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SHAKTI SUSTAINABLE ENERGY FOUNDATION

CII

Widening the coverage of PAT Scheme

Indian Automobile Industry

December 2013

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7. Tata Motors, Pune

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List of Abbreviations

AR –Annual Report
BEE – Bureau of Energy Efficiency
CAGR – Cumulative Aggregate Growth Rate
CHP- Combined Heat and Power
CII – Confederation of Indian Industry

COP – Coefficient of Performance
DHI - Department of Heavy Industry
EAQ – Energy Award Questionnaire
ED – Electro Deposition
EMT – Energy Manager Training
EPC- Elliptical Plate Collector
ETP – Effluent Treatment Plant
FO – Furnace Oil
FPC – Flat Plate Collector
FRP – Fibre Reinforced Plastic
GDP – Gross Domestic Product
HCV –Heavy Commercial Vehicle
IBEF – Indian Brand Equity Federation
LCV – Light Commercial Vehicle
LDO - Light Diesel Oil
Lm – Lumen
MNRE - Ministry of Renewable Energy
MUV – Multi Utility Vehicle
NBER- National Bureau of Economic Research
OICA – The International Organization of Motor Vehicle Manufacturers
SEC- Specific Energy Consumption
SIAM – Society of Indian Automobile Manufacturers
SR – Sustainability Report
SSEF – Shakti Sustainable Energy Foundation
SUV – Sports Utility Vehicle
TR – Ton of Refrigeration
VAR – Vapour Absorption Refrigeration
VCR – Vapour Compression Refrigeration
VFD – Variable Frequency Drive

List of Measuring Units

kCal – Kilo Calorie
Kg - Kilogram
KWh- Kilo Watt Hour
MT – Metric Ton
MTOE – Metric Ton of Oil Equivalent

List of Conversion Factors

1 GCal = 10^6 kCal
1 GJ = 238,846 kCal
1 kWh = 860 kCal
1 MTOE = 10^7 kCal
1 USD = 55 Rs

1. EXECUTIVE SUMMARY

This report is an attempt of CII to provide an overview of the Indian automobile sector's total energy consumption, specific energy consumption (SEC), its variation and energy reduction potential. The report also highlights the major energy saving opportunities available in the sector and provides an overview of growth opportunities and technology/ policy barriers faced by the sector. A set of recommendations which will assist the sector in improving energy efficiency have also been highlighted in this report. This report has emerged after a wide stakeholder consultation with sector experts, automobile plants, associations, institutes and technology suppliers. This report also examines the energy saving possible if a mandatory energy efficiency scheme like Perform Achieve and Trade (PAT Scheme of Bureau of Energy Efficiency (BEE), Ministry of Power, Government of India) scheme is introduced in this sector. The scope of this report includes only manufacturers of two, three and four wheelers in India.

India is emerging as a global automotive hub.[1] The Indian automobile sector has been growing due the growing demand in India, which in turn has attracted many international players to set up manufacturing units in India over the past few years. The automobile sector has seen a compound annual growth rate (CAGR) of 15%[2] during the last 5-7 years.

In 2010-11, India became the 6th largest vehicle manufacturer in the world.

- Largest manufacturer of tractors,
- 2nd largest manufacturer of two wheelers,
- 4th largest manufacturer of commercial vehicles and
- 10th largest passenger car market in the world

In automobile plants, fuel is used for steam applications, curing ovens of painting lines, heat treatment and casting operations. Majority of the energy is consumed in the form of electricity, which is used throughout the facility for compressed air requirements, metal forming, lighting, air conditioning in office spaces, painting (fans and curing), material handling, welding, robotic arms, machining etc.

The study involved secondary research (review of annual reports, sustainability reports, CII's internal data and other technical reports of automobile companies), visits to various manufacturing facilities and interaction with experts and technology suppliers. Views, comments and suggestions from various stakeholders on energy trends, reduction opportunities, technology / policy barriers, etc. were gathered and deliberated upon during a stakeholder consultation workshop organized as part of this study.

In order to estimate the sector's overall energy consumption, two approaches have been used:

[1] Department of Heavy Industry (12th five year plan)
[2] Department of Heavy Industry (12th five year plan)

Approach 1: Energy consumption details were gathered from company annual reports and data available with CII, for automobile plants belonging to four different categories[3]. Such data, available in the public domain/ accessible to CII, was available for a significant share of manufacturers (> 70%) in the country. This has then been extrapolated for each sub-sector for the entire manufacturing capacity for the year 2011-12. Based on such extrapolation, the sector's overall energy consumption is estimated to be 0.415million MTOE.

Approach 2: SEC data for several manufacturers is also available in the public domain. Such SEC values (of production > 70% in each sub-sector) is assumed to represent the entire sub-sector, and have been utilized to estimate the overall energy consumption to be 0.414 million MTOE.

The overall energy consumption of automobile sector is estimated to be 0.41 million MTOE.

Most automobile plants outsource a large number of their operations (manufacturing of various parts, glass components, rubber components, casting, forging and other auxiliary operations) and/or buy parts from vendors. The in-house operations, which generally are painting, final assembly, machining, few auxiliary operations etc., constitute only about 1/7th to 1/9th[4] of total energy needed to manufacture the vehicle. Rest of the energy consumption occurs at ancillary units outside the automobile manufacturing facility.

Vehicles manufactured by different plants differ in shape, size, design, materials used, processes carried out in-house etc., making it difficult to compare energy consumption and their relative energy efficiencies. Specific and well-defined equivalent vehicle, mapping operation-wise SEC and developing energy consumption benchmarks is thus needed for this sector to enable comparison of energy performance, initiate activity-wise efficiency improvement and identify reduction opportunities.

With vehicle production forecasted to grow at a rate of about 15%[5] during the current Five Year Plan, the sector's overall energy consumption is expected to reach about 0.98million MTOE by 2017. [6]

The major areas with high energy saving potential in automobile plants have been identified to be machining operations, use of low embedded energy materials, painting technologies and automation, compressed air systems, low thermal mass jigs and fixtures, vapour absorption refrigeration, automation and control, waste heat recovery systems and utilization of renewable energy sources. The various energy efficiency measures have also been highlighted in chapter 4.4 of the report. The estimated energy saving potential in typical automobile plants is estimated to be about 15 to 20 percent.

[3] Two wheelers, three wheelers, passenger vehicles & commercial vehicles
[4] From interaction with various stakeholders of this sector
[5] Department of Heavy Industry (DHI) 12th five year plan
6 Based on forecasted production by DHI in 2017 (PV= 7.9 mill, CV=2mill,2 W=27.77mill,3W=1.558mill) & avg. SEC (0.095,0.065,0.0035 and 0.0047 respectively)

The sector, consisting of large private players, is highly competitive and enthusiastic towards energy saving initiatives. Most automobile plants are aware of and are pursuing energy efficiency measures in a big way. On the other hand, the level of energy efficiency at ancillary units (to which the automobile plants outsource their operations) is comparatively low. Thus, there is potential to save energy at these units, but quantifying it at this stage is complex due to lack of data or a standard to compare with.

- **Energy consumption of Automobile sector = 0.41 million MTOE**
- **Energy saving of overall sector considering 5% reduction in 3 years = 0.02 million MTOE**
- **Energy consumption Automobile sector (including ancillary units) estimated to be 3.7 million MTOE**
- **Suggested threshold and potential number of automobile plants, if included in PAT :**
  - **Two wheelers (3,000 MTOE) : 9**
  - **Three wheelers (3,000 MTOE) : 0**
  - **Passenger vehicles (7,500 MTOE) : 8**
  - **Commercial vehicles (3,000 MTOE) : 7**

Due to the attractive energy savings potential, the Indian automobile sector could be a potential sector for inclusion in cycle 2 of PAT.

The challenges faced while estimating the sectors energy consumption are:

1. There is a huge variation in SEC between plants due to varying product mix and varying in-house processes carried out. There is no standard equivalent vehicle for comparison.

2. Data available in public domain does not provide enough inputs to analyze energy consumption data at process or equipment level, making it difficult to compare plants. More detailed study is required to arrive at such analysis.

The next steps suggested to be carried out in this sector are:

1. Process level and equipment level data for different automobile plants and their corresponding ancillary units are to be collected and analyzed.

2. A standard equivalent vehicle is to be arrived at, such that all parameters are comparable and common to each of the vehicle segments.

3. Most automobile manufacturing groups have more than one manufacturing facility. Few of the operations are carried out at one facility and the parts are used in various other facilities belonging to the same group. Hence comparing energy consumption of automobile plants at a corporate level is suggested instead of comparison at plant level.

4. Collect energy consumption data from vendors to estimate the overall energy needed for the equivalent vehicle.

5. Demonstrate and share best practices to improve the overall sectors performance.

2. INTRODUCTION

2.1 Sector importance

The contribution of the automobile sector to India's Gross Domestic Product (GDP) was about 6%[7] in 2012 and the CAGR of the sector was 15%[8] during the last 5-7 years. It also contributes 22% and 21% to the manufacturing GDP and excise duty respectively.[9] This sector is a major customer of the iron and steel sector, which, in itself, is one of the major Indian sectors. Therefore, any changes in market demand for automobiles affects the steel sector and the overall GDP of the country.

The Indian automobile industry alone accounts for providing direct and indirect employment to over 13.1 million people.

2.2 International scenario

The global automotive sector had a turnover of about USD 2,418 billion[10] in the year 2012. Competition amongst automobile manufacturers has increased globally due to increasing global trade. Japanese automakers in particular, have implemented innovative production methods by modifying the U.S. manufacturing model, as well as adapting and utilizing technology to enhance production and increase product competition.

The per capita car ownership (expressed in cars per 1000 population) of the global automobile sector is as shown below: [11]

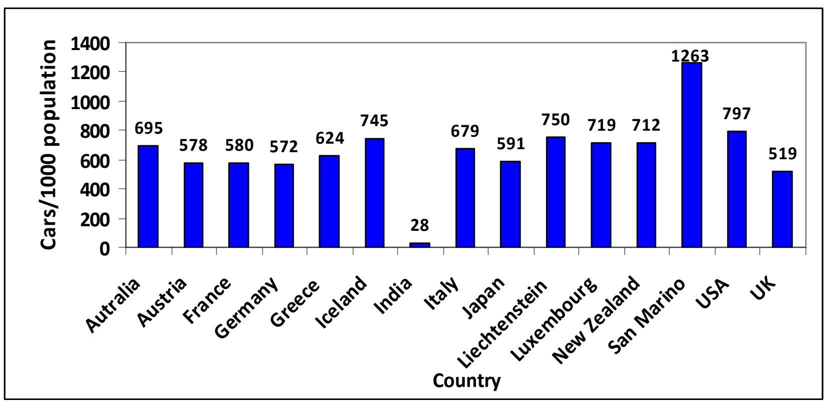

Figure 1- Per capita ratio of cars[12]

India's present per capita car ratio is, at 28, among the lowest in the world's top auto markets. However, the per capita ratio has seen an increase from 18 to 28 from 2009 to 2011.

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[7] Department of Heavy Industry (12th five year plan)
[8] Department of Heavy Industry (12th five year plan)
[9] Department of Heavy Industry (12th five year plan)
[10] OICA- The International Organization of Motor Vehicle Manufacturers (http://oica.net/category/economic-contributions/facts-and-figures/)
[11] World bank data
[12] World bank data

2.3 International standing of subsector

India surpassed countries like France, UK and Italy to become the 6th largest vehicle manufacturer in the world during the year 2010-11. It is the largest manufacturer of tractors, second largest manufacturer of two wheelers, fourth largest manufacturer of commercial vehicles and the tenth largest passenger car market in the world and is emerging as a global automotive hub.[13]

The global production of passenger and commercial vehicles stood at 63,069,541 and 21,071,668[14] respectively, of which India accounted for 3,123,528 and 911,574[15] respectively, for the year 2012, amounting to 4% of global production. The twin phenomena of low car penetration and rising incomes, along with increasing affordability of cars, are contributing to an increase in automobile demand in India.

2.4 Market scenario

There are 19 manufacturers of passenger cars, 14 manufacturers of commercial vehicles, 16 of 2/3 wheelers and 12 of tractors, besides 5 manufacturers of engines in India. This includes almost all the major global original equipment manufacturers (OEMs) and also home grown companies. [16]

The automobile market can be broadly split into 4 segments viz. 2 wheelers, 3 wheelers, passenger vehicles and commercial vehicles. The market share by volume of each subsector of the automobile sector is as shown below:

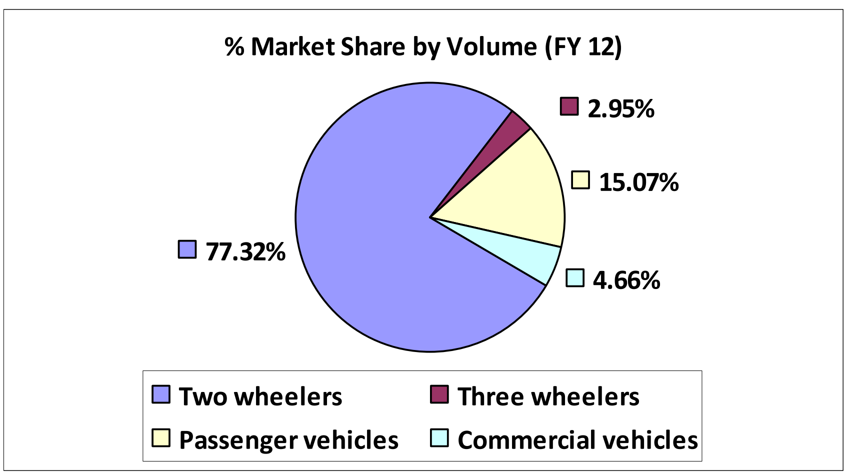

Figure 2- Market share of subsectors by volume (%)[17]

Present market trends indicate highest demand for two-wheelers, with a share by volume of 77.3%, followed by passenger vehicles with 15.07%, commercial vehicles with 4.66 % and three-wheelers with 2.95%.[18]

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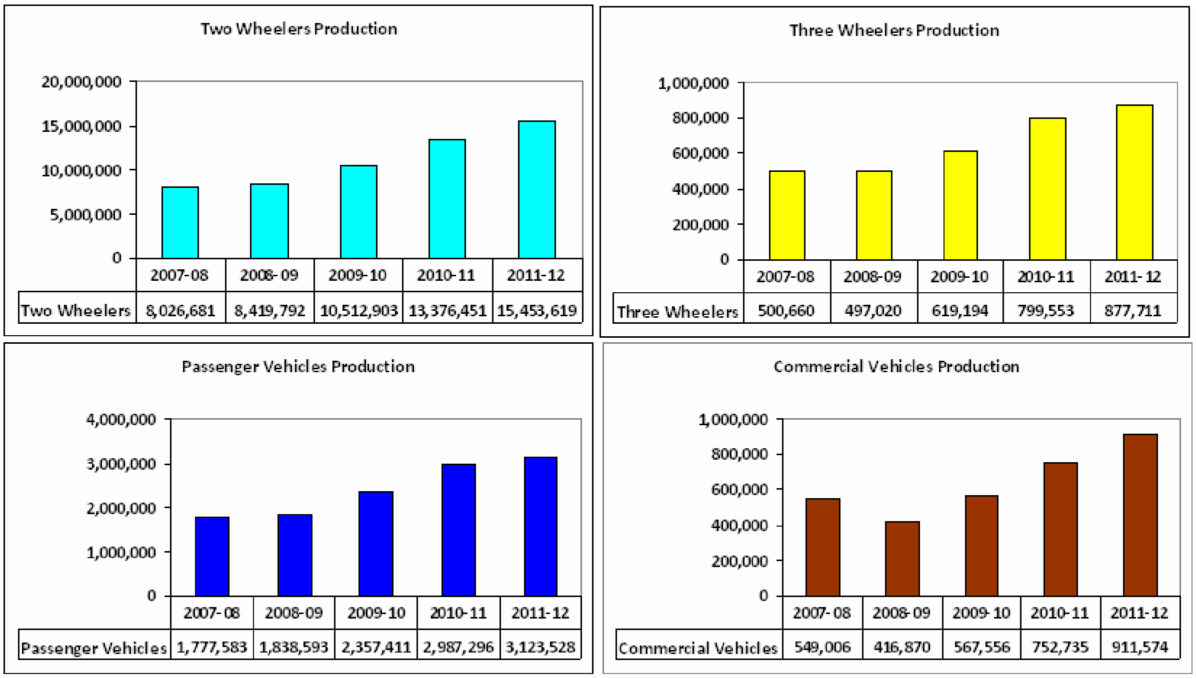
[13] Department of Heavy Industry (12th five year plan)
[14] OICA The International Organization of Motor Vehicle Manufacturers
[15] Society of Indian Automobile Manufacturers(SIAM)
[16] Department of Heavy Industry (12th five year plan)
[17] SIAM

The installed capacity of the four wheeler industry (comprising passenger vehicles and commercial vehicles) at present is over 4 million units and that of two and three wheeler industry is over 15 million units, with an overall investment of over USD 14,545 million[19].

2.5 Growth in past and future prospects

The Indian automobile industry has witnessed a steady cumulative aggregate growth rate of 15% [20] in the past five years. The growth in production of vehicles of each sub sector from the year 2007-08 to 2011-12 is as shown below[21]:



	2007-08	2008-09	2009-10	2010-11	2011-12
Two Wheelers	8,026,681	8,419,792	10,512,903	13,376,451	15,453,619
Three Wheelers	500,660	497,020	619,194	799,553	877,711
Passenger Vehicles	1,777,583	1,838,593	2,357,411	2,987,296	3,123,528
Commercial Vehicles	549,006	416,870	567,556	752,735	911,574

Figure 3-Growth of the sector[22]

Production in the two wheeler segment has increased from 8 million to 15 million at a CAGR of 11.9%, and the three wheeler segment has seen rise in production from 0.5 million to 0.8 million at 13% CAGR, in the past five years. The passenger and commercial vehicle segments have increased their production from 1.7 million to 3 million and 0.5 million to 0.9 million, with a 12% and 14% CAGR, respectively, during the same period.

The automotive industry is expected to grow rapidly over next five years at a CAGR of 15%. The production volumes estimated to be reached by 2020 are shown in the figure below:

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18 SIAM
19 Department of Heavy Industry (12th five year plan)
20 Department of Heavy Industry (12th five year plan)
21 SIAM
22 Department of Heavy Industry (12th five year plan)

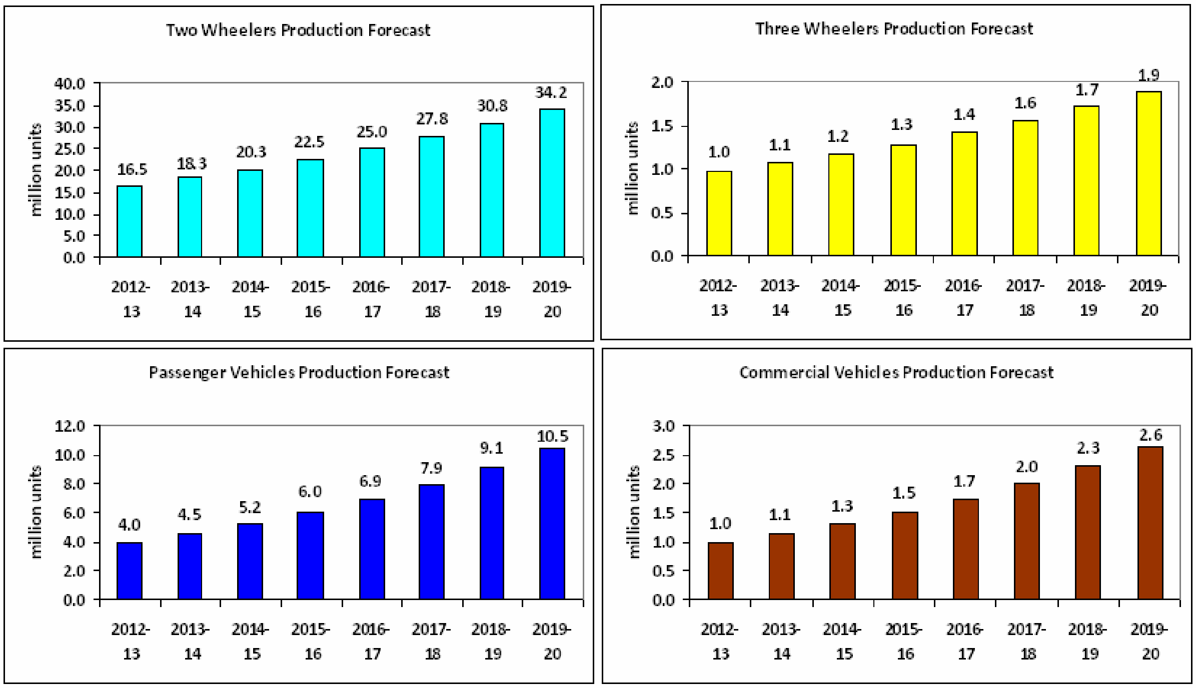

Figure 4 – Forecasted growth of the sector[23]

Production is forecasted to reach more than 25 million in the two wheeler segment, 1.4 million in the three wheelers segment, 6.9 million in the passenger segment and 1.7 million in the commercial vehicle segment. The individual CAGR for these segments has been calculated to be 11%, 10%, 15% and 15% respectively.

2.6 Production data

The Indian automobile industry has mainly developed in clusters which have a large number of companies along with their vendor base. The major Indian automotive hubs are concentrated in Maharashtra, NCR region, Tamil Nadu, Karnataka & Jamshedpur.

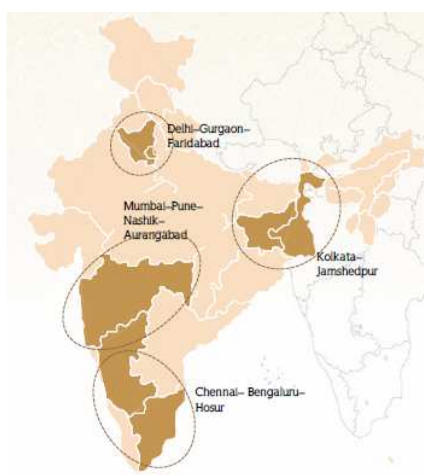

Figure 5- Geographical spread[24]

[23] Department of Heavy Industry (12th five year plan)

The overall production of vehicles in India has been increasing over the past 5 years. The production numbers for each subsector are shown in the table below:

Table 1 – Production Data[25]

Category	2007-08	2008-09	2009-10	2010-11	2011-12
Passenger Vehicles	1,777,583	1,838,593	2,357,411	2,987,296	3,123,528
Commercial Vehicles	549,006	416,870	567,556	752,735	911,574
Three Wheelers	500,660	497,020	619,194	799,553	877,711
Two Wheelers	8,026,681	8,419,792	10,512,903	13,376,451	15,453,619
Grand Total	**10,853,930**	**11,172,275**	**14,057,064**	**17,916,035**	**20,366,432**

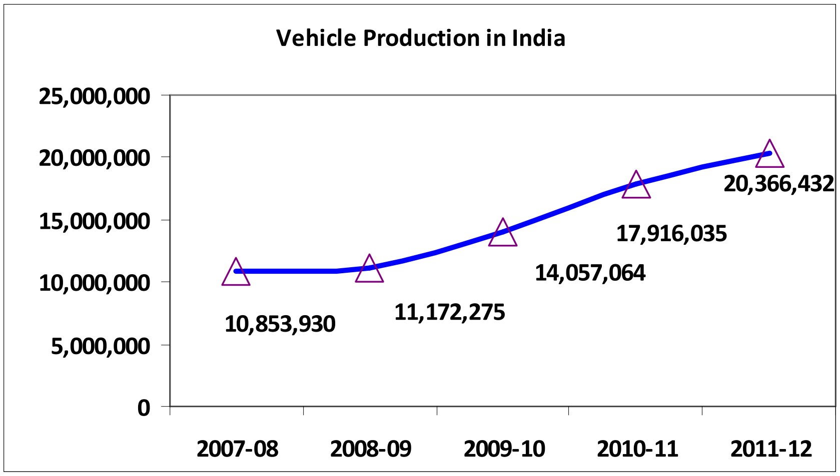

Figure 6 - Production data[26]

2.7 Important stakeholders

The important stakeholders of this sector include Associations, Government bodies, Manufacturing facilities, OEMs (original equipment manufacturer), economists, dealers, financiers and ancillary equipment manufacturers. Some of these are described below:

- The Department of Heavy Industry, under the Ministry of Heavy Industries and Public Enterprises, Government of India, is the main agency in India for promoting the growth and development of the automotive industry. The Department assists the industry in achievement of its expansion plans through policy initiatives, suitable interventions for restructuring of tariffs and trade, promotion of technological collaboration and up-gradation as well as research and development. (www.dhi.nic.in)

- Society of Indian Automobile Manufacturers (SIAM) is the apex Industry body representing 46 leading vehicle and vehicular engine manufacturers in India. It is an important channel of communication for the automobile industry with the Government, national and international organizations.

[24] IBEF automobile sector report 2012
[25] SIAM
[26] SIAM

The Society works closely with all the concerned stake holders and actively participates in formulation of rules, regulations and policies related to the Automobile Industry. SIAM provides a window to the Indian Automobile industry and aims to enhance exchanges and communication in order to expand economics, trade and technical cooperation between the Automotive Industry and its international counterparts. (www.siamindia.com)

- The Automotive Component Manufacturers Association of India (ACMA) is the nodal agency for the Indian auto component industry. Its active involvement in trade promotion, technology up-gradation, quality enhancement and collection and dissemination of information has made it a vital catalyst for this industry's development. Its other activities include participation in international trade fairs, sending trade delegations overseas and bringing out publications on various subjects related to the automotive industry. (www.acma.in)

- The Automotive Research Association of India (ARAI) has been playing a crucial role in assuring safe, less polluting and more efficient vehicles. ARAI provides technical expertise in R & D, testing, certification, homologation and framing of vehicle regulations. ARAI is a co-operative industrial research association established by the automotive industry with the Ministry of Industries, Government of India. It works in harmony and complete confidence with its members, customers and the Government of India to offer the finest services, which earned for itself ISO 9001, ISO 14001, OHSAS 18001 and NABL accreditations. (www.araiindia.com)

- There are 19 manufacturers of passenger cars and multi utility vehicles, 14 manufacturers of commercial vehicles, 16 of 2/3 wheelers and 12 of tractors besides 5 manufacturers of engines in India. This includes virtually all the major global original equipment manufacturers (OEMs) and also home grown companies.[27] These form a major stakeholder of the Automobile sector.

- Others include manufacturers and suppliers of hydraulic brakes, engine and engine products, transmission systems, suspension systems, cylinder block and head, crankshaft, intake and exhaust manifolds, chassis components, electrical systems, fuel systems, lighting, tyres, paint booth etc.

2.8 Product categorization

The automobile market is split into 4 segments viz. 2 wheelers, 3 wheelers, passenger vehicles and commercial vehicles. The further breakdown of these segments can be seen in the figure below:

[27] DHI

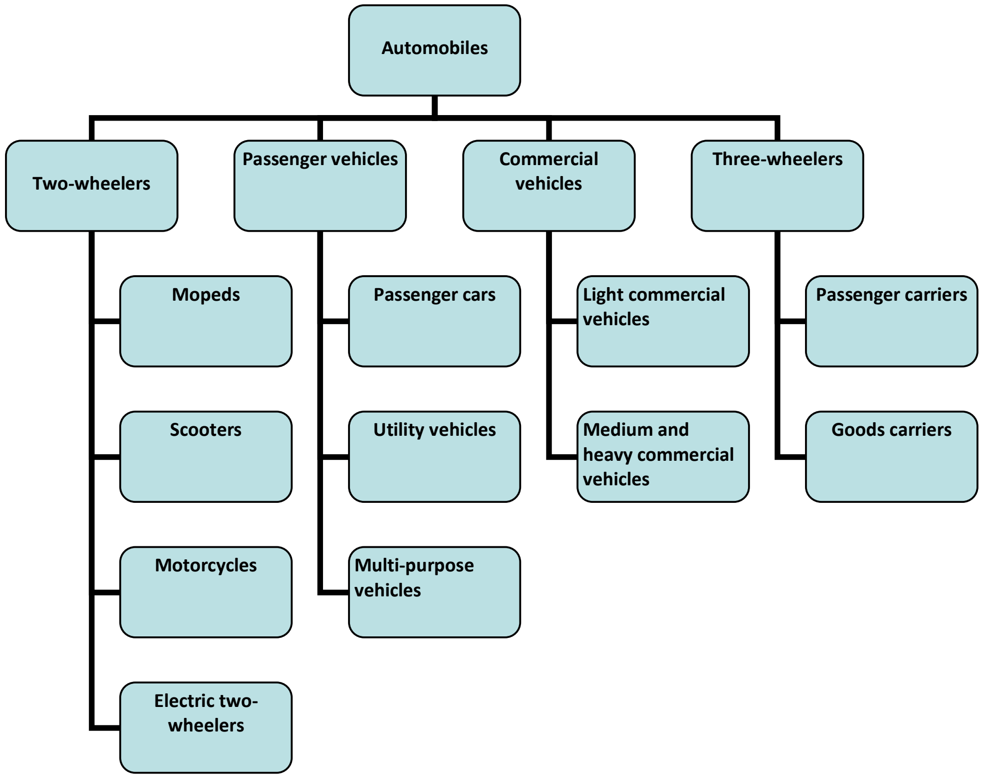

Figure 7 – Product categorisation

The scope of this project, as mentioned earlier, includes the above shown automobile manufacturing segments. The two wheeler manufactures include manufacturers of mopeds, scooters, motorcycles and electric two wheelers. The passenger vehicle segment is made up of passenger car, utility vehicle and multi-purpose vehicle manufacturers. Light and medium commercial vehicle manufacturers are included in the commercial vehicle segment, and the three wheeler segment takes into consideration passenger and goods carriers.

Farm equipment and tractors are not included in the scope of this report.

2.9 Major players

The automotive industry is a concentrated one in India, with market leaders in each segment commanding a share of over 40%.

2.9.1 Passenger Vehicles Industry

The passenger car segment is dominated by Maruti Suzuki India Limited, which has a market share of 46%. At the second position is Tata Motors, which has a share of 16.5%. Closely following in the third position is Hyundai Motors India Ltd. with a share of about 14%. The rest of the companies, which include Mahindra & Mahindra, Honda Cars India, Toyota Kirloskar Motor Pvt. Ltd, Ford India Pvt. Ltd., General Motors, Skoda, Force Motors, Fiat, and Hindustan Motors, account for the remaining share.

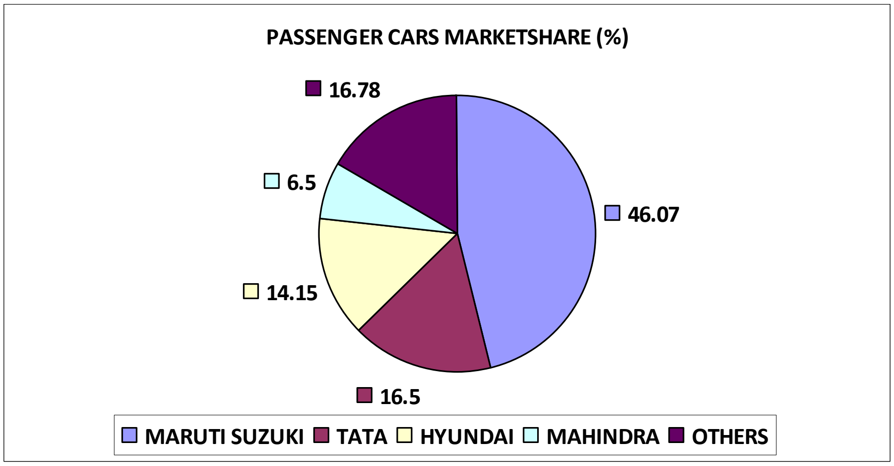

Figure 8 - Major players in passenger vehicle segment[28]

2.9.2 Commercial Vehicles Industry

The medium and heavy commercial vehicle segment is dominated by Tata Motors in India with a share of 63.94%. Ashok Leyland has the second position in the higher and medium commercial vehicle segment with 16.47% share of the market. In the light commercial vehicle segment, however, Mahindra and Mahindra holds the second position with a 30% share. The overall market share captured by Mahindra & Mahindra in the commercial vehicle segment is about 10%. The other Automobile companies like Eicher Motors, Force Motors, Swaraj Mazda, Volvo, Hindustan Motors and Tata Vectra Motors have shown their presence in the market but with very low market share.

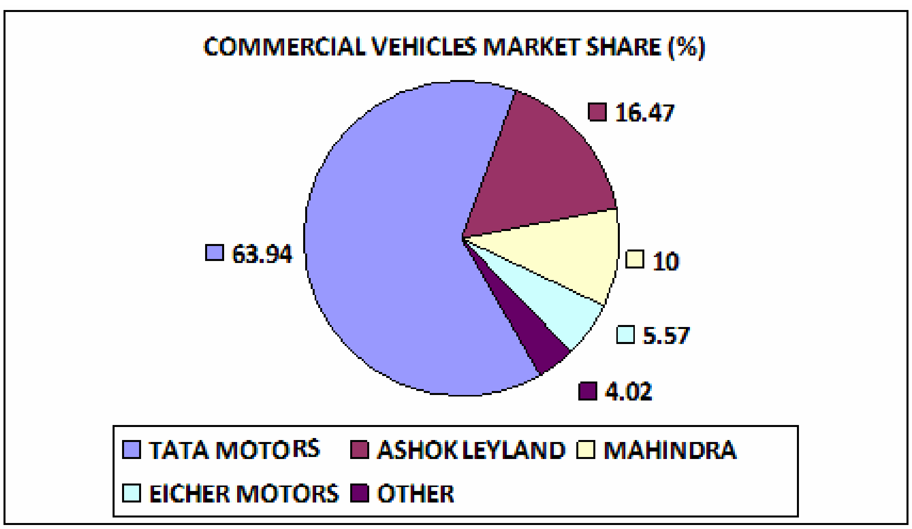

Figure 9 - Major players in commercial vehicle segment[29]

[28] SIAM & ajtmr
[29] SIAM & ajtmr

2.9.3 Two Wheelers Industry

Hero MotoCorp (earlier known as Hero Honda) has about 41.35% share in the two wheeler segment in India. Bajaj Auto holds second position with 26.7%. The third position is held by TVS Motors, which has a share of 18.14%. Honda Motorcycles follows with a share of about 8.8%. Rest of the two wheeler manufacturers including Yamaha, Suzuki, Royal Enfield and Mahindra have a share of less than 10%.

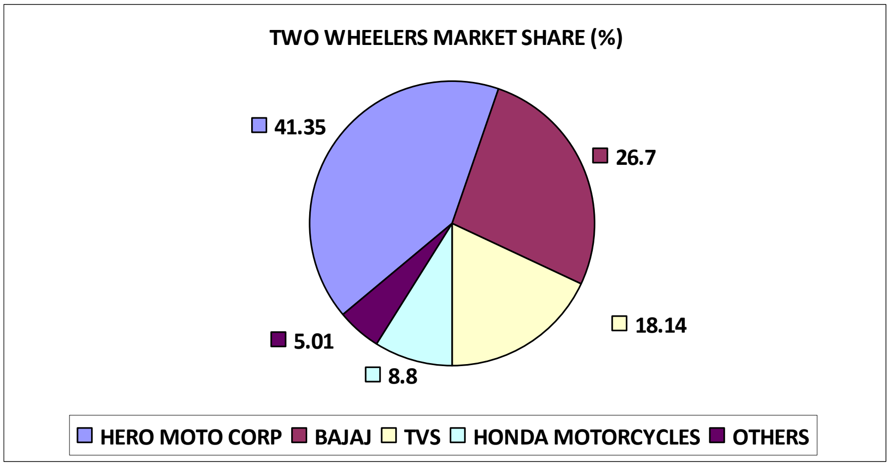

Figure 10- Major players in two wheeler segment[30]

2.9.4 Three Wheelers Industry

Bajaj auto and Piaggio dominate the three wheeler market with market shares of 58 and 32 percent respectively, followed by TVS Motors with about 6% share. The others, including Mahindra & Mahindra, Scooter India, Force Motors and Atul Auto, contribute less than 10%**.**

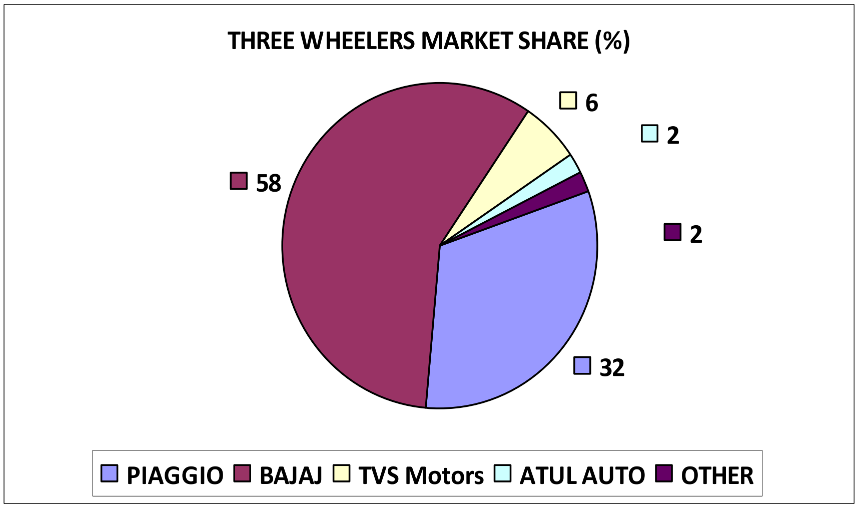

Figure 11 - Major players in three wheeler segment[31]

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[30] SIAM & ajtmr

2.10 Current regulatory / policy scenario and any change needed for growth

After the high degree of regulation and protection in the 1970s and 1980s, the reforms of de-licensing, liberalization and opening up of FDI in the auto sector led to a boom in the auto industry during 1991 - 1996. There was massive expansion of capacities and entry of multinationals which led to an over-capacity and intense competition. It also resulted in price wars and aggressive cost-cutting measures including layoffs and large-scale retrenchment.

A few major policies favoring technological improvements in the auto industry in India over the past few years are described below:

2002

- Auto Policy, 2002, stresses on the need to provide direction to the growth and development of the auto industry in India. This policy document resulted in reduction of duties in the auto-component sector to a large extent and the automobile sector to some extent and extension of R&D incentives to the auto sector. R&D thrust by the government can be inferred from measures such as 150 percent weighted deduction on R&D expenditure and increased R&D budget allocation for this sector. This has encouraged plants to willingly take up greater technological improvements in the past few years.

2006

- Draft of Automotive Mission Plan Statement, prepared in consultation with the industry, was released by the Ministry of Heavy Industries and Public Enterprises in 2006. This document draws up an action plan to increase the turnover of the automotive industry in India to US$145 billion by 2016, accounting for more than 10 percent of the GDP and providing additional employment to 25 million people, by 2016. A special emphasis is laid on small cars, MUVs, two-wheelers and auto-components. Measures suggested include setting up of a National Auto Institute, streamlining government/educational/research institutions to the needs of the auto industry, upgrading infrastructure, considering changes in duty structure and fiscal incentives for R&D.

Policies where industry is seeking change[32]:

- Excise duty on CVs, small cars and two-/three-wheelers is 12%, while for other cars, SUVs and MUVs, is fixed at 27 to 30%. This is a disputed issue among the Indian car manufacturers, because of the perception that it unjustly favors particular segments and hence, manufacturers who are strong in those segments, are at an advantage.

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[31] SIAM , ajtmr & plant's website

[32] Indian Council For Research On International Economic Relations, Determinants of Competitiveness of the Indian Auto Industry(working paper no. 201)

- There are many inter-state differences in terms of tax policies, incentives and emission norms. These could be minimized in order to smoothen the inter-state movements of goods and relocation of industries. Due to this reason, the Indian automobile industry has mainly developed in clusters which have large number of companies along with their vendor base, in the Maharashtra, Haryana, Tamil Nadu and Uttarakhand regions.

The existing differences in policies by state governments in the four major auto clusters have been compared below:

Incentives:

- Maharashtra is the only state that levies octroi taxes, among the major auto producing states in India. Thus, firms in this state find it expensive to procure components from other states. However, in an attempt to develop its backward districts, the Maharashtra Government is providing a few incentives to the industrial units that are set up in these districts. These incentives include exemption from electricity duty for 10 years, stamp duty and registration fees for 5 years. Octroi is also refunded to the industries in these places.

- Haryana Government provides exemption from sales tax and local area development tax (LADT) for certain time period for industries that are newly set up.

- Tamil Nadu offers exemption from electricity tax for three years to all new projects with investment between USD 9 million and USD 18 million.

- Uttarakhand provides many tax incentives. Few of them include exemption from central excise is given for 10 years of establishment and 100 percent income tax exemption is given for the first five years of establishment, followed by 30 percent for the next five years. They also grant exemption from entry tax on plant and machinery.

3. ENERGY PERFORMANCE

3.1 Sector-level energy performance in recent years

Energy is used for different purposes in automobile manufacturing facilities.[33] Fuels are used for steam applications, curing ovens of painting lines, heat treatment and casting operations onsite. Electrical energy is used throughout the facility for compressed air requirements, metal forming, lighting, air conditioning in office spaces, painting (fans and curing), material handling, welding, robotic arms, machining etc.

The table below shows the electricity and thermal energy use distribution in a few automobile plants from different subsectors.

Table 2- Usage of electrical and thermal energy at individual plants [34]

Plant	Capacity (No. of veh.)	Total MTOE	Electrical energy usage (MTOE)	Electrical energy share to MTOE (%)	Thermal energy usage (MTOE)	Thermal energy share to MTOE (%)
Two wheelers						
Plant1	1,800,000	5097	2147	42	2950	58
Plant2	1,969,500	5456	5353	98	104	2
Plant3	2,110,000	9268	4946	53	4322	47
Plant4	2,550,000	4083	3030	74	1053	26
Plant5	350,000	1199	477	40	722	60
Plant6 to 8	3,000,000	11140	6450	58	4690	42
Three wheelers *						
Plant2	450,000	2059	324	16	1735	84
Plant3	72,000	247	143	58	104	42
Passenger Vehicles #						
Plants 1 and 2	325,000	25287	16314	64.5	8973	35.5
Plant3	600,000	33889	21414	63	12475	37
Plant4	204,400	8301	4254	51	4046	49
Plant5	80,000	5619	3184	57	2435	43
Plant6	177,701	7268	5065	70	2202	30
Plant7	140,000	11636	5599	48	6038	52
Plant8	200,000	8620	5723	66	2897	34

[33] The energy performance of the automobile sector in general must refer to energy consumed in manufacturing and assembly line of the vehicle until it is rolled out; this includes everything from the smallest nut to the paint job. Many parts are procured from, and operations are outsourced to, ancillary units, which are estimated to consume about 7 to 9 times the energy consumed in automobile manufacturing plants. Ancillary units, however, not been accounted for as it is not within the scope of this project. The scope includes 2, 3 & 4 wheeler manufacturers only.

[34] This data has been collected from annual reports, sustainability reports or CII's energy award questionnaires (For full details of plants refer table 14)

Commercial Vehicles @						
Plant1	125,000	4164	3282	79	882	21
Plant2	249,000	17874	10171	57	7704	43
Plant3	144,000	24765	13162	53	11603	47
Plant4	500,000	13512	4773	35	8739	65
Plant5	75,000	3370	2337	69	1033	31
Plant7	64,000	4712	1470	31	3242	69
Plant8	90,000	2288	842	37	1446	63
Plant9	300,000	7273	3923	54	3350	46

* Plant 1 has been excluded since the breakup of electrical and thermal energy consumption has not been provided in the annual report.

Plant 9 & 10 have been excluded since the breakup of electrical and thermal energy consumption has not been provided in the sustainability report.

@ Plant 6 has been excluded since the breakup of electrical and thermal energy consumption has not been provided by the plant.

The distribution of energy use varies widely among automobile plants, based on the operations carried out in that facility. It has been seen that the typical contribution of electricity consumption to the overall MTOE of the plant is about 60 percent and thermal energy consumption is about 40 percent. The typical breakup of electricity usage can be seen in table 3:

Table 3 – Electricity usage in a typical vehicle assembly plant

Use	Electricity Usage
Paint systems	27-50%
Lighting	15-16%
Compressed Air	15-25%
Material Handling and tools	15-25%
Metal Forming	2-9%
Welding	9-11%
HVAC (office spaces)	3-5%
Miscellaneous	4-5%

3.2 International comparison

The energy consumption details of a few international players, as published in their annual reports or sustainability reports, are as shown below:

Table 4 – International SEC values

Passenger Vehicles	SEC (kWh/Vehicle)	SEC (MTOE/vehicle)[35]
General Motors[36]	2,590	0.22
Ford Motors[37]	2,778	0.23
Volkswagen[38]	2,380	0.2
Daimler Chrysler[39]	3,560	0.3
Commercial Vehicles	**SEC (kWh/Vehicle)**	**SEC (MTOE/vehicle)**
Volvo[40]	8,500	0.7
Daimler Chrysler(trucks)[41]	7,710	0.66
Daimler Chrysler(buses)[42]	9,300	0.79
Two Wheelers	**SEC (kWh/Vehicle)**	**SEC (MTOE/vehicle)**
Harley Davidson[43]	315	0.027
Piaggio[44]	307	0.026

The SEC figures of commercial and two wheeler manufacturers are about 8 times the typical SEC of data collected from Indian automobile plants, while those for passenger car manufacturers are about 4 to 5 times that of the Indian automobile plants. This may be because these international groups disclose the SEC for their vehicle by including energy consumed for operations carried out at ancillary units as well.

3.3 Technological movements

There has been progress in the level of technologies and systems used by manufacturing units of leading automobile manufacturers. Some include:

- Installation of VFDs for fans /pumps/compressors/motors
- Process modifications leading to sealant oven elimination (transformation from 2 coat + 2 bake system to 2 coat + single baking system)[45]
- Installation of energy efficient burners for paint shop - ED oven[46]
- Wind driven turbo ventilators[47]
- Pneumatic shut off valve in compressed air lines

35(kWh/vehX860)/10000000=MTOE/veh
[36] General Motors- Sustainability Report 2010
[37] Ford Motors - Sustainability report 2012
[38] Volkswagen - Sustainability report 2011
[39] Daimler Chrysler - Sustainability report 2012
[40] Volvo - Sustainability report 2012
[41] Daimler Chrysler - Sustainability report 2012
[42] Daimler Chrysler - Sustainability report 2012
[43] Harley Davidson - Sustainability report 2012
[44] Piaggio - Sustainability report 2012
[45] Mahindra & Mahindra (M&M) EMT 12
[46] M&M EMT 12
[47] EMT 12

- Occupancy sensors
- Use of efficient screw compressors in place of reciprocating compressors
- Energy conservation through process optimization
- Waste heat recovery systems
- Powder based coating in place of solvent based coating
- Microwave drying in place of or in combination with conventional drying
- Induction heating in place of fuel fired furnaces
- CHP and electric furnaces
- Combination of microwave drying and shuttle kilns in place of conventional kilns
- Use of regenerative thermal oxidizer in place of simple after burner for VOC control
- Furnace oil Emulsification Projects which can save up to 10 % of Fuel
- Installation of breeze air coolers in place of ARP
- Utilization of renewable energy /clean energy
  - Use of solar water heating system for process shops/canteen
  - Use of wind mill energy etc.
- Phosphate coating to new TecTalis coating technology
- Fluidized bed type incinerator for cleaning of paint booth gratings instead of direct burning type incinerator to reduce emission
- New generation electro deposition (ED) paint coating on car body was introduced which operates at low voltage and thus consumes less energy
- Aerodynamic energy efficient fiber reinforced plastic (FRP) blades were used in lieu of standard blades for cooling towers which consume less energy.
- Installation of light pipes and transparent polycarbonate sheets
- Super magnetic dust separator
- The skid design modified to accommodate two bodies on a single skid there by two bodies processed simultaneously[48]
- Paint trolley design modification in paint shop paint booths to accommodate two vehicles on a single trolley.

[48] Mahindra and Mahindra

- Permafrost treatment for chillers
- Super heat recovery from air conditioning units (vacuum chiller). It is the process of reutilizing the waste heat generated by refrigerant gas in close loop vapour compression cycle on which most air conditioners work.

Apart from manufacturing technology, there has been progress in producing cleaner automobiles. Automakers are developing clean, fuel-efficient technologies, and engines that run on diverse/ alternative fuels like clean diesel, biodiesel, ethanol, hydrogen, and compressed natural gas or those that run on hybrid technology using both conventional combustion engines (gasoline or diesel) and electric engines.[49]

3.4 Capacity utilization

The capacity utilization of a few individual plants is as shown below:

Table 5 – Capacity utilization [50]

Sr. No.	Capacity Utilization (%)	Sr. No.	Capacity Utilization (%)
2 WHEELERS		**3 WHEELERS**	
Plant1	97	Plant 1	115
Plant2	99	Plant 2	100
Plant3	97.5	**COMMERCIAL VEHICLES**	
Plant4	88.5	Plant1	90
Plant5	40	Plant2	98
Plant 6 to 8	72	Plant3	75
PASSENGER VEHICLES		Plant4	61
Plant3	98	Plant5	40
Plant4	97	Plant6	59
Plant5	94	Plant7	41
Plant6	63	Plant8	97
Plant8	67	Plant9	39

The average capacity utilization of each subsector has been estimated based on the data collected for each subsector:

Table 6 – Average capacity utilization of each subsector

Sector	Capacity Utilization (%)
Two Wheelers	88
Three Wheelers	90
Passenger Vehicles	80
Commercial Vehicles	66

[49] The International Organization of Motor Vehicle Manufacturers (OICA)
[50] (For full details of plants refer table 14)

3.5 Major energy consuming areas

The major energy consuming areas in an automobile manufacturing plant can broadly be classified in utility and process related.

Utility related areas include:

- Compressed Air systems
- Motors
- Heat and steam distribution-boilers
- Lighting
- Material handling and tools
- Pumping systems

Process related areas include:

- Painting systems
- Body weld
- Stamping
- Machining
- Heat treatment
- Casting

3.6 Energy saving potential and major areas

Some areas with good potential for energy savings in automobile manufacturing plants:

3.6.1 Low thermal mass jigs and fixtures

Painting is a common process carried out in every automobile manufacturing plant. A large amount of energy is used during the heat treatment of the body after the painting process. Considerable part of this energy is consumed by the paint line jigs and heat treatment fixtures which hold and transport the body in and out of the furnace.

The car body along with the jigs holding it undergoes firing and cooling cycles, as it moves through the furnace. Due to high thermal mass, these jigs and fixtures consume considerable amount of heat energy supplied to the furnace.

Modern techniques can produce castings that are lighter and stronger. Less thermal mass means that the process meets its optimal temperature more quickly – reducing cycle times and so improving process productivity, reducing per component processing cost and overall energy consumption and carbon release. Thus improved design would add strength in the vulnerable areas with a reduction in weight and an improvement in the thermal performance of the casting.

High strength low weight Carbon-Carbon jig assemblies are being used for vacuum heat treatment and brazing of turbine blades, oil coolers, stainless steel brazing and sintering, which offer increased furnace productivity and energy savings due to low thermal mass. There is also new high reflective ceramic coating and ceramic jig technologies available in Indian markets give similar benefits.

All these design and material modifications for thermal mass reduction jigs and fixtures will lead to a minimum of 10% fuel saving.

3.6.2 Phosphate coating to New TecTalis coating technology

Since painting accounts for a large share of energy consumed at an automobile plant, using a new energy efficient technology will provide substantial energy savings. TecTalis is one such green and efficient alternative to zinc phosphate. It is a multi-metal pre-treatment, which provides better corrosion resistance and paint adhesion. These coatings are composed of nano-ceramics free of nickel, phosphate, VOC and CO_2 equivalent emissions resulting in minimal environmental impact. TecTalis can also be applied in already existing lines, with slight modifications. This pretreatment coating is applied at ambient temperature, reducing utilities and natural resource requirements, resulting in energy saving. Thus, the pretreatment footprint can be reduced significantly in a brown field as well as in a green field project.

A typical two wheeler plant in India which has transformed from phosphate to TecTalis coating has seen the following savings:

Table 7 - Benefits of TecTalis coating[51]

Parameter	Phosphating	Tec Talis	Remark
Bath Temperature	50 deg ºC	Ambient temperature	Energy efficient Process
Electrical Energy Consumption	61 kWh/hr	29.50 kWh/hr	Saving-Rs.1.015 million (USD 18,000)
LPG Consumption	327 kg/day	245 kg/day	Saving-Rs.1.160 million (USD 20,000)
			Total Saving-Rs.2.175 million (USD 40,000)
Hazardous sludge	Phosphating Sludge-2.5-2.8 gm/m^2	Iron Oxide Sludge-0.1 gm/ m^2 of MS	Elimination of Hazardous phosphating and Chrome sludge
		< 5 kg/Month	
	190-200 kg/month		
Load of heavy metals on ETP	Heavy metals – Zinc, Nickel and Manganese	Free of Heavy metals	Green Process

[51] CII's internal energy award data submitted by plant

3.6.3 Compressors

Automobile manufacturing plants are large users of compressed air, consuming up to 15% to 25% of the electrical energy. Compressed air is one of the costliest entities in a utility system. Therefore any conservation activity in compressed air system will yield excellent benefits. Minimization of compressed air usage, use of energy efficiency compression system, arresting of air leakages are some of the steps to improve the energy performance of a compressed air system.

A few measures that can be taken up in compressed air systems involve:

- Maintenance and Monitoring: Inadequate maintenance can lower the operating capacity of the compressor systems. Once the capacity of the compressor system reduces the specific energy consumption of the system increases. Typically, this problem arises in a reciprocating compressor after 5 – 6 years of its operation. Constant monitoring and regular maintenance helps a compressor system to stay in pristine health and ultimately save energy.

- Replacing air powered tools with electric tools: As mentioned earlier, compressed air is one of the costliest entities in a utility system. This is because, the efficiency of the compressor, as such, very low. Therefore, proper utilization of compressed air is very important. In an automobile assembly plant, use of air powered tools is very common. The recent trend is to convert the air powered tools to electric tools. For performing the same amount of work, electric tools consumes less energy than compressed air system. Therefore pneumatic operated tools can be limited to application that absolutely requires compressed air operation.

- Segregation of high pressure / low pressure users: In any plant, the pressure requirements of compressed air vary from user to user. Normally, the set pressure is based on the highest pressure requirement of the user and for rest of the users the air is throttled. In this case, the compressor operates at a higher pressure even though majority of the users require only lower pressure. This leads to higher pressure consumption of the compressor. This phenomenon can be avoided by segregating the high pressure and low pressure requirements.

- Compressed air leaks must be identified and fixed, old braided tubing must be replaced with plastic sheathed tubing, and branch headers must be shut off when production lines are not in use. These will result in significant savings

- Controls: An automatic system that controls the operation of air compression can reduce electricity by matching output to demand. By installing a computerized control system for the air compressors, a luxury car manufacturer in England was able to reduce average weekday electricity by 16.5% and average weekend electricity consumption by 25%

3.6.4 Hydraulic systems

Energy Efficiency has become critical in hydraulic and pneumatic systems. Hydraulic and pneumatic producers are trying to reduce energy consumption in every area they can, from improved design in valves and pumps to right-sized components, pressure regulation, machine design, and advances in hydraulic fluids, which can give energy savings ranging from 15 percent to 35 percent.

Few latest approaches and technologies include:

Use of an adaptive electro-hydraulic load sensing system, where the system identifies and sets the pump and the valves to the high dynamic or fine control range accordingly, depending on the requirement. A conventional load-sensing control can be used over this function, to avoid sensors. This will not only guarantee higher efficiency, but also ensure a longer life of the system.

The conventional valve system can be replaced with a compact valve system (in a single block) which integrates all key hydraulic control functions within single cast housing. Adopting this approach reduces the risk of leaks, saves on space, simplifies the process for assembling the hydraulics and most importantly leads to better efficiency.

3.6.5 Paint booth automation and control

Paint shop is another major energy-consuming area at an automobile plant. Energy is used to condition the air for the painting process, drying and for treatment of the emissions. "Ford reports that about 70% of the total energy costs in its plants are used by the painting operations"[52]. Within the painting process, relatively less energy is required for curing (drying) the thin paint film when compared to the energy used in raising the temperature of the carriers as well as the car bodies. Energy can be saved automating the process and exercising improved control of the painting lines. Following measures must be taken for proper controls

- Implementation of additional controls to maintain optimal air to fuel ratio. Inadequate air will result in incomplete combustion, while excessive air will reduce energy efficiency, as the excess will have to be heated up as well. Additionally reducing excessive air volume will reduce equipment size and therefore capital costs, as well as avoid design problems in the chiller.

- Avoid heat loss that occurs due to badly functioning entry and exit doors and air locks.

- All automated processes must be enclosed and steps must be taken to reduce ventilation requirements where possible.

- Temperature, humidity and ventilation must be within the proper ranges for effective operation. This must be done by making sure thermocouples are positioned correctly, and adding more thermocouples or proportional integral device (PID) burner control systems for better monitoring and control.

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[52] Energy Star; Guides for Energy Efficiency Opportunities, Featuring the Motor Vehicle Assembly Industry

- Use energy efficient air recirculation oven, which can recycle up to 90% of the air within the oven. Air flow sensors can be installed to keep a check on whether the flow within the oven is balanced or not.

- Install separate combustion fans to control air flow through the dryers. Controlling the air flow can yield the biggest savings in a paint booth.

3.6.6 Furnace automation and control

Furnace is used in the automobile industry for the manufacture of critical automobile castings such as Cylinder Block, Cylinder Head, Chassis, etc. A huge amount of energy is consumed in this department as the raw material is to be melted and this molten metal is charged into the required moulds.

Electric Induction Furnaces are coming up as a better alternative for the conventional furnaces. They work on the principle of induction melting, i.e. a high voltage electrical source from a primary coil induces a low voltage, high current in the metal which acts as the secondary coil and gets heated. Compared to the Cupola furnace, the induction furnace emits a lot less emissions and harmful pollutants. So it provides us with cleaner melting and a better working environment. The overall efficiency of induction furnace is 55 to 75 percent which is significantly higher than conventional furnaces.

The efficient operation of the modern furnaces requires a high degree of automation in conjunction with computerized monitoring and control systems. Process automation system at furnaces can be done using sophisticated motor control centres, PACs, networked I/O and reusable software code to streamline its control of multiple-hearth furnaces. Few upcoming technologies also use heat exchangers to reclaim wasted heat and create power to offset a customer's natural gas costs.

Modular, expandable and upgradeable automation packages are available for a wide range of plant setups, operational strategies and input materials. They optimize the operation of the furnace without compromising raw material selection, steel quality, and productivity, while leading to energy efficiency.

3.6.7 Evaporative condensers

Up to 5% of energy is consumed in the HVAC system for office space cooling in an automobile plant. The system must thus be made as efficient as possible to avoid unnecessary use of energy. Evaporative condensers must be used for the refrigeration plants over conventional air cooled condensers. The disadvantage with air cooled condensers is that the compressor operates with higher specific power consumption as the condenser temperature and pressures are higher. Comparison between a typical water cooled and air cooled system would indicate a significant difference in specific power consumption. Typical figures are as follows.

- Air cooled system : 1.0 – 1.2 kW/TR

- Water cooled system : 0.6 – 0.8 kW/TR

Water cooled systems have higher heat transfer coefficients than the air cooled systems as the temperature of cooling water is lesser than that of air. Because of this, the refrigerant in the chiller circuit can condense at lower pressure, thereby reducing the work done by the chiller compressor and thus its energy consumption.

The latest trend is to install evaporative condensers which operate with even lower specific power consumption because of integrating the heat exchanger for condensing the refrigerant into the cooling tower. Evaporative condensers can cool refrigerant very close to the wet bulb temperature. Between conventional water-cooled condensers and evaporative condensers, power consumption of the auxiliaries in the case of evaporative condensers will be much lesser. The evaporative condensers consume only about 20% of the power consumption of a typical water-cooled condenser.

The advantages of the evaporative condensers are as below:

- Improved water to air contact
- Increased water flow over the refrigerant coil
- Enhanced heat transfer resulting in lower condensing temperature.
- Lower pumping power requirement for the cooling water
- Chiller systems fitted with Evaporative condensers are operating successfully in other plants with specific power consumption of about 0.6 – 0.7 kW / TR

About 10-15% of energy saving of compressor can be achieved on its power requirement.

3.6.8 Design and process modifications in paint line

Paint trolley design modifications can be made in paint shop booths to accommodate two vehicles on a single trolley instead of one vehicle. This is already being implemented at an Indian automobile manufacturing plant, leading to a saving of 0.245 million kWh and thermal energy saving of 155,000,000 kCal per annum with minimal investment of about USD 10,000.

Similarly other innovative process modifications must be carried out in order to reduce energy consumption in the various processes in an automobile plant. Another such example that has been implemented at an Indian auto automobile plant is, instead of a 2 coat – 2 bake systems, the process has been modified to accommodate 2 coats with a single baking system saving a lot of energy. The plant has been saving 153 tons of LPG per annum without any investments.

3.6.9 Waste Heat Recovery Systems

Reutilizing process waste heat for preheating and other process related heating applications will lead to a good amount of thermal energy saving. Waste heat recovery in automobile plants can be carried out in the following areas:

- Furnace
- Recovery on D.G. set exhaust at auto ancillary unit

- Paint baking oven exhaust
- Superheat recovery from air conditioning units (vacuum chiller). Waste heat generated by refrigerant gas may be reutilized.

3.6.10 Lighting

Lighting is an essential service in all the industries. The power consumption by the industrial lighting varies between 2 to 10 percent of the total power depending on the type of industry. Typical electrical load for lighting in an automobile plant is about 10-15 percent of total electricity consumption. Innovation and continuous improvement in the field of lighting such as LED, CFL and T-5 based lighting has given rise to tremendous energy saving opportunities in this area.

Light Emitting Diodes: LED light bulbs use only 2-17 watts of electricity (1/3rd to 1/30th of Incandescent or CFL). LED bulbs used in fixtures not only save electricity but doesn't emit heat and save money on replacement costs since LED bulbs last 10 to 15 times longer than with incandescent bulbs.

T-5: T5 lamps are fluorescent lamps that are 16mm or 5/8 of an inch in diameter. These have a higher luminous efficacy[53] when compared to the older fluorescent lamps like T8 or T12 lamps. The luminous efficacy of T5 lamps is about100 lm/W, while those of T8 and T12 lamps are only about80 lm/W and70 lm/W respectively. The higher the value, the more energy efficient the lamp is.

There exists energy saving potential even in the area of non-industrial purpose lighting in plants. Motion sensors may be a possible way to save some energy by automatically turning off lights in unoccupied areas.

Lighting is an area which provides major scope to achieve energy efficiency at the design stage and retrofitting, by incorporation of modern energy efficient lamps, luminaries and gears, apart from good operational practices.

3.6.11 Variable Frequency Drive

Variable speed control is an important means of achieving energy savings in automobile plants.

Pumps and fans consume a major portion of energy in an automobile plant. Valves / dampers are the simplest means of control for a pump or a fan. However, damper / valve control is the least energy efficient method of controlling centrifugal equipment. Damper / valve control is employed when the design is higher than the operating condition of the centrifugal equipment. In this case, the centrifugal equipment operates outside the design range and therefore with less efficiency. In this case, change of centrifugal equipment matching the actual requirement is recommended.

[53] luminous efficacy : indicates the amount of light a lamp generates from the energy it consumes

Damper/ valve control is also employed when the user end requirements vary continuously. When the requirements vary continuously, the centrifugal equipment adjusts itself for the varying requirements and operates accordingly but with lower efficiency. The most attractive option to save energy in this scenario is to install variable frequency drive. The VFD adjusts the speed of the centrifugal equipment by increasing or decreasing the frequency based on the requirement and thereby saving energy. VFDs are now a common feature for most of the pumps / fans with variable flow operation.

3.6.12 Advanced melting technologies

Advances in retrofitting ferrous and nonferrous melting technologies can significantly reduce energy consumption in melting operations in integrated plants with a foundry. Such technology advances include installing oxygen-enriched fuel combustion, preheating charge material and recovering heat from flue gases which will improve the efficiency in various steps of the melting operation. Table below shows the estimated efficiency savings achievable by implementing these technologies. Furnace efficiency can increase from 25-30% by utilizing one or a combination of these technologies.

Table 8 –Advanced retrofitting technologies in melting and estimated savings

Melting Technology	Estimated Efficiency Savings
Charge Preheating	5-10%
Air Preheating	10-20%
Operational Adjustments	0-30%
Oxygen Enrichment Technologies	1-40%

3.6.13 Renewable energy application

The manufacturing process of an automobile involves only few operations such as machine and paint shops that utilize a significant amount of thermal energy while other operations majorly use electrical energy. The temperature requirement in machine shops is well beyond 300˚C, whereas it is less than 150˚C in paint shops. The paint shop requires water of varying quality and temperatures. Generally hot water at 30–45˚C is required for rinsing the body during pre-treatment. Therefore, solar thermal energy technology may be applied in paint shops for pre-treatment, drying and air-conditioning. Solar PV technology may also be applicable in the press shop, body shop and assembly shops that operate on automated machines powered by electricity.

Table 9 - Solar technology mapping for automobile sector [54]

Process	Energy/fuel being used	Application media	Temperature required ˚C	Technology
Press shop – electric and pneumatic machines	Electricity	-	-	Solar PV system
Body shop – electric and pneumatic machines	Electricity	-	-	Solar PV system
Paint shop –pretreatment	Electricity and boiler fuels	Hot water	40	Flat plate Collector (FPC)

[54] MNRE's - Identification of Industrial Sectors Promising for Commercialization of Solar Energy

Paint shop –air conditioning	Electricity and boiler fuels	Hot/cold air Supply	5–50	Evacuated tube collector (ETC) based chillers
Paint shop – evaporation and drying	Boiler fuels	Hot air supply	80–100	Solar air heating systems
Assembly shop – automated robots and machines	Electricity	-	-	Solar PV system

The potential for conventional energy replacement by solar energy in various processes in an automobile manufacturing plant and the savings that may be obtained has been estimated in MNRE's report - Identification of Industrial Sectors Promising for Commercialization of Solar Energy. PwC's analysis shows electrical energy replacement potential of about 10,200 MTOE and boiler fuel of about 300 MTOE by transforming from conventional to solar energy. Thus a total potential of about 10,500 MTOE has been estimated.

4. ANALYSIS OF ENERGY CONSUMPTION

4.1 Methodology

In order to estimate the energy consumption of this sector, the following methodology has been adopted:

- ❖ Initial desk research was conducted to gather information from secondary sources like annual reports, sustainability reports, other technical reports and websites of Government Ministries (DHI), organizations (SIAM, ACMA, IBEF, etc.) and other stakeholders.

- ❖ Automobile plants were visited to understand the extent of technology adoption, energy consumption, type of fuels used, product mix, level of energy efficiency practices and constraints faces by them in taking up energy efficiency at their plants.

- ❖ Interacted with technology suppliers, plant representatives and experts to understand their perspectives and take inputs.

- ❖ A first draft report was prepared and circulated to a small stakeholder group. A stakeholder consultation workshop was then organized to discuss views of the participants on the report, existing trends and future prospects of energy efficiency and constraints faced in comparing plants of this sector. It was attending by representatives from different automobile manufacturers. The experienced stakeholders from this sector during the workshop provided many more inputs regarding the trends and constraints faced by the sector. These input have been also been incorporated. [55]

- ❖ Based on collected data, the initial report was drafted and reviewed by the various stakeholders. Their inputs regarding the present trends in the sector, level of energy efficiency, the issues regarding arriving at an equivalent vehicle and possible way forward to establish benchmarks in the sector have been incorporated in the report.

- ❖ Energy consumption data collected from 8 two wheeler plants (corresponding to 70% market share), 3 three wheeler plants (corresponding to 69% market share), 10 passenger vehicle plants (corresponding to 92% market share) and 9 commercial vehicle (corresponding to 85% market share) plants have been used to analyze and estimate the sector's existing energy consumption level.

Assumptions used for calculations:

1. 860 kCal = 1 kWh
2. Based on data available for more than 70% market share has been used to arrive at an average SEC. This SEC has been assumed to be same for the remaining 30 % of market share.

[55] List of participants has been included in the annexure

In order to calculate MTOE consumption of individual units the following method has been used:

a) Electrical energy

Total electrical energy (kCal) = Total electricity consumed (kWh) X 860[56]

b) Thermal energy

Total thermal energy (kCal) = (Fuel 1 X Gross calorific value) + (Fuel 2 X Gross calorific value) + ….

c) Specific electrical energy consumed per annum

SEC = total electricity (kWh) / eq. vehicle

d) Specific thermal energy consumed

SEC = total thermal energy (kCal) / eq. vehicle

e) Total energy consumption for each plant (MTOE)

$$\text{Total energy consumption} = \frac{\text{Total electrical energy (kCal)} + \text{Total thermal energy (kCal)}}{10{,}000{,}000^{57}}$$

f) MTOE of the entire sector[58]

Energy consumption data has been collected through plant visits and other available reports. As mentioned above, SEC and MTOE of individual plants have been calculated for each sub-sector i.e. 2 wheelers, 3 wheelers, passenger and commercial vehicles.

[56] 1 kilocalorie is equal to 4186.8 joules, and 1 joule/sec = 1 watt. So 1 kWh = 1000 x 3600 watt secs = 3.6 x 10^6 joules. => 1kWh=860kCal

[57] 1 MTOE = 10000000 kCal

[58] The metric ton of oil equivalent (MTOE) is a unit of energy: considered as 10,000,000 kCal.

Two approaches have been used to estimate the overall sectors energy consumption.

Approach 1:

Based on available data on plants' contribution to market share in the corresponding subsector, the energy consumption has been directly extrapolated for 100% market share.

Table 10 – Overall sector's energy consumption (Approach 1)

Subsector	Energy consumption based on available data (MTOE)	Data corresponds to (%) market share	Energy consumption of 100 % market share (MTOE)
Two wheelers	36,243	70	51,634
Three wheelers	2,599	69	3,757
Passenger Vehicles	242,128	92	264,117
Commercial Vehicles	80,823	85	95,628
Overall sector MTOE	**415,135**		

The estimated sectoral energy consumption by this method has been calculated to be **0.415 million MTOE.**

Approach 2:

The specific energy consumption of individual plants of each subsector varies widely .The range of variation of data collected has been shown below and average energy consumption has been arrived at by a weighted average approach. Using the production data for each subsector during 2012 (as per SIAM) and the average SEC the total energy consumption of each subsector has been calculated.

Table 11 – Overall sector's energy consumption (Approach 2)

Subsector	SEC (MTOE/vehicle)	Weighted average energy consumption(MTOE/ vehicle)	Production during 2012 (SIAM)	Total Energy consumption (MTOE)
2 wheelers	0.0018 – 0.005	0.0035	15,453,619	54,268
3 wheelers	0.003 – 0.01	0.0047	877,711	4,151
Passenger vehicles	0.04-0.1	0.095	3,123,528	296,735
Commercial vehicles	0.02-0.17	0.0652	911,578	59,419
Overall Sectors Energy Consumption (MTOE)				**414,573**

The estimated sectoral energy consumption by this method has been calculated to be **0.414 million MTOE.**

The sector's overall energy consumption calculated using both approaches is estimated of about 0.41 million MTOE.

Estimated energy consumption of the Indian Automobile sector is about 0.41 million MTOE.

4.2 Plants and their energy consumption data

Energy consumption data of has been collected from plant visits, questionnaires, annual reports, sustainability reports, data available with CII and other technical reports. The data collected accounts for 70%, 69%, 92% and 85% of the market share of the 4 segments above, respectively and contributes to 0.36 million MTOE of energy consumption. The following table shows the individual plant-wise capacity, production and energy consumption data.

Table 12 – Collected data set (28 plants data and their energy consumption)

Plant No.	Capacity (No. of vehicles)	Production (No. of vehicles)	SEC (kWh/eq.veh.)	SEC (Kcal/eq.veh.)	MTOE	Source
Two wheelers						
1	1,800,000	1,746,000	14.3	16,894	5,097	CII Data 2013
2	1,969,500	1,952,956	31.9	531	5,456	CII Data 2013
3	2,110,000	2,056,743	28.0	21,016	9,268	CII Data 2013
4	2,550,000	2,256,639	15.6	4,668	4,083	CII Data 2013
5	350,000	140,719	39.4	51,314	1,199	CII Data 2012
6 to 8	3,000,000	2,167,802	34.6	21,633	11,140	CII Data 2013
Three Wheelers						
1	48,000	27,563	124	0[59]	294	Annual Report '12
2	450,000	450,000	8.4	38,558	2,059	CII Data 2013
3	72,000	72,000	23.1	14,422	247	CII Data 2013
Passenger vehicles						
1 to2	325,000	271,000	700	331,100	25,287	Plant visit
3	600,000	589,107	423	211,616	33,889	CII Data 2010
4	204,400	198,268	193	160,000	8,301	CII Data 2012
5	80,000	75,099	493	324,250	5,619	Sustainability Report '11
6	177,701	112,638	523	195,472	7,268	CII Data 2011
7	140,000	105,000	465	431,250	11,636	EMT '10
8	200,000	134,706	494	215,098	8,620	CII Data 2013

[59] Overall energy consumption (electrical + thermal) given in kWh

9 to 10	1,260,000	1,008,000	0[60]	1403849	141,508	Sustainability Report '12
Commercial vehicles						
1	125,000	112,407	313	78,267	125,000	EMT 2012
2	249,000	244,798	483	314,700	249,000	CII Data 2013
3	144,000	229,621	667	504,199	144,000	CII Data 2012
4	500,000	304,864	182	167,000	500,000	CII Data 2012
5	75,000	29,441	923	350,000	750,00	EMT 2012
6	150,000	88,234	377	0[61]	2,865	CII Data 2011
7	64,000	26,534	1,227	2,318,664	4,712	CII Data 2012
8	90,000	87,562	112	165,100	2,288	CII Data 2013
9	300,000	116,502	391.6	284,783	7,273	CII Data 2012

4.3 Plant vs. Energy Consumption (MTOE)

The energy consumption calculated for individual plants (MTOE) has been plotted against each plant for all the four sub sectors in the figure below:

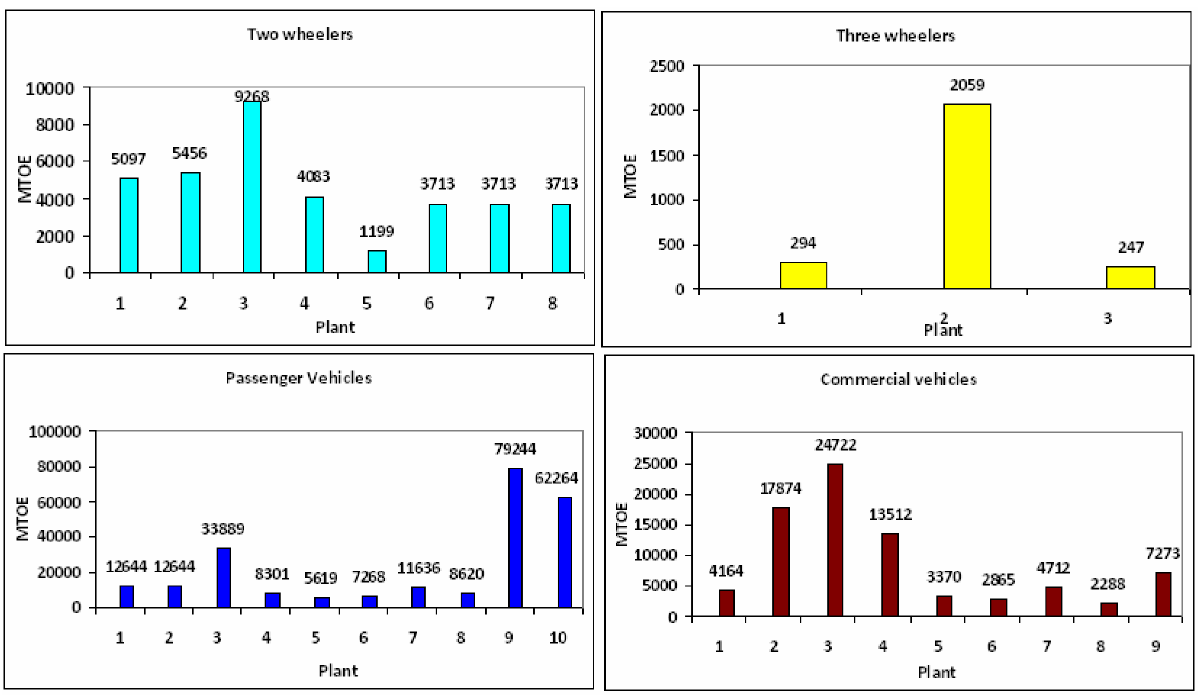

Figure 12 – Plants vs. MTOE[62]

60 Overall energy consumption (electrical + thermal) given in GJ which has been converted to kCal
61 Overall energy consumption (electrical + thermal) given in kWh
62 For full details of plants refer table 14

4.3.1 Reasons for wide variation of SEC in different plants

As seen earlier in table 12 the SEC of each plant varies widely even within the same subsector.

- Equivalent vehicle consideration: Each automobile plant rolls out a number of models/products even under the same sub sector. For. E.g. Tata Motors's passenger car division produces the models Indica and Indigo. Bajaj produces bikes of different engine capacities. Maruti produces a number of models of passenger cars in its facilities. The size, shape, capacity, operations and processes carried out for each are different. Thereby the energy consumption of each also varies.

  Companies reporting in public domain generally include their overall electrical and thermal energy consumption. However in order to internally measure SEC, they define their company specific equivalent vehicle based on different parameters (for e.g. an automobile plant in India producing both two and three wheelers in the same facility has defined its standard bike to be the equivalent vehicle. Based on the different parameters considered for defining its equivalent vehicle, the energy consumed for the manufacture of a bike is calculated to be 1.7 times that of a three wheeler[63]. Thus they use their overall energy consumption data to calculate SEC of each vehicle considering 1 bike = 1.7 three wheeler).

  The definition of equivalent vehicle of each automobile manufacturer is different (each company uses a different set operations/processes to arrive at their equivalent vehicle).Therefore equivalent vehicles cannot be compared even among players of the same subsector. Defining a common standard equivalent vehicle relevant to all subsectors is thus necessary.

- Varying fuel mix: Depending on the cost of energy, either electrical of thermal energy can be used for various heating applications. This might result in a change in the SEC values and therefore might make it difficult for comparison.

- Capacity utilization: It has been seen that plants in which are capacity utilization is low, the SEC is high. Few examples have been shown in the table below which clearly indicates this trend.

Table 13 – SEC variation due to capacity utilization

Plant No. (sub sector)	Year	Capacity Utilization	SEC (MTOE/eq. Veh.)
Plant 3 (commercial)	2011-12	75	0.01
	2012-13	51	0.12
Plant 1 (two wheeler)	2011-12	85	0.0037
	2012-13	97	0.0034
Plant 8 (passenger)	2010-11	36	0.082
	2011-12	68	0.064

[63] Methodology of calculation has not been provided by plant.

❖ Technology: The level of technology used is clearly a contributor towards the SEC in any industry. Utilization of new, energy efficient technology and higher level of automation reduces the SEC when compared to old equipment. The Indian automobile manufacturers need to continuously pursue technology up gradation to reduce their SEC.

❖ In-house operations: The number of in-house operations carried out at automobile plant has been agreed to be the most important factor affecting the SEC of any vehicle, by experts, stakeholders and plants. Difference in number of operations carried out in-house could lead to large variations in SEC of plants thus making it difficult to compare. The SEC of two plants in the two wheeler and commercial vehicle segment producing similar products have been compared below based on the operations carried out in the plant to highlight SEC variation due to in-house operations:

Table 14- SEC and in-house operations mapping (example)

In-house operations	Two wheeler		Commercial	
	Plant 2	Plant 4	Plant 2	Plant 1
Foundry (Engine parts)				
Engine assembly	√	√	√	
Foundry (power train and transmission parts)				
Chassis assembly (Power train, suspension and transmission assembly)	y		√	
Forging (Stamping , Pressing and blanking)	y		√	
Heat treatment	√		√	√
Body shop/Shell forming by weld	y	√	√	√
Machine shop	√	√	√	√
Paint shop	√	√	√	√
Final assembly	y	√	√	√
SEC kWh/vehicle	31.9	15.6	483.1	313
SEC kCal/vehicle	531	4,668	314,700	78,267
MTOE/vehicle	0.0029	0.0018	0.07	0.037

4.4 Possible energy efficiency measures for key processes/systems

The general areas in which energy efficiency measures may be taken are listed below:

4.4.1 Process related energy efficiency measures

4.4.1(a) Painting systems

❖ Reducing the volume of air put through the paint booths also limits the amount of air that must be heated and treated.

- Insulation of the drying tunnel can reduce the heat losses through radiation. The radiation losses are estimated to be 5% of the total energy input

- 40 to 60% of the heat input is vented through the exhaust from the painting process, while additional heat is lost as waste heat through the oven walls. Heat can be recovered using heat wheel technology.

- The largest energy consumer in industrial painting operations is ventilation. A computer-controlled system must be utilized to optimize ventilation which is estimated to give a saving of about 5%.

- Painting wet paint onto wet paint will eliminate a baking step between the two coats of paint, and in turn save energy.

- Ultra filtration /Reverse Osmosis for waste water cleaning.

- High pressure jet water must replace the hot caustic paint stripping for cleaning the buildup. This jet can undercut the paint and lift it off the skid. More efficiently. The paint residue, in the form of flakes and suspended particulate matter, is separated from the water by a filtration process and then disposed. Water may be recycled to be reused in the cleaning process.

4.4.1(b) Body weld

- Use computer controls to precisely control the electric current in welding applications.

- High efficiency welding/inverter technology must be used where power to the transformer is shut off during system idling and cooling fans only run when needed, avoiding continuous electrical consumption. These new technologies can provide 10 to 40% energy savings over older ones apart from improved power factor.

- Multi-welding units, number of different welding machines can be run using one power source. These units are seen to use lesser power, have higher deposition rate, reduce cleanup time and require no down time for switching between their bridge and building fabrication.

- Electric robots: Energy can be saved in the weld shop by converting from hydraulic to electric robots or pneumatic to electric servos. Toyota has achieved savings of about 20% from converting from pneumatic to electric servos.

4.4.1(c) Stamping

- Variable voltage controls must be used in drives in order to match speed to load requirements for motor operations, and therefore ensure that motor energy use is optimized to a given application.

- Replacing pistons on die cushions on stamping presses with air actuators will have close to no air leakages thus saving energy.

4.4.1(d) Casting

In metal casting facilities, melting is the most energy-intensive operation accounting for about 55% of the total energy use in foundries. Inefficiencies in melting is generally found in stack losses, inaccuracies in temperature measurement, conduction and radiation losses, poorly-fitting charge well covers and doors, temperature imbalance when adding cold metal to the charge and improper handling procedures. The following measures can be considered to avoid energy loss in casting operation:

- ❖ Use advanced retrofitting technologies which include installing oxygen-enriched fuel combustion, preheating charge material, and recovering heat from flue gases can improve the efficiency in various steps in the melting operation.
- ❖ Shifting to stack melter which is a modified reverberatory furnace that preheats the metal charge with waste heat gases. A traditional reverberatory furnace has a thermal efficiency of 20-25% with melt loss of 3-5%, where as a stack melter has a thermal efficiency of 40 to 50% with a melt loss of approximately 1%.
- ❖ Optimizing Melting and Heat Treating Operations by implementing operating practices and incorporating some cutting-edge melting equipment.
- ❖ Covering the furnace and maintaining refractories, since it account for 10 to 50% of total energy losses depending upon furnace design, operating practices, metals melted, and the source of energy used.
- ❖ Installing radiant panel linings in crucible furnaces which combine a dense, high-alumina radiant panel with low thermal-mass insulation back-up materials. This reduces the heat loss through the sides of the furnace and increases the furnace's efficiency.

4.4.1(e) Heat Treatment

New heat treatment technologies with reduced energy consumption relative to commercial heat treating processes need to be adopted. Few measures that can be taken include:

1. Measures taken: Installation of Recuperator for Waste Heat Recovery,
2. Installation of temperature sensor based to regulate fuel flow in burner
3. Installation of automated Damper to avoid Draft losses when burner is in OFF condition
4. Apply ceramic coatings and replace inefficient burners in melting and heat treatment furnaces. This will result in 10-20 % of savings in fuel consumption.

4.4.2 <u>Utility related energy efficiency measures</u>

4.4.2(a) General Utilities

- ❖ Energy management system: Establishing formal management structures and systems for managing energy on continuous improvement is an important strategy in order to help the plant manage its energy use and implement energy efficiency measures.

Management frameworks, such as ISO 50001, can be used to ensure better organizational management of energy.

- Alternative fuels: Some processes produce waste products that can be incinerated exothermically to provide an ideal fuel for the boiler. The energy saved by using some of these waste streams must be balanced against the potential release of environmental toxins into the atmosphere. Use of other fuels like biomass must also be explored wherever possible.

4.4.2(b) Motors

- Sizing of motors: inappropriately sized motors result in unnecessary energy losses. When there is a huge mismatch between the design and operating parameters of the motor, the loading of the motor will be less. When the loading of the motor is less, the efficiency comes down. Therefore by installing a new motor matching the actual requirement, energy can be saved. This correction can save about 1.2% of their electricity consumption.

- Replacing standard v-belts with high torque cog-belts as they provide about 5 - 7 % savings in energy. This is because the standard v-belts have drag losses and tend to stretch, slip, bend and compress.

4.4.2(c) Lighting

- Setting lighting standards: Lighting levels (lumen per surface area) should be set in the design stage for each section of the automobile plant and followed in each step of the ordering, manufacturing and installation stages.

- Controls: Lights can be shut off during non-working hours by automatic controls, such as occupancy sensors, which turn off lights when a space becomes unoccupied.

- Day lighting: the need for artificial light in buildings can be minimized by efficiently using natural lighting. This can in turn reduce the electrical lighting loads up to 70%. Tata motor, Pune has also utilized day lighting in certain areas of their shop floors thus cutting down electricity consumption for lighting for close to half of the working hours.

- Replace incandescent lamps with fluorescents or CFLs

- Replace T-12 with T-5

- Replace metal halide HID with high intensity fluorescents

4.5 <u>Challenges and Recommendations</u>

The automobile sector is made up of large private automobile manufacturers and ancillary parts manufacturers (which includes OEMs). The automobile plants are fewer in number compared to the ancillary units and estimating the total energy consumption of manufacturers in the facility is comparatively easy. The ancillary units, on the other hand, are large in number and their energy related data is not as easily available.

However most of the energy consumed is at the ancillary parts manufacturers (it is estimated to be about 7 to 9 times the energy consumed at assembly plants). Thus it is necessary to identify the level of energy efficiency and potential towards energy saving in these plants.

4.5.1 Initial steps undertaken by CII

CII has identified the existing issues in this sector in terms of estimating the energy consumption levels, the major issues being lack of a standardized equivalent vehicle to compare plants with varying product mix and non-availability of data for split of energy consumption for all operations involved in the manufacture of a vehicle.

Initially the following questionnaire was sent to major automobile plants to map their overall energy consumption to the in-house operations carried out.

Table 15 - Initial questionnaire sent for SEC and operations mapping

Production details FY 2011-12				
Products	Installed Capacity of Eq. Vehicles	Production of Eq. Vehicles	SEC-electrical (kWh/veh)	SEC-thermal (kCal/ veh)
Product 1				
Product 2				

In-house operation and process details		
Operations Carried out inside the plant (please mark √ or X)		
1	Foundry (Engine parts)	
2	Engine assembly	
3	Foundry (power train and transmission parts)	
4	Chassis assembly (Power train, suspension and transmission assembly)	
5	Forging (Stamping , Pressing and blanking)	
6	Heat treatment	
7	Shell forming by weld	
8	Machine shop	
9	Paint shop	
10	Final assembly	
11	Other operations please mention	

Details received from plants are shown below:

Sub sector	Two wheelers					Commercial vehicles					Passenger vehicles
Plant	1	2	3	4	5	1	2	3	4	5	1
Foundry (Engine parts)											
Engine assembly	√	√	√	√	√	√		√			
Foundry (power train and transmission parts)											
Chassis assembly (Power train, suspension and transmission assembly)	√		√		√	√	√	√			
Forging (Stamping , Pressing and blanking)		√	y		√	√	√			√	√
Heat treatment	√	√	√		√	√	√	√	√		
Body shop/Shell forming by weld	√	√	y	√		√	√		√	√	√
Machine shop	√	√	√	√	√	√	√	√	√	√	
Paint shop	√	√	√	√	√	√	√		√	√	√
Final assembly	√	√	√	√	√	√	√	√	√	√	√
SEC kWh/veh	22.6	27.96	31.8	15.6	34.6	483.1	667	1119	313	391.6	193
SEC kCal/veh	17,500	21,016	531	4,668	21,632	3,14,700	5,04,199	0	78,267	2,84,783	1,60,000

The data shows a wide variation in SEC due to the varying operations carried out; however the extent to which they are affected was not clear from this. The lack of energy consumption data for the outsourced operations and the split of operational level data in-house did not help in arriving any benchmarks.

A stakeholder consultation workshop was organized to discuss these issues and the possible methods to work towards arriving at some standards for this sector which will in turn drive this initiative towards estimating the potential of energy efficiency. The need for this activity was well appreciated by all participants who also agreed to extend their support in terms of providing their inputs.

4.5.2 Challenges faced

For the purpose of this report, establishing SEC of various auto players was essential. This will help in assessing the relative energy efficiency performances, establishing benchmarks and pursuing energy reduction opportunities. However establishing SEC in auto sector is challenging due to the following reasons:

- ❖ Each automobile plant has a different methodology to arrive at and define their equivalent vehicle which is not comparable even within the same sub sector. There is no standard equivalent vehicle to compare SEC in each subsector.

- ❖ The SEC of automobile plants varies with the operations carried out in-house and those outsourced. It is essential therefore to have operation or part level energy consumption data.

4.5.3 Recommendations

The following recommendations are proposed in order to formulate a methodology to arrive at a common energy consumption standard for this sector. A universal equivalent vehicle needs to be arrived at, for use as a standard measure and comparison with any vehicle, from a bike to a truck. The following data is required in order to arrive at this (propositions and inputs of various stakeholders and experts have also been incorporated from the discussion during the stakeholder consultation workshop held by CII):

- ❖ The exact number of parts that go into making the vehicle and their corresponding operations/processes are to be listed down right from the beginning to the final assembly of vehicles in each subsector. It must be noted that many of these operations might occur outside the automobile plant (like foundry operations, engine manufacture, tyre manufacture, glass manufacture etc.).

- ❖ The various parameters affecting the energy consumption of each of these operations need to be listed. The quantity of these parameters varies among different products and so does the corresponding energy consumed. A single unit must be arrived at to compare the different vehicles. For example the number of welds in welding operation, the wheel diameter in case of wheel base manufacture, the volume of casting, area of heat treatment, capacity of engine block manufactured, area of press operation, painted surface area etc.

- ❖ A split of energy consumption data is to be gathered for each operation/process specific to each of the decided quantitative parameter. For example the energy consumption for painting $1m^2$ of area by ED process, painting $1m^2$ of area by TecTalis process, $1m^3$ of casting, $1m^2$ heat treatment for different material alloys etc.

- ➢ Data for operations which are outsourced are to be collected from vendors and OEMs.

- ❖ Once the number of parts, operations and processes and their corresponding quantitative parameters are defined along with the energy consumption details. The fixed and variable energy consumption areas are to be determined.

- ❖ Once data is gathered, a standard equivalent vehicle is to be clearly defined. This can used to compare vehicles of different sizes and arrive at a sectoral energy benchmark.

- ❖ An energy consumption benchmark at each operational level considering the various parameters is to be arrived at for this standard equivalent vehicle.

This data collection and arrival at a standard equivalent vehicle can be done only with the support and interaction of the different stakeholders of the sector.

The following approach may then be used to arrive at a benchmark, as described in the example below:

Assume a standard equivalent vehicle (eq. vehicle) has been defined and two plants, Plant 1 and Plant 2, are being compared. The eq. vehicle of Plant 1 = 1 (i.e. it consumes the same amount of energy as the standard eq. vehicle) and Plant 2 = 1.5 (i.e. it consumes 1.5 times the energy as that of the standard eq. vehicle).

As recommended, all operation level SEC data is collected for both plants for the standard eq. vehicle, irrespective of being in-house or outsourced. This can be directly compared since they are measured for the same base parameters.

Table 16- Recommendation (approach to arrive at benchmarks)

Operations	Plant 1 (SEC) In-house operations	Plant 1 (SEC) outsourced operations	Total SEC for std. eq. veh. (=SEC * 1)
A	110	0	110
B	130	0	130
C	50	0	50
D	20	0	20
E	7	0	7
Total SEC	**317**	**0**	**317**

Operations	Plant 2 In-house operations		Plant 2 outsourced operations		Total SEC for std. eq. veh.
	(SEC)	(SEC for std. eq. veh. = SEC * 1.5)	(SEC)	(SEC for std. eq. veh. = SEC * 1.5)	
A	0	0	76.67	115	115
B	83.33	125	0	0	125
C	36.66	55	0	0	55
D	0	0	10	15	15
E	3.33	5	0	0	5
Total SEC	**123**	**185**	**86.67**	**130**	**315**

As seen in the table above, Plant 1 has all the operations in-house while Plant 2 outsources two of its operations. Thus Plant 2 clearly has lower SEC, when only in-house operations are considered. However, when overall operational energy consumption is compared, both plants have almost the same SEC.

Similarly, a study needs to be undertaken to collect data from at least two-three plants of each the subsectors and their corresponding vendors to have a good database. The large database is also to ensure that the equivalent vehicle and corresponding SEC values are applicable to all the vehicle segments. The collected data is to be analyzed in order to arrive at a standard equivalent vehicle. In addition to this the operational level energy consumption data must be used to arrive at a benchmark for the automobile sector as a whole.

❖ It has also been noticed that operations common to different plants belonging to the same manufacturer are carried out at one plant. This makes comparing energy consumption of individual plants even more complex. It is, therefore, suggested that that plants must be compared at a corporate level instead of at individual plant level.

4.5.4 <u>CII's Next steps</u>

The initial questionnaire has been further modified, based on inputs from stakeholders, to include further break up of operations and will be sent to participants. The further breakup of each operation and the measurable parameters will be incorporated based on one on one discussion with the plants.

Shop	Operation/process	Parameter	SEC electrical (unit)	SEC thermal (unit)
Foundry	Body Parts	Volume		
	Engine Parts	Engine Capacity		
	Power Train	Volume		
	Transmission	Volume		
Body shop	Casting	Kg		
	Forging	Surface Area Forged		
	Stamping	Surface Area Stamped		
	Pressing	Surface Area Pressed		
	Heat Treatment	Surface Area Treated		
	Machining	Surface Area Machined		
	Welding (Shell Forming)	No. Of Welds		
Assembly shop	Engine Assembly	Engine Capacity		
	Chassis Assembly			
	Drive Shaft Assembly			
	Suspension Assembly			
	Transmission Assembly			
Paint shop	Protective Coating	Surface Area		
	Baking	Surface Area		
	Paint Coating (First and Second Coat)	Surface Area		
Final Assembly				
Electricity use	HVAC			
	Compressors			
	Pumps			
	Lighting			
Thermal energy use	Boiler			

Once the final questionnaire is decided upon based on these interactions with stakeholders, CII will be circulating it to all the automobile plants, major ancillary part manufacturers (potentially above 3,000 MTOE) for data collection. This data collection process may be time consuming, considering the operational level data required not only from automobile plants, but from their vendors as well. Once this data is collected CII plans to work along with a team of technical sector experts and stakeholders to arrive formulate a methodology to arrive at a standard vehicle.

The benchmark level of energy consumption at every operational level will also be worked out based on gathered data, to arrive at a potential energy benchmarking number for the each operation and for the standard equivalent vehicle.

5. APPLICABILITY OF EXTENDING THIS SECTOR INTO PAT SCHEME

5.1 MTOE threshold and Issues

The energy data collected for automobile plants and their corresponding energy consumption has been used to estimate the sectors energy consumption to be 0.41 million MTOE. The overall automobile sector, which includes automobile manufacturers and ancillary units, is estimated to consume about 8 times[64] the energy consumed at manufacturing units alone. Thus this energy intensive sector is estimated, overall, to consume about 3.7 million MTOE[65]. However, as ancillary units lie outside the scope of work of this project, estimates in this section are made for automobile plants alone.

In the PAT cycle 1, the threshold limit for a plant to become a designated consumer was 3,000 MTOE for textile, 7,500 MTOE for aluminum, 12,000 for chlor alkali and 30,000 for cement, fertilizer, iron and steel, thermal power plants and pulp and paper sectors.

Considering the energy consumption data collected, threshold limits (as shown in the table 18 below) have been proposed. The numbers of automobile plants which may fall above the threshold limit (called designated consumers) and their corresponding energy consumption have been estimated using the MTOE calculated for the data collected. The same has been indicated in the figure below:

Table 17- Potential MTOE threshold, number of plants above threshold and their corresponding energy consumption

Subsector	Estimated threshold	No. of plants above threshold	Energy consumption
Two wheelers	3,000 MTOE	9	41,045[66]
Three wheelers	3,000 MTOE	0	0
Passenger vehicle	7,500 MTOE	8	2,29,242
Commercial vehicle	3,000 MTOE	7	75,671

[64] It is estimated to be about 7 to 9 times. An average of 8times has been used for estimation of overall sector's energy consumption including ancillary units

[65] 0.41+(0.41X8) million MTOE

[66] 2 plants whose energy data is unknown is estimated to be 3000 MTOE remaining 7 from collected data

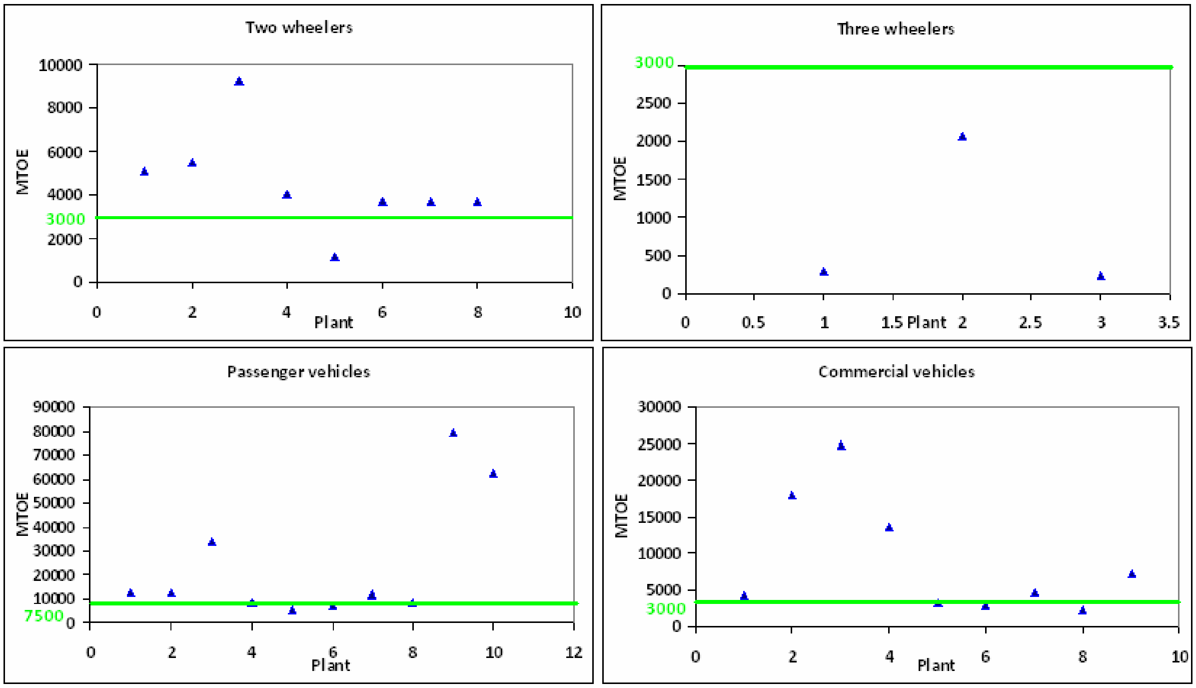

Figure 13- Plants above threshold

These estimated designated consumers alone account to about 345,958 MTOE which is about 80% of the energy consumption estimated for the overall automobile sector.

5.2 Potential saving in case included under PAT scheme

Based on CII's experience in energy audits in the automobile sector, we believe that this sector has very good energy savings potential. Estimates indicate a potential to save about 15-20% of energy in automobile plant by implementing energy efficiency measures mentioned in this report.

The potential energy saving from the automobile manufacturing sector, assuming a 5% reduction potential is about 0.02million MTOE.

Assuming a 5% reduction target is given to each of the facilities above the proposed threshold limit, the potential saving in each subsector from the designated consumers would be:

Table 18 – Potential energy saving from plants above threshold

Subsector	Potential MTOE saved (at 5% reduction)
Two wheelers	2,052
Three wheelers:	0
Passenger vehicle:	11,462
Commercial vehicle:	3,784
Total	**0.017 million MTOE**

- **The potential energy saving from the Indian automobile manufacturing sector assuming a 5% reduction potential is about 0.02million MTOE.**
- **The estimated annual energy reduction potential from designated consumers of the Indian automobile sector if included in PAT will be to the tune of 0.017 million MTOE.**

6. CONCLUSION

This report is an attempt of CII to provide an overview of the Indian automobile sector's total energy consumption, specific energy consumption (SEC), its variation and energy reduction potential. The report also highlights the major energy saving opportunities available in the sector and provides an overview of growth opportunities and technology/ policy barriers faced by the sector.

60% of energy in a typical automobile plant is consumed is in the form of electricity throughout the facility for compressed air requirements, metal forming, lighting, air conditioning in office spaces, painting (fans and curing), material handling, welding, robotic arms, machining etc. The remaining 40% is used is thermal energy for steam applications, curing ovens of the painting lines, heat treatment.

The sector is characterized by the varying product mix and in-house operations which is the major reason for widely varying specific energy consumption from plant to plant. Other reasons include the level of technology, loading and fuel mix.

The energy saving potential of this sector is estimated to be 15-20% based on CII's experience with the sector and interaction with plants.

High scope for improving energy efficiency exists in the in areas of machining operations, use of low embedded energy materials, painting technologies and automation, compressed air systems, low thermal mass jigs and fixtures, vapour absorption refrigeration, automation and control, waste heat recovery systems and utilization of renewable energy sources.

The energy consumption of the overall sector is estimate to be 0.41 million MTOE.

The energy saving potential of the overall sector at 5% reduction is estimated to be 0.02million MTOE.

Considering similar thresholds as in PAT Cycle 1, the estimated number of plants above the proposed thresholds of 3,000 MTOE[67] and 7,500[68] MTOE are 24. It has been seen that no three wheeler manufacturer consumes more than 3,000 MTOE.

The energy savings achieved if these 24 estimated designated consumers are brought under PAT scheme with a 5% target reduction is estimated to be 0.017 million MTOE.

The number of players of the automobile sector considered for inclusion under PAT would increase if ancillary units consuming more than 3,000 MTOE are also brought under its purview. Including ancillary units in calculation of total energy consumption will reflect a more accurate estimation of energy that goes into manufacturing a vehicle.

[67] Threshold for 2 wheeler, 3 wheeler and commercial vehicle plants
[68] Threshold for passenger vehicle plants

The sector may be included under the purview of the second cycle of PAT. However, it is also recommended to include the ancillary units (consuming above 3,000 MTOE) within the scope of this sector.

A major issue faced in order to estimate and compare the SEC of different vehicles is the lack of process/equipment level data. It is also difficult to compare performance of different plants due the lack of a standard equivalent vehicle. It is necessary to collect energy data for the various outsourced and in-house operations carried out to arrive at a standard equivalent vehicle followed by establishing energy benchmarks for a standard equivalent vehicle.

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8. ANNEXURE

Annexure-A: Process flow [69]

Automobile manufacturing basically consists of four steps: parts manufacture, vehicle body production, chassis production and assembly. Although we focus on vehicle assembly plants, some of the plants have other manufacturing facilities on-site. Therefore, we discuss the whole production process in this section, while providing more detail on the assembly process.

Engine and Parts Manufacture

The vehicle industry produces many parts itself, while other parts are purchased. Engines are cast from aluminum or iron, and further processed in engine plants. Metal casting is an energy-intensive production process. Engine parts must be assembled to produce the finished engine. Other major cast parts are axles and transmissions.

Vehicle Body Production

Automotive and other vehicle bodies are generally formed out of sheet steel, although there is a trend toward more plastic and aluminum parts in vehicle bodies. Different steel alloys are used because of their general availability, low cost and good workability. For certain applications, however, other materials, such as aluminum, fiberglass and reinforced plastic are used because of their special properties. For example, Saturn (GM) uses plastic in doors and other vehicle body parts, while most manufacturers use plastic in bumpers. Tooling for plastic components generally costs less and requires less time to develop than that for steel components and therefore may be changed by designers at a lower cost, making it an attractive material for vehicle makers, despite its higher cost per pound. The relative low weight also contributes to higher fuel efficiency in cars.

Chassis

The chassis of the vehicle is the main structure of the vehicle. In most designs, a pressed-steel frame forms a skeleton on which the engine, wheels, axle assemblies, transmission, steering mechanism, brakes, and suspension members are mounted. In modern small car designs, there has been a trend toward combining the chassis frame and the body into a single structural element. In this arrangement, the steel body shell is reinforced with braces that make it rigid enough to resist the forces that are applied to it. Separate frames are used for other cars to achieve better noise-isolation characteristics.

Painting

To protect vehicle bodies from corrosion, special priming and painting processes are used. Bodies are first dipped in cleaning baths to remove oil and other substances. They then go through a succession of painting cycles, which help to maintain the visual quality of the paint and give the required hardness. Enamel and acrylic lacquer are both in common use.

[69] (LBNL report 2008)

The latter is water-based and reduces the output of smog-forming volatile organic compounds (VOC).

Electrostatic painting, a process in which the paint spray is given an electrostatic charge (50 – 80 kV) and then is attracted to the surface of the car (which is at ground potential), helps assure that an even coat is applied over the total car body. Ovens with conveyor lines are used for the drying process. Alternative technologies use infrared-curing to save energy and production time and decrease the size of the dryer. After painting, the vehicle body is checked for inaccuracies in paint coverage and repaired if needed.

Assembly

Virtually every new car and light truck comes from the moving assembly line introduced by Ford, although the process has been refined by various companies through such concepts as 'just-in-time' (e.g. especially by Toyota) and other manufacturing experiments (e.g. Volvo's human-centered assembly operations). An accurately controlled flow of materials and parts is essential to maintain production of the assembly plants, to avoid high inventory costs and possible disruptions in the manufacturing process. This was pioneered by Ford, and perfected by Japanese car manufacturers.

The automobile assembly process itself has a uniform pattern between different plants.

Generally, there are two main assembly lines: body and chassis. On the body assembly line, the body panels are welded together, the doors and windows installed, and the body painted and trimmed (wiring, interior). On the chassis assembly line, the frame has the springs, wheels, steering gear, and power train (engine, transmission, drive shaft) installed, as well as brakes and exhaust system. The two lines merge at the point where the body is bolted to the chassis. A variation on this process is "unitized" construction, whereby the body and frame are assembled as a unit. In this system, the undercarriage still goes down the chassis line for the power train, front suspension, and rear axle, to be supported on pedestals until they are joined to the unitized body structure.

Assembly lines have been elaborately refined by automatic control systems and transfer machines, which have replaced many manual operations. Automatic transfer machines were first introduced by Austin Motors in Britain in 1950, and were first used in the U.S. by Ford in 1951. Today, computers manage the assembly process, offering the opportunity to build different versions of the same model, or even different car models on one assembly line, while welding robots do most or all of the welding. After assembly, the car is finished for shipment to dealers and customers.

Annexure-B: Stakeholder consultation workshop

We would like to thank the following people for participating and sharing their views on the existing trends of energy efficiency in the Automobile sector during the stakeholder consultation workshop held at Hyderabad on the 19th of August 2013.

1. Mr. Ananda R. Kale, Tata Motors, Pune
2. Mr. B Ravi kumar, Mahindra Automotive division, Zaheerabad
3. Mr. Ganesh Narkhede, Manager, Bajaj Auto Ltd., Waluj
4. Mr. Harshad Kale, Mahindra & Mahindra, Pune
5. Mr. Hemant Naik, Manager, Bajaj Auto Ltd., Waluj
6. Mr. Novokesh Mishra, Mahindra &Mahindra, Nashik
7. Mr. Pramod G. Kaulgud, Tata Motors, Pune
8. Mr. R Pandey, Bajaj Auto Ltd., Waluj
9. Mr. Subodh Manchanda, Hero MotoCorp, Haridwar
10. Mr. Sushel Koul, D G M Maintenance, Hero MotoCorp, Gurgaon
11. Mr. Swapnil Ratogi, Mahindra & Mahindra, Nashik
12. Mr. V Murali, Mahindra Automotive division, Zaheerabad
13. Mr. Venkat, Hero MotoCorp, Haridwar
14. Mr. Vijay Jadhav, Mahindra &Mahindra, Nashik
15. Mr. Vivek V. Joshi, Tata Motors, Pune

Annexure-C: Names of plants whose data was collected from publically available sources

Plant No.	Name	Sub Sector	Source
1	Atul Auto	Three Wheelers	AR 12
4	Toyota Kirloskar	Passenger vehicles	SR11
6	General Motors	Passenger vehicles	EMT 2010
1	Tata Motors, Lucknow	Commercial vehicles	EMT 2012
9 to 10	Maruti Suzuki India Ltd, Manesar & Gurgaon	Passenger vehicles	SR 12
5	Ashok Leyland, Pantnagar	Commercial vehicles	EMT 2012

Shakti Sustainable Energy Foundation

Shakti Sustainable Energy Foundation works to strengthen the energy security of the country by aiding the design and implementation of policies that encourage energy efficiency as well as renewable energy. Based on both energy savings and carbon mitigation potential, it focuses on four broad sectors: Power, Transport, Energy Efficiency and Climate Policy. Shakti acts as a systems integrator, bringing together key stakeholders including government, civil society and business in strategic ways, to enable clean energy policies in these sectors.

Shakti is part of an association of technical and policy experts called the ClimateWorks Network. For more information, please visit http://www.shaktifoundation.in/

Confederation of Indian Industry (CII)

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government alike through advisory and consultative processes. CII is a non-government, not-for-profit, industry led and industry managed organization, playing a proactive role in India's development process. Founded over 116 years ago, it is India's premier business association, with a direct membership of over 8,100 organizations from the private as well as public sectors, including Small and Medium Enterprises (SMEs) and multinationals, and an indirect membership of over 90,000 companies from around 400 national and regional sectoral associations. For more information, please visit www.cii.in

CII - Sohrabji Godrej Green Business Centre (CII - Godrej GBC), a division of CII is India's premier developmental institution, offering advisory services to the industry on environmental aspects and works in the areas of green buildings, energy efficiency, water management, environment management, renewable energy, green business incubation and climate change activities.
For more information, please visit www.greenbusinesscentre.com