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Analysis of The Indian Automobile Industry:

A Trend towards Electric Vehicles

(2019 - 2020)

Research Project

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Abstract

The COVID-19 pandemics led the Indian Automobile Industry on the backfoot nearly for about seven months. The industry is not in its best position considering the high competition from international players, buyers' high bargaining power, and some threat from ride-hailing services. Considering the industry's value chain due to the new government norms, companies have to include mandatory safety factors like air-bags & ABS, which increase the cost tremendously for lower segment vehicles. However, the recent numbers in Quarter 4 tell a different story because of the increase of about 20% compared to the previous year's quarter. This can be attributed to the festive season and the government's decision to reduce the interest rate on the loans and provide ex-gratia payment benefit. Therefore, most vehicle manufacturers ended 2020 on a positive note, registering good wholesales growth, and entering the new year with 'cautious optimism' driven by expectations of a V-shaped economic recovery.

Companies in the automobile industry have also increased their budget for the R&D and have focused more on the safety and feature up-gradation in mid & upper segment vehicles. Also, India's automobile sector has the highest spending in R&D than any other sector in India, which indicates a huge potential for this industry's future. With the rapid growth in this sector, market leaders like Tata Motors have accelerated its drive for engineering excellence and innovation receiving 98 patents in 2020. These patents predominantly relate to CESS's megatrend (connected, electrified, sustainable and safe) automobiles. This shows the industry's willingness towards adopting Electric Vehicles shortly.

However, the EVs market is still in its early stages and is difficult to predict. Once the EVs hit the market, the existing equation in the automobile industry might change. EV's produce less sound and is efficient & quick. The dilemma comes in the charging infrastructure and government tax policies. A large part of the Indian government's tax revenue comes from petrol and diesel. So, if the EVs start dominating the market, the government might lay a tax on the EV & even on charging stations that are exempted in the current tax regime. EVs are not entirely carbon-neutral, but they emit significantly fewer emissions throughout their life-cycle than existing vehicles. Also, one can reasonably expect these emissions to further reduce in the future. Several domestic players like M&M & Tata Motors have already launched Electric variants of existing traditional automobiles in the market, including bus, car & 3-wheeler. With the entry of the electric car company Tesla in India, it is a clear indicator that there will be significant competition in the market, and only a few players will survive at the end. EVs are superior compared to their traditional counterparts in almost all the parameters. The shift in the automobile industry trend towards EVs can be observed, and hence, it's not too late to predict that EVs in the coming years will dominate the automobile industry.

A. Overview of the Industry – Current Scenario and Trend

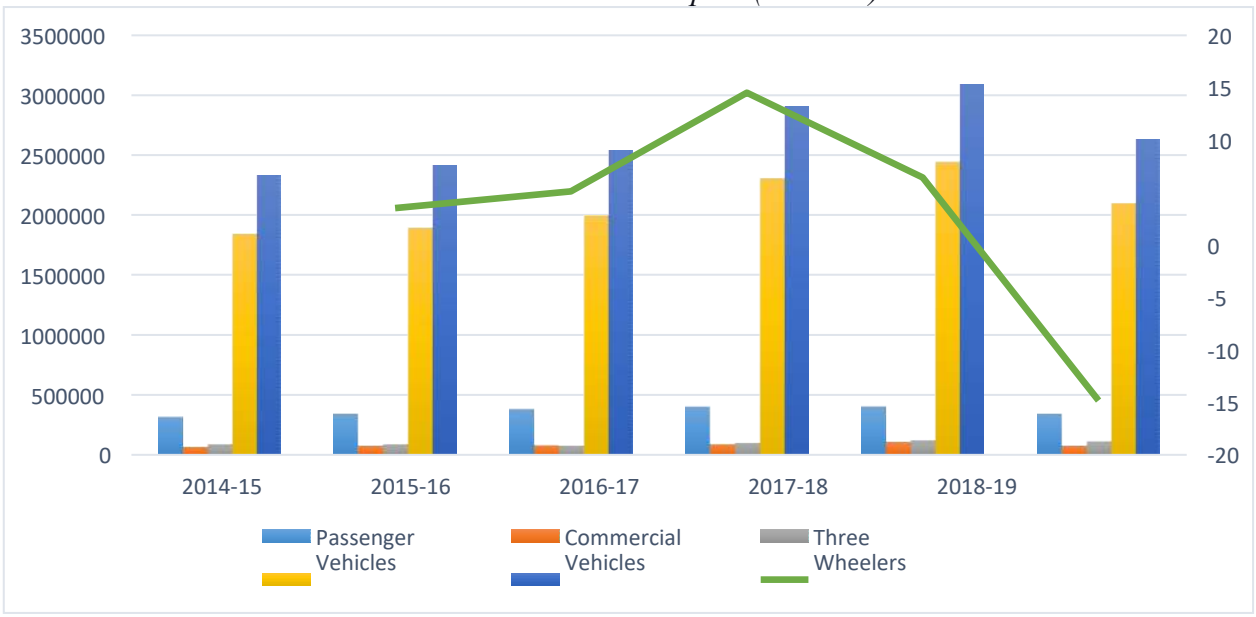
- India is the 4th largest producer of Passenger and Commercial Vehicles. Out of the total, around 80% are passenger cars, and 20% are commercial vehicles.
- Around 26 million total vehicles (including 2 and 3 wheelers) were produced in 2019-20, which is a 14.84% decline YoY.

The Big 7 of PVs (As per Production in Mn Units)	
China	23.52
Japan	8.35
Germany	5.12
India	**4.06**
South Korea	3.66
USA	2.79
Brazil	2.38

The Big 7 of CVs (As per Production in Mn Units)	
USA	8.51
China	4.27
Mexico	2.52
Japan	1.35
Canada	1.34
Thailand	1.29
India	**1.06**

The Global Big 7 (As per Production in Mn Units)	
China	27.80
USA	11.31
Japan	9.72
India	**5.17**
Germany	5.12
Mexico	4.10
South Korea	4.02

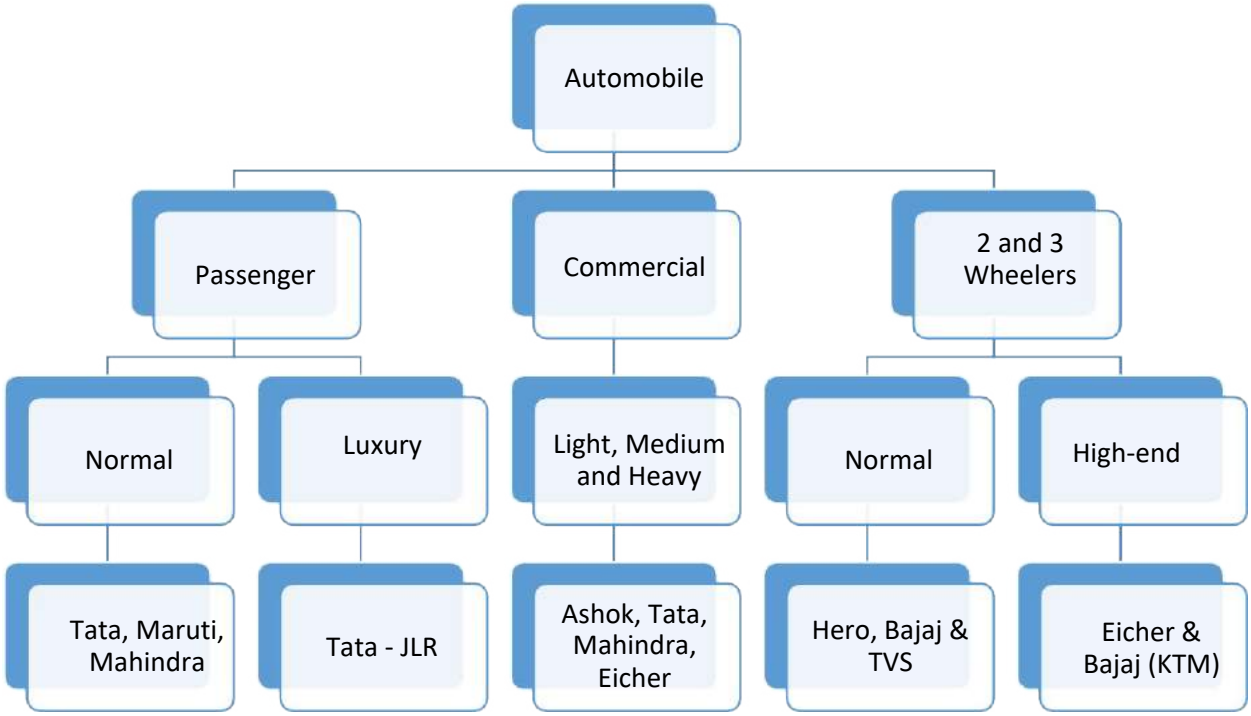
Source: SIAM Annual report (2018-19)



Source: SIAM Website

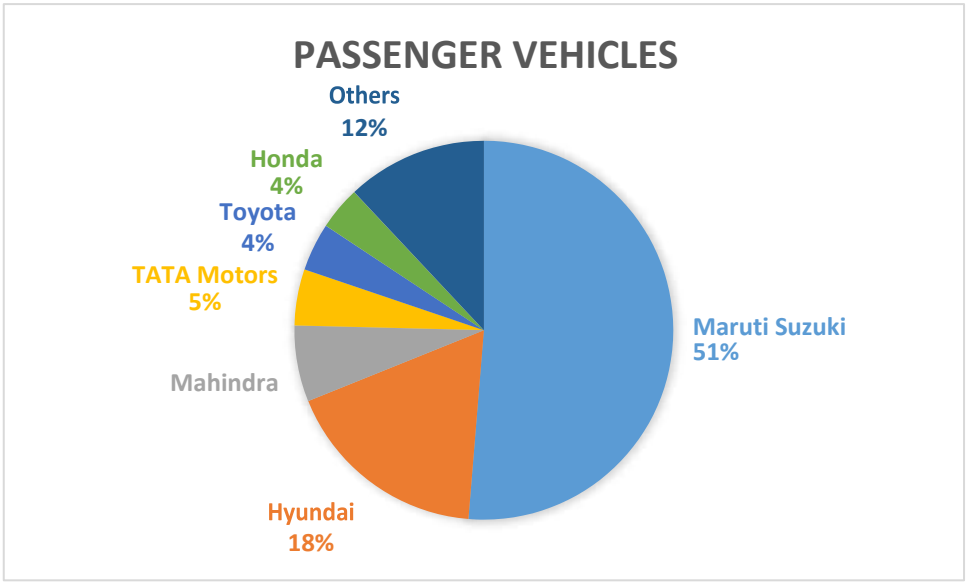
- In the first three quarters of 2020, around 2.16 million vehicles were produced, which is a decline of 38.4% compared to the first three quarters of 2019.
- Such decline can be attributed to the following:
  a) Rise in prices of cars due to the strengthening of safety and emission regulations.
  b) Credit availability since finance houses have become more cautious about lending and increasing down payment.
  c) Initial decline can be attributed to the expectation that GST on Automobiles might be lowered, which led to customers delaying purchases.
  d) Implementation of BSVI norms led to customers delaying the purchase.
  e) Excessive rainfall and floods have led to the suppression of rural demand.
  f) COVID outbreak led to a significant decline in production and demand from March 2020 onwards.

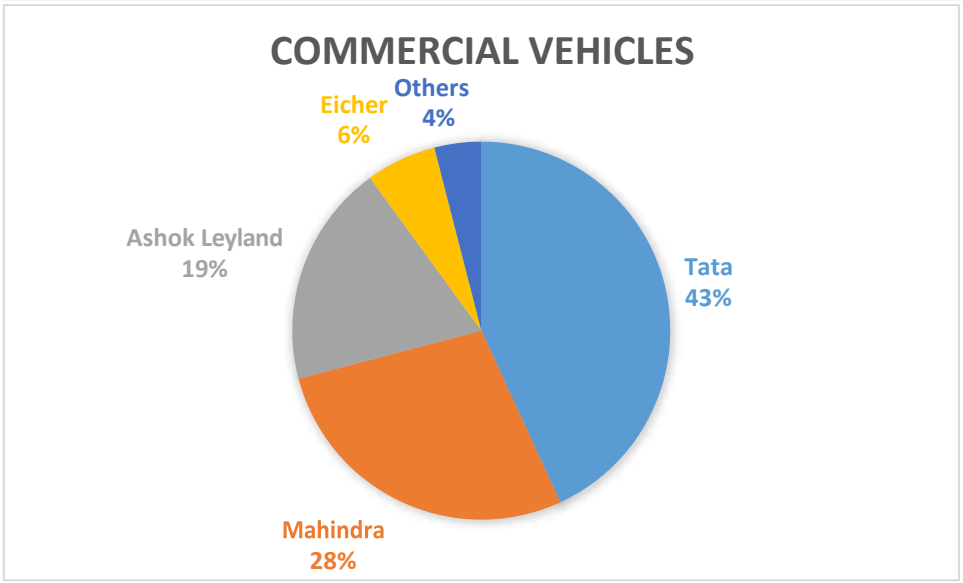
- However, a recovery can be seen in the last quarter of the year 2020.
- Tata Motors Limited has recorded a total cumulative domestic sale of 53,430 units in the month of December 2020. The figures are 21% higher when compared to the business done by the Indian automaker last year in December 2019.
- Maruti Suzuki India Limited posted total sales of 160,226 units in December 2020. This is a growth of 20.2% over December 2019.
- Tata Motors, India's leading automobile company, has announced that it has accelerated its drive for engineering excellence and innovation in 2020 by filing 80 and receiving 98 patents in 2020.
- The industry is now focusing more on petrol passenger vehicles due to diesel cars' high cost and decreasing the price gap between petrol and diesel. Although in the commercial segment, diesel engines are still prominent due to their high-power generating capabilities.
- Despite decline in the passenger vehicle segment, the two-wheeler segment is experiencing decent growth (except in 2020) (India is the largest producer of two-wheelers).
- Following chart shows broad segments of the industry and significant listed players in each segment:

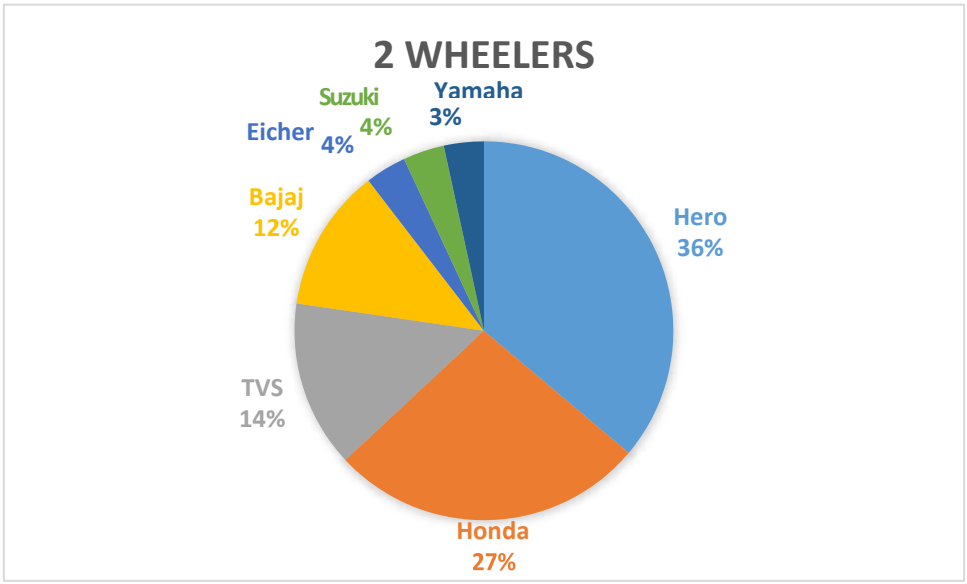


B. Porter's 5 Forces Model

1. Competition

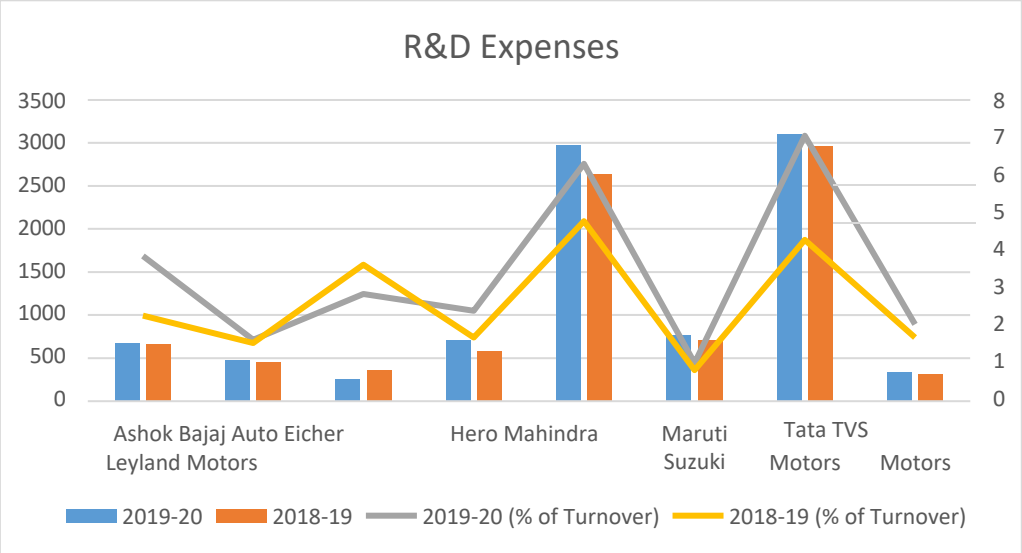






Source of Charts: Companies' Annual Reports (2019-20)

- Number of Players are relatively high.
- Passenger Vehicle segment dominated by Maruti Suzuki with around 51.3% share.
- Commercial vehicle segment dominated by Tata Motors with around 43% share.
- Hero dominates the 2-Wheeler segment with around 36% share.
- Although a particular player dominates each segment, it cannot be said that competition is not challenging. Because players' domination is due to the cost advantage and features, they provide to the consumers and not due to any inherent resource advantage, they can quickly lose their market.
- Participants compete by trying to offer superior features and new models. Also, players try to manage and reduce their costs, which results in significant investment in R&D (Automobile and Pharma industries being top R&D spenders in India).
- Recently, Tata Motors has called out a cost savings program. As part of this, the company has deferred or cancelled lower margin and non-critical investment. It targets capital expenditure of ₹ 1,500 crores in FY21, substantially lower than ₹5,300 crores in the last two financial years.
- For Jaguar Land Rover, the company has now increased the cost and cash savings target for March 2021 to £2.5 billion.



Additionally, Maruti Suzuki also paid Royalty amounting Rs. 38.2 Billion in 2019-20 which is 5% of Revenue.

Note- Such Royalty payments to foreign parents is capped at 5% of revenue. Any excess payment requires Shareholders' approval. Government is asking automakers to reduce it even more.

Source: Companies' Annual Reports (2019-2020)

- Some players have resorted to building strategic partnerships like Renault-Nissan-Mitsubishi alliance, Fiat-Peugeot merger, Suzuki-Toyota alliance and Tata-VW alliance.
- During early September 2020, Mahindra & Mahindra signed an MoU with Israel-based REE Automotive to collaborate and develop commercial electric vehicles.
- Volkswagen announced the merger of its three entities in India; the new entity will be called Skoda Auto Volkswagen India Private Limited.
- In April 2020, TVS Motor Company bought UK's iconic sporting motorcycle brand, Norton, for an about Rs. 153 crores (US$ 21.89 million), making its entry into the top end (above 850cc) segment of the superbike market.
- In January 2020, Tata AutoComp Systems, the auto-components arm of Tata Group entered a joint venture with Beijing-based Prestolite Electric to enter the electric vehicle (EV) components market.

Takeaway: Competition is quite challenging in this industry which is by companies offer value added services to attract the customer. Companies are also trying to lower their production & marketing cost by merging in one another and forming an alliance to survive in the market.

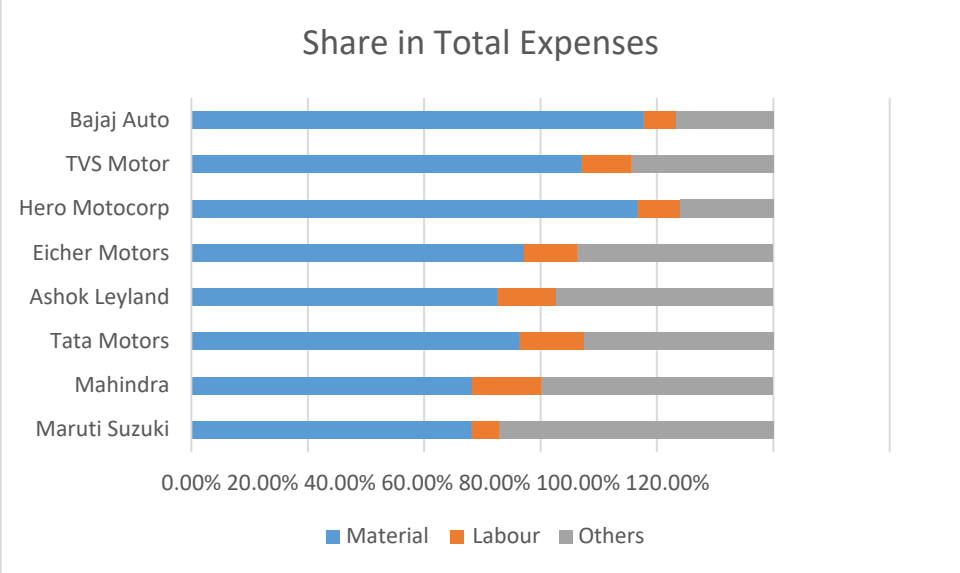
2. The threat of New Entrants

- The automotive industry requires large investments, so the threat of new domestic players ought to be low.
- However, improving India's infrastructure and growth prospects, compared to those of other mature markets, has attracted several international companies to India, either through joint ventures with local partners or independently owned operations in India.
- In October 2020, MG Motors announced its interest in investing Rs. 1,000 crores (USD 137 million) to launch new models and expand operations despite the anti-China sentiments.
- In October 2020, Ultraviolette Automotive (Associate of TVS Motors), a manufacturer of electric motorcycle in India, raised an undisclosed amount in a Series B investment from GoFrugal Technologies, a software company.
- In September 2020, Toyota Kirloskar Motors announced investments of more than Rs 2,000 crore (USD 272.81 million) in India directed towards electric components and technology for domestic customers and exports.
- In December 2019, Morris Garages (MG), a British automobile brand, announced plans to invest an additional Rs. 3,000 crores (USD 429.25 million) in India.
- Audi India planned to launch nine all-new models including Sedans and SUVs and futuristic E-Tron EV by the end of 2020.
- Such foreign players bring enhanced Tech and years of international experience, which is a severe threat to the existing players.

Takeaway: Threat of International players is high although, the entry of new domestic entrants is low.

3. Bargaining Power of Suppliers

- Majority of costs in the Auto industry is of Material and Labour.



Source: Companies' Annual Reports (2019-2020)

- More than 800 Auto Component Manufacturers in the organized sector and numerous others in the unorganized sector.
- Apart from domestic manufacturers, auto parts are also imported specially from China. Around $4.2 Billion worth of Auto parts were imported from China in 2019.
- So, the availability of many suppliers may indicate that suppliers' bargaining power is low.
- Cost of switching the suppliers is also generally low.
- Although switching has an impact on quality, such switching is not generally done.

- Also, recent developments and Anti-China movement may affect the accessibility to the Chinese Market.

Takeaway: Suppliers do not dictate significant power in the industry.

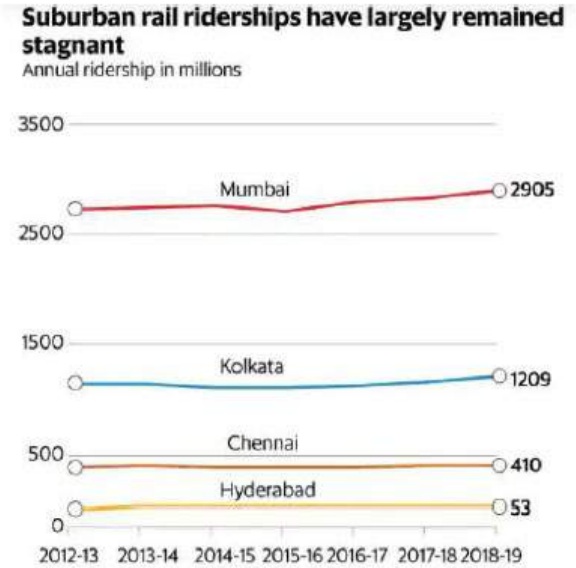
4. Bargaining Power of Buyers

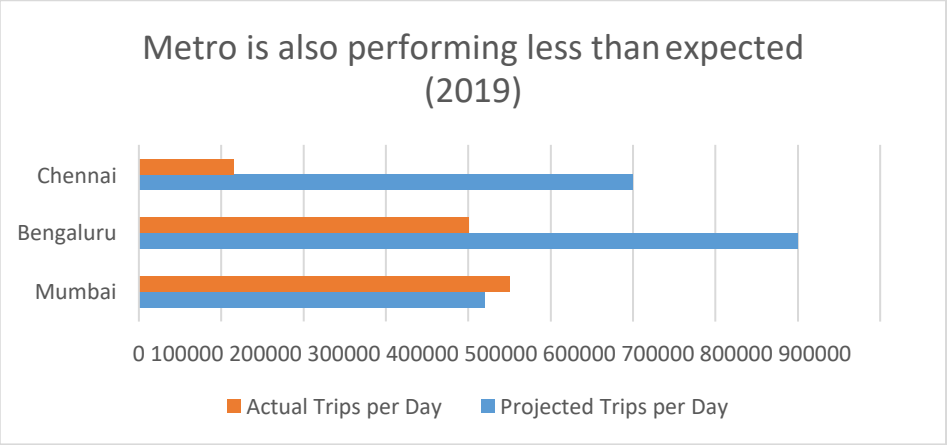
- Many players with varieties of different options and the low cost of switching make the automobile industry a buyer's market.
- Brand loyalty also does not impact much, so players resort to providing a more efficient and better-quality product at the lowest possible cost, which requires continuous research and development.
- Manufacturers also have to incur huge cost on market research and promotion at time of new launch.

Takeaway: Automobile industry is the buyers' market.

5. Threat of Substitutes

- Substitutes include other modes of transport like Ride-hailing services and Public Transport.
- Around 57 per cent of the Indian consumers prefer using ride-hailing service instead of using their own vehicles, reveals a study by Deloitte.
- The study further shows that around 64 per cent of the consumers in India, who were born after the 1980s, question the need to own a vehicle. It also reveals that the frequency of Indians using app cabs increased to 32 per cent in 2020 from 26 per cent in 2019. However, the percentage was 47 per cent in 2017.
- Ride-hailing market in India is expected to grow at CAGR 14% to reach $43.3 Billion in 2025.
- However, some automakers have seen it as an opportunity like Ride-hailing app Ola tied up with Korean carmakers Hyundai and Kia Motors. Under the arrangement, the three companies extensively collaborate on developing unique fleet and mobility solutions; building India-specific electric vehicles and infrastructure, and nurturing best in class opportunities and offerings for aspiring driver-partners with customized vehicles, on the Ola platform. Hyundai and Kia will invest a total of $300 million in Ola
- As far as Public transport is concerned, despite the government's efforts to modernize public transport, the industry has remained stagnant.





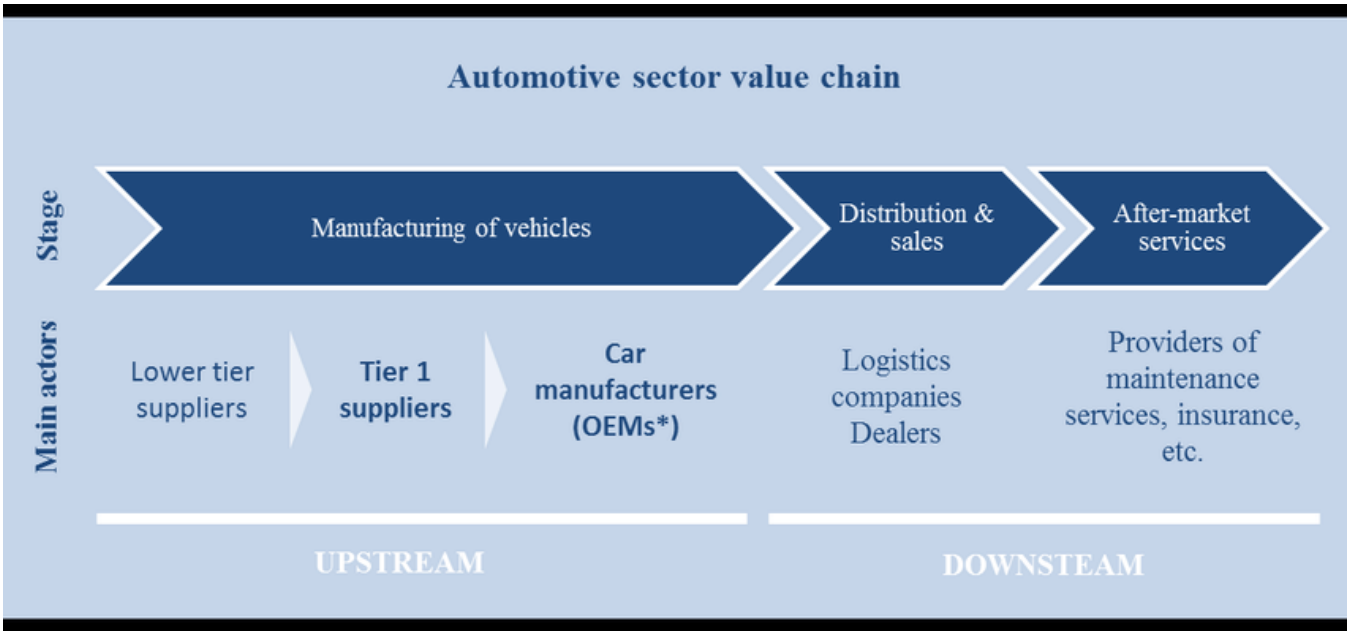
Source of Charts: Livemint Article

Takeaway: Automobile Industry does not face a significant threat from Public Transport but faces some threat from Ride-Hailing Services (although some can perceive this as an opportunity).

Conclusion:

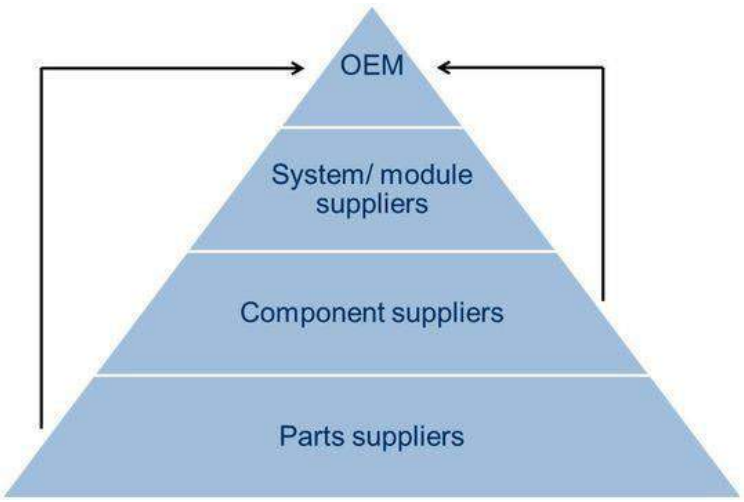
- The Indian Automobile industry is not in its best position considering High Competition, Threat from International players, high bargaining power of Buyers and some threat from Ride-hailing services.
- However, the emergence of Electric Vehicle (EV) may turn the equation altogether.

C. Automobile Industry Value Chain



- Automotive suppliers can be differentiated according to their value-added stage. The supplier pyramid serves this purpose.

- The supplier pyramid represents the OEM suppliers' hierarchical order (Original Equipment Manufacturer) - right up to the end product, i.e., the vehicle. This car manufacturer is at the top of the pyramid. The supply chain ranging from parts suppliers to component, system and module suppliers to original equipment manufacturers is represented in the pyramid.



- A Tier 1 supplier supplies the OEM directly. They are followed by Tier 2 and Tier 3 suppliers in the supply chain. Suppliers at the bottom of the supplier hierarchy can also skip levels and supply the OEM — i.e., the manufacturer directly.
- If we divide the car into the different vehicle areas, we can use an example - let us take the Audi A4 - to explain which parts and assemblies are manufactured by which suppliers.
- These parts and assemblies and the suppliers are only selected by way of example - of course, and there are many more in a vehicle.

1. Driver Assistance and Safety

Driver assistance and safety also include the areas of car IT and connectivity. It is about driver support, infotainment and operation, navigation systems and telematics, the networked vehicle (Car-2-X) or cloud computing. In addition to driver assistance systems, restraint systems and airbags, simulation and automated driving also play a role in the field of safety. The 2015 edition, for example, has a security system with a front camera supplied by **Valeo**. Various systems, such as lane change and lateral traffic assistants, require a radar produced by **Bosch**.

2. Interior

A cord of integrated air vents covers the curved front of the instrument panel. Dr Schneider made the component. **Lear** is involved in the seat system. **Schock Metall** supplies roll-formed special profiles and guide systems for the storage and luggage compartment package.

3. Car Body

The A4 has significantly slimmed down compared to its predecessor; also, because the front strut domes are highly integrated cast aluminium parts. **Magna** supplies reinforcements and stamped parts. Gestamp supplies structural parts. **TRW** supplies caps and module clamps.

4. Undercarriage

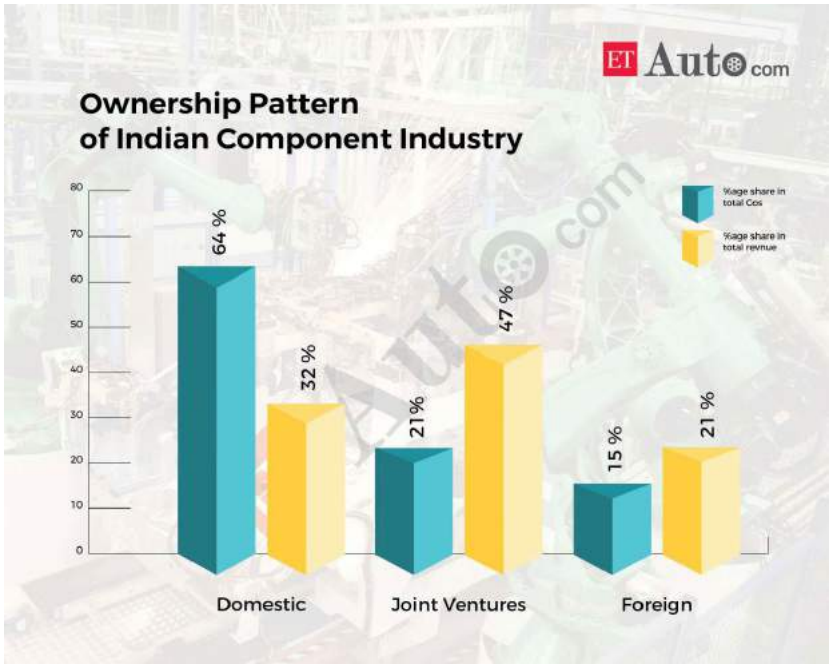
The rear axle of the A4 comes from **Gestamp**; LuK supplies the wheel bearings.

5. Infotainment and Electronics

A tablet is available for entertainment in the rear. A Tegra-40 processor from **Nvidia** drives the system. **Kromberg & Schubert** will supply the wiring system for the A4.

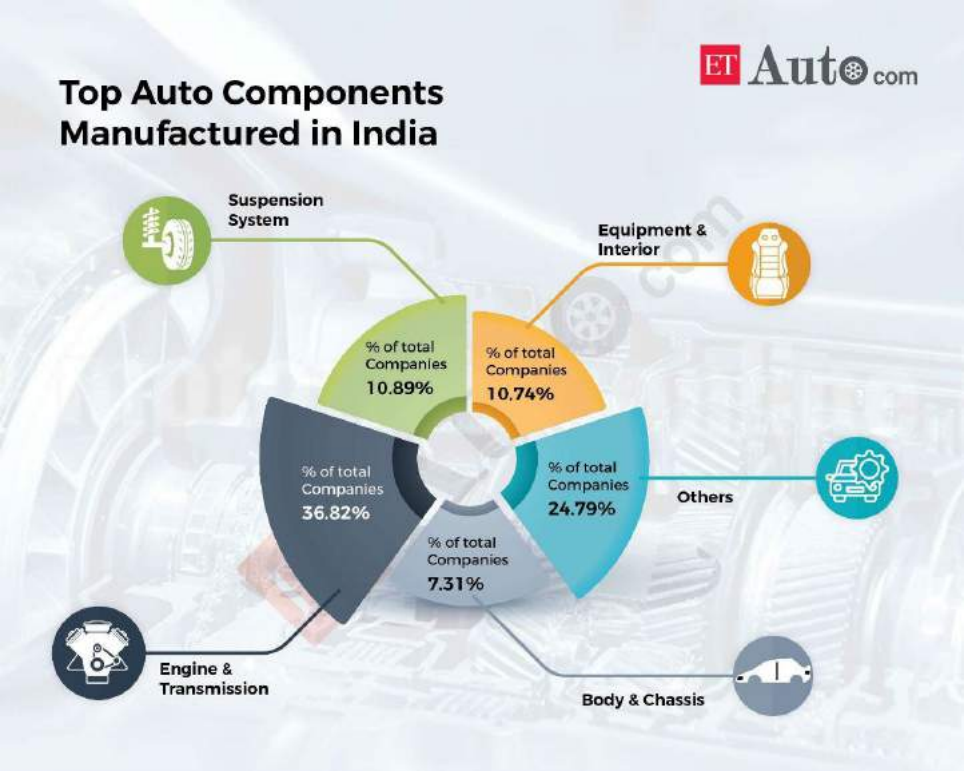
6. Powertrain

The transmission control comes from **Continental**. **Hirschvogel Automotive** produces wheel hubs and transmission shafts and rails and injector bodies for the diesel aggregates.



Top Players in Indian Auto Component Industry includes the names of:

- WABCO India Ltd
- Minda Industries Ltd.
- Endurance Technologies Ltd.
- Bosch Ltd.
- Varroc Engineering Ltd.
- Sundaram Clayton Ltd.
- Motherson Sumi Systems Ltd.



As far as the downstream chain is concerned, there are around 15000 Auto dealers led by T V Sundram Iyengar & Sons (Rs. 5025 Crores), Kuttukaran Group (Rs. 4276.66 Crores) and Kataria Automobiles (Rs. 3675.86 Crores) in terms of Annual Revenue.

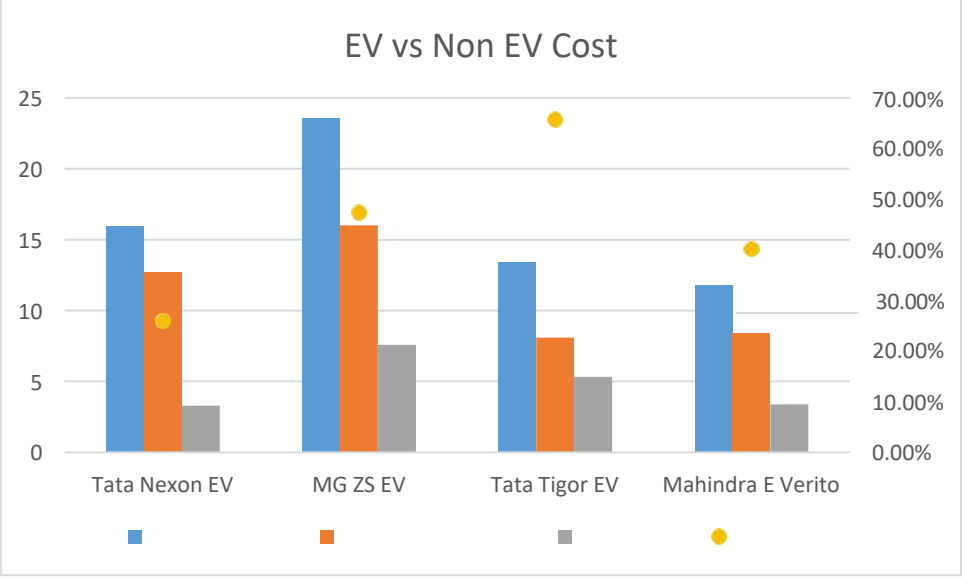
D. Electric Vehicles (EV) – The Future of the Automobile Industry

1. What is EV?

- Battery Electric Vehicles (BEV) and Hybrid Electric Vehicles (HEV) have two types of EVs.
- BEV runs solely on Battery while HEV runs primarily on fuel but also have electric components.
- HEVs have been on the market for a while. They are not that different from traditional combustion engine vehicles, so here we will focus on BEV.
- EVs use electric motors instead of internal combustion motors.
- The main difference between these motors is that ICM uses the gases produced by combustion of fuel to move the parts while EM uses a magnetic field and electric current to generate force. This is the reason why EM does not create any pollution.

2. Cost Analysis

- The upfront cost of purchasing EV is high, but as the tech progresses, the difference is declining.
- EVs also tend to have lower maintenance costs because of a few mechanical parts, and changing the transmission fluid, coolant, and engine oil of an ICE vehicle can slowly add up. However, due to the tech being new, repair costs of EVs can be a bit higher.
- Moreover, most importantly, the main benefit that one can get from an EV is the low cost of electricity compared to fuel.
- So, let us try to run some numbers to analyse the cost-benefit.
- There are currently six electric cars on sale in India Mercedes-Benz EQC, Tata Nexon EV, MG ZS EV, Tata Tigor EV, Hyundai Kona Electric Mahindra E Verito. Of these, the Tata Tigor EV is the cheapest EV while the Mercedes-Benz EQC is the most expensive electric car in India. 4 out of them also have non EV variant.



Source: Companies' Websites

		Tata Nexon	MG ZS	Tata Tigor	Mahindra Verito
	Highest Price - EV (Lakhs)	15.99	23.58	13.41	11.8
	Highest Price Non - EV (Lakhs)	12.7	16	8.09	8.42
a	**Difference (Lakhs)**	3.29	7.58	5.32	3.38
b	**Battery Size (kWh)**	30.2	44.2	21	16
c	**Range (Km)**	312	340	213	181
d	**kWh per Km (b/c)**	0.097	0.130	0.099	0.088
e	**Avg. Electricity cost per Kwh**	6	6	6	6
f	**Cost per Km (d*e)**	0.58	0.78	0.59	0.53
g	**Mileage (Km/L)**	22	14	24.7	21
h	**Avg. Cost of Diesel per L**	80	80	80	80
i	**Cost per Km (h/g)**	3.64	5.71	3.24	3.81
	Cost recovery (Km) [a/(i-f)] [This represents, how much KMs we have to use an EV to recover the premium paid on purchase]	107671	153619	200958	103076

Note: - Prices of cars are taken of costliest variant available. Both for EV and Non EV.

- From the above calculation, we can see that the overall cost of EV variant of Tata Tigor is more as generally, a person does not drive a car for more than 2 Lakh KMs throughout its lifetime. For MG ZS, the overall cost of both EV and Non-EV would be similar because a person drives a car for around 150000 KMs throughout its lifetime. However, the EV version of Tata Nexon and Mahindra Verito seems to be more cost-effective.
- Keep in mind that we have not considered the cost of maintenance which is lower in EVs and that in future, the price difference of EVs is bound to reduce.

Takeaway: We can say that even in current scenario EVs are competitive as far as the overall cost is considered. Nevertheless, there is one point that needs to be considered. Since EV is bound to prevail, this will lead to a sharp decline in Petrol and Diesel's consumption, one of the government's primary revenue sources. Whether or not the government will put a tax on the electricity charging will play a huge role in determining EVs' cost-effectiveness in the future.

3. Quick vs Fast

- Quick refers to how much time it takes us to get between two points, while fast is the maximum speed we hit.
- Generally speaking, EVs can generate more torque (the rotational force that drives the car) than ICEs, because most of the power generated by ICEs are lost in Powertrain. So, EVs are quicker although ICEs can be faster.

Takeaway: Considering the general user's needs, we would prefer EV because of its efficiency and considering that one would not be concerned about how fast his car is.

4. The Sound Problem

- Electric cars are quieter than their internal combustion engine-having counterparts. The only noises EVs usually generate are caused by wind resistance or tire noises, which is only at moderate to higher speeds.
- Most of us would be happy to have a noiseless vehicle. However, some auto enthusiasts may not be happy without the sound, especially in high-end cars. Well, it depends on a person's taste!
- One concern with noiseless EVs is that low-emission cars and vans are too quiet, putting pedestrians and cyclists at risk because they cannot be heard as they approach.
- So, governments across the world including USA, Japan, China and EU have formed regulations where a four-wheel electric vehicle must be fitted with the device, which emits a sound when reversing or travelling at low speed (i.e. when cars are most likely to be near pedestrians).

Takeaway: EV can be a key to solve noise pollution trouble and be preferred by the public.

5. The government also wants us to have an EV!

- Owing to the rising environmental concerns, the Indian government has committed to reducing CO2 emission intensity by 33-35% by 2030 from the level taken in 2005. The transport sector contributes an estimated 142 million tonnes of CO2 emissions annually in India, and 90% of it is contributed by road transport only.
- Government of India launched the Faster Adoption and Manufacturing of Hybrid & Electric Vehicles (FAME) scheme in 2015 and has sanctioned an amount of Rs. 795 crore for the project. Under Phase 2 of FAME, Govt. of India is planning to extend the support to Rs. 8,730 crore which will span for three months. Energy Efficient Services Ltd has also issued tenders for 20,000 EVs for government use across India.
- Government has also provided a deduction of interest paid on loans taken to purchase EV under 80EEB of IT Act.
- GST on EVs is also kept significantly low @ 5% compared to traditional vehicles that attract GST, which may be as high as 50%.

Takeaway: Government is also trying to push EV sales by offering supports and tax incentives.

6. Charging Infrastructure

- Currently, India has several hundred charging stations. However, the government is trying to increase this number significantly.
- According to a MarketWatch report, India's charging infrastructure market is expected to grow at a compound annual growth rate (CARG) of 40% in the next five to six years. Most industry experts also believe that 40-45% electric conversion by 2030 is a realistic expectation, provided that the infrastructure is created for it.
- In February 2020, the government had given an in-principle nod to firms, including NTPC, EESL and REIL, to set up 2,600 EV charging stations.
- As part of the government's bid to make India an electric vehicle nation by 2030, Union transport minister Nitin Gadkari has announced setting up infrastructure for one e- charging kiosk at around 69K petrol stations across India.
- In October 2020, India's Department of Heavy Industries invited companies to set up electric vehicle charging stations on major existing and upcoming expressways and highways running across the country's length and breadth.

- An expression of interest (EoI) invitation put out by the government states its plans to have one charging station every 3km in cities and every 25 km on both sides of the highway to facilitate faster adoption of electric vehicles under the second phase of the "Faster Adoption and Manufacturing of Electric and Hybrid Vehicles (FAME)" programme.

Takeaway: Considering the above points, it is safe to say that we can see significant growth in EV infrastructure in the recent future.

7. Cost of setting Charging Infrastructure (Estimate)

- Electric Vehicle Public Charging Stations (PCS) business is de-licensed by India's government, as an initiative of the Make in India scheme. So, it is quite easy for an individual to open an electric car charging station business.
- For setting up Power Charging Stations, one has to process applying for connection and obtaining required permissions. Ministry of Power has issued guidelines for minimum requirements for setting up EV PCS, some of which are:
  - A Minimum three fast chargers and two slow charge points.
  - Transformer with a safety appliance.
  - Electricity supply to power up the charging station.
  - Network Service Providers (NSPs) to enable advance remote/online booking of charging slots.
  - Safe area for charging and public amenities.
  - Liquid-cooled cables and climate control equipment if the charging station provider plans a fast-charging option.

  Appropriate civil works and start-ups are free to create Charging Hubs and install an additional number of Chargers.
  Cost of Chargers:

Charger type	Output power	Cost of charger
Bharat AC-001	3.3kW	65000
Bharat DC-001	15kW	247000
Type 2 AC	22kW	120000
CHAdeMO	50kW	1350000
CCS	50kW	1400000

Other Estimated Cost:

Electricity cost - New connection, transformer, cables, Energy meters and cables	600000
Civil works for EV charging station	200000
Brand building and promotion	50000
Technical team, manpower and maintenance	3,00,000
location rental for EV charging station	250000
TOTAL	**1400000**

- So, depending on the location, existing infrastructure available and several chargers one is planning to put, setting up a PCS may cost around 40 Lakhs which is similar to the cost of setting a petrol pump.

Takeaway: We can see that cost of setting up a PCS is similar to setting up a petrol pump which will encourage the development of EV infrastructure.

8. Charging Time

	Tata Nexon EV	MG ZS EV	Tata Tigor EV	Mahindra E Verito	Mercedes Benz EQC	Hyundai Kona
Charging Time (Fast charge – 50kW) (Minutes)	75	60	150	115	115	75
Charging Time (Normal charge – 7.5kW) (Minutes)	640	600	690	690	810	370
Range (Km)	312	340	213	181	460	452
Price (Lakhs)	15.1	22.23	9.74	9.29	99.3	24
Range (Km) per Minute of Charge (Considering Fast Charge)	4.16	5.67	1.42	1.57	4.00	6.03

- Because traditional vehicles can travel twice as much with a full tank which takes 2-3 minutes to fill, charging time may turn the consumers sceptical towards adopting EV.
- The fact that technology already exists which can charge a car in about 20 minutes can be a sign of relief. However, the availability of tech in India is uncertain.
- EVs can be charged at the standard household electric output. Currently, companies selling EVs offer free service of setting EV charging infrastructure at our home.
- So even if we consider current tech in India, it is safe to say that electric vehicles are viable for intra-city transport as it can be charged overnight at our home.
- EVs are also equipped with smart tech that shows the details of charge on our smartphone so that we can plan our travel and charging beforehand.
- Companies are also providing Mobile Charging services if we are stranded without charge, although such services' reliability and availability in specific regions are not clearly mentioned.

Takeaway: Although it takes significant time to charge an EV (as compared to filling a fuel tank), it cannot be said to be a significant setback, at least for intra-city commuters.

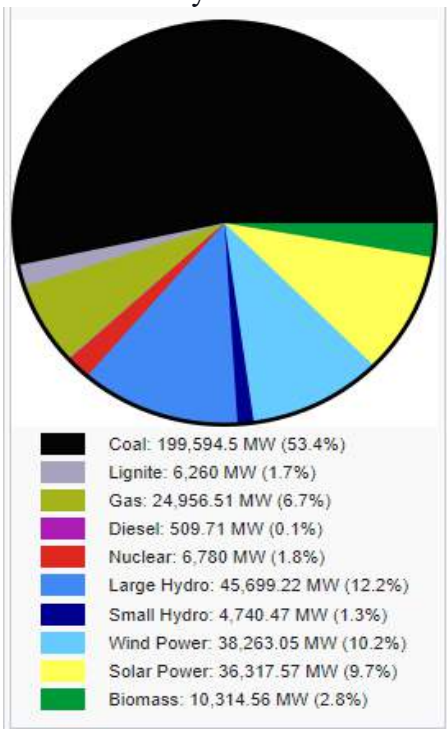
9. Availability of Electricity

- Although the government had claimed that it had electrified 97% of Villages in India, there is a loophole in this claim.
- A village is declared electrified if 10% of the households can access power and public institutions such as schools, the panchayat office, health centres, dispensaries and community centres.
- So, it is safe to assume that Electric infrastructure in most of the villages will be far from adequate to support EV infrastructure.

Takeaway: Lack of Electricity Infrastructure could prove to be a hurdle in India's EV ambition. The widespread use of EV in rural areas may not be expected in the recent future.

10. Carbon Neutrality of EV's

- The scientific understanding of electric vehicles' exact environmental impacts continues to evolve, and the impacts of battery production on electric vehicles' overall emissions is an enormously complex topic. However, generally speaking, EVs indirectly cause emission while they are manufactured, and there are emissions related to the production of electricity.
- Here is the chart that shows sources of Electricity in India:



Source: Wikipedia

- Above chart shows that most electricity is generated from coal and other sources that are NOT carbon neutral.
- Following chart shows the Life cycle emissions of Conventional Vehicles and EVs in the European context:

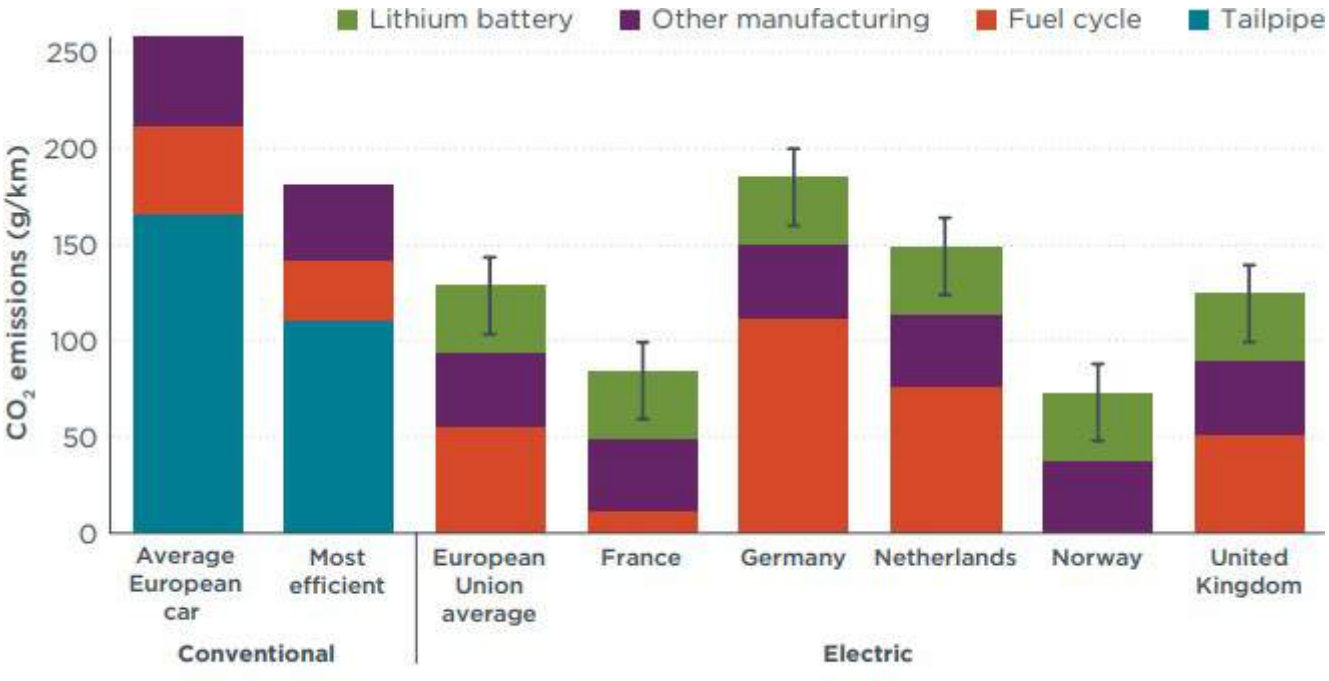


Figure 1. Life-cycle emissions (over 150,000 km) of electric and conventional vehicles in Europe in 2015.

For detailed report refer: https://theicct.org/sites/default/files/publications/EV-life-cycle- GHG_ICCT-Briefing_09022018_vF.pdf

- Electric vehicle manufacturing requires more energy and produces more emissions than manufacturing a conventional car because of the electric vehicles' batteries. Lithium-ion battery production requires extracting and refining rare earth metals and is energy-intensive because of the high heat conditions involved. Most lithium-ion batteries in electric vehicles in Europe in 2016 were produced in Japan and South Korea, where approximately 25%–40% of electricity generation is from coal.
- On the other hand, electric vehicles travel farther with a given amount of energy and account for fewer emissions through fuel production and vehicle use phases.
- An average electric vehicle in Europe produces 50% less life-cycle greenhouse gases over the first 150,000 kilometres of driving, although the relative benefit varies from 28% to 72%, depending on local electricity production.
- An electric car's higher manufacturing-phase emissions would be paid back in 2 years of driving with European average grid electricity compared to a typical vehicle.
- In future this benefit is also expected to increase due to Following:
  - **Decarbonisation of electricity production:** Increased use of renewable sources of electricity in future.
    - **Battery Second life:** When batteries are removed from electric vehicles after their early life, they are likely to retain significant capacity, typically 75%–80% of their original capacity. They could, therefore, play an essential role in supporting the electric grid, especially as renewables become more widespread. This, in turn, allows the initial battery production footprint to be spread across more use.
    - **Battery recycling:** As the electric vehicle industry grows, battery recycling also will become more feasible. Materials production is responsible for approximately half of the greenhouse gas emissions from battery production, and recycled materials typically have a lower carbon footprint than the same materials from virgin sources. For example, recycled aluminium production creates approximately 95% less greenhouse gas emissions than producing aluminium from natural sources.
    - **Battery technology improvements**. Lithium-ion batteries and manufacturing techniques continue to improve as the electric vehicle industries grow. Battery energy density, or the energy storage per kilogram of battery, steadily increases at an average rate of approximately 5%–8% per year. Longer battery lifetimes will allow for longer vehicle lifetimes and fewer replacements, as well as longer or more demanding second lives in stationary applications.
    - Higher charging and discharging efficiencies will lead to lower energy consumption during the vehicle battery use phase.

Takeaway: Although EVs may not be considered entirely carbon-neutral, they emit significantly fewer emissions throughout their life-cycle. Also, one can reasonably expect these emissions to further reduce in future.

Conclusion:

- EV is one of the most disruptive trends in the Automobile Industry.
- Industry players have already sensed this trend and are trying to capture the market by investing significantly in this area.
- EVs are superior as compared to their traditional counterparts in almost all the parameters that we considered.
- Development of EV infrastructure is also expected to increase significantly in the near future.
- Widespread use of EV is not a far fledged dream, and this can be expected sooner than we think.