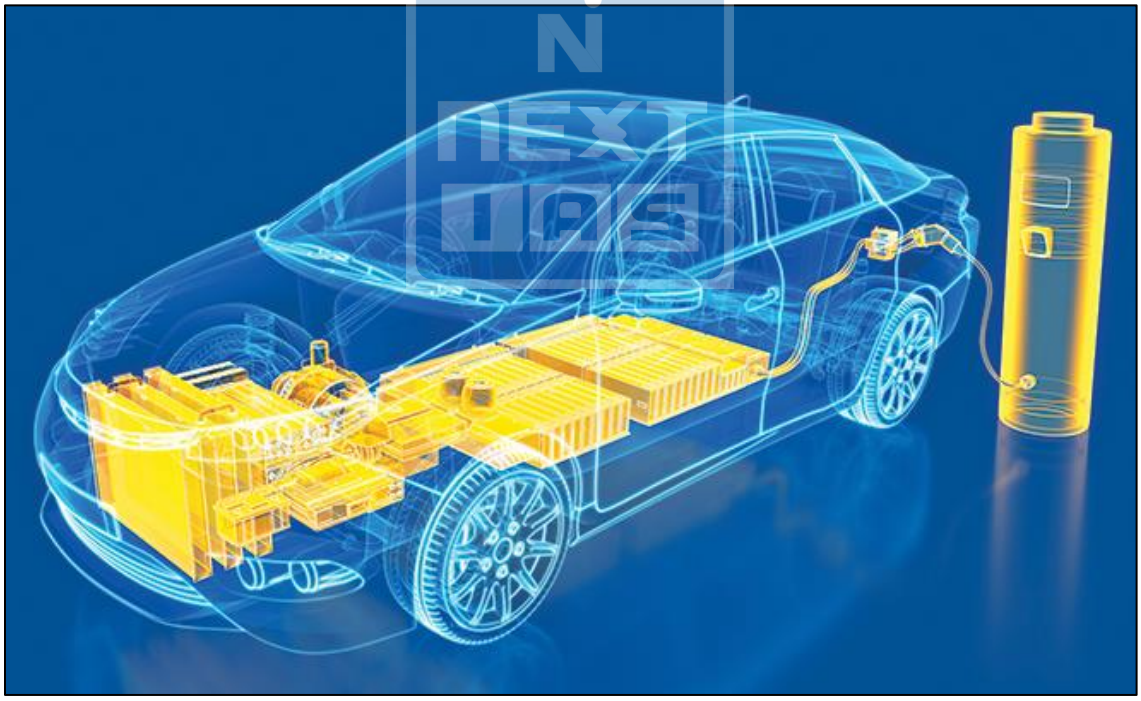
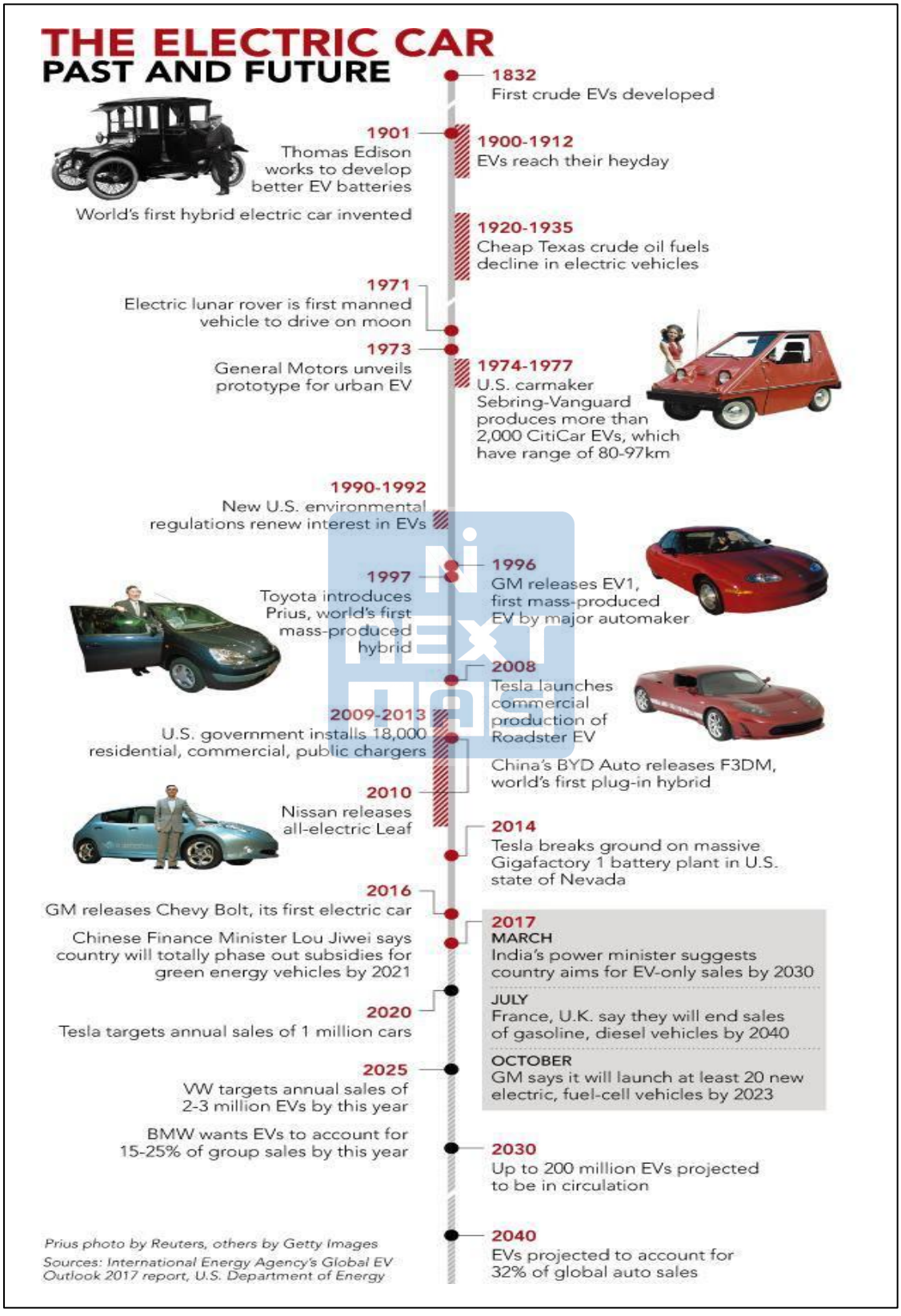
Electric Vehicles: Future of Transportation

What is an Electric Vehicle?

- An **EV** is defined as a vehicle that can be powered by an **electric motor that draws electricity from a battery** and is capable of being charged from an external source.
- An **EV includes both a vehicle** that **can only be powered by an electric motor** that draws electricity from a battery **(all-electric vehicle)** and a **vehicle that can be powered by an electric motor that draws electricity from a battery** and by an internal combustion engine **(plug-in hybrid electric vehicle)**.

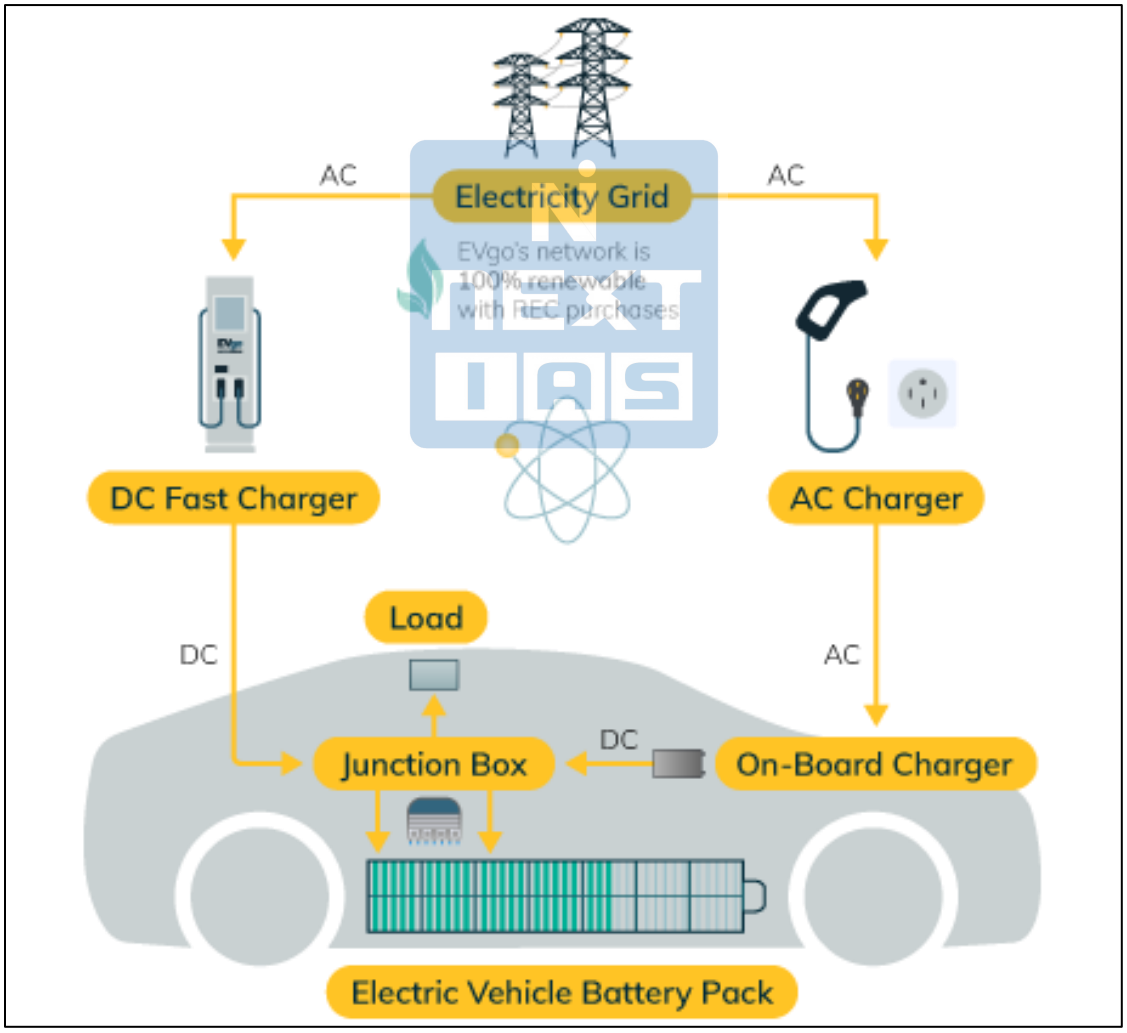


What is the history of Electric Vehicles?

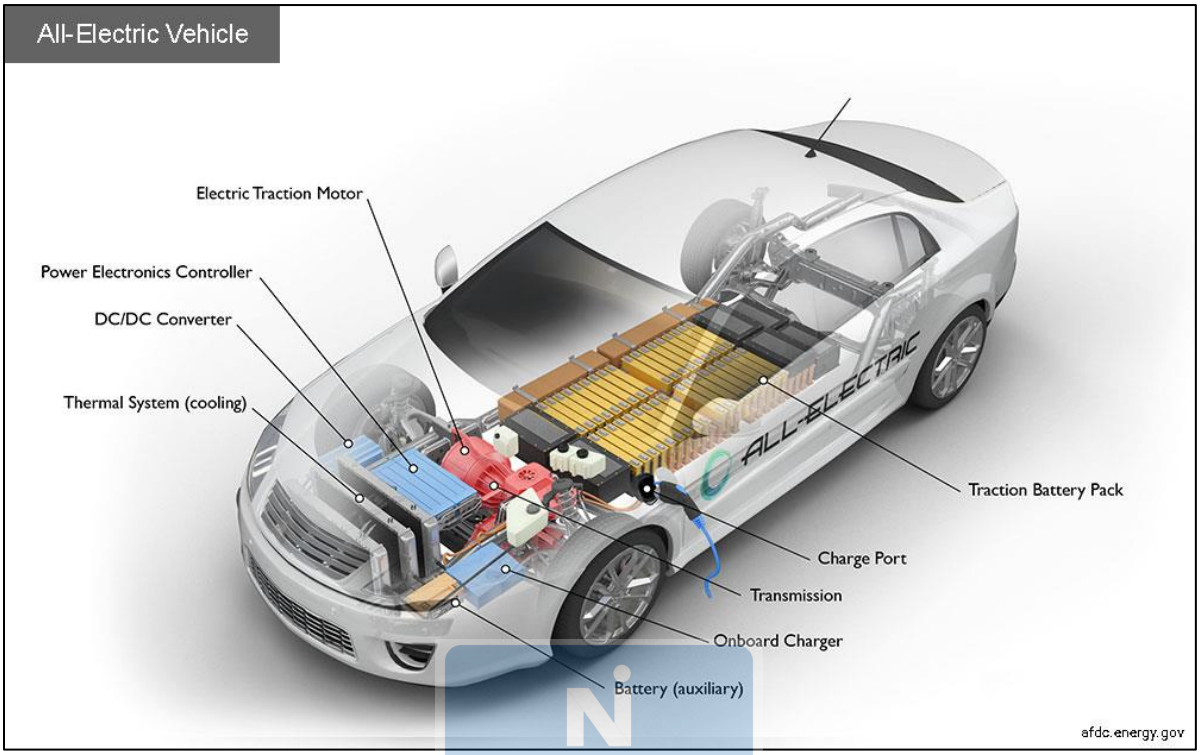


How do Electric Vehicles Work?

- All-electric vehicles, also referred to as battery electric vehicles **(BEVs)**, have an electric motor instead of an internal combustion engine.
- The vehicle uses a **large traction battery pack to power the electric motor and must be plugged into a wall outlet** or charging equipment, also called electric vehicle supply equipment **(EVSE)**.
- Because it runs on electricity, the vehicle emits no exhaust from a tailpipe and does not contain the typical liquid fuel components, such as a fuel pump, fuel line, or fuel tank.



Components of Electric Vehicles:



Electric Vehicles consists of following components:

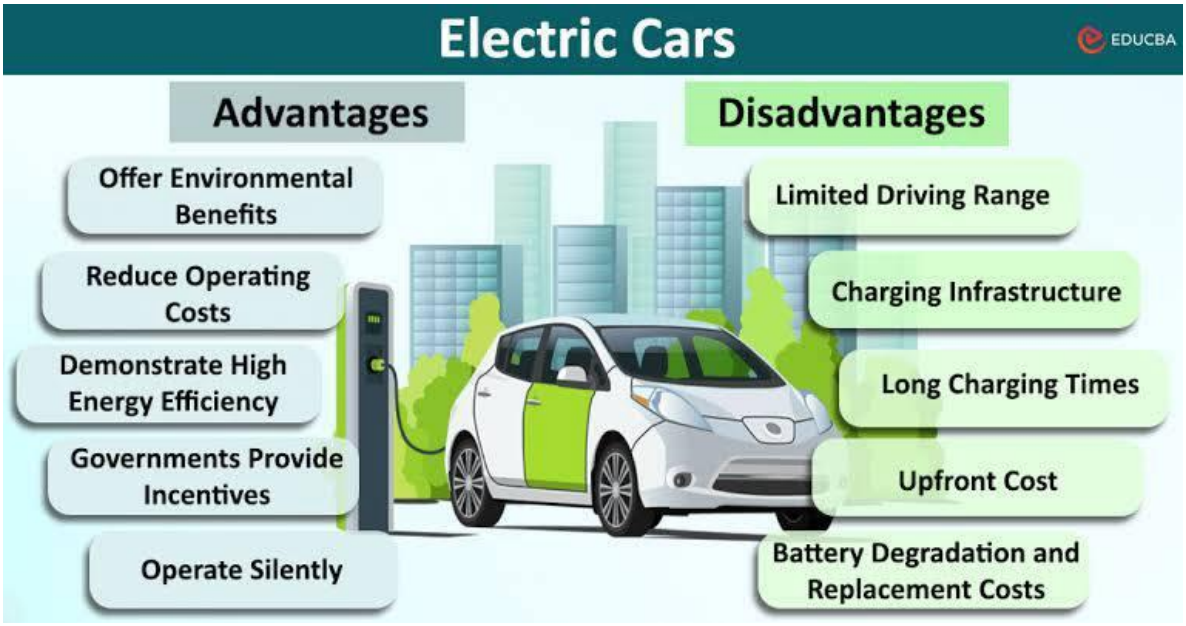
1. **Battery (all-electric auxiliary):**
   - In an electric drive vehicle, the auxiliary battery provides electricity to power vehicle accessories.
2. **Charge port:**
   - The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.
3. **DC/DC converter:**
   - This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.
4. **Electric traction motor:**
   - Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.

5. **Onboard charger:**
   - Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery.
   - It also communicates with the charging equipment and monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.
6. **Power electronics controller:**
   - This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.
7. **Thermal system (cooling):**
   - This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
8. **Traction battery pack:**
   - Stores electricity for use by the electric traction motor.
9. **Transmission (electric):**
   - The transmission transfers mechanical power from the electric traction motor to drive the wheels.

Enlist different types of Electric Vehicles?

	Battery Electric Vehicle (BEV)	Plug-In Hybrid Vehicle (PHEV)	Hybrid Electric Vehicle (HEV)	Conventional Vehicle
Key mechanism	Powered by an electric motor and a battery that can be recharged by plugging into an electric outlet	Powered by a conventional engine (petrol/diesel), along with an electric motor and a battery that can be plugged-into an electrical outlet for recharging	Along with a conventional (petrol/ diesel) engine, HEVs are powered by an electric motor and a battery that is recharged by regenerative braking	Powered by an internal combustion engine (petrol/diesel)
Propulsion	Electric motor drive	Electric motor drive; Internal Combustion Engine (ICE)	Electric motor drive; Internal Combustion Engine (ICE)	Internal Combustion Engine (ICE)
Energy source and infrastructure	Charging stations drawing power from electric grids	Charging stations drawing power from electric grids plus Petrol/ diesel stations	Petrol/diesel stations	Petrol/diesel stations
Advantages	• Higher efficiency • Home/workplace charging • Low engine noise • Few auto parts	• Higher efficiency • Home/work place charging • Many refueling stations	• Higher efficiency • Many refueling stations	• Wide variety of models • Many refueling stations
Disadvantages	• Range anxiety • Long-time to recharge • Fewer recharging stations • Battery management in Indian context where temperatures go up to 45-50 degree centigrades	• Technologically complex • Fewer recharging stations	• Tail-pipe emissions • Oil dependency • Engine noise • Technologically complex	• Low efficiency • Tail-pipe emissions • Oil dependency • Engine noise

What are the advantages and disadvantages of Electric Vehicles?



Advantages of Electric Vehicles:

1. Environmentally friendly	• Electric vehicles produce **zero direct emissions** which can help reduce pollution and therefore your carbon footprint. • It also significantly improves the air quality - especially in cities.
2. Lower running costs	• The **fuel prices** have **increased significantly** over the last two years, and show no signs of going down. • Switching to electric cars protects your wallet from the high rates for fuel, making it a cost-effective option. ▪ Talking about the cost of running, one will spend somewhere between **Rs 7-8 Rs per kilometer in a small petrol car.** In an **EV, it costs approximately Rs 1 to 1.5 per kilometer.**

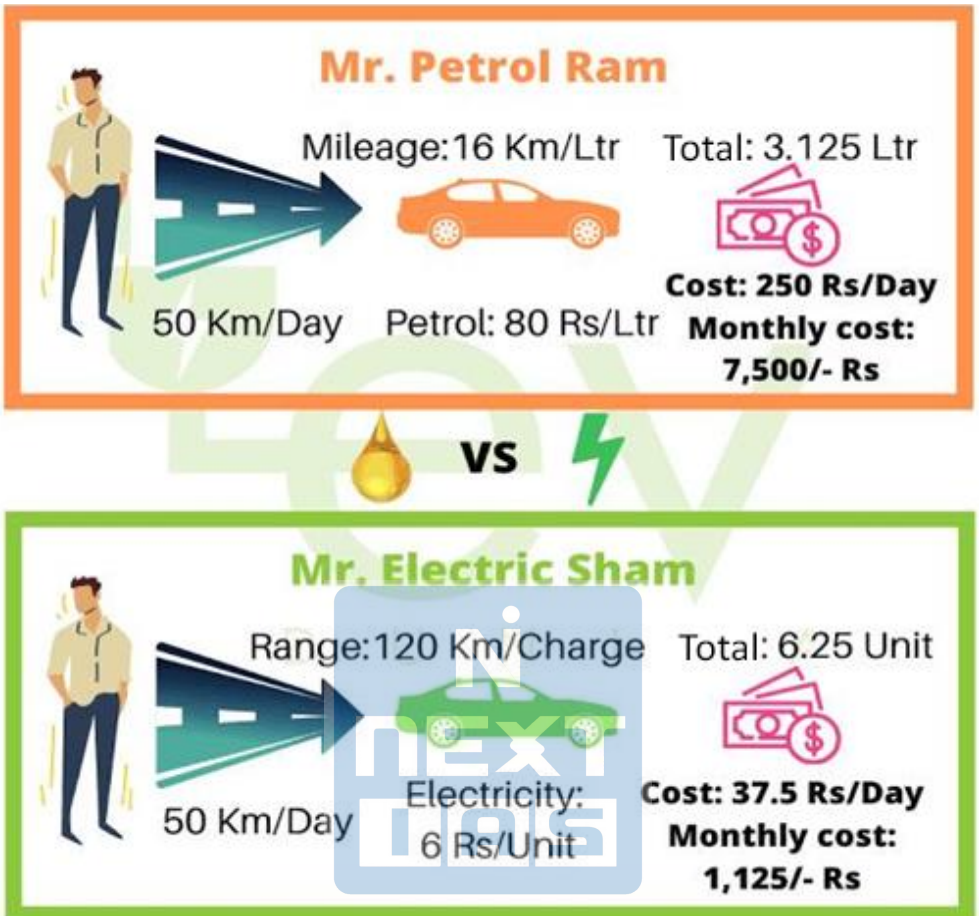
3. Low Maintenance Costs	• While the **conventional fuel-powered** vehicles may require **regular oil changes and engine repair**, the **cost of maintaining an electric car is minimal.** • The motor, battery, and electrical components associated with an **electric vehicle require little to no maintenance.**
4. Energy independence	• As more renewable energy sources are used to power EVs, it can reduce dependence on fossil fuels.
5. Charge conveniently from the comfort of your home	• Electric vehicles have the a**bility to charge at home** using a standard electrical outlet, eliminating the need to visit a gas station. • It **takes 4-5 hours to fully charge** an electric vehicle which can run for the entire day. 

6. Reduce Noise Pollution	• One benefit of electric vehicles is that they're **very silent as they have no engine under the hood.** • It gives peace of mind and makes those long rides much more enjoyable. 
7. Easy to drive	• If you have **trouble maneuvering the gears** in your car or find it overwhelming, you should consider opting for an electric vehicle. • **Electric cars don't operate** on **gear mechanisms** but rather buttons and pedals. • The added pressure of switching gears at the right time is eliminated, so you can **go cruising down the highways effortlessly with total control.** 

Disadvantages of Electric Vehicles:

1. High cost	• Electric vehicles have a **high initial purchase cost**, and many consumers **cannot afford** them in their budgets, thus they are hesitant to move from regular vehicles to electric vehicles.
2. Lack of Choices available for consumer	• Due to the **lack of electric car models accessible to the market**, buyers have few alternatives in terms of **design, appearance, or customized variants**
3. Lack of charging infrastructure	• Lack of **sufficient charging stations** decline the zeal for adoption of Electric Vehicles.
4. Blood Batteries	• Electric vehicle batteries require certain minerals, such as **cobalt, lithium, and nickel.** • The mining of these minerals raises concerns about **unethical mining practices, child labour, and environmental degradation.** • These issues, often associated with the term **"blood batteries,"** add ethical challenges to the adoption of electric vehicles. • It is essential for the industry to prioritize responsible sourcing and ensure that the minerals used in EV batteries are extracted sustainably and ethically.

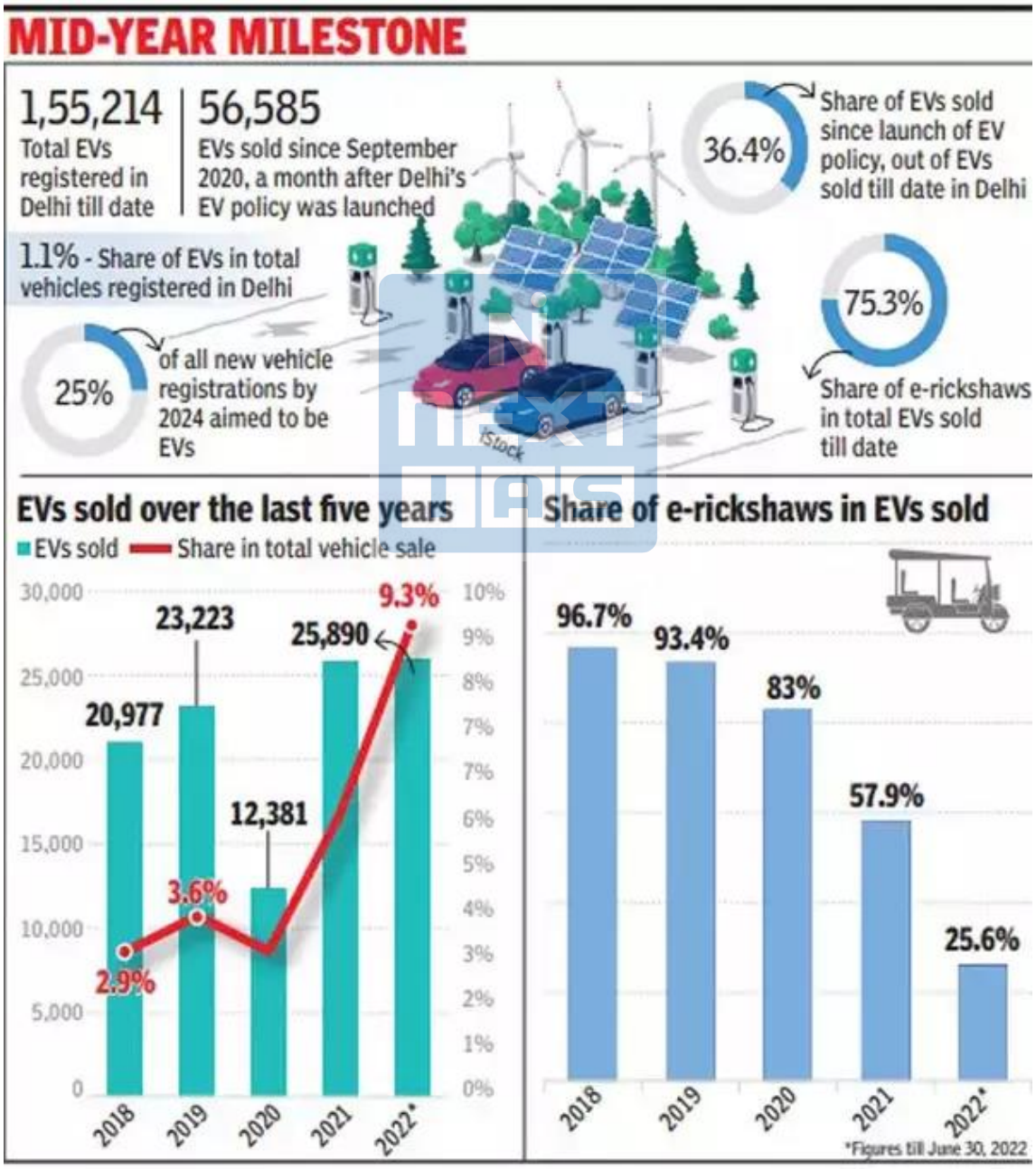
How are Electric Vehicles different from Conventional fuel vehicles?



	ELECTRIC	PETROL	DIESEL	CNG
Ex-showroom price (Delhi)*	₹14.24 lakh	₹8.29 lakh	₹9.59 lakh	₹8.84 lakh (CNG kit in petrol car)
Claimed mileage / range	312 km	17.4 km/litre	22.4 km/litre	20 km/kg
Running cost per month	₹392 (charging station) ₹697 (home charge)	₹5,375	₹3,484	₹2,342
Annual maintenance cost	₹5,102 (Tata Nexon claim)	₹6,500-7,000	₹9,500-10,000	₹7,000-8,000
Annual third part insurance premium*	₹1,855 (>30 kW) ₹2,838 (30-65 kWh) ₹6,707 (<65 kWh)	₹3,221	₹3,221	₹3,281
Annual comprehensive insurance premium	₹14,439	₹7,096	₹6,496	₹7,681
Car life	8-10 years	15 years	10 years	15 years
Infrastructure	Negligible/ upcoming	In place	In place	Partially in place
Carbon emissions (g Co2/km)	Nil; 70** (30 kWh)	117 (<1000 cc)	105 (<1000 cc)	63 (<800 cc)

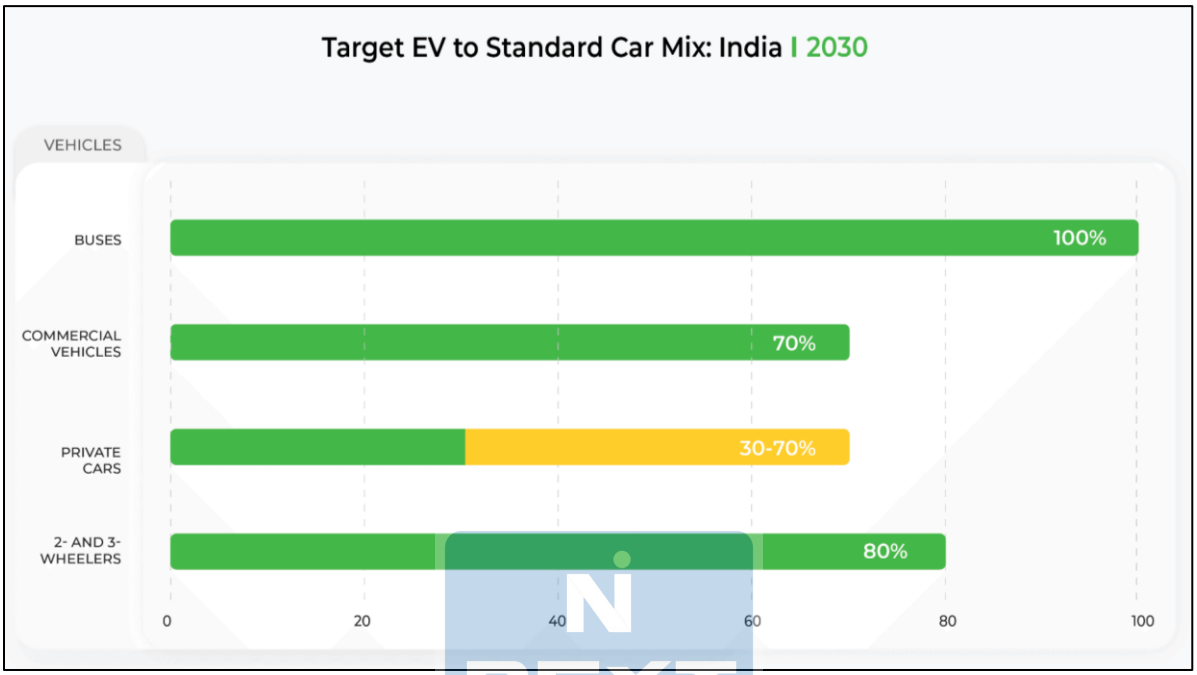
What is the status of Electric Vehicles in India?

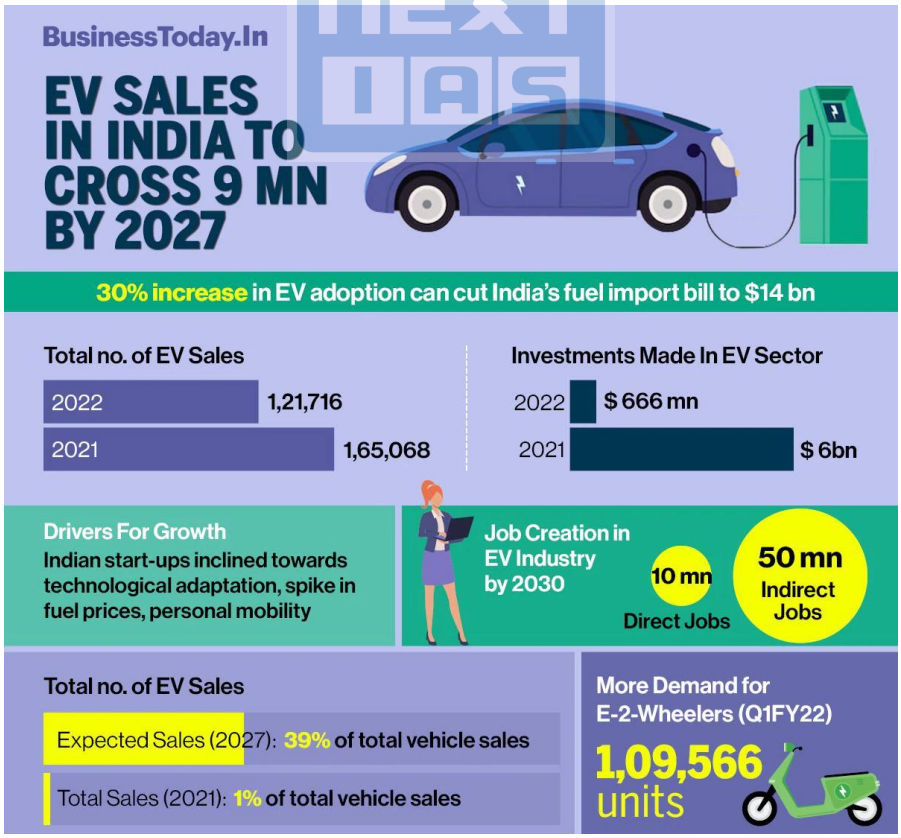
- India is one of the **world's largest markets for two- and three-wheeled vehicles**, ranking among the global top five for private cars and commercial vehicles.
- **India's Ministry of Road Transport and Highways** has claimed that 1,334,385 electric vehicles in India were on the road as of July 2022.



India Sets Ambitious Targets

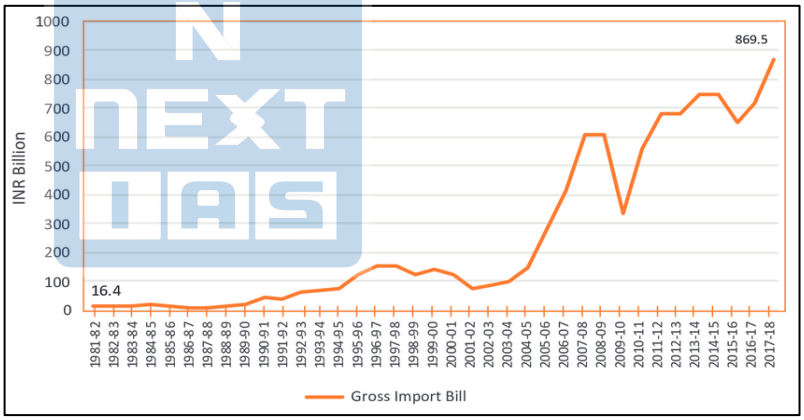
According to Union Minister Nitin Gadkari, the Indian government intends to achieve the following EV mix in **India by 2030:**





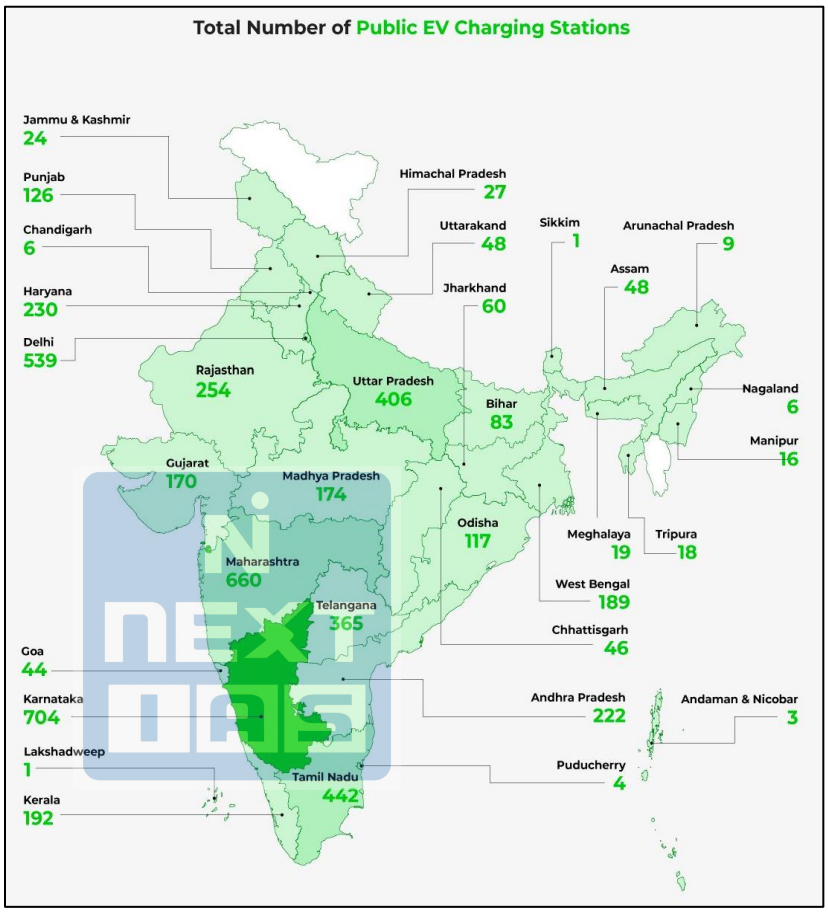
Why does India need to adopt Electric Vehicles?

1. Reducing Air Pollution	• Within India alone, **vehicular traffic contributes to 27% of total air pollution and claims 1.2 million deaths annually.** • EV adoption in India will therefore significantly **reduce the negative global environmental** impacts originating from Internal Combustion Engine (ICE) vehicles.
2. Reducing Noise Pollution	• Noise pollution is also a major challenge in India due to the rapid urbanization increasing the need for vehicles. • According to the **2022 UNEP report, five Indian cities feature in the world's noisiest cities.** Though vehicles are not the only source mentioned in the report, **EVs are likely to bring down the noise levels** because they don't have the mechanical valves, gears, or fans common to ICE vehicles.
3. Improving Operational Efficiency	• From a fuel efficiency standpoint, **petrol or diesel cars convert only 17 to 21% of stored energy while EVs can convert 60% of electrical energy from the grid.** • Clearly, this shift to electric vehicles in India can **improve the efficiency of fuel production** and optimization. • It will bring down the operational costs for end-users, thereby increasing demand for EVs.

4. Lowers economic burden on consumers.	• According to Weforum.org, the **Total Cost of Ownership (TCO) for a two-wheeler in New Delhi is Rs 2/km when it's run on petrol.** • **This cost comes down to Rs 0.52/km when switched to EVs.**
5. Reduce dependence on Petrol/Diesel	• The availability of **fossil fuels is limited,** and their use is destroying our planet. • Crude oil increased the burden on economy and thereby **increasing Current Account Deficit.** • **India's import bill of petroleum products** from **1981-82 to 2017-18** is as follows: 
6. The Real Estate Sector	• **A report by Colliers** shows that the **EV industry will require 1,300 acres to set up 110 GWh** battery manufacturing capacity by 2030. • The country will also **need 13.5 million square** feet for **charging stations by 2025.** • These numbers reflect the ample opportunities available for every player in the real estate space.

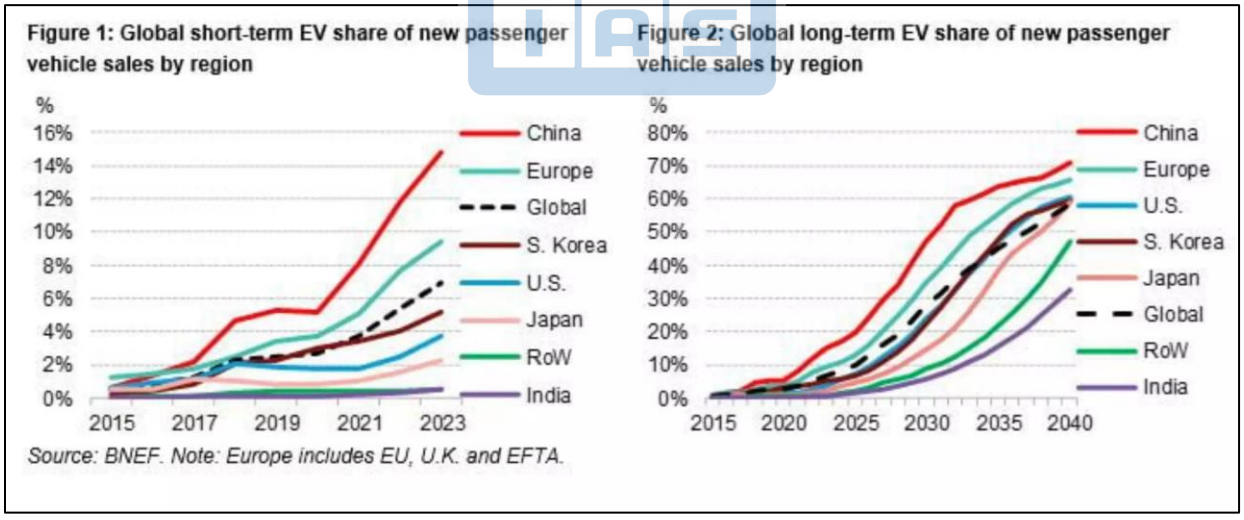
What are the challenges faced By India in adopting Electric Vehicles?

1. Cost of EV	• One of the biggest challenges with **electric vehicles in India is the high cost.** • EVs are still expensive when compared to traditional petrol or diesel cars. • For comparison, the **Tata Nexon(XMA AMT S) Petrol and EV Prime model whose ex-showroom prices are ₹994,900 and ₹1,663,000 respectively.** 
2. Extreme Weather Conditions	• **India is known for its extreme weather** conditions, and it has a significant impact on the performance of electric vehicles. • **The battery life of an EV can be reduced by up to 50% in extreme temperatures.** • The **ideal range** for electric vehicles to operate **is 15- 40 degrees Celsius.** • Moreover, charging an EV in hot weather can lead to **thermal runaway,** which is a significant safety concern.
3. Lack of Charging Infrastructure:	• The infrastructure required for **EVs is still in its nascent stages in India.** • There are only a few public charging stations in the country, making it difficult for EV owners to travel long distances.

	• Currently **India has 934 charging stations**, most of which are located in urban areas. • In comparison, **China had 1.8 million electric charging stations as of 2022.** 
4. Lack of Standardization:	• EV charging infrastructure in India is still in its early stages, **leading to a lack of standardization.** • Different charging connectors, charging speeds, and swappable batteries across OEM's make it difficult for EV owners.
5.Limited Range:	• The **limited range of EVs is still a significant challenge in India.**

	• The majority of EVs available in **India have a range of 100-150 km, which is not enough for long-distance travel.**
6.Persistent Resistance to Change	• **Indian consumers are still resisting the adoption of EVs**, despite their long-term economical and environmental benefits. • This stems from a **lack of awareness of EVs and a general reluctance** to embrace new technologies, especially in rural areas.
7.Lack of Clean Energy	• **Much of India's electricity is generated from burning coal**. • Relying on coal to generate power for all the EVs would defeat the purpose of reducing carbon emissions through EV adoption.

What Can India Learn from Other Countries' Success?



Power, infrastructure, and financing all are primary antagonists in India's EV adoption story. But the country can take cues from others already making inroads towards full EV adoption. The countries leading global EV adoption paint an interesting picture.

But players in the Indian market must come together to address consumers' concerns. They should also build a supportive ecosystem to promote the widespread adoption of EVs in India. This can be done through the development of more affordable EVs, the expansion of charging infrastructure, and the creation of awareness and education programs to educate consumers about the benefits of switching to EVs.

What Can India Learn from Other Countries' Success?

Power, infrastructure, and financing all are primary antagonists in India's EV adoption story. But the country can take cues from others already making inroads towards full EV adoption. The countries leading global EV adoption paint an interesting picture.

Graph-2.png

India can learn from other countries' successes and mistakes. Source: acea.auto

The top countries in the graph above are all wealthy countries in northern Europe. Combined, they don't even represent 3% of India's population. This may lead us to believe that their success will be impossible to replicate in a much more diverse and densely-populated country, like India.

However, China comes in second and turns that argument on its head. Let's delve into what different regions have done for EV adoption and what India can learn from these efforts.

The EU, EFTA, & UK

- **In 2021,** electric car registrations in the EU-27 region was **1,729,000, up from 1,061,000 in 2020**, representing a **17.8% increase.**
- **All EU countries, including Norway, which has the highest number of registrations in a year,** offered financial incentives like **tax reductions and exemptions.**
- **India is also offering tax incentives along the same lines.**

- And with favorable government policies and the presence of first-mover companies, the country will be able to improve the **adoption of EVs in the next three to five years.**

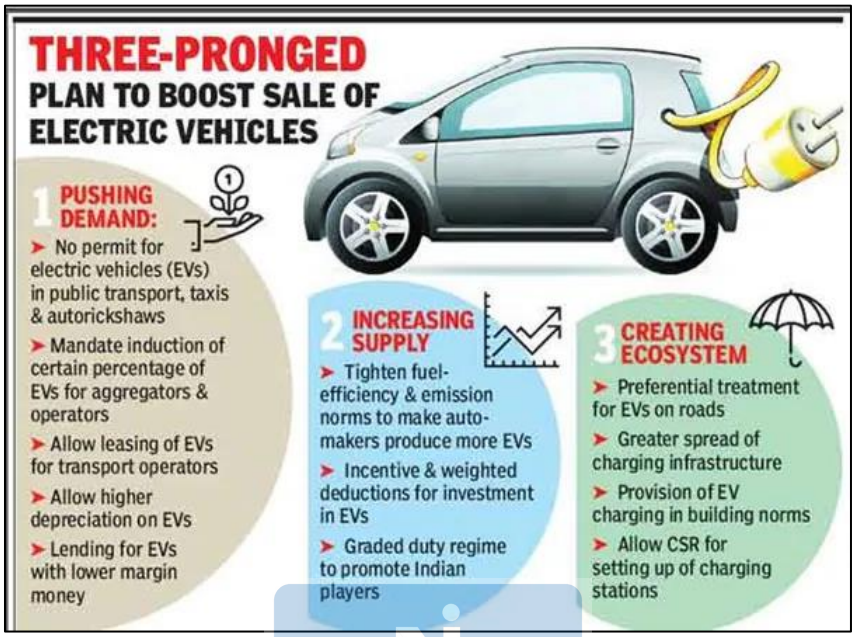
China

- According to the **China Association of Automobile Manufacturers (CAAM)**, China sold **6.89 million EVs in 2022 alone.**
- It also boasts the **largest electric car fleet in the world: 4.6 million + electric cars on roads in China.**
- This success story is attributed to **generous government support as well as intense domestic competition**, both of which fueled innovation and reduced car prices.
- In comparison, **India is also offering support, but the domestic market is not robust and competitive yet**. But that is expected to change in the coming years as the impact of the current policies becomes more widespread.

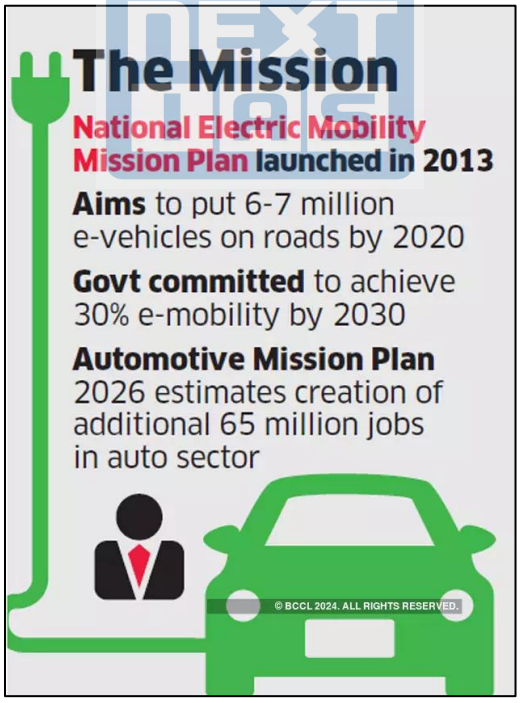
The USA

- EV car sales in the **US represent 5.8% of all vehicles sold, up from 3.2% a year ago.**
- However, the **overall sales fell by 8% in 2022 when compared to 2021.**
- Experts believe that **stricter requirements for claiming federal incentives, high car prices, and concerns about raw materials for batteries were the cause of the decline.**
- The EV car industry is still huge in the US, and it grew due to government investments and policies. Innovation by leading players like **GM and Tesla also added to the appeal.**

Enlist a few initiatives taken by India to promote adoption of Electric Vehicles ?



1. National Electric Mobility Mission Plan:



- **The National Electric Mobility Mission Plan was launched in 2013**, which aims to have **at least 30% of vehicles on Indian roads be electric by 2030.**

- It provides a roadmap for the faster adoption of electric vehicles in the country as well as their manufacturing in the country to achieve national fuel security.
- The initiative is expected to save 9500 million liters of crude oil or INR 62,000 crores.
- The NEMMP seeks to invest approximately INR 14000 crores in R&D activities and fledgling technologies, accelerate the adoption of electric cars, and establish critical infrastructure through public-private partnerships.

2. Electric Vehicles Promotion via FAME and FAME II:

- The FAME India (Faster Adoption and Manufacturing of (Hybrid and Electric Automobiles) Scheme is a government incentive program in India that promotes the **use of electric and hybrid vehicles.**
- FAME focuses on four important areas: **technology development, demand creation, pilot projects, and charging infrastructure**—all of which span electric and hybrid technologies such as mild hybrid, strong hybrid, plug-in hybrid, and battery electric vehicles.

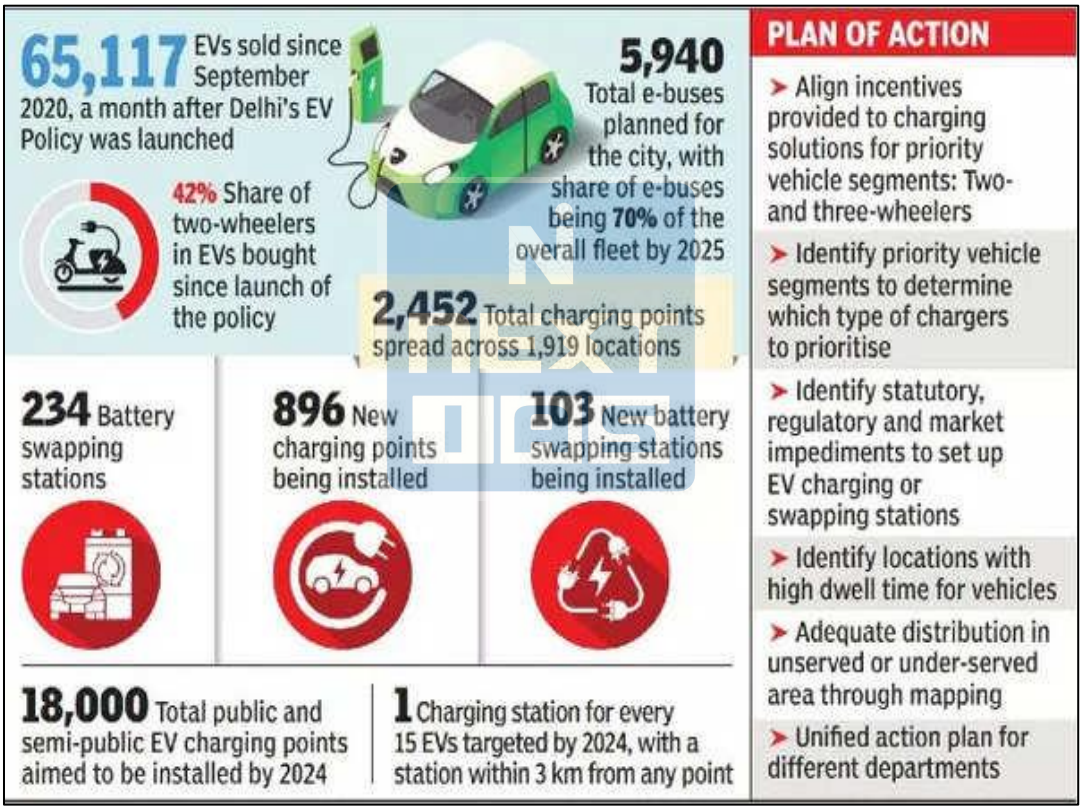
3. PLI:

- The government has announced a **Production Linked Incentive (PLI) scheme** to **boost domestic manufacturing** and attract global companies to invest in the Indian market.

4. Tax benefits:

- The Government has announced plans to provide an additional income tax deduction of INR 1.5 Lakh on the interest paid on loans taken to purchase electric vehicles.

5. Electric Vehicle Policy 2024:

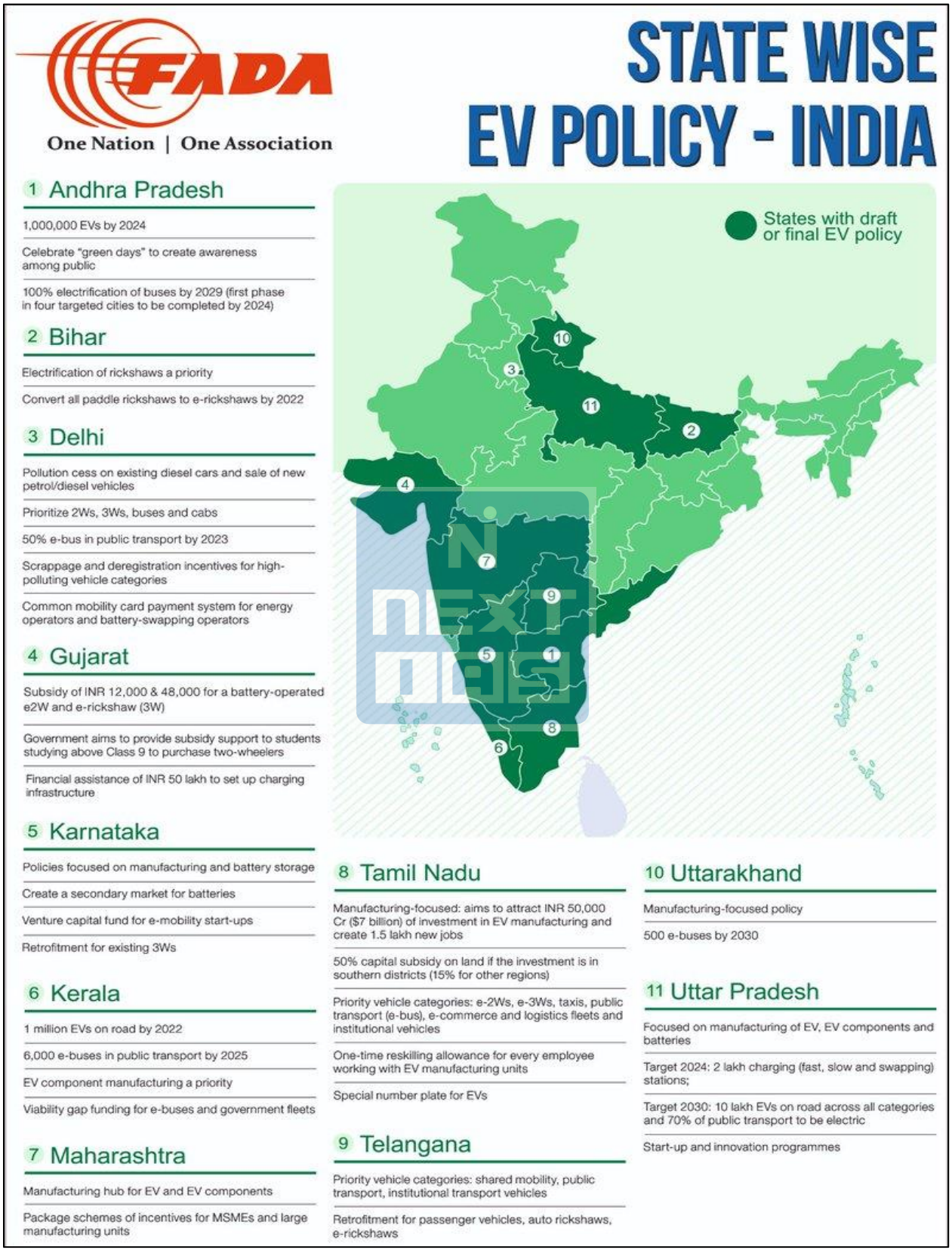


- The Union Government has approved a scheme to promote India as a manufacturing destination so that **e-vehicles (EV)** with the latest technology can be manufactured in the country.
- The policy is designed to attract investments in the e-vehicle space by reputed global EV manufacturers.

The policy entails the following:

- **Minimum Investment required:**
  - Rs 4150 Cr (~USD 500 Mn)No limit on maximum Investment
- **Timeline for manufacturing:**
  - 3 years for setting up manufacturing facilities in India, and to start commercial production of e- vehicles, and reach 50% domestic value addition (DVA) within 5 years at the maximum.
- **Domestic value addition (DVA) during manufacturing:**
  - **A localization level of 25% by the 3rd year and 50% by the 5th year will have to be achieved**
- The **customs duty of 15% (as applicable to CKD units) would be applicable on vehicle of minimum CIF value of USD 35,000** and above for a **total period of 5 years** subject to the manufacturer setting up manufacturing facilities in India within a 3-year period.
- The duty foregone on the total number of EV allowed for import would be li**mited to the investment made or ₹6484 Cr** (equal to incentive under PLI scheme) whichever is lower. **A maximum of 40,000 EVs at the rate of not more than 8,000 per year would be permissible if the investment is of USD 800 Mn or more.**
- The carryover of unutilized annual import limits would be permitted.
- **The Investment commitment made by the company** will have to be backed up by a bank guarantee in lieu of the **custom duty forgone**
- The **Bank guarantee will be invoked in case of non-achievement of DVA** and minimum investment criteria defined under the scheme guidelines

6. State wise Electric Vehicle Policy



What is the relevance of the topic for UPSC CSE?

For Prelims: Lithium, Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, Vehicle Scrappage Policy, Production Linked Incentive (PLI) scheme

For Mains: EVs: Advantages, Challenges, Way Forward and Government policies

Some previous years prelims questions

Q1. In the cities of our country, which among the following atmospheric gasses are normally considered in calculating the value of the Air Quality Index? (2016)

1. Carbon dioxide
2. Carbon monoxide
3. Nitrogen dioxide
4. Sulfur dioxide
5. Methane

Select the correct answer using the code given below:

(a) 1, 2 and 3 only

(b) 2, 3 and 4 only

(c) 1, 4 and 5 only

(d) 1, 2, 3, 4 and 5

Ans. (b)

Some previous years mains questions

Q1. Describe the major outcomes of the 26th session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). What are the commitments made by India in this conference? **(2021)**

Q2. How is efficient and affordable urban mass transport key to the rapid economic development in India? **(2019)**

Some questions for QUIZ.

Q1. Consider the following statements regarding Hybrid EVs

1. They combine a conventional internal combustion engine (ICE) system with an electric propulsion system.
2. A hybrid EV's fuel economy is 1.5-2x times higher than in conventional ICE vehicles.
3. Plug-in hybrid vehicles combine the best of both hybrid and full EVs.

How many of the above statements are incorrect?

Select the correct answer using the code given below:

(a) Only one

(b) Only two

(c) All three

(d) None

Ans. (d)

Q2. Consider the following statements regarding Electric Mobility Promotion Scheme (EMPS) 2024:

1. It aims to promote the purchase of electric two-wheelers (e2W) and four-wheelers (e4W).
2. This scheme does not cover electric three-wheelers (e3W) and e-buses.

Which of the above statements are incorrect?

Select the correct answer using the code given below:

(a) 1 Only

(b) 2 Only

(c) Both 1 and 2

(d) None

Ans. (c)

Some questions for POLL.

Q1. Can India reach the desired target of EV by 2030?

(a) YES

(b) NO

(c) Can't say.

Q2. Should EV be made tax free ?

(a) YES

(b) NO

(c) Can't say.