

The Need and Urgency of Electric Vehicles or EVs in World today

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ABSTRACT

Mitigating Environmental pollution poses one of the greatest challenges to mankind and therefore the race against time is on to search for technologies and devices that can reduce or at best make the entire processes carbon free. The rate of generation of carbon dioxide from industrial and transportation sectors is causing increase in percentage share of major greenhouse gas - carbon dioxide this is causing rise in average global temperatures over decades with serious ramifications, transportation sector is one of the major contributors to greenhouse gases. The major sinks of carbon dioxide the Amazon forests on land called “lungs of Earth” are shrinking and together with largest sink -The Oceans are unable to sequester the carbon dioxide generated by man. To maintain balance, we have to adopt carbon free cycles and Electric Vehicles with their battery charging from renewable sources viz, solar, wind and hydel generators shall make this cycle carbon free. This is the need of the hour as by 2030 quarter of energy generated shall be consumed by transportation sector and making its cycle carbon free shall greatly help in reducing major greenhouse gas - carbon dioxide.

Keywords: Paris climate treaty, Renewable generation sources, Lithium carbonate, Lithium hydroxide, SOH (state of health), half reaction, Solid state batteries

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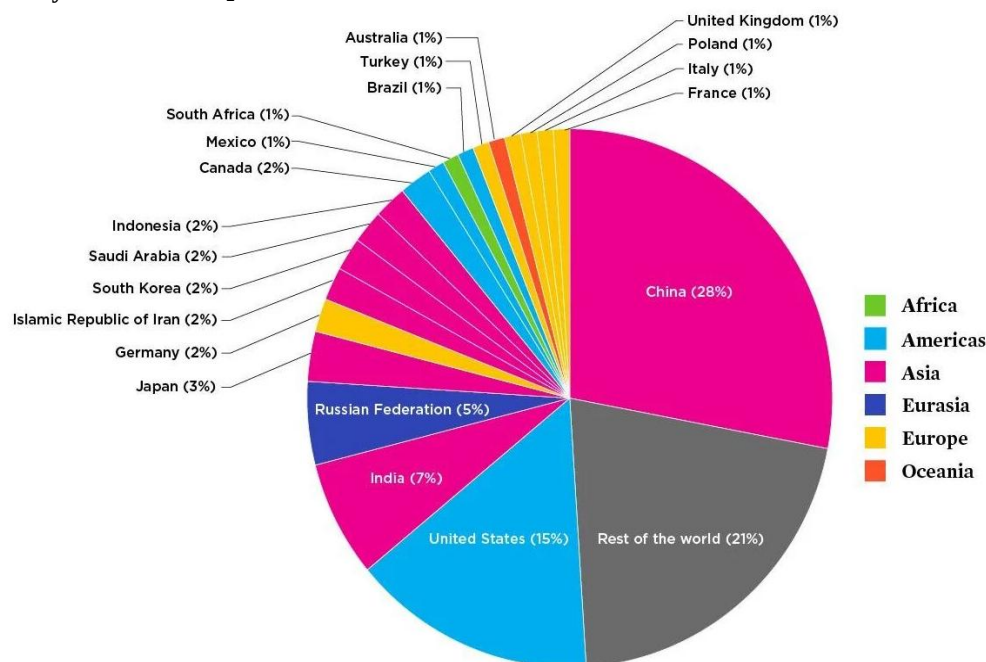
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1. Introduction

The world is on the cusp of another automobile revolution this time change is from IC engines to electric. This change is hastened by two reasons. financial & environmental.

- (1) **Financial reasons:** Take the case of India for instance, Petroleum import which is at present 150 billion dollars is expected to inflate up to 300 billion dollars by 2030. Use of EVs sourcing their charge of batteries from renewable sources of generation viz, solar, wind shall not only save petroleum import costs for India but also make entire cycle of EVs carbon free.
- (2) **Environmental reasons:** India is a signatory to Paris climate treaty, which envisages that India is to reduce its GHG emissions intensity by 33.3% below 2005 levels by 2030. Present carbon dioxide emissions are annually 2066 million tons (2015 figures). Global net emissions caused by humans of carbon dioxide need to fall by about 45% from 2010 levels by 2030, reaching to net zero by 2050. It is necessary to keep average Global temperature at 1.5 degrees centigrade below pre-industrial levels instead of anticipated two-degree centigrade increase which will happen if no steps are taken today to mitigate, which would otherwise cause rising sea levels, extremes of weather. loss of biodiversity. food scarcity and will have impact on water supply. Human induced activities have increased average Global temperature by one degree centigrade above pre-industrial levels by 2017 already & this is increasing at the rate of 0.1 degrees centigrade every decade. Controlling Global temperature below 2 degrees centigrade would require \$480 billion in Clean Energy and Energy efficiency methods.

Each Country's Share of CO₂ Emissions

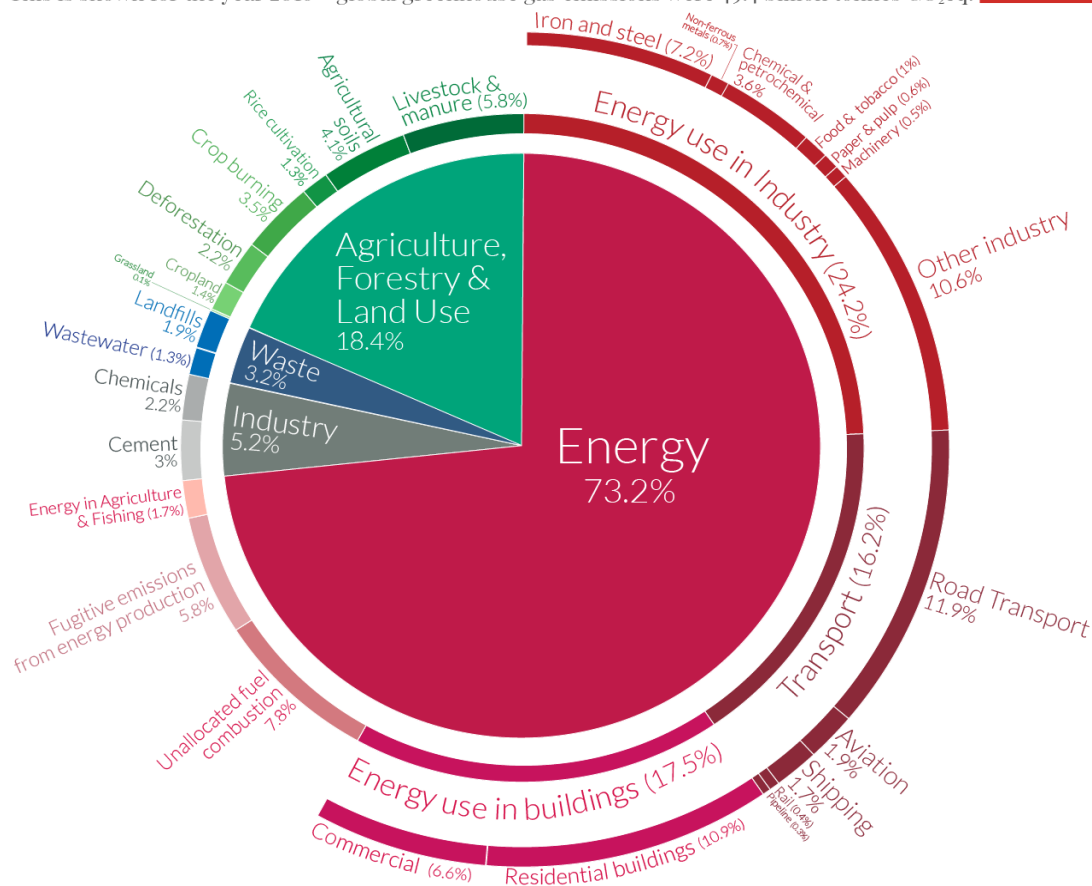


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Data: Earth Systems Science Data 11, 1783–1838, 2019

Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.

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Source: Climate Watch, the World Resources Institute (2020).

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2. Feasibility of Electric Vehicles

India had total registered motor vehicles figure of 230 million in 2016 out of which share of two wheelers stood at 73.5 % and share of cars including jeeps and taxis was 13.1 % i.e., about 29 million (source: offices of state transport commissioners/UT administration), and by 2022 this figure will increase to 40 million and further anticipated to increase up to 100 million by 2030.

Take the case of much touted Tesla car for instance whose Li-ion battery bank which can be charged to 85KWH (85 units of electricity) and this gives a mileage of 500km per charge. For charging 100 million cars by 2030 we shall be needing $85 \times 100 \text{ million} = 850 \text{ crore units}$ or 8.5 billion units of electricity, for on an average let us say let us say that a car needs a charge every third day in that case we will require at least 100 charging of car every year so the total units of electricity required to charge 100 million cars in a year shall be 8.5×100 that is equal to 850 billion units of electricity by 2030. Total anticipated generation capacity of India by 2030 shall be 850 Gigawatts including 60 gigawatts of Hydel power and 60% of the total generation capacity by 2030 is expected to come from Renewable Sources that is 510 Gigawatts, therefore the energy requirement in 2030 shall be around 2800 billion units and energy requirement for EVs shall be 850 billion units, this translates to 25% of the total energy generated in 2030 if only 80% cars are EVs. Energy consumption by 2030 in India by EVs alone is therefore anticipated to be around 25% of the total energy generated, this figure compares well with that of USA where transport sector today consumes 25% of the total energy generated. India gets great advantage by converting its IC engine vehicles to EVs. Its oil-import bill would considerably reduce. IC engines are a major contributor to pollution in cities and their replacement with EVs will definitely improve air quality.

Savings in costs of imported crude:

Take for example total projected population of cars as 10 crore by 2030 and a run of 25000 km/year and average mileage of 9 km/litre, then average consumption by a car would be roughly 2700 litres and for 10 crore cars this would be 27000 crore litres per year, at today's prices of about 100 Rs /litre this would be about 27 lakh crores/year and assuming that 50% of this is the cost of imported crude (as tax and other duties may be 50%), one may save $\square 13.5$ lakh crores worth of imported oil and if we take 170 million two-wheelers population of today only and assuming that each of these vehicles uses about half a litre of petrol daily or about 200 litres per year, the total amount of petrol used by such vehicles is about 34 billion litres. At $\square 100$ per litre, this would cost about $\square 3.4$ lakh crores and assuming again that 50% of this is the cost of imported crude (as tax and other duties may be 50%), one may save $\square 1.7$ lakh crores worth of imported oil and, so together with two wheelers figures of today, this would total about 15 lakh crores per year of saving in petrol costs to the nation.

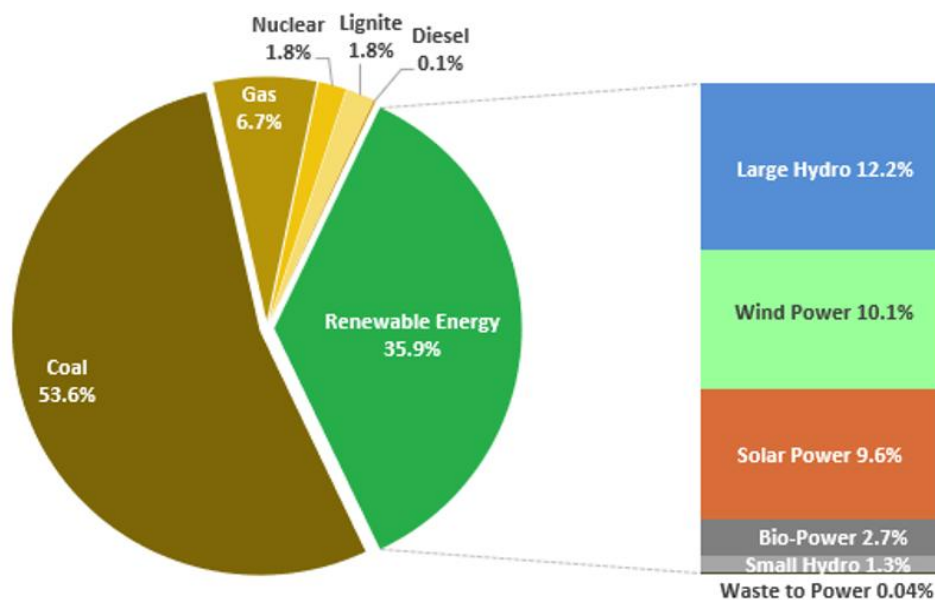
Projected Electricity Capacity in 2030		
FUEL TYPE	Capacity in GW	%
Hydro (large, small, and imports)	73.44	9%
Coal + Lignite	266.82	32%
GAS	24.35	3%
Nuclear	16.88	2%
Solar	300	36%
Wind	140	17%
Biomass	10	1%
Total Installed Capacity	831.5	
Total Non-Fossil Fuel (Hydro, Nuclear, Solar, Wind, and Biomass)	540.32	65%
Total Renewables (Solar, Wind, Biomass)	450	54%
Battery Storage	34 GW	

Source: Central Electricity Authority, Draft report on Optimal Generation Capacity Mix for 2029-30, Feb 2019

India - Cumulative Installed Power Capacity Mix (%)

MERCOM
India research

Renewables (including Large Hydro) comprise ~35.9% of India's total installed capacity, with solar accounting for ~9.6%. Among renewables, solar accounts for ~26.7% of the installed capacity



Data from CEA, MNRE, Mercom India Solar Project Tracker (Installed Capacity as on 31 Dec 2019)

Source: Mercom India Research

3. Economics of Electric Vehicles

Charge of 85-kilowatt hour on a Tesla car allows it to run 500 kilometres and the rate of Rs 7/ per unit, the cost of 85 units comes to around 600 rupees this means a mileage of 500 KM can be achieved in 600 rupees and the cost/ km is around 1 Rupee and 20 paisa and considering the maintenance charges on electric car are almost nil compared to conventional IC engine car as the moving parts in electric car are only 10% of IC engine car. The cost /km for a petrol car is around Rs 8/km and considering 1Rs/km maintenance charges, there is a saving of about 7Rs /km for EVs and if we consider a run of 25000 kilometres per year total savings Shall be 1.75 lacs/year and in 5 years EVs would have recovered 10 lacs in cost compared to an IC engine car.

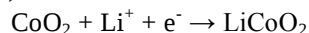
Batteries used in EVs car are that of Lithium-ion. These batteries are the most important component of EVs, it is also the component which forms the main cost of the EV. Lithium batteries are used because Lithium is the lightest known metal and is least dense solid element it has good electrochemical potential due to low melting point. Lithium carbonate is the main source of lithium some 5.3 tonnes of Lithium carbonate is used to produce one tonne of lithium.

An EV with 5000 cells would need around 10 kg of lithium, so about 60,000 Tonnes of lithium carbonate equivalent is required to produce 1 million electric cars, Tesla owner Elon Musk estimates that by 2027 to produce 30 million electric cars it would require 1.8MT of lithium carbonate equivalent. According to NS energy business. Global Lithium mineral Reserves are about 80 million tonnes with Bolivia holding 21 million Tons followed by Argentina 17 million tonnes, Chile 9 million tonnes, USA 9.8 million tonnes, Australia 6.5 million tonnes and China 4.5 million tonnes, India on the other hand has reserves of around 1600 tonnes lithium resources in rocks in Marlagalla-Allapatna region in Mandya district, Karnataka

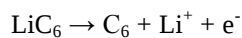
Lithium-ion batteries are preferred as they are:

- (1) Rechargeable and they are scalable (2) have higher energy density compared to rechargeable nickel-metal hydride batteries i.e., higher specific power per kilowatt besides a longer life cycle.
- (2) However due to their higher initial cost they cost up to 30% of total EV cost
- (3) Chemistry involved in Li-ion batteries:

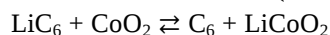
Reduction takes place at the cathode. There, cobalt oxide combines with lithium ions to form lithium-cobalt oxide (LiCoO_2). The half-reaction is:



Oxidation takes place at the anode. There, the graphite intercalation compound LiC_6 forms graphite (C_6) and lithium ions. The half-reaction is:



Here is the full reaction (left to right = discharging, right to left = charging):



4. Advantages of Electric Vehicles Over IC Engines

- (1) The largest source of climate pollution in the United States is transportation. To solve the climate crisis, we need to make the vehicles on our roads as clean as possible. We have time till 2030 to change the way we use energy to avoid the worst impacts of climate change.
- (2) Lesser moving parts so less maintenance.
- (3) Ease of charging even at home.
- (4) Electric motors have excellent torque and output characteristics due to which they can develop maximum torque from standstill and thus allow the EV to accelerate much faster than IC engine vehicles producing the same output.
- (5) EVs have high degree of efficiency up to 96% compared to 35-40% of IC engines.

5. Drawbacks of Electric Vehicles

- (1) Limited range due to battery size, Battery capacity and range are currently the Achilles' heel of the energy revolution that are keeping electric cars in second place to fossil fuel-powered vehicles.
- (2) However companies, like Tesla Toshiba, Panasonic, and Samsung are making great strides in improving range and battery capacity, but all have yet to fully surpass significant hurdles. Moreover, the life of battery is an important issue since it is the major cost component costing up to 30 % of total EV cost, However, the current prediction is that an electric car battery will last from 10 – 20 years before they need to be replaced. For example, Kia offers a battery pack warranty for 10 years or 100,000 miles, while Hyundai provides a lifetime coverage of its electric cars' batteries.
- (3) Charging takes long time depending upon battery charge and power source. Although fast charging battery can charge up to 80% of battery within 20 minutes are now coming up. Moreover, heat and lithium-ion do not pair well together. Cars that are located in hotter climates like India will typically experience a faster battery depletion. This is why most electric vehicles are equipped with a liquid-cooled battery pack. Another thing that can diminish batteries' lifespan is using fast-charging stations. These stations can charge the battery up to 80% in 30 minutes, but they can also overheat the battery. Analysts warns that this can affect the battery's long-term performance and longevity. A battery's condition is called its state of health (SOH). Batteries start their life with 100% SOH and over time they deteriorate. For example, a 60-kWh battery that has 90% SOH would effectively act like a 54-kWh battery.
- (4) Charging station network is very less though this may expand greatly in coming days.
- (5) But the greatest drawback is the issue of battery waste pileup in coming years which necessitates development of technologies for recycling of scarce Lithium metal from used batteries. For instance, Tesla one of the famed EV car manufacturer of United States is at present recycling only 10% of Lithium from used batteries although it is trying to ultimately recycle 90% of Lithium from its used batteries in next 5 years.
- (6) Since reserves of lithium carbonate are limited world over, lithium hydroxide is fast upcoming alternative for lithium source, it is better in lifespan and performance than carbonates due to the fact a higher temperature is required to synthesise cathode material with lithium carbonate and this damage the crystal structure of cathode and changes the oxidation state of nickel in the battery.
- (7) Recent researches to increase battery range, energy density and reduction in volume.

Researchers at the University of Waterloo claims that the use of negative electrodes made of lithium metal could “increase dramatically storage capacity of battery,” which could in turn drastically improve capabilities of electric-powered vehicles. They published this in the journal Joule wherein they described, details of adding a compound made up of phosphorus and sulphur

elements to the electrolyte liquid, which carries charge within batteries. The team claims that this compound reacts with the lithium metal electrode in a battery to “spontaneously coat it with an extremely thin protective layer.” This protection, supposedly, allows for the use of lithium metal electrodes within batteries, which adds greater storage capacity, without risks or degradation. This improvement could triple the range of these nascent vehicles.

6. New Upcoming Solid-State Batteries from Tesla, Samsung, Panasonic & Toyota Shall Be Game Changer for Electric Vehicle

New solid-state batteries are being developed which have almost double charging capacity than presently used Li-ion battery banks in EVs, these new solid-state batteries being developed can charge to 80% of capacity in less than 15 minutes and can retain more than 80% of its capacity after 800 charging cycles, that is nearly double the energy density of present LI-ion batteries. Toyota for instance which is a leading Japanese car maker in collaboration with Panasonic another leading Japanese battery manufacturer worldwide is developing a solid-state battery with a sulphur based electrolyte that allows for a more efficient ion transfer between the electrodes, these batteries charge quicker and offer more range in mileage in the same size, these batteries claims Toyota will get fully charged from flat in 10 minutes and a range of 500 km. Samsung a Korean company is also developing a solid state battery which shall use thin silver carbon layer instead of Li metal anodes, this gives battery with a higher capacity and cycle life and makes batteries safer and they are 50% smaller by volume than Li-ion counterpart battery, these prototypes are offering 500km range with cycle life of over 1000 charges, these prototypes shall soon be commercialised. Tesla presently leader in EVs is developing a new solid state battery 4680 battery which can improve EVs range and power, these cells will give 5 times more energy capacity, make them 6 times more powerful and enable 16% range increase, and these batteries Tesla claims will be 56% less expensive to manufacture. For comparison energy density of presently used 2170 battery in Tesla's model 3 is around 260 WH/KG with 80% charge in 40 minutes with the new solid-state battery 4680 being developed will have 50% more energy density and charge to 80% in 25 minutes. Tesla's 2170 battery presently costs about \$156/KWH which means for a 90KWH battery would cost \$14000 and the 4680 battery would be half as expensive and since battery pack in an EV costs 30-35% of total cost of EV, the cost of EVs with these new upcoming battery packs would come down drastically and comparable to present gasoline cars. Present Li-ion batteries used by Tesla use liquid electrolytes which make them flammable and its associated safety concerns of batteries and EVs, solid state batteries have separators that are non-combustible and isolate anode and cathode at high temperatures and have a battery life of 1 million miles instead of present batteries of 500,000 Hrs. All these solid-state batteries from Samsung and Tesla are likely to be available by 2025. So advancements in battery chemistry and technology will lead to higher energy densities, faster charging and reduction in battery life and degradation from fast charging.

7. Conclusion

It is clear that EVs shall replace IC engines sooner than later, also with almost nil maintenance costs coupled with one fifth of running costs and with quick charging batteries & ease of charging from home the switch to EVs shall be fast, and the new upcoming batteries shall not only make them cheaper than today but also much safer than gasoline cars. As estimated by 2030 in India about quarter of electricity produced shall be used by EVs and as per projections about 60% of electricity generated in India and about 50% world over shall come from renewables and with EVs getting charged from these carbon free sources of power the entire cycle from generation of power to automobiles emissions shall be carbon free. This should go a long way in meeting the targets of Paris protocol of reducing emissions by 33% below 2005 levels by 2030 and keeping global temperature rise below 1.5°C of preindustrial levels and reducing impact on human health and ecology and also reducing pollution in cities.

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