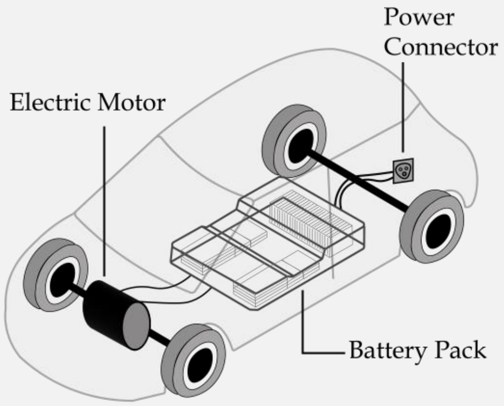
PRS LEGISLATIVE RESEARCH

Science & Technology Policy Brief

Electric Vehicles



The government is encouraging the adoption of Electric Vehicles. This brief dicusses the potential benefits of EVs and possible implications of large-scale EV uptake in India.

Summary

- Electric vehicles (EVs) are more energy-efficient machines than conventional internal combustion engine vehicles.
- Large-scale EV adoption can ensure energy security, reduce oil import bill, and curb local air pollution.
- Carbon emissions due to EVs depend on the source of power generation used to charge their battery.
- Key challenges to EV adoption include availability of critical battery materials, and recycling and disposal of EV batteries.
- Many government incentives are currently driving EV sales. High rate of EV adoption may adversely impact government finances.

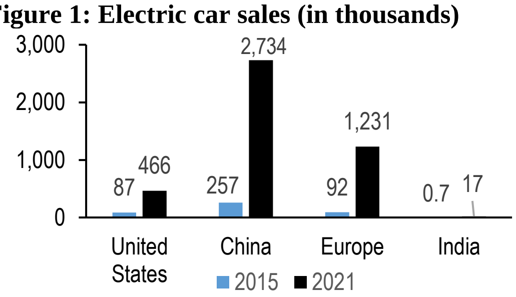
Background

An electric vehicle (EV) uses battery cells as a power source. It contains a rechargeable battery pack, its associated battery management system (BMS), an electric motor and other electronic components.[1] Most vehicles in use today run on internal combustion engines (ICE). In contrast, EVs use a battery pack to provide power to the electric motor, which rotates the wheels. Electric motors convert 80-85% of stored energy, making EVs more efficient than ICE vehicles, which are 25-35% efficient.[1] There are also hybrid electric vehicles that have both an internal combustion engine and a battery.[2]

Currently, EV adoption in India is in its early stages compared to United States, Europe, and China (see Figure 1 for EV car sales).[3,4] Until October 2022, 17 lakh EVs have been sold, constituting 0.6% of all registered vehicles.[5] Of the registered EVs, 97% are two wheelers (2W) and three wheelers (3W). 2W include e-scooters and e-mopeds, and 3W include e-autos, e-carts, and e-rickshaws. E-rickshaws are generally powered by lead-acid batteries that are less efficient than the standard Lithium batteries.[6,7] In this note, we exclude e-rickshaws from our analysis as they do not have similar concerns as electric vehicles powered by Lithium batteries.

India aims to reach 30% sales share for EVs by 2030.[8] Various reports suggest that the 2/3W vehicle segments in India will lead the transition to electric mobility by 2030. The International Energy Agency (IEA) projects that 2/3W and four-wheeler (4W) EVs will comprise 48% and 11% of total vehicle sales in 2030, respectively.[9,10] Similarly, NITI Aayog estimates EV sales share of 2/3W at 86% and 4W at 13% in 2030.[11]

Figure 1: Electric car sales (in thousands)



Source: IEA; Vahan portal, Ministry of Road Transport and Highways (4W, FY 2015-16, 2021-22); PRS.

Cost analysis: Petrol vehicle vs. EV

To understand the difference in cost of owning an EV compared to owning a petrol vehicle, it is useful to look at the combined cost of the initial upfront price and lifetime operating cost. Table 1 (on page 2) compares the costs under some broad assumptions. We assume the life of a 4W vehicle to be 1,50,000 km and of a 2W at 50,000 km, and use the current price structure of petrol and electricity in Delhi. In the absence of any tax or subsidy, petrol vehicles (4W and 2W) are cheaper than EVs. However, the high tax on petrol, subsidy on domestic electricity, lower registration fee and road tax for EV, and upfront subsidy for 2W EVs (under FAME-II) together make the lifetime cost of EVs lower than that of petrol vehicles.

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Table 1: Cost breakdown for Petrol vehicles and EVs (4-Wheeler and 2-Wheeler)

Parameters	4 -Wheeler		2-Wheeler	
Upfront cost (Rs, Lakh)	Petrol	EV	Petrol	EV
Base price	6.7	14.3	0.67	1.4
Taxes - Subsidies	2.6	0.8	0.25	-0.4
Final price	9.3	15.1	0.92	1.00
Upfront cost per km (in Rs/km)				
Without taxes/subsidy	4.5	9.5	1.3	2.8
With taxes/subsidy	6.2	10.1	1.8	2.0
Running cost per km (in Rs/km)				
Without taxes/subsidy	4.1	1.0	1.2	0.2
With taxes/subsidy	6.4	0.7	1.9	0.2
Total cost per km (in Rs/km)				
Without taxes/subsidy	8.6	10.5	2.5	3.0
With taxes/subsidy	12.6	10.8	3.7	2.2

Assumptions: Lifetime running distance assumed: 1,50,000 km (4W) and 50,000 km (2W). Maintenance costs and insurance costs excluded. Petrol prices – Rs 97 (retail) of which Rs 36 (taxes) for Delhi.[12] Electricity tariff without taxes/subsidies is taken to be average cost of supply (ACS), here taken as Rs 8/kilowatt hour (kWh).[13] Subsidised EV tariff for Delhi is Rs 5.4/kWh.[14] Mileage of petrol 4W and 2W are 15 and 50 km per litre, respectively. EV mileage for 4W and 2W are 8 and 34 km/kWh. 4W (petrol and EV) specifications and prices based on Tata Nexon variants (September 2022). 2W specifications and prices (November 2022) based on Honda Activa 125 Delux (petrol) and Ola S1 (~3 kWh battery capacity). Prices and taxes are for Delhi. FAME II subsidy for 2W is Rs 15,000/kWh.[22] Running costs not discounted for time value of money.

Potential benefits of EVs

Electrification of the transport sector can provide long-term benefits by addressing three major issues – local air pollution, greenhouse gas emissions (GHG), and energy security.

Pollution and carbon emissions

Exhaust emissions from ICE vehicles lead to local air pollution. For example, the contribution from vehicles to Delhi's particulate matter (PM 2.5) air pollution was estimated at 41% in 2018.[15] In contrast, EVs do not have exhaust emissions.

The emissions contain greenhouse gases (GHG) which contribute to climate change. In 2019, the transport sector accounted for 13% of total GHG emissions from Indian energy sector, of which one-sixth each were by 2W/3W and 4W vehicles.[16]

A shift to EVs will help improve both ambient air quality and reduce harmful GHG emissions. However, the overall emissions of an EV depend on the source of electricity used to charge its battery. In India, 70% of electricity generation is based on coal.[17] Coal-fired power plants were responsible for about 44% of total carbon emissions in 2019.[16,18] Shifting to cleaner energy sources of fuel such as solar and wind energy may help address this issue.

Energy security

Energy security refers to the ability of a country to ensure uninterrupted energy supply at affordable prices. It can be affected by natural, economic or geopolitical factors. Between 2000 and 2019, due to rising vehicle ownership and road transport usage, the energy demand in the transport sector has grown 3.5 times.[18] India is heavily reliant on imports to meet its energy needs. In 2021-22, India's net import of petroleum products was about USD 94 billion.[19] A high import bill also results in current account being in deficit (around USD 39 billion in 2021-22, which was 1.2% of GDP).[19]

If a significant segment of road transport shifts to EVs, they will depend on electricity as the energy source instead of oil. If the electricity needed can be generated from indigenous coal and renewables, the move to EVs would help reduce India's import dependency and decrease its current account deficit. The attainment of such results depends on which type of vehicles—2/3W or 4W get electrified. In 2019, 2/3W vehicles constituted about 80% of the total vehicles in the country but accounted for only 21% of the total fuel consumption in road transport.[18,20] The remaining 79% of energy demand came from cars and heavy-duty vehicles such as buses and trucks.

Box 1: Government Initiatives

Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME): FAME offers financial incentives for purchasing EVs and developing charging stations.[21,22]

Production-linked Incentive (PLI) Scheme for Automotive Industry: Boosting domestic manufacturing of EVs, fuel-cell vehicles and associated components.[23]

National Programme on Advanced Chemistry Cell Battery Storage: PLI scheme to promote domestic manufacturing of EV batteries.[24]

GST Reduction: GST rate is 5% on all EVs as compared to 28% tax on ICE vehicles.[25,26]

Income Tax Concession: Deduction of up to Rs. 1.5 lakh for the interest paid on financing an electric vehicle.[27]

Draft Battery Swapping Policy: Replacing depleted batteries (2W, 3W) with charged ones at swapping stations.[28]

Charging Infrastructure Guidelines: Availability of different types of charging connectors at public charging stations.[29]

Indian Space Research Organisation (ISRO) Lithium cell technology: Transfer of indigenous Lithium cell technology to Industries by ISRO.[30]

State EV Policies: Concessional EV charging tariff, road and registration tax exemptions by several states including Delhi, Karnataka, Maharashtra and Telangana.[31]

Issues with EV adoption

EV battery

Structure: An electric vehicle battery is usually a rechargeable lithium battery.[32] It is structurally different from portable electronic batteries used in tablets, phones, and laptops.[33,34] The EV battery contains a series of small cells grouped in a module. Several modules are then tightly assembled to make a traction battery pack.[35]

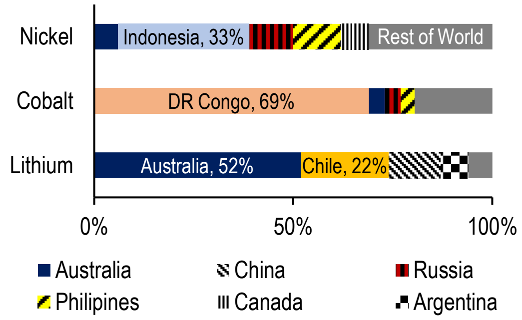
Capacity and stability: Commonly used Lithium chemistries are nickel manganese cobalt oxide (NMC) and Lithium-ferro (iron) phosphate (LFP).[36] The proportion of these elements (by weight) decides the energy capacity of a battery pack which is measured in kilowatt-hours (kWh). A mix of high-energy density metals such as cobalt and nickel can pack more energy per kilogram and increase energy capacity.[36] LFP batteries are not as efficient as NMC ones, but can withstand higher temperatures when charged.[37]

Pricing: The cost of different Lithium batteries depends on the prices of raw minerals. In 2022, on an average, LFP cells were 20% cheaper than NMC ones due to the absence of costly elements like cobalt and nickel.[38] Due to the high prices of the metals involved, batteries constitute about one-fourth of the cost of a 4W and about one-third of a 2W EV.[38,39,40,41] Presently, NMC batteries are used in most electric car models globally, but in the price-sensitive markets, LFP ones are more prevalent.[42,43] Electric scooters use both LFP and NMC variants.[44,45]

Availability of battery minerals

The global push for electrification of vehicles has created a rush for a secure supply chain of battery materials such as lithium, cobalt, nickel, and graphite.[42] The shortages of minerals will depend on which battery chemistry (NMC or LFP or other emerging options) becomes the predominant technology used in EVs.[3,42] Currently, lithium mining is concentrated in Australia, Chile, China and Argentina (See Figure 2).[42,46] Lithium is not a scarce resource and its current reserves are estimated at 21 million tonnes.[33,46]

Figure 2: Share of top producers of battery minerals, 2019



Sources: IEA, US Geological Survey; PRS.

In 2020-21, India imported Lithium batteries (for cellphones, EVs and powerbanks) worth about Rs 9,000 crore.[47] The chief suppliers were China (73%) and Hong Kong (23%). China has a presence across the value chain, i.e., mining, production, fabrication, manufacturing, and sale of copper, cobalt, nickel, and lithium.[42] Access to these minerals can be affected by social, environmental, economic, and geopolitical factors. India has formed strategic alliances with resource-rich countries (e.g., Australia for lithium and cobalt) to ensure the supply-chain security of critical and strategic minerals.[48]

Recycling and reuse

Recycling and reusing EV batteries can partly address the problem of supply-chain risk. Efficient and robust recycling is also required to avoid unsafe and careless disposal of spent Lithium batteries, as they can cause significant environmental issues.

Once the battery pack loses 20-30% of its original capacity, it is deemed unfit for the vehicle.[49] However, it can be repurposed for other less demanding applications such as stationary energy storage systems, low-speed e-bikes, and backup power supply.[49] The question of recycling and disposal will become pronounced after the end of this second life.

EV batteries need dedicated waste centres as they contain materials that can harm the environment. Currently, most Lithium batteries are not designed to be recycled, making it difficult to take apart the nested cells within a battery pack.[34,50] Segregation is a complex task, and the entire process is energy-intensive and also expensive.[35] The recycling process is currently economically viable because of the recovery of rare precious metals such as cobalt and nickel.[33,34] Given the development of cobalt-free batteries and the increasing market share of LFPs, the economic viability of the recycling sector is a key question.[3] NITI Aayog estimates that LFP batteries have the lower economic value (~Rs 155/kg) than NMC batteries (~ Rs 385-400/kg).[51] The government notified Battery Waste Management Rules, 2022, which specify the standards for handling used EV batteries for manufacturers and consumers.[52] It also mandates the use of recovered minerals in a new battery.

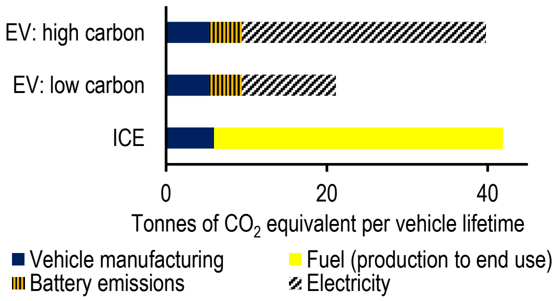
Evolving battery tech and role of green hydrogen

Emerging battery technologies include sodium-ion, all-solid-state, lithium-sulphur, and metal-air batteries.[51] If successfully commercialised, they may emerge as a viable and sustainable alternative to Lithium batteries and resolve the dependence on critical minerals. Another emerging alternative is hydrogen fuel-cell-powered EVs (FCEVs) in which the electric motor is powered by both fuel cell and battery pack.[53] They use compressed hydrogen to produce electricity in the vehicle as well as draw electricity from the battery packs. If FCEVs become prevalent then renewable energy sources will also play a vital role in producing green or low-carbon hydrogen which provides valuable energy storage. Current methods of large-scale hydrogen production have high carbon emissions.[54] Green hydrogen addresses this issue by using solar or wind energy to produce hydrogen.[55] This hydrogen can be used to power fuel-cell electric vehicles. Fuel-cell cars have not yet been deployed in India for sale.[56] Currently, these are mostly used in Korea, United States, China, Japan and Germany.[3] The government has released the Green Hydrogen policy and National Hydrogen Mission which outline future goals.[57,58]

Greenhouse gas (GHG) emissions

As mentioned earlier, large-scale EV adoption could potentially reduce local air pollution. However, EVs can also contribute to GHG emissions depending on the source of electricity used for charging their battery. Thus, life-cycle emissions of EVs running in the regions with coal-based electricity will be higher than those with renewable power generation sources. Also, battery manufacturing is an energy-intensive process that involves the extraction and refining of metals such as lithium, cobalt, and nickel, and contributes to overall GHG emissions (see Figure 3).[42,59]

Figure 3: Comparative life-cycle GHG emissions: ICE vs EV



Note: EV: high carbon and EV: low carbon refers to charging using high-carbon and low-carbon electricity sources, respectively. Fuel emissions include total emissions from production of fuel to its use in vehicle.
Sources: IEA, Kelly et al. (2020); PRS.

Currently, 75% of India's power is generated from thermal sources and 22% from renewable energy sources.[17] The Central Electricity Authority (CEA) projects the share of renewables in total electricity generation at 44% by 2031-32.[17] With reliable renewable energy supply, EVs could help reduce GHG emissions from the transport sector.

EV charging and future electricity demand

EV charging basics: EV battery can be charged using Alternating Current or Direct Current power supply.[60] AC chargers (typically slow, low power) are installed in residential and workplace outlets, whereas DC chargers (fast, high power) are found in public charging stations.[60] Faster EV adoption in India would require adequate charging infrastructure (public charging stations and battery swapping centres).[61]

Availability of electricity

Sufficient availability of electricity is crucial for EVs to be adopted. CEA estimates electricity requirement and peak demand in 2031-32 to be 2,538 billion units (kWh) and 363 GW, respectively.[17] To meet this increase in peak demand, India aims to add a total of 472 GW of installed capacity during the next ten years.[17] This capacity addition target will require an investment of about Rs 32 lakh crore.[17] The capacity addition target for the 2017-22 period was 176 GW, out of which India could only add 85 GW. As per CEA, the possible reasons for such shortfall were the COVID-19 pandemic, land-acquisition issues, fund constraints with contractors, and contractual disputes. The increased load on the distribution system due to EVs will depend on when EVs are charged (during peak or slack demand hours). This extra load can be spread away from the peak-demand period using Time-of-Day metering (higher electricity price at peak hours).

Effect on finances of discoms

Consumers can charge an EV at any available charging outlet. The distribution companies (discoms) are required to provide free (or very cheap) electricity to agricultural consumers. There is a possibility that such subsidised connections are used for domestic or commercial EV charging (as a car can be driven to a farm). This could cause financial losses to discoms and increase the government's subsidy bill. Some states, like Madhya Pradesh, have mandated separate power connections for EV charging to curb such practices.[62] However, it may be difficult to monitor and ensure compliance.

Impact on government finances

Petrol and diesel are taxed heavily (about 50-60%) while electricity for EVs is subsidised (domestic prices or lower). [12,14,63] As a measure to encourage production and adoption of EVs, GST is lower on EVs and many states also impose lower road tax and registration tax.[25] FAME-II subsidy (valid until 2024) also offers up to 40% reduction on upfront purchase cost for 2W (see Box 1).[21,22] A high rate of adoption of EVs could therefore have an adverse impact on government finances.

Impact on employment

One possible concern is the potential job loss of automobile mechanics, given that EVs have few working parts and need minimal maintenance. However, this may not be a concern in the scenario of 13% penetration of new 4W EV sales by 2030 as ICE vehicles on the road will still be more than now (assuming overall sales growth of at least 6% per annum, similar to expected GDP growth).[11]

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