

Impact of Electric Vehicles Adaption on the Balance of Payment and Current Account Deficit in India

Finold Jose¹, Dr. Preeti Mehra²

¹Research Scholar, Mittal School of Business, Lovely Professional University & Assistant Professor, Department of Management, Kristu Jayanti College, Bengaluru. E-mail: finu5555@gmail.com

²Associate Professor, Mittal School of Business, Lovely Professional University, Mittal School of Business, LPU, Kapurthala, Punjab. E-mail: Preeti.23746@lpu.co.in

Abstract

One of the major problem faced by the Indian Economy is a balance of payment. India is always having the Current Account Deficit (USD 7.6 billion Q3 2020). This is because of the large presence of crude oil in the import basket of the nation. The lion share of the petroleum used by the transportation sector. India imports 96% of its oil consumption. The current electric vehicle penetration of the market is around 5 % in India. This paper tries to find out the effect on the balance payment and current account if half of the transportation sector is converted to the electric segment especially bikes, Cars, utility vehicles (UVs), and three-wheelers. This research trying to find out whether electric vehicles can make a huge impact on India's sustainable development and balance of payment of the nation and also find out whether it will be a huge burden on the Electric Grid.

Keywords: Balance of Payment, Current Account Deficit, Electric Vehicles, Non-renewable Resource, and Sustainable Development.

DOI: 10.47750/pnr.2022.13.S03.114

INTRODUCTION

The Indian economy is heavily reliant on oil imports. India consumes nearly 5% of the world's total oil output. (Dalei, N. N., & Gupta, A., 2020). According to the Economic Times, India is on the verge of surpassing China as the world's second-largest importer of crude oil. Electric vehicles also helped China develop its transportation infrastructure. (LiZ., & Ouyang, M., 2011). The electric vehicle (EV) is viewed as one of the alternate ways to improve Energy expense and decrease carbon dioxide (CO₂) outflows in the transportation area (Li and Ouyang, 2011). The battery-powered car is being considered as an alternative to the current problems associated with ordinary combustion engines due to its low tailpipe emissions and high power drain performance. Even though under ideal conditions, an IC engine can only convert 33 per cent of total energy to useful work, humans have been relying on inefficient IC engine machines for more than a century. Energy efficiency is typically less than 15% of overall energy consumption. This kind of failure is extremely costly in today's world (Joshi, A., 2020).

India has been a significant contributor to global air pollution as one of the world's fastest-growing economies. (Guttikunda, S. K., Nishadh, K. A., & Jawahar, P., 2019). The use of electric vehicles for regular commutes was one

of the options they proposed. Since India is on a similar development path, the government will have to deal with this problem sooner or later. All nations are committed to reducing the consumption of non-renewable resources. Nations are cutting down their oil consumption which is also a strong commitment to sustainable development. But India being a developing nation had increased the oil consumption year after year.

India as a nation heavily depended upon import for its oil consumption. Almost 96% of the oil consumed in India is being imported. Oil imports in March 2020 had been USD10.01 billion, a 15.00 per cent decrease in dollar terms (9.03 per cent decrease in rupee terms) from USD11.78 billion in March 2019. Oil imports were USD129.43 billion in April-March 2019-20, an 8.15 per cent decrease in Dollar terms (6.99 per cent decrease in Rupee terms) compared to USD140.92 billion in the same period last year. For the past 10 years, India's current account always closed at a deficit. In the past 10 years, India recorded a Current Account deficit of 1.86 per cent of the country's Gross Domestic Product. Oil is one of the major components of the purchase basket. India's current account deficit (CAD) was US\$ 1.4 billion (0.2% of GDP) in Q3 of 2019-20.

Moving forward, electric vehicles are an inevitable technology that must be embraced to ensure the country's long-term viability. India's National Electric Mobility

Mission Plan (NEMMP) 2020 was launched in 2013 with this vision in mind. By 2020, the Indian government hoped to sell about 7 million electric and hybrid vehicles. As a result, national fuel security and oil consumption are improved. Sadly, the goal was not reached as soon as it should have been. (Kumar, M.A.R., & Padmanaban, D.S., 2019).

The country's balance of payments situation reflects its economic health. A country's balance of payments is a thorough and systematic record of all the various transactions that occurred between its inhabitants and the rest of the globe over a specific period. On the one hand, the balance of payments keeps detailed classified records of various types of receipts against exports of goods, services, and all capital received by its residents, and on the other hand, it keeps detailed classified records of all payments made by residents against imports of goods and services received, as well as capital transferred to non-residents and foreigners. As a result, the balance of payments is far more comprehensive than the balance of trade, which primarily considers merchandise exports and imports.

The balance of payments is divided into two categories:

- (a) Current account: visible exports and imports; invisible items relating to receipts and payments for various services such as banking, insurance, shipping, travel, and other unilateral transfers of payments such as donations, grants, and taxes; and other unilateral transfers of payments such as donations, grants, and taxes.
- (b) Capital account: All current economic transactions for the country's international financial position resulting in changes in foreign financial assets and liabilities are included in the capital accounts of the balance of payments. Private, banking and official capital transactions are all included.

The double entry system of bookkeeping is used to keep track of the payment account's balance. When a country's current account of its balance of payments is in deficit, the imbalance is usually covered by liquidating assets or borrowing from abroad. As a result, a continuous deficit in a country's balance of payments leads to a significant debt burden on the economy. With the introduction of planning in India, the country's balance of payments status has seen significant fluctuations as its imports and exports have fluctuated.

During the Sixth Five-Year Plan period, India had a massive balance of payments deficit of Rupees. 11,384 crore. Due to a persistently expanding trade deficit, the total balance of payment deficits during the Seventh Plan increased to Rupees. 38,313 crores, with an annual average deficit of Rupees. 7,662 crore. In 1990-91, the total amount of deficits in the balance of payments reached Rupees. 17,369 crore once again. However, the cumulative balance of payments deficits in 1999-2000 and 2000-2001 were Rupees. 20,331 crore and Rupees. 11,431 crore, respectively. The overall excess in the BOP was Rupees. 16,426 crore in 2001-02,

and it climbed to Rupees. 47,952 crore in 2003-04. The entire deficit in the BOP in 2008-09 was Rupees - 131,614 crore. During the entire Sixth, Seventh, Eighth, and Ninth Plan years, the massive deficit in the balance of payments position was the result of a phenomenal rate of increase in imports accompanied by a mediocre rate of development in exports. The trade deficits throughout these four plans were so large that they couldn't be covered by the net invisible flow of funds.

In 2018-19, India's external sector suffered severe global pressures. As a result, CAD increased from 1.3 per cent of GDP in 2013-14 to 2.1 per cent of GDP in 2017-18. In the spring of 2018, trade tensions took a toll on corporate confidence and financial market sentiment, tightening financial conditions for vulnerable emerging markets. Net capital flows fell short of CAD's funding requirements due to net outflows of foreign portfolio investments (FPI). As a result, foreign exchange reserves were depleted only slightly during the year.

Petroleum always has been a major portion of the Indian purchase basket. India is one of the fast-developing nations. Being one of the fast-growing nations it will have a tremendous requirement for energy. According to the World Energy Outlook (WEO) 2020, announced on October 13, India would dominate global energy demand over the next ten years. Most of this demand is met by non-renewable energy especially petroleum products. This further depletes India's Current account. India had purchased around 100 billion petroleum for the year 2019-20. This figure is going to increase shortly because of the energy need of the nation. Further the national heavily relies on the import of oil.

India's need for imported energy may have cost the country a chance to run a current account surplus for the first time in 12 years in the January-March 2020 quarter. A higher drop in India's imports in the fourth quarter of the previous fiscal year 2019-20 was predicted by the government to enable India to generate a current account surplus. Imports and exports both fell precipitously as a result of the sharp drop in trade activity, giving India this once-in-a-lifetime chance. India, on the other hand, imported a large volume of crude oil in March to take advantage of low crude oil prices and to fill strategic reserves, preventing imports from declining in line with the stagnant domestic economy. Oil imports increased by 3.7 per cent to USD 33.7 billion in Q4 FY20 from USD 32.5 billion a year earlier, owing in part to an increase in the volume of oil imports in March 2020 to take advantage of low international crude oil prices, according to Aditi Nayar, Principal Economist, ICRA.

When Fossil fuels burn in an internal combustion engine, they not only produce carbon dioxide but also carbon monoxide, nitrogen oxides, and hydrocarbons. They can also be released when vehicle tailpipes expel residual air and gasoline. Fuel vaporises from engines and fuel systems due to vehicle operation or hot weather, releasing gasoline vapours into the atmosphere. Pollutants in automobile or lawn machine engine exhaust damage lung tissue and can

cause or exacerbate respiratory disorders like asthma. Acid rain is caused in part by pollutants from motor vehicles. Pollution also produces greenhouse gases, which contribute to global warming. Diesel engines are both long-lasting and efficient. They do, however, emit some pollutants since they use diesel fuel, which is a complex mixture of petroleum components. A small amount of fuel is unburned as it exits the engine. When these airborne hydrocarbons come into touch with dust and other particles in the atmosphere, they can produce bigger particles. Usually when the internal combustion engine work may not receive enough air into the cylinder for combustion, operate with surplus air, resulting in very low carbon monoxide emissions, but they are still detectable. Carbon monoxide is a colourless, odourless gas that binds to blood and reduces the ability of the blood to transport oxygen. Engines use fuel and air and produce heat during the combustion process. Nitrogen can be converted into nitrogen oxides during combusting which are reddish-brown fumes that irritate the lungs and eyes.

Pollutants emitted directly from automobiles aren't the only thing to be concerned about. On hot, bright days, hydrocarbons mix with nitrogen oxides to form ozone, a secondary pollutant. Motor vehicles are the single largest source of ground-level ozone, a frequent component of smog, in many urban areas. Coughing, wheezing, and shortness of breath are all symptoms of ozone exposure. It can also cause long-term lung damage, making it a significant public health concern. Delhi Fog issue is the biggest example of this kind of pollution.

The majority of an internal combustion engine's emissions is produced during normal operation. When several mid-sized automobiles with internal combustion engines are compared, they produce an average of 150.4 g CO₂ eq per kilometre. When several SUV class internal combustion engine vehicles are compared, they produce 269.2 g CO₂ per kilometre on average. This means that a mid-sized automobile with 100,000 miles on the clock would have produced around 24 million g CO₂ throughout its life. Throughout its operation, an SUV class car with 100,000 miles would have produced approximately 43 million g CO₂. According to another study, a combustion vehicle with 160,000 miles on the clock will emit approximately 45 metric tonnes of CO₂ throughout its operation or 45 million g of CO₂.

Air pollution is already a serious issue in India, with nine Indian cities ranking among the top ten most polluted in the world, according to the WHO. In the medium future, electric cars will only have a modest market share in India. Two-stroke two-wheeler engines account for around two-thirds of the vehicle population in big cities, and we are responsible for discharging 70% of pollutants into the atmosphere. According to research, 97 per cent of buses and trucks release excessive emissions, with three-wheelers accounting for 88 per cent of the total and privately owned two-wheelers accounting for 51 per cent. The use of non-standard petroleum also contributes significantly to

vehicular air pollution. Even the unleaded gasoline sold in our nation contains 0.13 per cent lead. This figure is 2.5 times greater than the international standard of 0.005 per cent. Also, additives such as Benzene, Toluene, and Zylene, which are added to gasoline at the refinery stage, have only increased the amount of Benzene in the environment. The same may be said for diesel's high Sulphur content, which is extremely harmful. Another issue is the age of the vehicles running in the nation most of the engines are very old. Even though the nation has moved to Bharath Standard VI most of the vehicles on road are not matching with the requirement of the standard. Even though the nation follows 15-year-old engines are limited in cities. These engines are still running in the rural interior of the nation.

According to the research, vehicle tailpipe emissions were related to about 361,000 premature deaths worldwide in 2010 from ambient PM_{2.5} and ozone, and about 385,000 in 2015. In 2015, 70 per cent of these impacts were projected to have occurred in the four main vehicle markets: China, India, the European Union, and the United States (Susan *et al.*, 2019). In India, air pollution, especially in the form of particulate matter, is a serious problem, and transportation is a major contributor to the country's air quality issues. According to the 2017 Global Burden of Disease report, air pollution causes the deaths of 1.1 million people in India each year, making it the country's fifth leading cause of death. In India, transportation sources account for about a third of PM emissions, as well as a slightly higher proportion of nitrogen oxides, another group of compounds that are hazardous to human health. India has very low per capita transportation emissions due to its limited vehicle fleet in comparison to its large population. However, the fleet is steadily expanding: total vehicle sales (including motorcycles) rose from about 10 million in 2007 to over 21 million in 2016, and the total number of vehicles on the road is projected to nearly double by 2030, to about 200 million.

THE PURPOSE OF THE STUDY

The purpose of this study is to see what is the effect on the balance of payment and current account deficit if half of the transportation of the national happens by electric vehicles. The two-wheelers, three-wheeler, cars and UVs are the segment which has market-ready technology. If so how much will be the extra load on the power generation of the nation? This study also intends to find out how much reduction in the pollution if at all these vehicles run on the eclectic platform.

OBJECTIVES

- To find out the total reduction in import cost if half of the transportation is electric
- To find out the impact on the current account of the nation if half of the transportation is electric

- To find out the reduction in pollution if half of the transportation is electric

METHODOLOGY

The reach methodology adopted for his research is the quantitative methodology and the research rely mostly on the second data collected for the official sites of the government as well as the information from the company websites. The study adopts cost Analysis for finding out the effect on the Current account and balance of payment.

3.1 Method

Cost analysis is selected for the study. This study is trying to find out the cost reduction in the term of oil import if half of the transportation in India happened by electric vehicles. We have selected only the two-wheelers, three-wheeler, cars and UVs to be more pragmatic. We intended to compare the cost with the current cost of import. When we convert half of the transportation to Electric then it put a lot of pressure on the energy sector in India. Almost 60 % of the power produced in India is by burning fossil fuel. So in a way, it will bring back to the same problem. But when we analyse the efficiency of the IC engine and the turbines fossil fuel are more efficiently burned in power plants.

3.2.1 Consumption by the transportation sector

M/s Nielsen (India) Pvt Ltd conducted an all-India study for the Petroleum Planning and Analysis Cell (PPAC) of the Petroleum Ministry, which revealed interesting data on the use of diesel and gasoline sold in various states. According to a report submitted to PPAC by an all-India survey, the transportation sector consumes 70% of diesel and 99.6% of gasoline. Also, it was revealed that private cars and UVs account for 13.15 per cent of diesel sold in the country, commercial cars and UVs account for 8.94 per cent, and 3-wheelers account for 6.39 per cent. In the case of gasoline, 99.6 per cent is consumed in the transportation sector. Two-wheelers account for 61.42 per cent of total consumption, with cars accounting for 34.33 per cent and three-wheelers accounting for 2.34 per cent.

In total India had consumed almost 29975000 metric tonnes of petrol (motor spirit) and almost 82602000 tonnes of high-speed diesel in the year April 2019 to March 2020. Of which 99.6 percentage of the petrol and 28.5 percentage of Diesel is consumed by three-wheelers, cars and UVs which are can move to electric segment. So 29855100 metric tonnes of petrol and 23541570 tonnes of high-speed diesel.

3.2.2 Crude oil equivalence of the consumption of half the vehicles

29855100 metric tonnes of petrol and 23541570 metric tonnes of high-speed diesel of had been used by transport sector especially two-wheelers, three-wheeler, cars and

UVs. Half of this is converted to electric then 14927550 metric tonnes of petrol and 11770785 metric tonnes of high-speed diesel can be taken out the import.

After a single barrel of crude oil (equivalent to around 159 litres) was refined, the volume of the finished products was greater than the volume of the crude oil itself. The final 170 litres are made up of about 73 litres of gasoline, 40 litres of diesel and heating oil.

Crude oil requirement of petrol equal to 14927550 metric tonnes multiplied by 159 and then divided by 73. Which gives us 32,513,430.82 metric tonnes of crude oil.

Crude oil requirement of diesel equal to 11770785 metric tonnes multiplied by 159 and then divided by 40. Which gives us 46,788,870.38 metric tonnes of crude oil.

Since both petrol and diesel can be made from the same cured oil we have to choose the highest value of crude oil. That is 46,788,870.38 metric tonnes of crude oil. Which are 342962420 barrels which are almost equal to **20.5 billion USD**. Barrel price had been taken as 60 USD by analysis of the pre-pandemic situation and current.

3.2.3 Power requirement for the corresponding electric vehicles

In petrol, Two-wheelers account for 61.42 per cent of total consumption, with cars accounting for 34.33 per cent and three-wheelers accounting for 2.34 per cent.

Table 1: Total power requirement for running half of the vehicles

Segment	Petrol consumption in a year ('00,00,000)litre	Distance travelled in a year ('00,00,000)kM	Power consumed for travel TWh
Two-wheelers(Petrol)	916.85	45842.50	10.62
Three-wheelers(Petrol)	34.93	873.26	0.71
Three-wheelers(Diesel)	75.22	1880.38	1.51
Cars(Petrol)	512.46	7686.94	11.48
Car and UVs (Diesel)	260.01	5200.33	7.76
Total Power consumption			32.08

*mileage of two-wheeler is taken as 50 km/L, three-wheeler as 25 km/L and cars as 15 km/L

*power consumed = (distance X power per km)/1000000

3.2.3.1 Power consumption by individual segment

For the conversion, we have to select one model for each

segment. So we have selected Hero Electric Photon as the electric version of two-wheelers, Mahindra Treo SFT for the three-wheeler segment and TATA Nexon EV XZ+ car segment.

Table 2: Total power requirement for running one kilometre

Type of Vehicles	Distance per full charge kM	Battery Power KWatts	Power required for travelling 1 kM Unit
Hero Electric Photon	80	1.2	0.023
Mahindra Treo SFT	141	7.37	0.080
Nexon EV XZ+	312	30.2	0.149

Unit current needed for traveling one k M = $B.C. / (D \times C_{char} \times C_{dis} \times CT)$ kWatt / H

Where,

B.C.=Battery capacity of the vehicle

D=distance travelled on a full charge of the Battery (mileage of full charge)

C_{char} =Coefficient of charging efficiency of battery =.90

C_{dis} =Coefficient of discharging efficiency of battery =.90

CT=Coefficient of power used for transport=.80

3.2.4 Additional load of the power supply of the nation

As per the government report, India has generated around 1,598 TWh. If we add this segment of vehicles to the grid then there is an additional 30.08 TWh to the total production. Which is merely an increase of roughly 2 percentage of the total production.

3.2.5 Reduction in the Air pollution

The major pollutants that come from IC engines are CO₂, CO, NO_x unburned hydrocarbons (HC) and other particulate emissions.

Diesel weighs 835 grams per litre. Diesel contains 86.2% carbon or 720 grams of carbon per litre of diesel. 1920 grams of oxygen are needed to convert this carbon to CO₂. The total CO₂/litre diesel is then 720 + 1920 = 2640 grams. On average Diesel requirement of half of the 28.5 % of the diesel IC engines equal to 11770785 metric tonnes. So a total of 31,074,872 metric tonnes of CO₂ can be taken out.

One litre of gasoline weighs 750 grams. Petrol has an 87 per cent carbon content, or 652 grams of carbon per litre. 1740 grams of oxygen are needed to convert this carbon to CO₂. The sum is 652 + 1740 = 2392 grams CO₂/litre of gasoline. On an average petrol requirement of half of the petrol IC engines equal to 14927550 metric tonnes. So a total of

35,706,699 metric tonnes of CO₂ can be taken out.

LIMITATION OF THE STUDY

In this research, the Environmental impact is calculated by only considering the carbon dioxide count. There are other harmful gases emitted from the tail end of the vehicle such as Carbon mono oxides, different Nitrites, sulphites, unburned fuel droplets, lead oxides etc. which has not been considered in the research.

This research had only considered transportation done by two-wheelers, three-wheeler, cars and UVs, whereas other segments such as big trucks, buses and trains can also be converted to electric. The technology is getting ready. Few companies have already launched some products in this category.

SCOPE FOR FURTHER RESEARCH

As mentioned, there are other harmful gases emitted from the tail end of a vehicle such as Carbon mono oxides, different Nitrites, sulphites, unburned fuel droplets, lead oxides etc. which has not been considered in the research. So a further study can be conducted to analyse how much is the actual environmental benefit if half of these vehicles are converted to EV.

RESULTS

If half of the transportation especially transportation done by two-wheelers, three-wheeler, cars and UVs in the nation is converted to electric means then we can save around 20.1 billion USD per year. If at all this much reduction happen in the current account. This is more than enough to make the current account surplus for the nation. Which is equivalent to 118 Rafale aircraft every year.

The additional load on the power grid is merely 2 percentage of the current capacity. One of the major advantages of EV adaptation is that. This additional load can bring balance in the capacity utilization of the power plants. These loads are connected to the grid mostly at night time so which will bring balance to the power grid. That implies additional installation are not needed much.

In term of pollution, the data show that if at all half the vehicles are converted into electricity 62.14 million metric tonnes of CO₂ can be taken out of the atmosphere. Along with that considerable amount of carbon mono oxide, sulphate, nitrites, unburned hydrocarbons (HC) and other particulate emissions.

CONCLUSION

The research shows that the conversion of half of the vehicles population into electricity is not only just an effective decision to save a lot of money in term of the balance of payment but also it will aid the nation in its sustainable development goal. The result shows that if half

of the transportation of the vehicles done in India especially transportation done by two-wheelers, three-wheeler, cars and UVs which have market-ready technology, is done by electric means then we could save 20.1 billion USD every year. Also, this will reduce a substantial amount of pollution. At very least 14 million metric tonnes of CO₂ emission can be removed from the atmosphere every year. Along with that considerable amount of carbon mono oxide, sulphate, nitrites, unburned hydrocarbons (HC) and other particulate emissions.

REFERENCES

- Anenberg, S.C., Miller, J., Henze, D.K., Minjares, R., & Achakulwisut, P. (2019). The global burden of transportation tailpipe emissions on air pollution-related mortality in 2010 and 2015. *Environmental Research Letters*, 14(9), 094012.
- Dalei, N.N., & Gupta, A. (2020). India's Crude Oil Consumption: Empirical Estimations and Future Projections. In *Energy, Environment and Globalization* (pp. 17-33). Springer, Singapore.
- Dhruvil B. Gohil, Apostolos Pesyridis and Jose Ramon Serrano (2020) Overview of Clean Automotive Thermal Propulsion Options for India to 2030. *Applied science*
- Dr. Chhabi Sinha Chavan. (2014). Future of sustainable personal mobility solution in India. *International Journal of Case Studies*, 3(2014-08), 01-08
- Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*, 48(2012), 717-729. <https://doi.org/10.1016/j.enpol.2012.06.009>
- Figenbaum, E. (2017). Perspectives on Norway's supercharged electric vehicle policy. *Environmental Innovation and Societal Transitions*, 25, 14-34.
- Gareev, R.G. (2002). Power supply and energy conservation in fractional distillation of crude oil. *Chemistry and technology of fuels and oils*, 38(2), 75-80.
- Guttikunda, S. K., Nishadh, K. A., & Jawahar, P. (2019). Air pollution knowledge assessments (APnA) for 20 Indian cities. *Urban Climate*, 27, 124-141.
- Hawkins, T.R., Singh, B., Majeau-Bettez, G., & Strømman, A. H. (2013). Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles. *Journal of Industrial Ecology*, 17(1), 53-64.
- Joshi, A. (2019). Review of vehicle engine efficiency and emissions. *SAE International Journal of Advances and Current Practices in Mobility*, 1(2019-01-0314), 734-761.
- Juyal, S., Sanjeevi, H., Saxena, A., Sharma, S., Singh, A., Chander, S., & Jhunjhunwala, A. (2019, April 7). Zero emission vehicles (ZEVs): towards a policy framework. NITI Aayog, 1-20. Retrieved from http://niti.gov.in/writereaddata/files/document_
- Karden, E., Ploumen, S., Fricke, B., Miller, T., & Snyder, K. (2007). Energy storage devices for future hybrid electric vehicles. *Journal of Power Sources*, 168(1 SPEC. ISS.), 2-11. <https://doi.org/10.1016/j.jpowsour.2006.10.090>
- Kumar, R., & Padmanaban, S. (2019). Electric vehicles for India: overview and challenges. *IEEE India Informatics*, 14, 139.
- Li, Y., Lim, M. K., Tan, Y., Lee, Y., & Tseng, M. L. (2020). Sharing economy to improve routing for urban logistics distribution using electric vehicles. *Resources, Conservation and Recycling*, 153, 104585.
- Li, Z., & Ouyang, M. (2011). A win-win marginal rent analysis for operator and consumer under battery leasing mode in China electric vehicle market. *Energy Policy*, 39(6), 3222-3237.
- Ma, Z., Callaway, D. S., & Hiskens, I. A. (2013). Decentralized charging control of large populations of plug-in electric vehicles. *IEEE Transactions on Control Systems Technology*, 21(1), 67-78. <https://doi.org/10.1109/TCST.2011.2174059>
- Mittal, S., Dai, H., & Shukla, P. R. (2016). Low carbon urban transport scenarios for China and India: A comparative assessment. *Transportation Research Part D: Transport and Environment*, 44, 266-276. <https://doi.org/10.1016/j.trd.2015.04.002>
- Nagendran, R., & Senthil Kumar, K. (2010). Hybrid electric bike with three speed transmission system an energy efficient bike for next generation. *ICCET 2010 - 2010 International Conference on Computer Engineering and Technology, Proceedings*, 7, 133-135. <https://doi.org/10.1109/ICCET.2010.5485320>
- Parker, A. A., & Alan, A. (2004). The electric power assisted bicycle: a clean vehicle to reduce oil dependence and enhance the mobility of the elderly. In *International Conference on Sustainability Engineering and Science*, Auckland, New Zealand. <http://web.mac.com/parker15/pubs20002004>.
- Reşitoğlu, İ. A., Altinişik, K., & Keskin, A. (2015). The pollutant emissions from diesel-engine vehicles and exhaust aftertreatment systems. *Clean Technologies and Environmental Policy*, 17(1), 15-27.
- Susan C Anenberg, Joshua Miller, Daven K Henze, Ray Minjares and Pattanun Achakulwisut (2019). The global burden of transportation tailpipe emissions on air pollution-related mortality in 2010 and 2015. *Environmental Research Letters*, 14(9).
- Tarei, P. K., Chand, P., & Gupta, H. (2021). Barriers to the adoption of electric vehicles: Evidence from India. *Journal of Cleaner Production*, 291, 125847.
- Vidhi, R., & Shrivastava, P. (2018). A review of electric vehicle lifecycle emissions and policy recommendations to increase EV penetration in India. *Energies*, 11(3), 483.
- Hero Electric hero electric photon specs [online] <https://heroelectric.in/photon/> (Accessed 13 March 2021)
- International council on clean transportation Air pollution challenge in India [online] <https://theicct.org/india#:~:text=Transportation%20sources%20account%20for%20approximately,low%20per%20capita%20transportation%20emissions.> (Accessed 13 March 2021)
- Mahindra Electric Mahindra electric tree prices [online] <https://www.mahindraelectric.com/vehicles/tree-electric-auto/#:~:text=The%20new%20Mahindra%20Tree%20is,certified%20range%20of%20141%20km.> (Accessed 12 March 2021)
- Ministry of new and renewable energy, Government of India [online] INITIATIVES & ACHIEVEMENTS [online] <https://mnre.gov.in/> (Accessed 10 March 2021)
- Ministry of power, Government of India annual report 2019-20 [online] https://powermin.nic.in/sites/default/files/uploads/MOP_Annual_Report_Eng_2019-20.pdf (Accessed 12 March 2021)
- Ministry of power, Government of India Generation Capacity executive summery [online] <https://powermin.nic.in/en/content/generation-capacity> (Accessed 12 March 2021)
- Petroleum ministry, Government of India India petroleum and natural gas statics [online] http://petroleum.nic.in/sites/default/files/pngstat_1.pdf (Accessed 19 March 2021)
- Petroleum planning and analysis cell, Government of India cure oil price India basket [online] https://www.ppac.gov.in/content/149_1_PricesPetroleum.aspx (Accessed 19 March 2021)
- Press Information Bureau, Government of India INDIA'S FOREIGN TRADE: March 2020 [online] <https://pib.gov.in/PressReleaseDetail.aspx?PRID=1614754> (Accessed 15 April 2021)
- Press Information Bureau, Ministry of finance -Government of India India's Balance of Payments Position Improves, as Current Account Deficit Declines Further: Economic Survey [online] <https://pib.gov.in/newsite/PrintRelease.aspx?relid=197786#:~:text=The%20Union%20Minister%20for%20Finance,forex%20reserves%20in%20March%2C%202019.> (Accessed 31 January 2021)
- Press Information Bureau, Ministry of Petroleum & Natural Gas-

Government of India Results of the Survey [online]
[https://pib.gov.in/newsite/printrelease.aspx?relid=102799#:~:text=As%20per%20the%20All%20India,UVs\)%20and%203%2Dwheelers.](https://pib.gov.in/newsite/printrelease.aspx?relid=102799#:~:text=As%20per%20the%20All%20India,UVs)%20and%203%2Dwheelers.)
(Accessed 1 January 2021)

Tata Nexon (2021, March 12) Tata exon EXV+ specs[online]
<https://nexonev.tatamotors.com/> (Accessed 12 March 2021)