell slightly between 1961 and 1980. This is evidence of the fact that population size increased at a faster rate than the rate of absolute material consumption. Thereafter, per capita consumption of materials grew faster than population size.

While material consumption in industrialized countries has remained at high levels during the past few decades, the relatively less industrialized countries are also increasingly emerging as large consumers of materials. Global material use increased sharply from around 35 billion tonnes in 1980 to more than 67.8 billion tonnes in 2009 [SERI, 2012]. Out of these 67.8 billion tonnes of renewable and non-renewable materials used globally, India consumed around 7.1% or 4.83 billion tonnes while hosting around 14% of the global population. If India continues the impressive economic development of the past few decades, it will more than triple its resource demand until 2030 – using as much materials as all the OECD countries combined consume at the present time.

The Indian society is going through structural changes, which is leading to transformations in consumption patterns and lifestyles, which has an impact on resource consumption patterns. India is witnessing dynamic transformations due to its rapid economic growth, which is characterized by five main interlinked factors. These factors act as drivers of demand and have a strong impact on resource consumption. These drivers of demand are:

- Growing population
- Expanding industrial and service-related production
- Rising (average) income
- Growing middle class and/or expanding cohort of middle class
- Increasing urbanization

One of the most promising options to address the needs to increased material demands is improved resource efficiency, which is being promoted in several countries. The potentials of resource efficiency have by no means been fully exploited as yet. Thus, even incremental improvements could lead to quick material and cost savings for India's companies. These incremental material-efficiency measures could comprise changed production process parameters (e.g. temperature, proportioning, shuffling), the optimization of production processes (e.g. batch sizes, set- up times), new production elements or technologies (e.g. cartridges, filters, application technology), alternative production methods (e.g. for coating, grease removing, segregation), as well as the qualification and training of employees (e.g. team-building measures, definition of responsibilities, offering of incentives), etc. Resource efficiency should be adopted as an organizing principle of the Indian economy to support sustainable and inclusive growth in the country.

5.2 Current Status of Resource Efficiency In Auto Sector In India

The auto component sector is a resource intensive sector. It consumes about 12% of global steel production[64] and 15% of aluminium production. Cars are one of the most recycled commercial products. Currently, approximately 75% of the total vehicle weight gets recycled globally[65]. The remaining 25%, known as Auto Shredder Residue (ASR), go to landfill. ASR is mainly composed of foams and fluff (40-52%), plastics (20-27%), rubbers (18-22%) and metals (4-15%) and there is currently no cost-effective recycling technology for plastics and foam[66]. The End-of-life vehicles try to push the recycling process further: it fixed the percentage of recyclability (85%) and recoverability (95%) in developed countries. The motivation for this work comes first from the observation of the huge material consumption of the automotive industry.

Metal recycling sector is one of the neglected sectors in India. The metals recycling business suffers from government apathy and to some extent, even a lack of awareness on part of the various participants within the metals ecosystem. In a survey of the managers of top manufacturing companies in India [Bhattacharya et al., 2012; Confederation of Indian Industry / The Boston Consulting Group, 2012], the question regarding the future focus of governmental and industrial action in order to boost the manufacturing sector had no reference to resource efficiency. India's metal recycling rate is just about 25%, putting it at the bottom of the global list of recycling nations. In the US metals are recycled at a rate of 90%[67].

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[64] World Steel Associations
[65] 2014 IEEE International Conference on Innovations in Engineering and Technology, International Journal of Innovative Research in Science, Engineering and Technology
[66] 2014 IEEE International Conference on Innovations in Engineering and Technology, International Journal of Innovative Research in Science, Engineering and Technology
[67] Article by Sohrab Darabshaw, Metal Miner, Feb 2015

Currently, about 98% of the aluminium waste scrap generated from the auto component manufacturing gets recycled and only about 2% gets wasted in the Indian automobile sector[68].

The scrap metal generated from the production processes is sold back to metal recyclers. This is done through long term agreements signed between the metal recyclers and the company in case of big component manufacturers. In case of small/unorganized manufacturers, small/unorganized recyclers collect the scrap metals. The metal recyclers follow the procedure of recycling by re-melting the metal and selling it into various applications like construction, packaging, transport, equipment etc. In some cases, the component manufacturers enter into a buy back agreement with their material suppliers, where the material supplier himself collects back the metal scrap and a cost is negotiated based on the oxidation losses of the metal. In this case, the supplier recycles the metal and the end-use of this recycled metal is restricted to auto components only.

Interaction with various component manufacturers revealed that generally vehicle OEMs provide the drawings of the components to the component manufacturer, to which OES has to comply. The OEM dictates the specifics of the raw material and source as well. In some cases, the raw material is itself procured and provided by the OEM to the component manufacturer for controlling the cost part. This leads to inflexibility for the component manufacturer to introduce secondary material sources or introduce changes in the process.

To introduce any such changes in the process or material sourcing, an approval from OEM is required.

During another interview with a piston manufacturer, it came to the notice that having design capabilities enables the component manufacturer to convince the vehicle OEMs to introduce changes in the processes or materials leading to better efficiencies. The component manufacturer was able to use recycled material in their processes by proving that the output quality remains same to their customers and has been able to introduce design changes in their products leading to resource efficiency. However, there are challenges in this process. For instance, When the manufacturer started sourcing its secondary material, their products were rejected by the OEMs; after conducting detailed metallurgical analysis, traces of antimony were found in the product. The sourcing and right kind of secondary material was then chosen. Also, the testing costs of such initiatives are very high. The access to such testing and R&D facilities is restricted as their numbers is very less as well as have location constraints.

For another transmission gears manufacturer, major inputs comes from the forging industry, which are small units and the yield lies between 45%-55%.

There is a huge scope of technology up gradation as well as training requirements, in the absence of which about 20% of material gets wasted. These units do not get soft loans or financing at low interest rate which hinders the technology up gradation. Where-as big companies who are exporters have excess to low interest loans as low as 2% because of their export licence status.

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[68] Stakeholder Interactions with component manufacturers

Also, gears involve wet cutting of gears currently which uses a lot of oil. The dry cutting equipment is very expensive and the high interest rate financing (as high as 12%) again acts as obstacle for this technological change.

In another interview[69] with a leading shock absorber manufacturer, it was revealed that OEMs have tighter control over processes, materials, cost etc. because of these components being in A category because they are related to safety in vehicles. The OEM controls the design, raw material vendors as well as costing part. The OEM provides the year on year target of 2% reduction in the cost to the component manufacturer and the benefit is shared between OES and OEM for first 3 years and then is entirely passed on to the OEM. That is why, the incentive for taking up of resource efficiency initiatives is not too high for them, since the benefits gets passed on to the OEM directly.

Another issue that auto component makers are facing is with regard to sharply rising imports of auto components from ASEAN countries (south-east Asian countries like Thailand, Malaysia, Philippines) following the coming into effect of the Free Trade Agreement between India and ASEAN in January, 2010. Almost 70% of component imports into India are from countries with which India either has a FTA or is planning to have one soon. Even though the FTAs give an equal opportunity to the Indian players in terms of exports, the import duty on raw materials results in an inverted duty structure that makes certain Indian components (those dependent on imported raw materials) uncompetitive in both domestic and export markets[70].

For the recycling of the materials, the Indian recyclers are facing a challenge due to the recent levies of import duty on metal scrap (2.5%). This makes the recycled material expensive in India whereas the competing countries do not have any such levies.

69 Source: Industry Stakeholder Consultation

70 Report of the working group on Automotive sector for the 12th five year plan (2012-2017), Ministry Of Heavy Industries and Public Enterprises, Govt. Of India

Box 2: Major Issues and Challenges for Resource Efficiency (Based On Stakeholder Consultation and Secondary Research)

- Support for innovation (R&D Centres) to attain global standards of operational efficiency and productivity, build R& D competence of Auto Component Sector.
- Domestic and international cooperation in emerging areas of automotive and component manufacturing technologies
- The material recovery and recycling industry is highly unorganized and there is no incentives for recyclers on type and volume of material recycled
- Recycling in India is carried out mostly manually in the un-organized sector without any consideration for the environment and safety of the people.
- Import duty on secondary raw materials import resulted in cost and uncompetitive in both domestic and export markets
- High Raw Material Prices (Raw material prices will have to be matched with the global prices to provide a level playing field.)
- Access to Technology for Upgradation including ICT
- Non-availability of easy access to Capital (funds / soft loans) for expansion and upgradation
- Inadequate availability of skilled labor (Training and skill development center network), interaction between institutes and the industry to minimizing the gap between skill requirement and the availability.
- Rationalization of labor laws to ensure availability of human resources with the requisite skill and competence
- Up-gradation and debottlenecking of rail, road, port and power infrastructure
- No specific policy on ELV, Vehicles and recyclability of the materials used in the vehicles
- Continuous development of existing and new materials and processes in order to produce the components that are cost effective and recyclable

5.3 Scope of Resource Efficiency In India

Metal recycling[71] has following advantages:

- **Recycling 1 Tonne of steel saves**
  - 1.2 tonnes of Iron Ore
  - 0.7 tonnes of Coal
  - 0.5 tonnes of Limestone
- **Recycling 1 Tonne of Aluminum saves**
  - 8 tonnes of Bauxite ore
  - 14 megawatt hours of electricity
- **Energy saved using recycled material versus virgin ore**
  - 74% for Iron and steel scrap
  - 95% for Aluminum scrap
  - 85% for Copper scrap
- **Reduction in CO_2 emissions by using scrap**
  - 58% for Iron and Steel scrap
  - 92% for Aluminium scrap
  - 65% for Copper scrap

As per an estimate from SIAM, with efficient recycling, India can hope to recover by the year 2020 over 1.5 million tons of steel scrap, 180,000 tons of Aluminium scrap and 75,000 tons each of recoverable plastic and rubber from scrapped automobiles.

Since steel constitutes the largest amount of materials used in vehicles, its recycling potential is high. Additionally, the steel components of a car are easy to remove and could be collected in homogeneous fractions. Steel recycling of an Indian compact car can decrease raw material consumption theoretically by 23%[72]. The potential is determined by the assumption of recycling rate 0% compared to 100%. Taking the increasing demand for cars into account, it is seen that this could save up to 60 million tons of primary raw material in 2030. Since recycling is already taking place in India, the unexploited potential is less than 23%.

Major processes used in auto component manufacturing where there is scope of increasing resource efficiency practices are:

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[71] Article in Afternoon Dispatch & Courier , August 04 , 2014
http://www.afternoondc.in/business-investment/msme-minister-assures-mrai-of-resolving-issues/article_116476

[72] Indian Future Needs For Resources, November 2013

- Die Metal Casting (Losses Upto 25-30%)

In metalworking, casting involves pouring liquid metal into a mold, which contains a hollow cavity of the desired shape, and then allowing it to cool and solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. The die casting process forces molten metal under high pressure into mold cavities (which are machined into dies). The die casting process also produce fine details such as textured surfaces or names without requiring further processing. Aluminium is consumed in auto component sector majorly in the form of castings.

- Forging Process (Yield Up To 50%)

  Metal forging is a metal forming process that involves applying compressive forces to a work piece to deform it, and create a desired geometric change to the material. The forging process is very important in industrial metal manufacture, particularly in the extensive iron and steel manufacturing industry. A steel forge is often a source of great output and productivity. Metal forging is known to produce some of the strongest manufactured parts compared to other metal manufacturing processes. Forged components are commonly found at points of shock and stress such as wheel spindles, kingpins, axle beams and shafts, torsion bars, ball studs, idler arms, pitman arms and steering arms and also in transmission gears. There is a scope of yield improvement to up-to 70% in the forging industry by technology up-gradation. One of the component manufacturers (included in our survey) has been able to achieve this yield by employing latest technology in one of his plants.

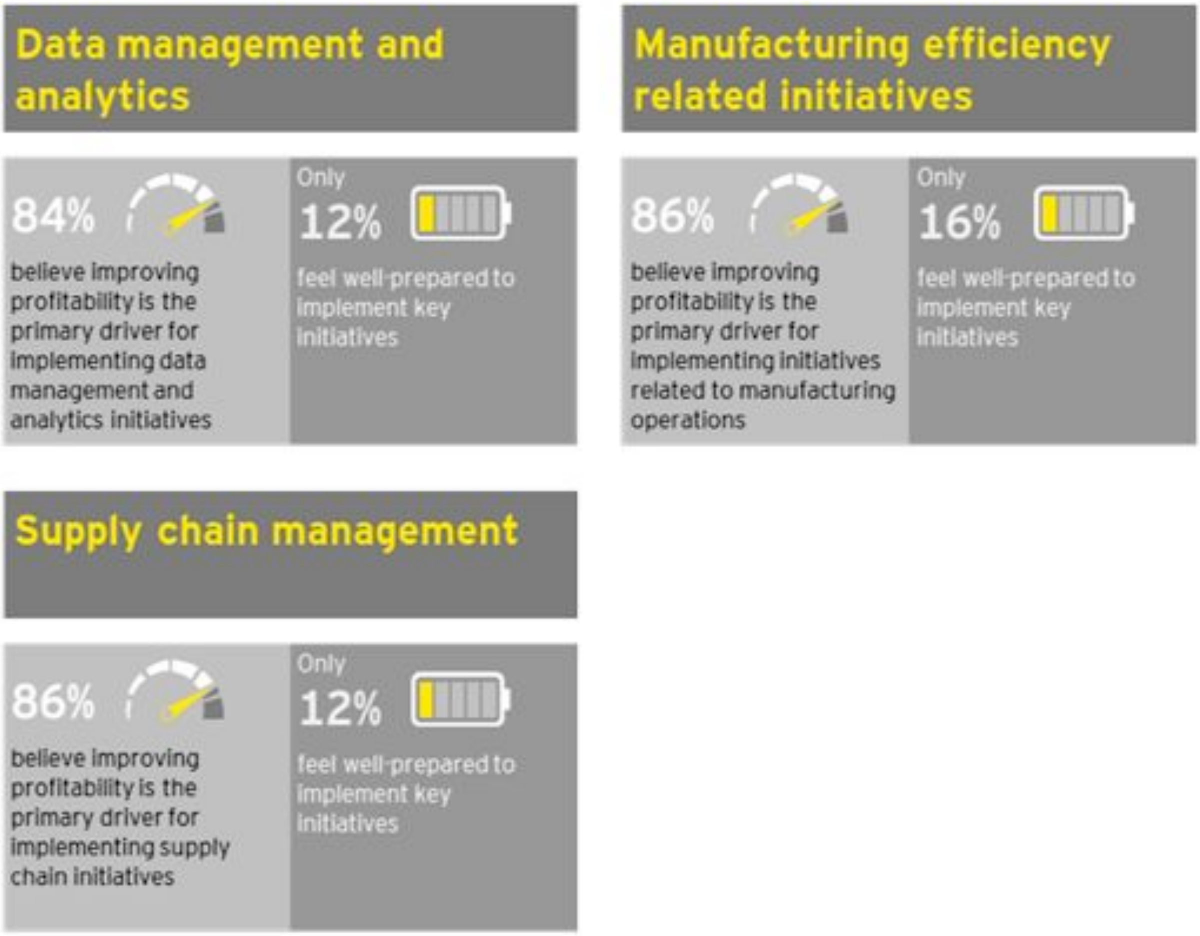
- Stretch Forming and Stamping (Losses up to 20%)

  Stamping (also known as pressing) is the process of placing flat sheet metal in either blank or coil form into a stamping press where a tool and die surface forms the metal into a net shape. Stamping includes a variety of sheet-metal forming manufacturing processes, such as punching using a machine press or stamping press, blanking, embossing, bending, flanging, and coining. Stamping is majorly used in steel panels in the vehicle body.

- Machining (Losses 0.5 - 15%)

  Machining is done for precision components and giving the final finishing to the components. While fully automated CNC machining has losses of as low as 0.5% which rise to losses upto 15% in some cases.

As per an EY survey conducted - Changing lanes 2015-16, the C-suits of the auto components have following on their agenda to increase the operational efficiencies:



Few of the recommendations to increase the metal recycling in India from 2015 Metal Recycling Association of India International Conference held in Mumbai were - Removal of basic import duty of 5% on steel scrap, give it industry status, subsidize lending rates, allow Foreign Direct Investment and increase financing facilities.

Component manufacturers through our interactions expressed the need of set up of expert knowledge base and an institution where they can have easy access to the solutions and guidance to any initiatives.

As per a leading frame assembly manufacturer, increased Automation and robotic manufacturing would lead to resource efficiency and increase in productivity.

Also, having in-house design capabilities would help in introducing resource efficiency initiatives, since the process and the alternate materials can then be introduced at the design stages itself.

5.4 Case Studies / Best Practices in Resource Efficiency

Case Study 1: ABILITIES INDIA PISTONS AND RINGS LTD.

Core products & processes: Pistons and Rings

Average annual turnover: INR 96.08 million (USD 1.60 Million)

Initiative: Reducing rejects leading to material savings

To reduce rejection levels, all critical processes were analysed in the course of this programme and modifications were made where appropriate. The company repeatedly faced problems like short filling, blow holes, pit marks, bulging, turning marks, grooving size and run out. In order to overcome such problems, 23 quality circles were formed. Based on prior analysis, redesigning of runners and gates, for instance, helped AIP to reduce in-house rejections in the casting section. Clubbing of operations in the casting tool also reduced the probability of manufacturing defective pieces. Re-defining processes like selection of machines for a particular product, defining speed and feed of the machines, establishing parameters and monitoring the process capability further helped to reduce rejection rates. In addition, the optimal re-sharpening frequency of the tools was clearly defined and marked. Quality alert boards were posted in all stations where critical quality parameters needed to be adhered to (fifteen in total) to prevent mistakes as much as possible. These quality alert boards included pictures showing the difference between good and bad parts to make it easier for workers to comprehend.

While carrying out improvements on machines/equipment, important learning and experiences where made. These were captured in the form of so-called “one-point lessons” (OPL) – short visual presentations that communicate standards, problems and improvements about work processes and equipment. OPLs were displayed at different places on the shop floor, so that previously committed mistakes would not be repeated.

At the same time, operating procedures (master document) were standardized and displayed in a proper format in 20 crucial workstations. It took about three months for the operators to have all the above mentioned visual displays in place.

Key Results

- Productivity increased by 15%
- Overall equipment effectiveness (OEE) increased from 67% to 84.6%

Case Study 2: RICO AUTO

Core products: Engine, transmission, chassis and braking system components.

Turnover: US$ 285 Million (INR 11000 Million) - 2013

Initiative: Material losses savings due to re-melting

Aluminum and Ferrous alloy are used for the casting of various auto parts at Rico Auto. Aluminum ingots are supplied by local vendors, as a part of manufacturing process Aluminum ingots are melted and casted at the manufacturing units. Following processes were involved before implementing the initiatives:

At Local Vendor Site:

i. Melting of scrap and treatment of aluminum
ii. Casting of molten aluminum to Aluminum Ingots

At Rico Auto Site:

i. Conversion of Aluminum ingots to molten Aluminum using Fuel oil fired furnaces
ii. Pressure die-casting of molten aluminum in to desired parts
iii. Finishing and packing of parts

The initiative taken eliminated the re-melting of the Aluminum ingots at plant site. The vendor did set up an aluminum processing unit in the vicinity of Rico auto and started the supply of molten aluminum directly in place of aluminum ingots. This new process eliminated the oxidation losses involved in the re-melting which were of the tune of 1.5% of the material processed. This also led to avoidance of fuel usage and hence emissions.

5.5 Component Manufacturers With High Level of Interest In Pilot Study

Rico Auto

Rico supplies a wide range of fully machined aluminum and ferrous components and assemblies to automotive OEMs across the globe. Rico's consolidated group total turnover is over US$ 285 Million (INR 11000 million).

As per our interaction with the Rico Auto's management, integrated services provided by them include design, development, tooling, casting, machining and assembly across ferrous and aluminium products. Rico mainly manufactures engine, transmission, chassis and braking system components.

Abilities India Pistons (AIP)

As per the market research, AIP is one of the biggest manufacturer of PISTONS & RINGS for automobiles (mainly two / three wheelers), chain saws, brushcutters, agriculture sprayers and compressors, AIP is a major OEM supplier for many reputed vehicle & engine manufactures of the country and overseas. AIP has developed 200 models of pistons for Chain Saws / Brush Cutters, which places it in a unique position to be a global supplier of Pistons to the OEM and after markets as the necessary infrastructure for these models is readily available. AIP has an annual turnover of about INR 96 million (USD 1.6 Million) and a capacity to produce about 1.6 million pistons/annum

Omax Auto

Omax auto mainly manufactures frames and pistons rods. It produces 5 million 2 wheeler frames/annum and has 20% market share in the segment. In piston rods category it produces about 6 million piston rods for shock absorbers and has 40% market share in the passenger cars segment. It has a turnover of INR 11,000 million (180m US$) in FY 2014. As per the analysis, Omax also features in the list of top 10 automotive component manufacturers in India.

Raunaq Automotive

As per the industry stakeholder interaction, Raunaq auto is one of the biggest producer of Transmission Gears. Along with gears, company manufactures sub-assemblies, Industrial Gears for Electrical Switch Gears & Circuit Breakers, Winches & Cranes. Raunaq auto has an annual turnover of about INR 1000 millions (USD 16 million).As per our interaction, Raunaq auto produces about 5 Million gears/annum

Sunbeam Auto

Sunbeam auto manufactures various die castings and pistons. It has a production capacity of about 55000 MT/annum. As per our interaction, Sunbeam caters to many clients such as Hero MotoCorp, (the World's largest two wheeler motorcycle manufacturer in India), Maruti Suzuki India Ltd., Suzuki Powertrain India Ltd., Suzuki Motorcycle India Pvt. Ltd., Munjal Showa Ltd., Sona Koyo Steering systems Ltd., Daimler Chrysler AG of Germany, Robert Bosch Corporation - Germany & USA, Ford Motor Company - USA, Continental Automotive Systems - USA, Cooper Standard Automotive - USA, and Valeo Engine Management Systems - France to name a few. Sunbeam has a turnover of about INR 12000 million (USD 20 million) and employee strength of about 4000.

6. Policy and Regulatory Landscape In Auto Component Sector: India

6.1 Overview of Regulatory and Policy Environment In India In Auto and Auto Component Sector

Pro-industry policies like manufacturing and imports free from licensing and approvals, 100% FDI in auto sector and no local content regulation of the Government have helped the auto component sector to grow in the past. In order to give further fillip to the sector and move to next phase of rapid growth, timely policy decisions and support from the Government is required. It was felt by DSIR that any policy change for the industry must evolve from the understanding of the challenges faced by the potential stakeholders.

Below are few policies/initiatives by Govt. of India to ensure sustained growth of the sector:

Auto Policy 2002:

- This policy was formulated by Ministry of Heavy Industries and Public enterprises with an objective to promote integrated, phased, enduring and self-sustained growth of the Indian automotive industry.
- Automatic approval for 100% foreign equity investment in auto components manufacturing facilities.
- Manufacturing and imports in this sector are exempt from licensing and approvals.

Automotive Mission Plan 2006-16:

- Setting up a technology modernisation fund focusing on small and medium enterprises.
- Establishment of automotive training institutes and auto design centres, special auto parks and virtual SEZs for auto components.

National Automotive Testing And R&D Infrastructure Project (NATRIP):

- A total of USD 388.5 Million to enable the industry to adopt and implement global performance standards.
- Focus on providing low-cost manufacturing and product development solutions.

Department Of Heavy Industries & Public Enterprises:

- USD 200 Million fund to modernise the auto components industry by providing an interest subsidy on loans and investment in new plants and equipment.
- Provided export benefits to intermediate suppliers of auto components against the Duty Free Replenishment Certificate (DFRC).

National Mission For Electric Mobility (NMEM) 2020:

- The National Mission for Electric Mobility 2020 was launched on 9 January, 2013 to foster adoption of electrical vehicles (including hybrid vehicles), and their manufacture in India to encourage reliable, affordable and efficient EVs that meet consumer performance and price expectations through government industry collaboration for promotion and development of indigenous manufacturing capabilities, required infrastructure, consumer awareness and technology, helping India emerge as a leader in the EVs two wheeler and four-wheeler market in the world by 2020, with total EV sales of 6-7 Million units.
- INR 10000 million (USD 166.67 billion) has been earmarked for next two years 2015-2017 for the mission[73]. It is estimated that there will be excellent demand in India for low cost xEVs that are suited for safe short-distance urban commute (average 50-100 km/trip), and are rugged enough to perform reliably through the most hot climatic conditions that also see torrential monsoon rains for 3-4 months of the year.

Pilot Projects of Electric Vehicle:

- Department of Heavy Industry (DHI) is launching pilot projects on electric vehicles in Delhi and subsequently in other metros and other cities all across the country with a dual purpose of demonstrating and educating the people about the benefits of adopting clean and green mode of transportation.
- It will provide the viability gap funding through subvention to support the extra cost of acquisition and operation of these vehicles by state governments or designated bodies. In the first phase, a pilot project to provide last mile connectivity to Delhi Metro by electric passenger vehicles has been approved.

[73] National Mission On Electric Mobility , Article in Economic Times,15 Jan, 2015

6.2 Resource Efficiency: Policies In India

The National Environment Policy, introduced by Govt. of India in 2006 governs the domain of ensuring responsible use of resources. Other than this, the government currently does not have a big focus on increasing raw material efficiency in the auto component sector. Therefore the policies/regulations currently do not have much thrust in this area. However, increasing fuel efficiency and decreasing the carbon emissions has always been a great area of research and regulations. Below are few policies/regulations which exist in increasing the efficiency in auto sector:

- National Environmental Policy in 2006, formulated by MoEF with an overall objective to conserve environmental resources through their efficient use, encourage intergenerational equity, ensure application of principles of good environmental governance and promotes ways for environmental protection. The policy aims towards 'creating incentives to minimize wasteful use and consumption of natural resources'.

- Zero-defect, Zero effect: Zero Defect Zero Effect is a slogan coined by Prime Minister of India, Narendra Modi which signifies production mechanisms wherein products have no defects and the process through which product is made has zero adverse environmental and ecological effects. The government is set to launch this 'Zero defect, Zero Effect' model to rate and handhold one million small and medium enterprises over the next three to five years to deliver top quality products using clean technology. The move is in line with the Prime Minister's pitch for high quality local manufacturing and Make in India campaign. The 'ZED maturity model' is being jointly worked out by the Ministry of Micro, Small and Medium Enterprises; the Department of Industrial Policy and Promotion (DIPP) and Quality Council of India (QCI), and is expected to be finalised soon.

- In regard to fuel efficiency standards for the automotive sector, the Bureau of Energy Efficiency (BEE) has introduced new fuel efficiency standards designed to force auto companies to decrease fuel consumption (distance covered for every litre of fuel). The standard called the Corporate Average Fuel Economy (CAFE) has given auto manufacturers until 2015 to improve the fuel efficiency of cars by about 18%, up from the average of 14.1 km/litre of petrol to 17.3. Under this standard, cars will be assigned labels ranging from one-star labels to five-star labels depending on their fuel efficiency.

- The Directorate General of Civil Aviation (DGCA) has established an aviation climate change task force to assess carbon emissions, to monitor data collection from airports, and to chart out measures to deal with climate change.

- Indian Railways is developing fuel-efficient diesel locomotives that could lower fuel consumption by up to 20%. It is the single largest consumer of diesel in the country, and has to pay market-linked prices for diesel. Hence, this state-owned transport system is also moving towards a massive programme for the electrification of its network.

6.3 Challenges In the Auto Component Sector Growth and Implementation of Resource Efficiency Measures

Issues/Challenges	Support Required
Inability to Have Dedicated R&D, Testing and Design Capability:	
In-house designing and testing capability is a pre-requisite for being selected as a direct supplier of the automotive companies and large tier-I suppliers. Indian auto component companies having designing capability are preferred by foreign companies looking for collaboration in India. There are a large number of small size companies who don't have capabilities to design the products end-to-end and test them. These companies do not have necessary infrastructure for doing R&D to match the requirements of their customers. Their financial strength and their size do not permit them to have a dedicated in-house designing and R&D facilities. Government has taken major initiatives under NATRIP and has big plans under this scheme to provide expensive infrastructure for developing capabilities of automotive industry. However, the non-availability of such facilities in each hub does not serve the requirements of SME auto component manufacturers.	Government shall facilitate and or incentivize the auto-component manufacturers for creation of shared infrastructure and capacity development for R&D and testing labs. Schemes run by institutions like National Manufacturing Competitiveness Council and some Ministries like Micro-Small and Medium Enterprises can be tapped to meet financial requirements of setting up such facilities. There seems to be a lack of awareness about such schemes in the industry. Government institutions interested in encouraging auto component sector shall take initiative of creating awareness about such schemes and should also facilitate the stakeholders' to avail of the benefits of such schemes.
Finance Related Issues:	
Availability of capital, high cost of capital for technology upgradation, working capital, and expansion of operations in India and abroad are the key challenges for auto component manufacturers in the SME sector. Availability of capital and cost of capital is a function of the technological sophistication and robustness of business model of individual companies. While the companies need to work towards improving their credit worthiness by leveraging on their strength. Financial institutions have been reported to be giving preferential treatment to manufacturer of small and medium size in financing and offering credit at better rates subject to a better rating by SME Rating Agency of India Limited (SMERA).	The Government should create awareness among SMEs about the need for getting credit worthiness rating done. There is also a need for creating awareness among the SMEs about availability of low cost institutional equity capital and risk capital funds for expansion plans of SMEs. Some of the schemes of this category include SME Growth Fund of SIDBI Venture Capital Limited (SVCL) that can be tapped to meet the financial requirements for transnationalisation of auto-components' SMEs. Unlisted companies are the focus of this Growth Fund. The Risk Capital Fund proposed in 2008-09 budget to be administered by SIDBI Venture Capital Limited can help Indian auto component industry in acquisition of high-end technology and manufacturing facilities outside India.

	Government may take steps to ensure that the assurance of Minister of Finance, Government of India that “SIDBI will reduce the guarantee fee from 1.5 per cent to 1 per cent and the annual service fee from 0.75 per cent to 0.5 per cent for loans up to INR 5 Lakh”, is implemented at the earliest. The EXIM bank also has several schemes for financing SMEs, firms, product export and overseas investments. There is a need for creating awareness among the SMEs about such schemes.
Availability of Trained Manpower and Productivity:	
Due to emerging employment opportunities in new manufacturing units and service industry, retention of skilled manpower is proving to be a challenge for auto component manufacturers in SME sector. If companies do not plan ahead, there may be disruptions in production. The quality requirements from the industry are changing with the global requirements and achieving skill development for a new set of employees on a regular basis is a challenge. Excessive job security has vitiated the work culture at lower levels.	Training for specific skills suited for the specific work is needs to be imparted to help India emerge as a global player. Industry is increasingly feeling the need for skill development and attitudinal training of work force for improving productivity. The Government should encourage and support schools and universities to collaborate with the industry to come up with short and industry relevant courses. This will help the industry meet the requirements of technically qualified and trained manpower needed for its ambitious growth and realization of the potential of the sector. Sensitization of workforce for attitudinal change is needed. This will help improve productivity. The Government shall support setting up of facilities for attitudinal training of manpower in different auto hubs.
Setting up Greenfield Projects is Expensive and Time Consuming:	
The acquisition of land for a Greenfield venture is perceived to be major problem with prohibitive rates and bureaucratic procedures. Land prices in most of the industrial hubs have become prohibitively high, creating barriers for expansion for the small and medium enterprises. Even the expansion procedures are cumbersome with clearances required from a number of bodies/ boards.	The industry expects the Government to develop industrial clusters and provide land at a reasonable price or create infrastructure on the lines of China. The manufacturers pointed to the fact that in China built-in premises are available on lease and the companies only need to bring in the machinery to start the production. The time lag for setting up new production line is much shorter in China. High cost of land and time required to develop infrastructure is impacting competitiveness of Indian companies. Creation of special auto component parks, as recommended in the Automotive Mission Plan could be an answer to this. This would take care of various concerns related to SEZ and competitiveness related issues emerging out of various bilateral and multi-lateral trade agreements.

6.4 Limitations of the Study

- The study has been conducted based on the views of the stakeholders consulted.
- The cost data for most of the components was not available as this is most confidential for the manufacturers.
- The cost comparisons for virgin and secondary materials have not been carried out since both are regulated by the exchange rate of metal exchanges. This data was not provided by the stakeholders as well due to confidentiality issues.
- The composition of the components and calculations of the materials have been done based on the secondary research cross checked with the component manufacturers through interviews. In cases where Indian data was not available same is sourced from the global sources. This data is again confidential from the manufacturer's perspective.
- The primary data on amount of secondary material used in the components was not available, since the manufacturers are not aware of the percentages as this depends on the metal manufacturers/suppliers.
- The forecasts have been referred from the government/associations data (ACMA/SIAM) which are available till 2020. Time series linear forecasting has been done to estimate the numbers till 2030.
- Primary data on the production quantities and materials consumed of each of the components category is not available. The estimates for the identified components by resource intensity have been done based on the secondary research and stakeholders interviews. These individual components may not get summed up to provide the production or material consumption at component category level.
- The modalities, scope, areas in which pilot projects would be proposed was not available at the beginning of the study, hence the details of the pilots would need to be discussed with the component manufacturers and mutually agreed.

7. Anexures

7.1 Stakeholders Interviewed and Interview Questionnaire

S. No.	Organization
1	Abilities India Pistons
2	Omax Auto
3	RICO Auto
4	Munjal Showa Ltd.
5	Raunaq Automotive Components
6	Sunbeam Auto
7	Mark Exhaust
8	Gabriel Automotive
9	Hero Moto Corp
10	Ford India
11	CMR
12	Honda Motorcycles
13	ACMA
14	SIAM
15	Macas Automotive
16	Delphi
17	A.G. Industries
18	Subros
19	Shriram Pistons
20	Lifelong
21	Federal Moghul

Questionnaire

Auto Components Manufacturers

GENERAL INFORMATION:

1. Name of Auto-Component Manufacturer: ______________________________
2. Year of Establishment: ___________________
3. Type of Business Model: [ ] Full Indian ownership; [ ] Indian owner and MNCs in technical alliance; [ ] Indian owner and MNC JV; [ ] Complete MNC subsidiary);
   [ ] Others _____________ (Please specify)
4. Type of Auto-Component Manufacturer: [ ] OEM; [ ] OES; [ ] Tier-1; [ ] Tier-2; [ ] Others
   _______________________________ (Please specify)
5. Catering to Which Segment: [ ] 2Wheelers [ ] 4wheelers or [ ] Light Commercial Vehicles
   [ ] Others __________________ (Please specify)
6. Type of Product (Auto-component Manufactured): Out of 6 main categories
   [ ] Engine and Engine parts; [ ] Transmission and Steering Parts; [ ] Suspension and Braking Parts; [ ] Other Equipment; [ ] Electrical; [ ] Others ___________ (Please specify)
7. Main Products Category: ____
8. Annual Production Capacity (category wise): ______________________________
9. Implemented Quality and Other Management Systems (ISO/OSHAS/Six Sigma/Kaizen/5S etc.): ____
10. Main Customers: ____
11. Direct Sales/ Secondary Market (If any): _________________________________
12. Main Vendors/Suppliers: ____

SPECIFIC INFORMATION Concerning Resource Efficiency (Quantitative and Qualitative Information)

A. Resource Use for Products (Raw Materials)

<u>Expected Outcomes:</u>

- Major raw materials used;
- Quantity of raw materials;
- Target/Indicative raw materials for resource efficiency

1. a) For the components manufactured, what are the most important raw materials, in terms of quantity of use? In case there are multiple components identified for the same manufacturer/supplier:
   Component 1,2,3……n: Major raw materials and secondary raw materials, if any, by quantity of use?

Components → Raw Material ↓	Component-1	Component-2	Component-3	Component-4
Raw Material-1				
Raw Material-2				
Raw Material-3				
Raw Material-n				

   b) Please provide the quantities of major materials procured in previous three years.

Year → Raw Material ↓	Year-1	Year-2	Year-3
Raw Material-1			
Raw Material-2			
Raw Material-3			
Raw Material-n			

2. (a) Please explain the associated supply chain to the materials/semi-finished components?
   (b) Is there any imported material (raw/finished) in supply chain? If available, please also provide the quantity?

3. a) Please explain if there are secondary/substitute materials available which may be used to replace the major raw materials identified above.
   b) Please explain, if the raw material mix can be defined or changed by the component manufacturer, or if the vehicle OEMs has influence over them?

4. Do you expect any shortage/crucial cost increases for certain raw materials which might affect your production? If so, which materials could be affected?

B. Consumption of Resources during Sub-Processes

Expected Outcomes:

- Resource intensive sub-processes;
- Major raw materials used in these sub processes

1. a) Kindly explain the sub-processes during production where major raw materials are consumed?
   b) Percentage share of raw materials used in the resource intensive sub-processes?

2. Please explain if you have an authority/flexibility to introduce modifications in the design and process.

C. Major Output (Products and Waste)

Expected Outcomes:

- Major Components produced by quantity;
- Current and future demand of the products;
- Types of waste and quantities generated along with waste management practices

1. What are the key components manufactured that have highest share by sales/volume of production?

2. a) What is the current demand for these product(s)?
   b) To what extent do you expect the demand will change in future?

3. a) What is the major waste streams generated from the production process? If possible, please also provide the respective quantities and the segment wise components for the waste streams.
   b) What are the waste management practices followed in the company?
   c) What practices are being followed in your company or industry to reuse or recycle the waste?

D. Firm Policies/Practices for Resource Efficiency

Expected Outcomes:

- Current resource efficiency practices in the company
- Quantity of recycled raw materials
- Challenges in implementing resource efficiency initiatives

1. Please explain the possibility/scope of implementing resource efficiency measures in your company.

2. Please explain the quantity of recycled material used/possibility in these components.

3. Does recycling/secondary material use affect the quality/performance of the manufactured end products (sensitivity of secondary raw material used)?

4. What are the key drivers for the resource efficiency initiatives?

5. Please explain the challenges (perception based and experience based) that exist in implementing resource efficiency measures in your company?
(This may include the level of support from the management, human resources, training needs and technological challenges)

E. Preparedness/Willingness for Resource Efficiency and Pilot Project

Expected Outcomes:

- **Willingness to take up pilot project and resource efficiency initiatives**

1. Are you willing to implement resource efficiency in your organization? If yes what type of support you are looking for – from regulators, company management, associations etc.?

2. Please explain the level of interest and commitment to take up any Pilot studies for introducing resource efficiency in the identified components (Rate on the scale of 1 to 5)?

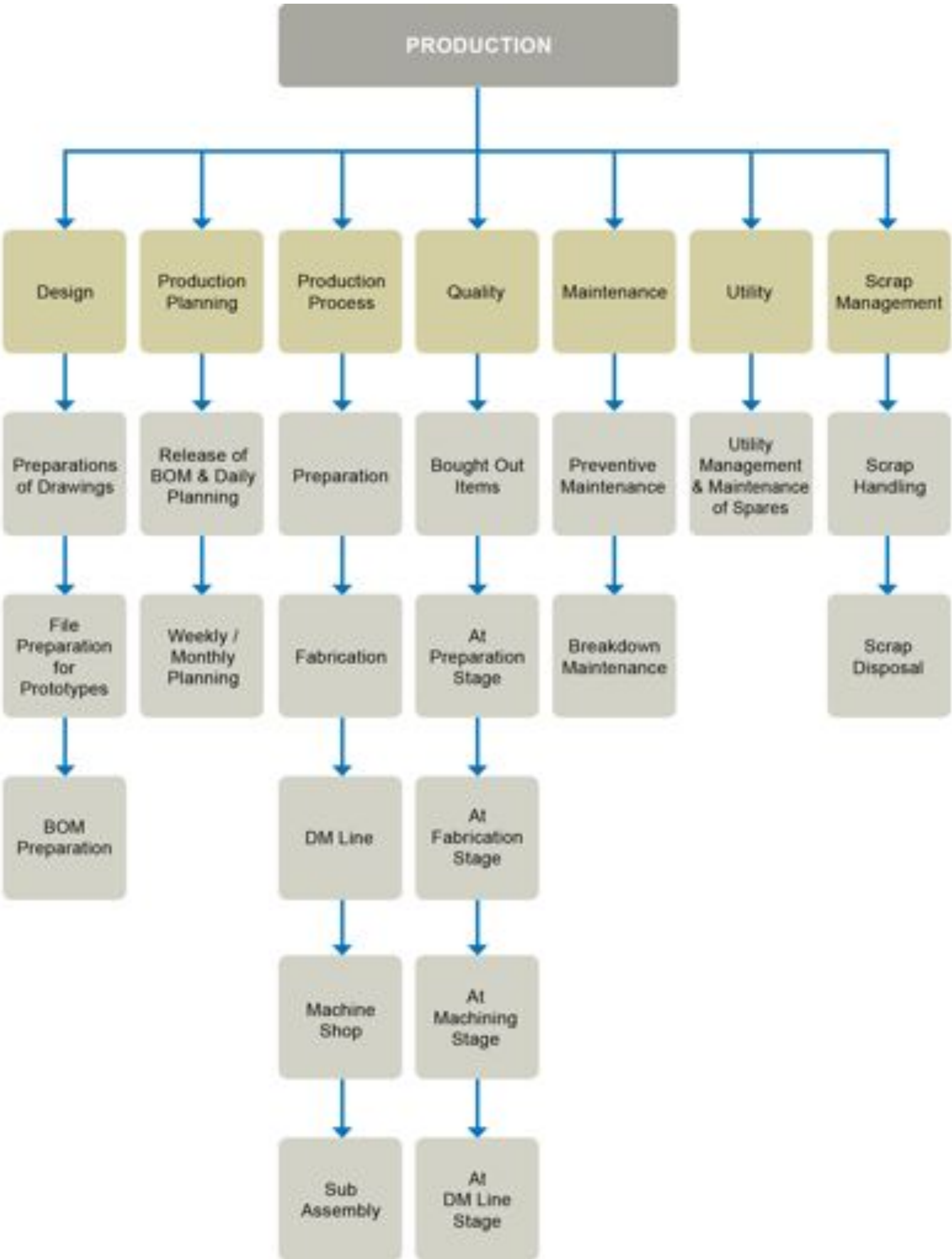
RATING				
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

If high, then please provide the specific areas where you would like to see pilot studies to happen?

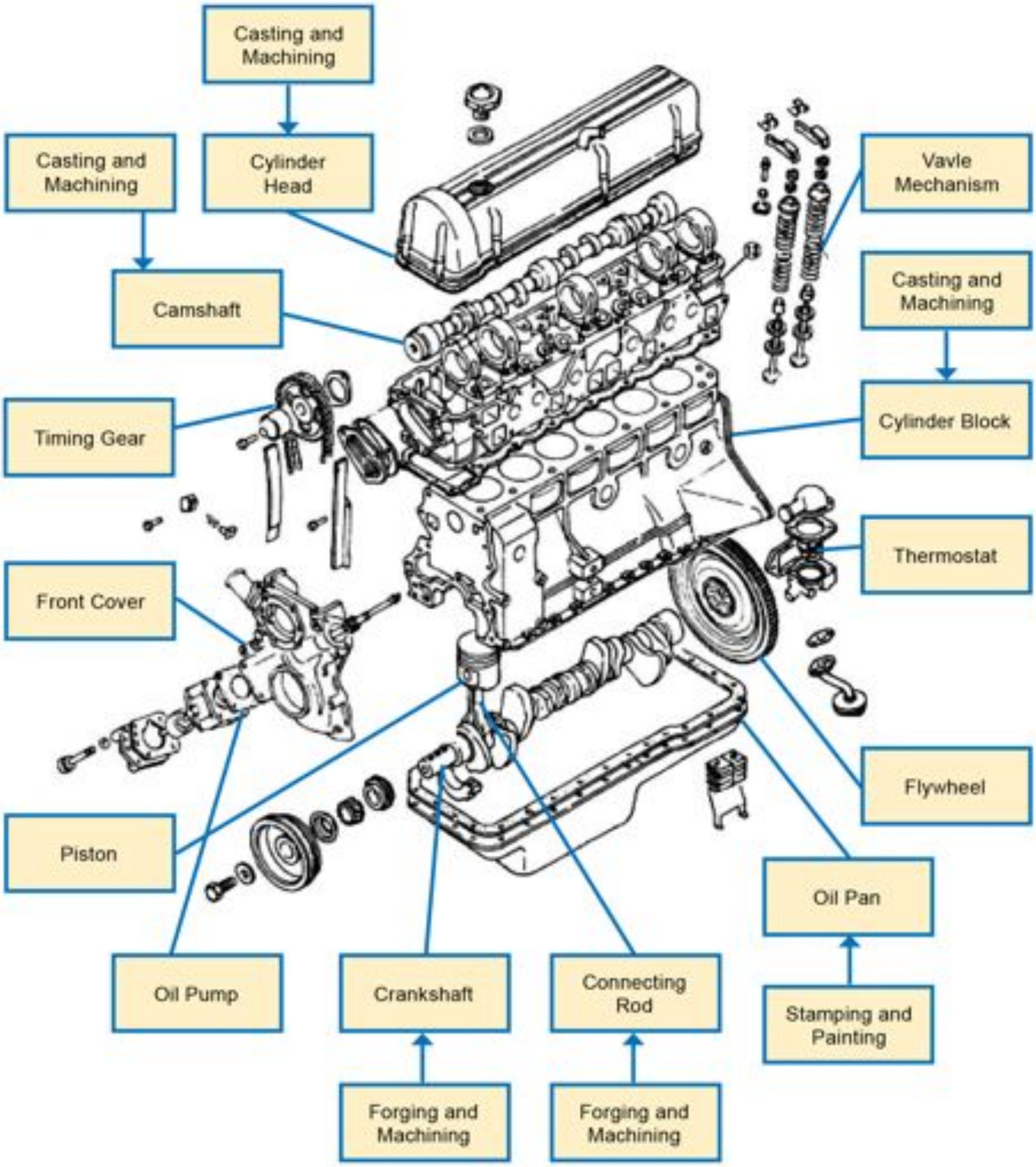
Date: ________________________

Place: ________________________

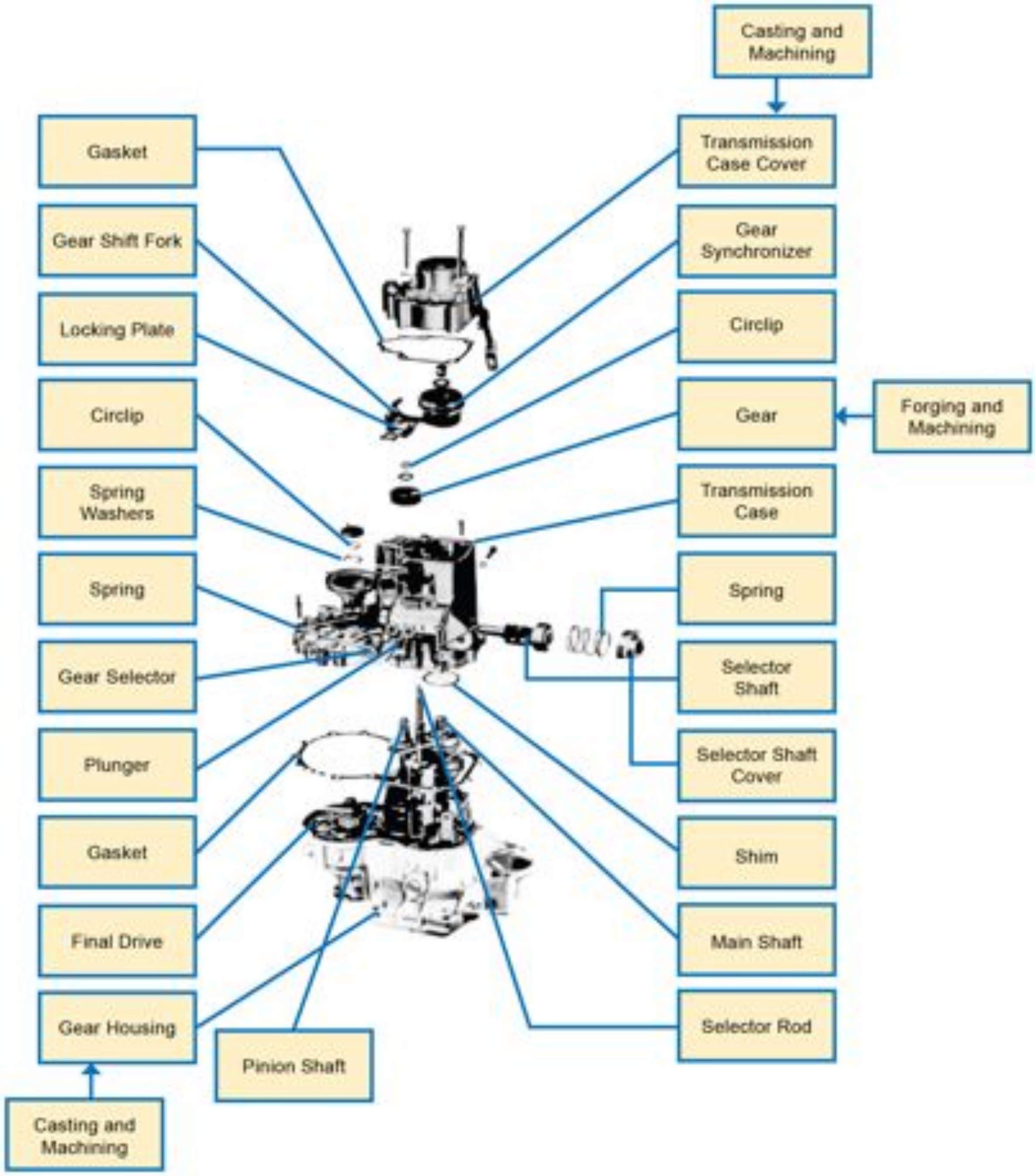
7.2 Manufacturing Process (Sub-processes & Process Level Map)



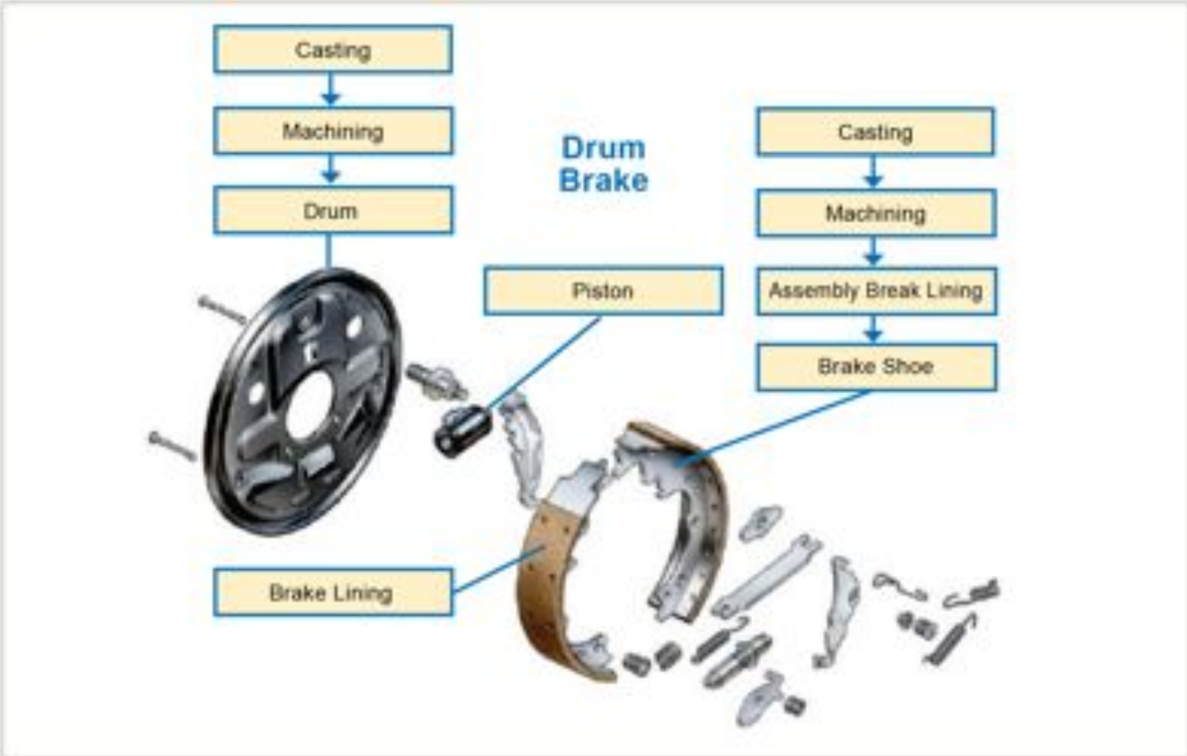
Manufacturing Process: Engine

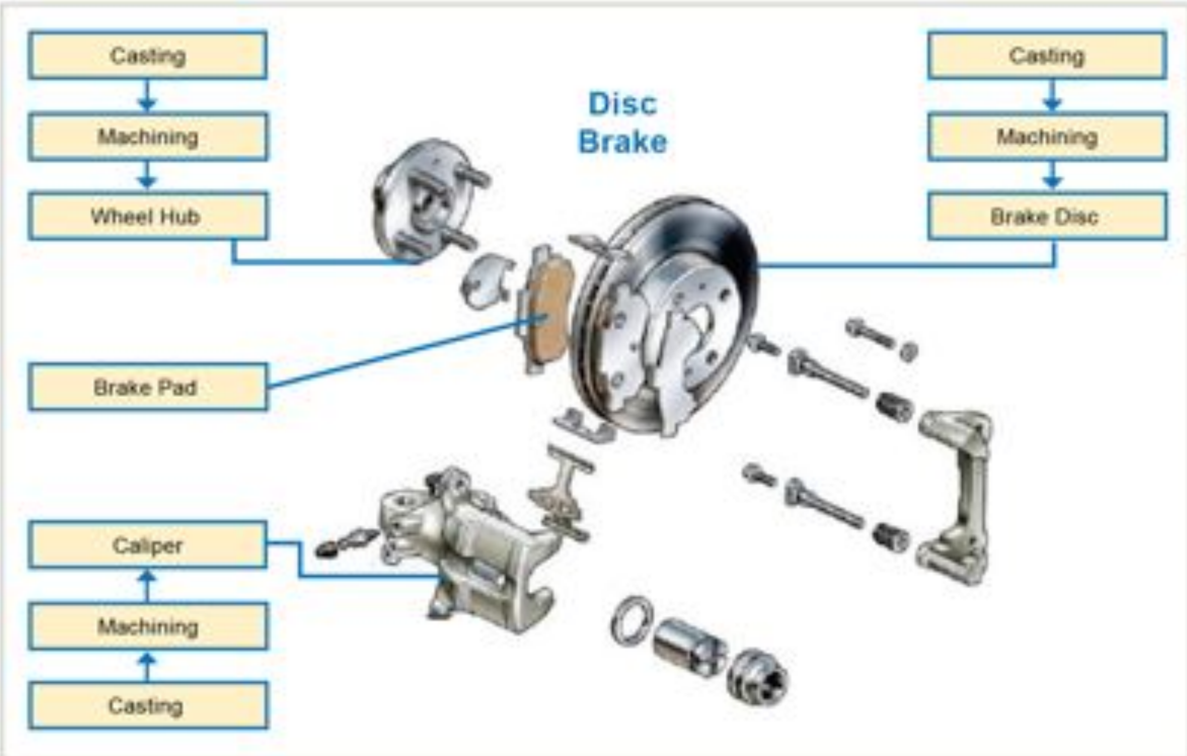


Manufacturing Process: Transmission Gearbox

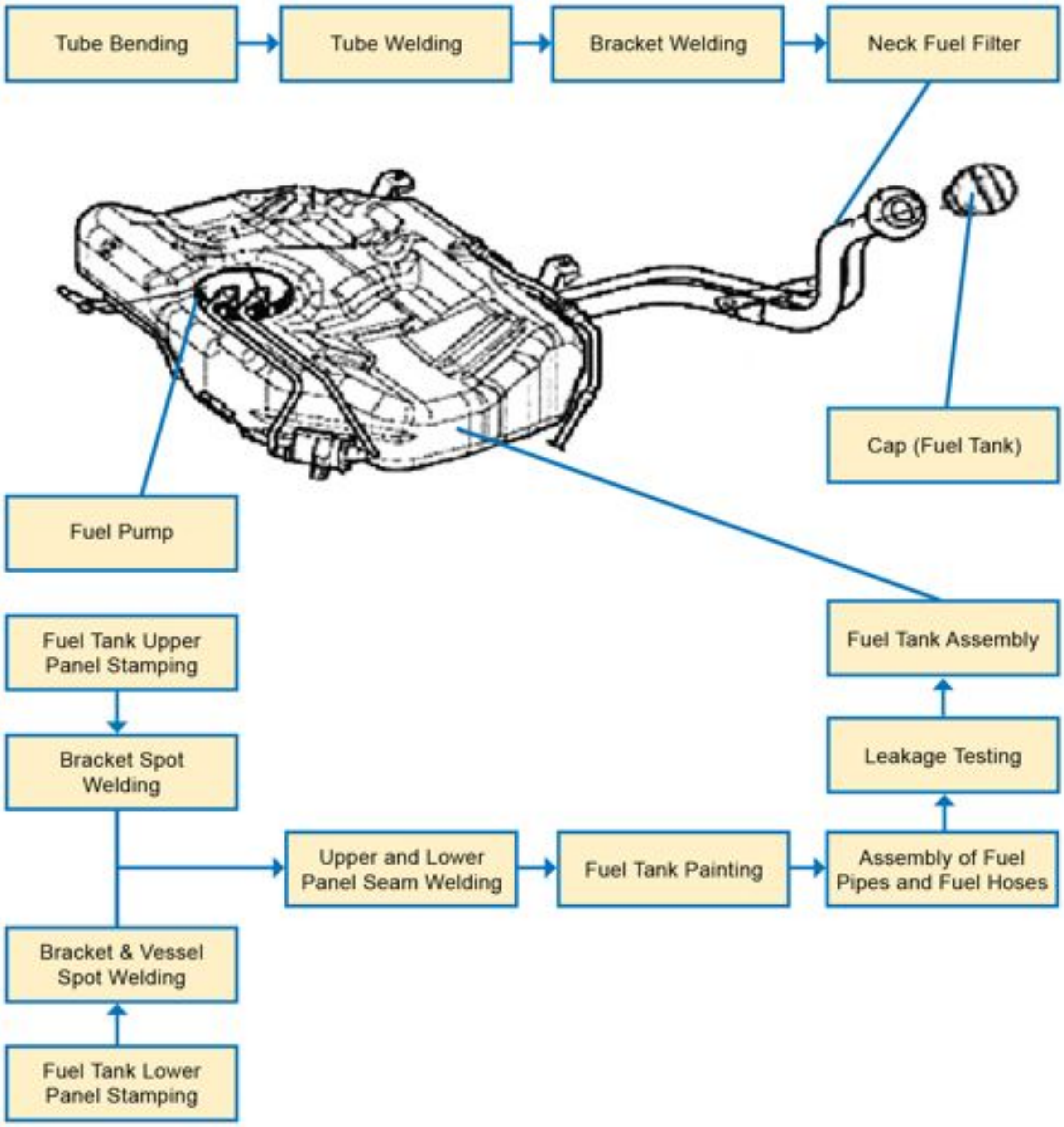


Manufacturing Process: Brakes

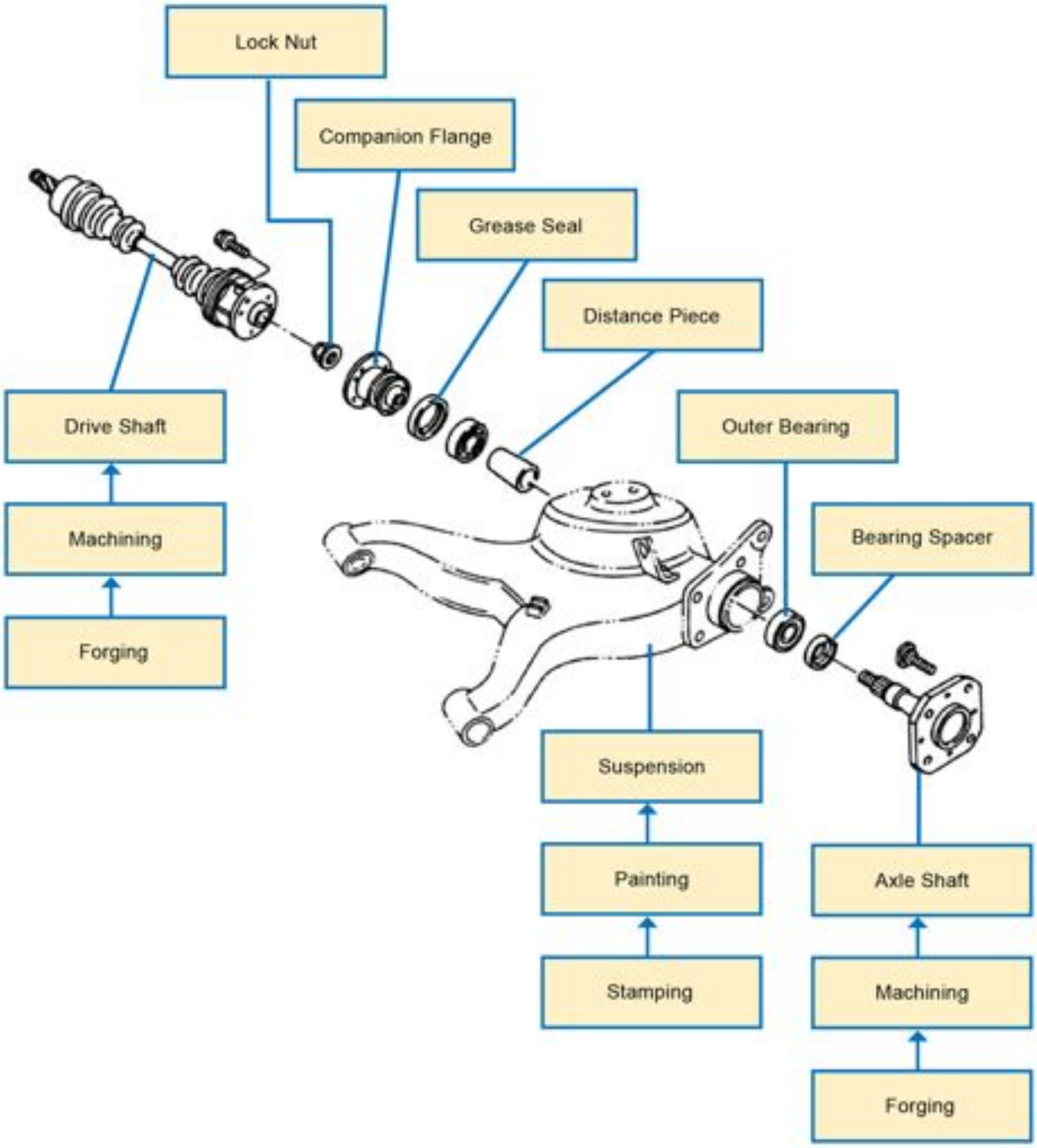




Manufacturing Process: Fuel Supply System



Manufacturing Process: Axle



References

1) Review of automotive mission plan 2006-2016
http://www.siamindia.com/uploads/filemanager/19ReviewofAutomotiveMissionPlan2006-2016.pdf

2) **Auto Component Industry in India:** Capabilities & Growing Opportunities
WWW.acma.in

3) Materials in Automotive Application, State of the Art and Prospects, New Trends and Developments in Automotive Industry(By Elaheh Ghassemieh
http://cdn.intechopen.com/pdfs/13343.pdf

4) Indian Auto Component Industry: A Decade of Growth and Way Forward, Velury Vijay Bhasker, 2013
http://isca.in/IJMS/Archive/v2i3/4.ISCA-RJMS-2013-014.pdf

5) Modelling and Structural Analysis of Ladder Type Heavy Vehicle Frame
http://www.ijmer.com/papers/Vol4_Issue5/IJMER-45012642.pdf

6) Engine block composition (Manufacturing Processes and Engineering Materials Used in Automotive Engine Blocks)
http://www.ewp.rpi.edu/hartford/~ernesto/F2010/EP2/Materials4Students/Lenny/Nguyen2005.pdf

7) Basic Mechanical Engineering (By Mohan Sen)
https://books.google.co.in/books/about/Basic_Mechanical_Engineering.html?id=oDAvCF_tbXMC&redir_esc=y

8) Effect of Alloying Elements on High Temperature Mechanical Properties for Piston Alloy (Express Regular Article
https://www.jim.or.jp/journal/e/pdf3/53/01/234.pdf

9) Microstructure and mechanical properties of pearlitic gray cast iron
http://www.sciencedirect.com/science/article/pii/S092150930701862X

10) Research Paper on Manufacturing of Gray Cast Iron Automotive Disc Brake
http://www.theglobaljournals.com/ijar/file.php?val=March_2014_1394790261_a111e_37.pdf

11) Indian Minerals (Part- II : Metals & Alloys)
http://ibm.gov.in/writereaddata/files/01012015112716IMYB-2013-VOL-II_Ferro-alloys.pdf

12) Indian Minerals (Part- II : Metals & Alloys) , Aluminium and alumina
http://ibm.gov.in/writereaddata/files/01202015120441IMYB_2013_Vol%20II_Aluminium%20and%20Alumina.pdf

13) Sohrab Darabshaw, Metal Miner, Feb 2015
https://agmetalminer.com/

14) Report of the working group on Automotive sector for the 12th five year plan (2012-2017)
http://natrip.in/download/Auto_report_12th_FiveyearPlan.pdf

15) Indian Future Needs For Resources, November 2013
http://www.igep.in/live/hrdpmp/hrdpmaster/igep/content/e48745/e50194/e58089/ResourceEfficiency_Report_Final.pdf

16) A metallographic examination of fracture splitting C70S6 steel used in connecting rods
http://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CB0QFjAA&url=http%3A%2F%2Federgi.marmara.edu.tr%2Fmarufbd%2Farticle%2Fdownload%2F1012000201%2F1012000073&ei=7meWVcaBFse2uQSQj4v4Aw&usg=AFQjCNFWqaKg6QitYEOMWUTlK8Vilf2qjA&sig2=6_A4Bx_8Yj9O1rIogXszoQ&bvm=bv.96952980,d.c2E

17) Indian Auto Component Industry: A Decade of Growth and Way Forward , Research Journal Of Management Sciences
http://www.isca.in/IJMS/Archive/v2i3/4.ISCA-RJMS-2013-014.pdf

18) Vehicle Parc Definition
http://www.inchcape.com/investors/shareholder_centre/glossary.jsp

19) Automotive Materials Plastics In Automotive Markets Today
http://www.mtf.stuba.sk/docs/internetovy_casopis/2010/3/szeteiova.pdf

20) Ultralight Steel Auto Body, (1998), Final Report. Southfield, MI: American Iron and Steel Institute, March.

21) DeCicco J.M., (2005), Steel and Iron Technologies for Automotive Lightweighting, Environmental Defense, March 3

22) Opbroek, E., and Weissert U., (1998), Ultralight steel auto closures project, SAE Paper No. 982308.

23) Magnusson C. and Andersson R., (2001), Stainless Steel as a Lightweight Automotive Material R&D-Forming & Materials, Swedish Tool & Die Technology, Luleå, Sweden, 2001

24) Singh, S. J. / Krausmann, F. / Gingrich, S. / Haberl, H. / Erb, K.-H. / Lanz, P. / Mertinez-Alier, J. / Temper, L. (2012): India's biophysical economy, 1961–2008. Sustainability in a national and global context. In: Ecological Economics. Vol. 76, pp. 60–69.

25) Bhattacharya, A. / Ganeriwalla, A. / and Bruce, A. (2012): Re-igniting India's Quest for Manufacturing Leadership. The Boston Consulting Group, Confederation of Indian Industry.

26) Sears K., (1997), Automotive Engineering: Strategic Overview 2 (1) 55–68.

27) Elaheh Ghassemieh (2011). Materials in Automotive Application, State of the Art and Prospects, New Trends and Developments in Automotive Industry, Prof. Marcello Chiaberge (Ed.), ISBN: 978-953-307-999-8, InTech

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