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# HOLISTIC STUDY OF ELECTRIC VEHICLES AND CHECK ON THEIR ECONOMIC AND ENVIRONMENTAL FEASIBILITY

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## INTRODUCTION TOELECTRIC VEHICLES

Electric vehicles are those which use one or more electric motors instead of any other fuel for vehicle propulsion. These vehicles are further sub divided into two heads. One, is Hybrid electric vehicles (HEV), they generate all their electricity on board the vehicle. These include all the varieties of hybrids that use electric motors for traction, including series hybrids, parallel hybrids, through the road hybrids and mild hybrids. Stop start vehicles are not included in HEV category. Another is Plug in hybrid electric vehicle, these vehicles use energy stored from grid but also have an ICE to extend the range of vehicles. Third category is Battery electric vehicles, these include vehicles which use energy stored in it.

## WORLD WIDE HISTORY OF ELECTRIC VEHICLES

**1832-1839:** Scottish inventor Robert Anderson invented the first crude electric carriage powered by non-rechargeable primary cells.

**1835:** American Thomas Davenport is credited with building thefirst practical electric vehicle -- a small locomotive.

**1859:** French physicist Gaston Plante invented the rechargeablelead-acid storage battery. In 1881, his countryman Camille Faure improved the storage battery's ability to supply current and invent the basic lead-acid battery used inautomobiles.

**1891:** William Morrison, a chemist from Des Moines,Iowa, built the first successful electric automobile in theUnited States.

**1893:** A handful of different makes and models of electric cars exhibited in Chicago.

**1897:** The first electric taxis hit the streets of New YorkCity early in the year. The Pope Manufacturing Companyof Connecticut became the first large-scale Americanelectric automobile manufacturer.

**1899:** Believing that electricity will run autos in the future,Thomas Alva Edison began his mission to create a long-lasting,powerfulbattery forcommercialautomobiles.Thoughhisresearchyieldedsomeimprovementstothe alkaline battery, he ultimately abandoned his quest a decade later.

**1900:** The electric automobile was in its heyday. Of the 4,192 cars produced in the United States 28 percent were powered by electricity, and electric autos represented about one-third of all cars found on the roads of New York City, Boston, and Chicago.

**1908:** Henry Ford introduced the mass-produced and gasoline-powered Model T, which had a profound effect on the US automobile market.

**1912:** Charles Kettering invented the first practical electric automobile starter. Kettering's invention made gasoline-powered autos more alluring to consumers by eliminating the unwieldy hand crank starter and ultimately helped pave the way for the electric car's demise.

**1920:** During the 1920s, the electric car ceases to be a viable commercial product. The electric car's downfall is attributable to a number of factors, including the desire for longer distance vehicles, their lack of horsepower, and the ready availability of gasoline.

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**1966:** Congress introduced the earliest bills recommending use of electric vehicles as a means of reducing air pollution. A Gallup poll indicated that 33 million (18%) Americans are interested in electric vehicles **(out of 179 million total population of America, 1960 census)**.

**1970s:** The Clean Air Act was established, which required states to take control of their air quality and meet certain standards by deadlines. The OPEC oil embargo of 1973, which skyrocketed gasoline prices, also sparked interest in alternatives to fueled vehicles.

**1972:** Victor Wouk, the "Godfather of the Hybrid," built the first full-powered, full-size hybrid vehicle out of a **1972 Buick Skylark** provided byGeneral Motors (G.M.) for the 1970 Federal Clean Car IncentiveProgram. The US Environmental Protection Agency certified that Wouk'svehicle **met the strict guidelines for an EPA clean-air autoprogram** and **REJECTED IT.**

The story about the vehicle and its inventor, who died in May, 2005, at age 86, is unknown to today's hybrid/electric car movement. America was ahead of all other countries in hybridcar science at least by three decades ahead.[1]

**EV'S INDIAN SCENARIO**

Indian automobile industry is currently the 5th largest in the world and is set to take over 3rd largest automobile industry by 2030.[2]It was the year 2000 when revolution in Indian automobile sector came and India's first electric car Reva was launched by Mahindra which made the manufacturers think and created a shift towards electric cars. Indian scenario in terms of EV manufacturing is quite different in comparison to global arena. Current market share of EVs is 0.1%. At present most vehicles relay on fossil fuel-based transportation.[3]In 2010 Toyota introduced Prius hybrid model in Indian market and has followed it up by introducing Camry hybrid in 2013. Recently, a couple of Indian announced plans to introduce electric cars in short to medium term (Banerjee 2013, Tata Motors 2012).[4]

**KEY MILESTONES TO EV POLICY IN INDIA[5]**

1. FIRST AUTOMATED MISSION PLAN (2006-2016)

(huge push towards making India a global hub for small cars and quality auto components).

2. MNRE INCENTIVE SCHEME FOR EV

(was withdrawn in March 2012 to be introduced as NEMMP 2012 but no incentives were given tillFAME was introduced)

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[1]VepacheduSreenivasarao, *The History of Electric Car*, Andhra Journal of Industrial News (1-3), (01/09/2017).

[2]Innovation Norway, *Indian Ev Story: Emerging Opportunities (2017)*available at https://www.innovasjonnorge.no/contentassets/815ebd0568d4490aa91d0b2d5505abe4/india-ev-story.pdf

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[3]Pritam k. Gujarathi, Varsha A. Shah and Makarand M. Lokhande, *Electric Vehicles in India: Market Analysis with Consumer Perspective, Policies and Issues,* Journal of green engineering (January, 2018) available at: https://doi.org/10.13052/jge1904-4720.813**,** last visited at October 8,2019

[4] P.R. Shukla and Subash Dhar, *Electric vehicle scenarios and roadmap for India* (january,2015) available at: https://www.researchgate.net/publication/271447336 , last visited at october1, 2019

[5] Innovation Norway, *Indian Ev Story: Emerging Opportunities(2017)* available at https://www.innovasjonnorge.no/contentassets/815ebd0568d4490aa91d0b2d5505abe4/india-ev-story.pdf

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3. NEMMP 2020(national electric mobility mission plan)

(EV industry got major policy boost)

4. FAME (FASTER ADOPTION & MANUFACTURING OF ELECTRIC VEHICLES 2015)

(manufacturing of hybrid electric vehicles was carried out)

5. SECONDARY AUTOMOTIVE MISSION

(launched as plan 2016-2026 in September 2015)

6. NITI AYOG Roadmap

(launched in 2017 as reformative mobility solutions for all)

**NEMMP 2020**

The National Electric Mission Mobility Plan 2020 has two objectives interrelated within its sphere: -

- National energy security.
- Growth of domestic manufacturing capabilities in full range of electric vehicles technologies.

In January 2012, the ministry of heavy industries unveiled its ambitious draft action plan for Electric Mobility 2020, which targets almost six to seven million vehicles on the road by 2020. With vision to encourage reliable, affordable and efficient XEVs (all type of electrical vehicles) that meet consumer performance and price expectations through Government – Industry collaboration for promotion and development of indigenous manufacturing capabilities, required infrastructure, consumer awareness and technology. Thereby helping India to emerge as a leader in the XEV two-wheeler and four-wheeler market in the world by 2020, with total XEV sales of 6–7 million units thus enabling Indian automotive Industry to achieve global XEV manufacturing leadership and contributing towards National fuel security.[12]

**FAME**

It was launched in April 2015 in order to achieve to goals of NEMMP 2020 plan. Under the FAME scheme government of India will provide various incentives in form of discounts and rebates to achieve lower purchasing cost of Electric vehicles. Under this discount-based incentive policy government spent 14,000 crores for customers purchasing vehicles and manufacturers performing research and development.[3] This FAME policy basically focused four major core areas of Technology Development, Pilot projects, Demand Generation and charging infrastructure for EVs.

**CURRENT POLICY BARRIERS AND FAILURES**

Present challenge in current EV policy framework is that it'smimicking of chicken and egg dilemma. As of now there exists no formal policy structure or announcement for regulating the EV. Although NITI AYOG is mandated to come up with set policy framework but the same is not declared yet and also it is implementation is another question that strikes the mind of customers and manufacturers. Government of India implemented NEMMP but no declaration of responsibilities and duties is done to the concerned authorities which is acting a pivotal to these plans.

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[1]*The National Electric Mobility Mission Plan-2020*, Ministry of Heavy Industries & Public Enterprises, Government of India, Available at: http://dhi.nic.in/NEMMP2020.pdf

[2]*Electric Vehicles in India Policies, Opportunities and Current Scenario* ADB Open Innovation Forum, Manila, 2015.

[3] Innovation Norway, *Indian Ev Story: Emerging Opportunities(2017)* available at https://www.innovasjonnorge.no/contentassets/815ebd0568d4490aa91d0b2d5505abe4/india-ev-story.pdf

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Policy related challenges includes choosing and instituting policy instruments to promote EVs, setting up infrastructure, incentivize automobile manufactures to produce and induce customers to switch to EVs[1]. These barriers could only be removed by proper policy frameworks and their implantations on ground levels. Until asymmetry exists between market (including manufactures and consumers) and policy makers no potential growth could be made.

**ENVIRONMENTAL IMPACT BY EV INTRODUCTION**

**LITHIUM BATTERY CONSEQUENCES**

Air pollutants including particulate matter (PM), Sulphur dioxide ($SO_2$), nitrogen oxide (NOx), carbon monoxide (CO), and ozone ($O_3$) often exceeds the National Ambient Air Quality Standards (NAAQS) in Indian cities. Vehicle manufacturing and industry, construction activities, road dust, and solid biomass combustion are most commonly identified sources of air pollution.[2] Several of Indian government's policies that focused on using a cleaner energy fuel did reduce vehicular emission during 2000s[3], electric vehicles is one of those strategies.

Adopting electric vehicles as alternative presents most unique challenge of disposing of Lithium-ion batteries.[4] Battery production process for Lithium batteries also emits several air pollutants including Sulphur dioxide, nitrogen oxide and carbon dioxide.[567]Lithium battery is most commonly used batteries currently for electric cars.[8] Increasing demand for electric cars will automatically increase demand for Lithium and consequently lead to increase in manufacturing of lithium based batteries. Increasing demand for lithium will

[1] P.R. Shukla and Subash Dhar, *Electric vehicle scenarios and roadmap for India* (january,2015) available at: https://www.researchgate.net/publication/271447336 , last visited at october1, 2019

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[3] Niti Aayog and Rocky Mountain Institute, Indian leaps ahead : Transformative mobility solutions for all (2017)

available at : https://www.rmi.org/insights/reports/transformativemobilitysolutionsindia visited on: october6, 2019

[4] Mohr S.H., Mudd G.M., Giurco D., Lithium resources and production: critical assessment and global projections. Minerals 2012,2,(65-84).

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Batteries to the Environmental Impact of Electric Vehicles. Environ. Sci. Technol. **2010**, 44, 6550–6556.

[6] Mohr, S.H.; Mudd, G.M.; Giurco, D. Lithium Resources and Production: Critical Assessment and

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analysis and process optimization of batteries based on life cycle assessment. J. Clean. Prod. **2018**, 174, 1262–1273

[8]Girardi, P.; Gargiulo, A.; Brambilla, P.C. A comparative LCA of an electric vehicle and an internal

combustion engine vehicle using the appropriate power mix: The Italian case study. Int. J. Life Cycle Assess.

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result in lithium mining, as less than 1% of lithium can be recycled today. It is estimated that close to 40% Lithium will be recyclable in 2050[1] but non-recyclable one will pose hazardous health issues.

The manufacturing process for lithium-based batteries too causes air pollution but as this pollution is caused at manufacturing sites, which are usually located farther from the densely populated areas where hydrocarbon-based cars cause pollution today, the net air pollution in the populated location decreases. A less polluting battery manufacturing process may be invented in future, further reducing air pollution. But if a pollution reducing battery manufacturing process is not invented in future, air pollution due to this process may become an environmental concern. Also, as the exhaust from this process is emitted through high stacks, these gases may cause an impact that is different from what we are used to seeing today.[2]

**AIR POLLUTION**

Studies in India and U.S.A have shown that EVs helps in reducing air pollutant emissions and $CO_2$ emission in long term[3] if the incremental load is supplied through non -emitting generation.[4]

As per the statistics from India energy mix 2015[5]is as follows:

Renewable sources- 6.2% in total

- 2.2% from renewable sources such as solar and wind.
- 4% is in the form of hydro electricity

Non-Renewable sources- 93.7% in total

- 27.9% oil.
- 6.5% natural Gas
- 58.1% coal
- 1.2% nuclear

Introduction of EVs in India will create air pollution because major sources for electricity generation in India are non- renewable in nature. Indian government though has proposed the policy for producing 100 GW of solar power and 40 GW of wind power by the year 2022. If the goal set is achieved successfully then Indian energy mix will be transformed with more than 25% of the energy coming from renewable sources by 2022[6]

[1]Mohr, S.H.; Mudd, G.M.; Giurco, D. Lithium Resources and Production: Critical Assessment and Global Projections. Minerals **2012**, 2, 65–84

[2] Girardi, P.; Gargiulo, A.; Brambilla, P.C. A comparative LCA of an electric vehicle and an internal combustion engine vehicle using the appropriate power mix: The Italian case study. Int. J. Life Cycle Assess. **2015**, 20, 1127–1142.

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and by 2030 the numbers will increase to 50%.[1]But if the energy generation continues at the same pace then shifting towards e vehicles will possess the challenge for Indian automobile industry. Shifting in present time will be of the nature in front there is a well and at the back is a trench. So, need for proper fuel generation system exists.

**NON-EXHAUSTIVE POLLUTION EMISSION**

Vehicles when run on roads emit two different nature of pollution one is exhaustive in nature caused by emission of CO2 and SO2 due to fuel exhaustion and another is non-exhaustive in nature which is caused by abrasion, road surface dust, driving style, breaks, clutch and tires. PM10 level released by both fuel run vehicles and clean energy vehicle is same in case of non-exhaustive emissions.

**ECONOMIC AND INDUSTRIAL DYNAMIC INFLUENCES**

Indian vision of e vehicle scenario is very much dependent on industrial dynamics. Introducing clean energy run vehicles in country will give a shot to new industry but the existing industries such as petroleum and Natural Gas will definitely going to suffer. Entire transportoptimization algorithms will be changed automobile sector will face more crisis and thus economic loss could be foreseen.

Automobile sector in India is already facing a slowdown in demand weaking the economic growth and liquidity crunch. India's biggest car company Maruti Suzuki is already going in loss and announced shut to production of diesel engine cars by year 2020. 6% cut in temporary workforce is announced by company. In month of July Maruti Suzuki's sales reported 33.5% dip. Cumulative sales of Hyundai motors also witnessed fell of 3.8%. Mahindra and Mahindra registered a fall of 15% in total sales of July, 2019.[2]

In India various many micro mini companies exists as auto ancillary companies for diesel and petrol and introduction of EV will hamper their existence for sure.

In such a critical situation if experiment with introducing clean energy fuel runned vehicle is done there might occur condition of economic loss and industrial threats. Policies and proper survey of the market is ultimate need before new introductions. A careful hand hold policy is required to make EV component implementation.

**INFRASTRUCTURAL REQUIREMENTS FOR EVs**

To make EVs work in India one of the essential requirements is charging infrastructure. Affordable availability of both AC and DC charging is needed for meeting customer needs. There are two means for providing energy to vehicles they are either adopt battery swapping or battery changing. Battery swapping needs another business of Batteryoperator who will take discharged battery charge the same in return and provide charged batteries on lease. But to make vehicle run this infrastructure required availability of energy operators easily. These energy operators can also deploy battery charging stations to meet needs of the customers. Further installation of charger on roads is required.

Presently 15 firms are supplying EV Chargers in India out of thoseonly 3 deals in 4W, AC Chargers so. RRT Electro Power Chennai, Mass Tech Controls Mumbai, Exicom New Delhi are the companies that deals in 4 wheelers AC chargers. All of these are mostly Power Electronics & Battery Charger manufacturers who have diversified into EV Chargers. 10-12 firms in small 2W AC Chargers who supply along with their

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online: http://shaktifoundation.in/wp-content/uploads/2014/02/Report-on-Indias-RE-Roadmap-2030full-report-web2.pdf last visited september29, 2019

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[2]Varun Singh,Indian automobile industry under intense pressure, major companies witness sales decline in July 2019, available at https://www.indiatoday.in/auto/latest-auto-news/story/major-indian-automobile-companies-witness-sales-decline-in-july-2019-1576200-2019-08-01 (last visited on 20 November, 2019)

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vehicles and a fewOEMs for EV Chargers.[1]To meet such high need for infrastructure minimum skeleton network of 4,230 public charging stations in 53 cities with a million plus population has been planned under FAME-II, but even that is just 1% of what is required to meet the needs of the targeted 30% of all vehicles by 2030.[2] No convincing step by the government is taken in the matter which does not give an encouraging message for such a big shift.

**POWER REQUIREMENTS**

However, with high cost of EVs and less infrastructure government is optimistic for EV success but the other point which could not be ignored is electricity requirement. Power cuts are quite rampant in India. So, to run such high number of power station what is needed is reliable excess power supply into which we are still lacking behind.

**CONCLUSION**

There is no doubt that there exist many merits for going towards Electric vehicle times but need should match appropriately with the efforts of government and requirement of customers. To have successful execution of electric vehicle programme, India as to make better policies and regulating framework for the same. Successful implementation of E vehicle programme depends upon coordination between infrastructure policies of government and ability of consumers to participate in the drive.

EVs possess various challenges such as higher cost, need of power, proper infrastructure, good government policies with incentivized programmes. Paper clearly identifies opportunities and threats for EVs in India. Existence of large market size and reduction in pollution emission are the opportunities for Evs to excel in the fields. Threats possessed are no clear horizons for EV emergence, existence of strong auto strong and infrastructure challenges.

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