လျှပ်စစ်ကားအကြောင်း တစ္ဆေတစောင်း

ELECTRIC VEHICLES INTRODUCTION

Engr. Khin Maung Win
Vice President
Federation of Myanmar Engineering Societies
17th October,2026

History of EVs လျှပ်စစ်ကားရဲ့ သမိုင်းကြောင်း

- The first EV was a small toy car built in 1828 by a Hangarian.
- EV was developed in the 1830s while an ICEV was in 1885.
- The early days of EVs employing lead-acid batteries started mainly from the 1890s.
- By the year 1920, its popularity started declining due to ICEV that was mass produced by Henry Ford.
- At the same time, huge reserves of petroleum were found all over the world.
- The ICEV had better mileage, speed, low capital, and running cost.
- These advantages led to the initial death of EVs and, by the year 1935, they almost disappeared from the market.
- Once again, the oil crisis upsurge of the 1970s generated fluctuations in gasoline in market, and this led to the renewed interest in EVs.
- By the year 1995, the digital systems, microprocessors, power electronic circuits, motors, control, and battery technology had also improved for high-performing EVs.

Source: The Institution of Engineering & Technology, London, UK.

Evolution of Electric Vehicles လျှပ်စစ်ကားများအဆင့်ဆင့်ပြောင်းလဲပုံ

- 1973: GM displayed initial prototype of EV for urban use
- 1991: New regulation released to environment made by US govt.
- 1996: GM mass produced EV1.
- 1997: Hybrid car PRIUS was released by Toyota
- 1998: Hybrid car INSIGHT launched by Honda
- 2008: ROADSTER EV launched by Tesla
- 2010: All EV launched by Nissan
- 2016: Chevy BOLT, an All-EV released by GM

Source: The Institution of Engineering and Technology, London, UK

Economic and environmental impact of conventional vehicle leading to selection of EV

- The petroleum fuel-based cars and trucks are responsible for almost 25% of CO2 emission and other such vehicles account for about 12%.
- A hybrid vehicle essentially combines petrol/diesel fuel along with one different power (energy) sources. The possible second source is generally one of the following : battery, flywheel, and fuel cell (FC).
- The major economic parameters for a customer to purchase any vehicle are the following: (i) vehicle price, (ii) fuel cost, (iii) maintenance costs and service station availability, (iv) driving range, (v) availability of the fueling station, (vi) time required for the fueling, and (vii) battery replacement cost.
- The modern world is employing technology in every aspect of life, and the use of chemicals, composites, and plastic is helping in newer developments. This is cause for newer challenges, . global warming, and irreversible climate change draws. It has only been recently acknowledged that some regulations have been decided internationally for stopping the global warning.

GLOBAL TRENDS ကမ္ဘာလုံးဆိုင်ရာဦးတည်မှုများ

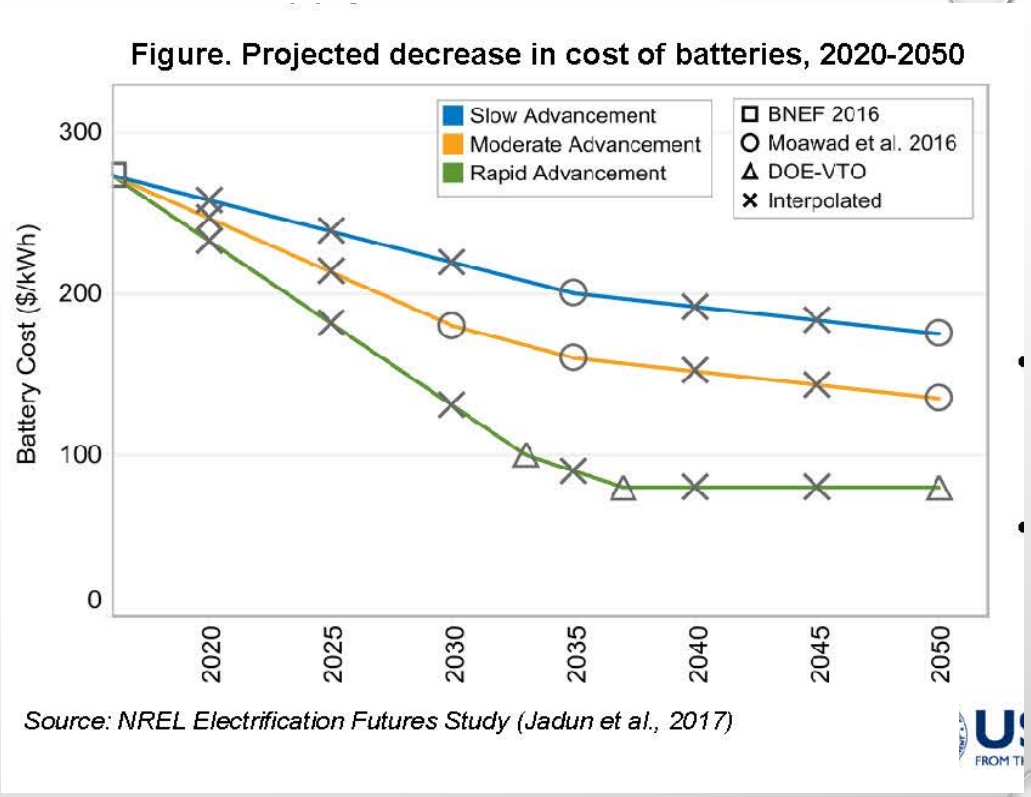
	• 2021 EV STOCK	2040 EV STOCK PROJECTIONS
❑ PASSENGER CARS	16.7 MILLION	727 MILLION
	(9% OF GLOBAL SALES)	(75% OF GLOBAL SALE)
❑ COMMERCIAL VEHICLES	180,000	15.5 MILLION
	(1% OF GLOBAL SALES)	(54% OF GLOBAL SALE)
❑ BUSES	685,000	1.7 MILLION
	(44% OF GLOBAL SALES)	(83% OF GLOBAL SALES)
❑ 2-3 WHEELERS	275 MILLION	758 MILLION
	(42% OF GLOBAL SALES)	(83% OF GLOBAL SALES)

SOURCE: USAID, NREL

COST DECLINES IN BATTERIES ကျဆင်းနေသောဘက်ထရီဈေးနှုန်းများ

- Higher upfront cost of most EVs compared to internal combustion engine (ICE) counterpart is due to cost of battery.
- Battery pack prices have fallen 89% since 2010, despite recent supply chain issues.
- Unsubsidized upfront price parity expected in most vehicle segments and markets by the late 2020s.
- Already, the lifetime operational cost of owning EVs is typically lower than the ICE counterpart due to reduced fuel and maintenance expenses.

Source: USAID, NREL



REGIONAL TRENDS ဒေသဆိုင်ရာဦးတည်ချက်များ

- India has set the following 2030 EV sales goals: 30% passenger cars, 70% commercial vehicles, and 80% of 2 & 3 wheelers.

Commitments by Japanese Automakers

Toyota: EVs constitute 40% of annual sales by 2030

Nissan: 50% sales from EVs and hybrids by 2030

Honda: 30 EV models and production of 2 million units by 2030

EV Charging, Charging Stations (all types) အားသွင်းခြင်းနှင့် အားသွင်းစင်တာများ

EV Charging

Purpose of Charging Stations (all types):

- Connects EV to grid
- Dedicated circuit prevents overloading
- Safe connection before power can flow
- Prevents EV battery damage



Figure. Range of typical dwell times for chargers at various locations

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Source: Bopp et al. (2020)

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CHARGING PORTS AND COMMON STANDARDS အားသွင်းပလပ်များ

- SAE J1772 – North America
  - 5-pin AC charging port (Type 1)
  - 7-pin DC charging port: Combined Charging Standard (CCS1)
- IEC 61851/62196 – Europe and emerging markets
  - 7-pin AC charging port (Type 2)
  - 9-pin DC charging port (CCS2)

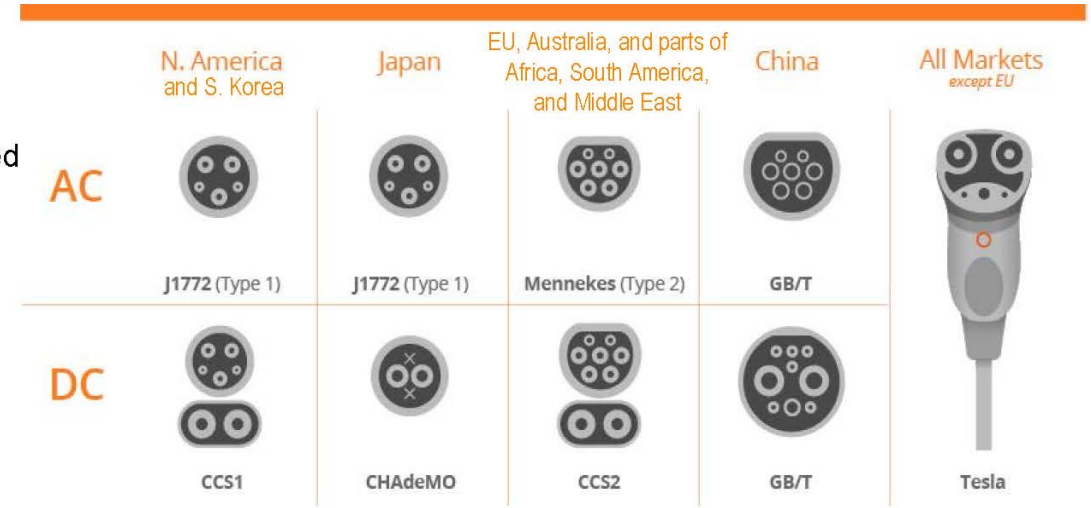


Figure. Predominant charging standards in different regions

Image: Enel X

- DC charging uses two additional dedicated DC pins.
- All chargers require additional pins for communication or controls.
- India has Bharat Standards (low power), CCS, CCS2, CHAdeMO, and Tesla.

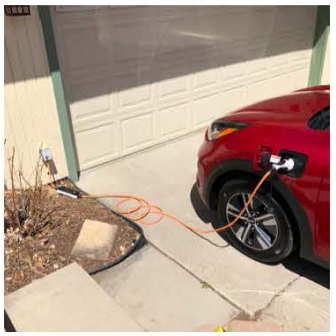
Source: Bopp et al. (2020)

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RESIDENTIAL CHARGING အိမ်တွင်းအားသွင်းခြင်း အဆင့် ၁

- Most established markets focused on residential charging first.
- Internationally, 50%-80% of all charging events occurred at residences (Hardman et al. 2018).
- Lack of residential charging availability is often found to be a barrier to EV adoption (Funke et al. 2019).
- Residential charging can use Level 1 or Level 2 EV supply equipment (EVSEs).



Level 1 EVSE

- 3–8 km per hour of charging
- Charging speed often limited by vehicle
- Alternating Current
- 120 V

Source: Aznar et al. (2021)

Image: Erik Nelsen (NREL)

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PUBLIC CHARGING အိမ်ပြင်ပအားသွင်းခြင်း အဆင့် ၂ နှင့် အမြန်အားသွင်းခြင်း

Level 2 EVSE



- 16–32 km per hour of charging
- Charging speed often limited by vehicle
- Alternating Current
- *7.2 kW, 240 V

*power ratings vary

- Public and home charging
- Less expensive to install and operate than DCFC
- AC charging power is limited by the capabilities of the vehicle's on-board charger
- Can process payments and data
- Can be networked

DC Fast Charger

- 95–128 km per hour of charging
- Direct Current
- *50 kW, 480–600 V
- Can be up to 350 kW



*power ratings vary

- Expensive to install and operate
- Faster charging
- Can process payments and data
- Can be networked
- Incompatible with many 2- and 3-wheelers

Source: Bopp et al. (2020), Images: Erik Nelsen (ICF)

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BATTERY SWAPPING အားပြည့်ဘက်ထရီဖြင့်လဲလှယ်ခြင်း

- Easier for motorcycles/scooters because liftable size and less expensive to carry redundant batteries
- Rickshaws use multiple batteries but can be compatible
- More compatible with renewables than EVSE
- Reduces the upfront cost of scooters and increases lifespan
- Largest networks operated by Gogoro (Taiwan), Immotor (China), KYMCO (Taiwan)
- Honda, KTM, Piaggio, and Yamaha have formed a swappable battery consortium for standards

Source: Aznar et al. (2021)

Image: electrek.co



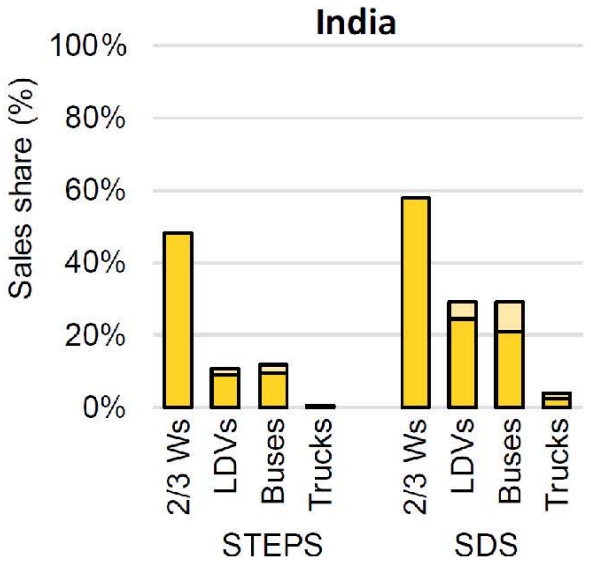
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CASE STUDY : INDIA

- National target of 30% EV sales by 2030
- Set stringent fuel economy standards aligned with Euro 6 in April 2020
- Faster Adoption and Manufacturing of EVs (FAME II):
  - Purchase incentives of $1.4B USD for 1.6M EVs and hybrids 2019-2024
  - Phased-in localization of component manufacturing
  - Charging infrastructure funding of $133M USD
  - Direct subsidies to purchase electric buses (nearly 6,000 so far) and 1 charger per bus
  - EV adoption far behind schedule:
    - Possibly due to no zero-emission vehicle sales requirements or ICE phase-out targets (IEA 2021)
    - EV manufacturers blame the aggressive localization criteria before large enough market (Chaliawala 2021)
    - Others blame the limited availability of inexpensive EV models.
- Large municipal fleets (especially New Delhi) are leading in electrification

Figure. Projected EV share of vehicle sales by mode and scenario in India, 2030



STEPS = Stated Policies Scenario
SDS = Sustainable Development Scenario

Source: International Energy Agency (2022)

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CASE STUDY : NEW ZEALAND

- 10,574 EVs sold in 2021
- Emission Reduction Plan promotes EVs, walking, cycling, and public transit
- Currently, public chargers every 75 km on highways, but more are needed to support increasing number of EVs
- Clean Car Discount Program: Rebates for vehicles (new and used) emitting less than 146 grams of CO_2 per kilometer, and fees on vehicles above the limit
- Low Emission Transport Fund: Supports EV chargers, car shares, bus fleets, e-bike storage, and more



Image: Google Maps

Source: Joshi et al. (2022, forthcoming)

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Types of EVs based on the power source 1 လျှပ်စစ်ကားအမျိုးအစားများ

1. **BEVs** rely solely on power from rechargeable battery packs like Li-on battery or metal-air battery.

   The presence of regenerative braking in BEVs improves its performance significantly.

   Battery charging takes a significant amount of time.

   Fast battery-charging stations are required, as a substitute or in parallel to exiting gasoline fuel stations.

   BEVs technology is yet to mature and at present range anxicty is associated with it.

   The BEVs are fast replacing the existing ICE-based vehicles due to the fast depletion of gasoline and the steep rise in its prices.

2. **HEVs** comply ICE along with the electric power train.

   The main power for vehicle propulsion is from ICE and the battery is employed to improve the vehicle performance by suitable switching of power source.

   Electric propulsion is used when power demand is low.

   HEVs have reduced fuel consumption and GHG emission compared to a pure ICEV.

Types of EVs based on the power source 2

3 **PHEVs** electric propulsion is the main driving force.

It has bigger batteries compared to an HEV

The batteries are required to be charged at regular intervals

Batteries can be charged directly from grids.

4 **FCEVs** employ fuel cells to generate electric power for the propulsion vehicles.

Fuel cells mainly employ hydrogen as the fuel for the chemical reaction to produce electricity.

High-pressure tanks are required in FCEVs to store hydrogen which is inflammable.

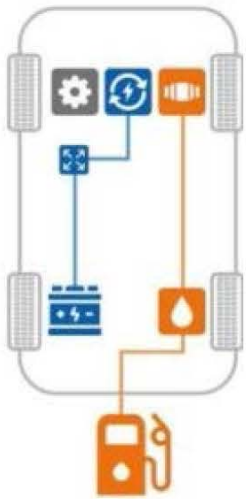
The hydrogen tank is a substitute for the gasoline tank of ICEV.

The by-product from a fuel cell is water and, therefore, it has no pollusion.

A FCEV has the advantages of BEV as well as ICEV; however, the technology is yet to mature.

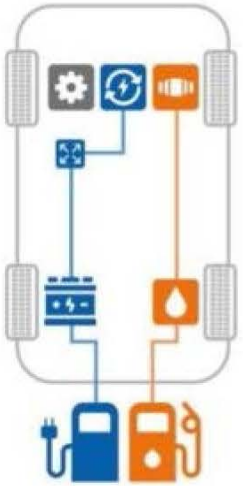
Moreover, the cost of hydrogen production is high and the most efficient and viable process for it is being researched.

EV Technology, Electric Drive Trains



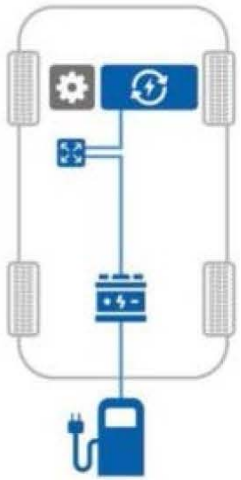
Hybrid Electric Vehicle

- ICE and electric motor
- Batteries are charged by engine (no external charging)



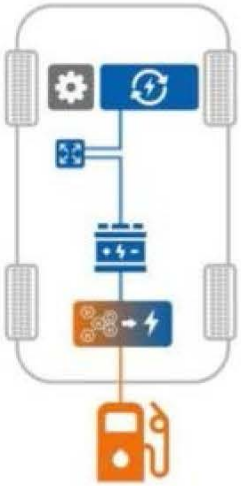
Plug-in Hybrid Electric Vehicle

- ICE and electric motor
- Batteries are rechargeable



Battery Electric Vehicle

- 100% electric motor
- Batteries are rechargeable



Fuel Cell Electric Vehicle

- 100% electric motor
- Fuel cell converts hydrogen and oxygen into electricity
- Requires hydrogen distribution infrastructure



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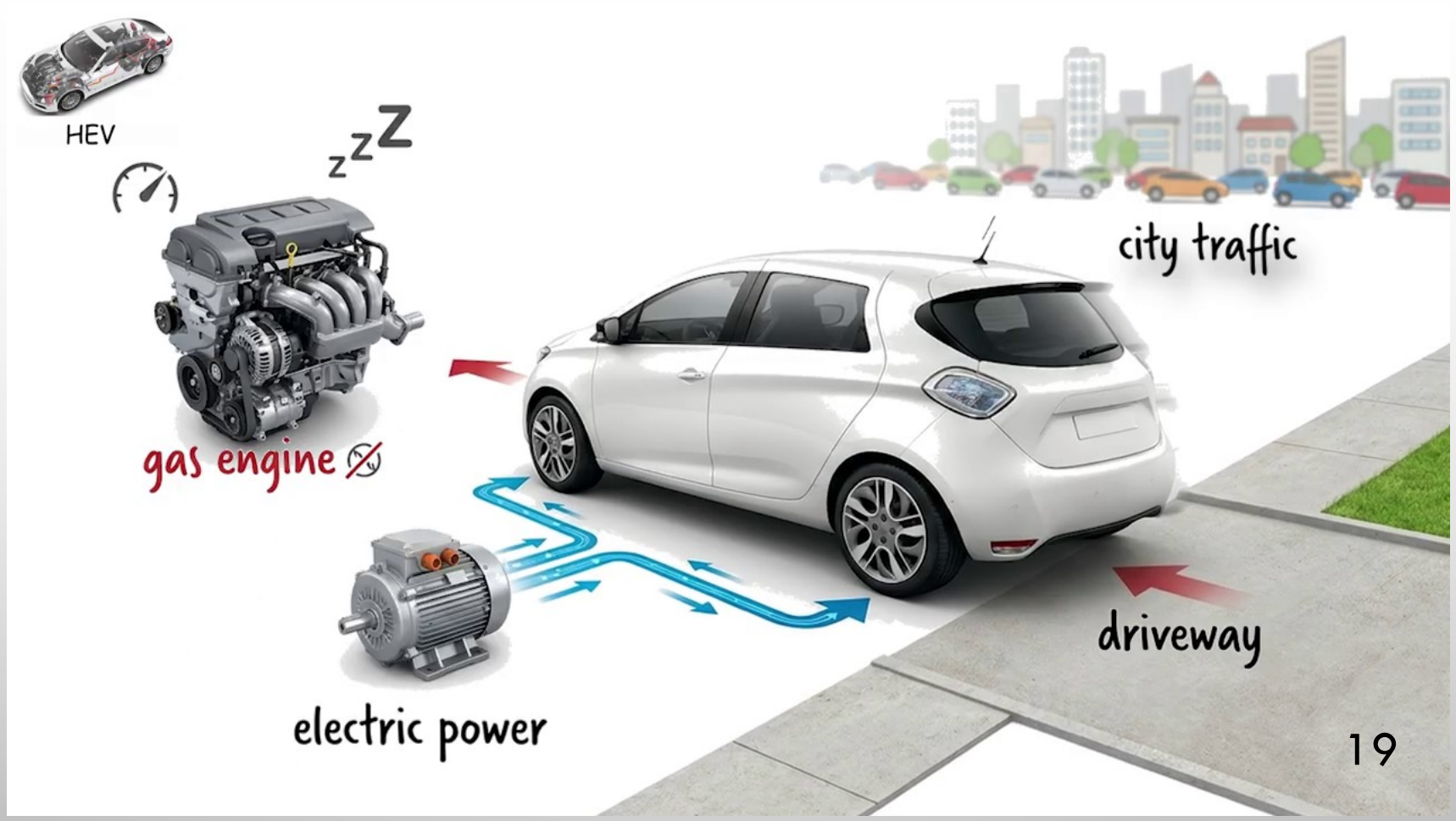
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Images: National Motorists Association Blog (2020)

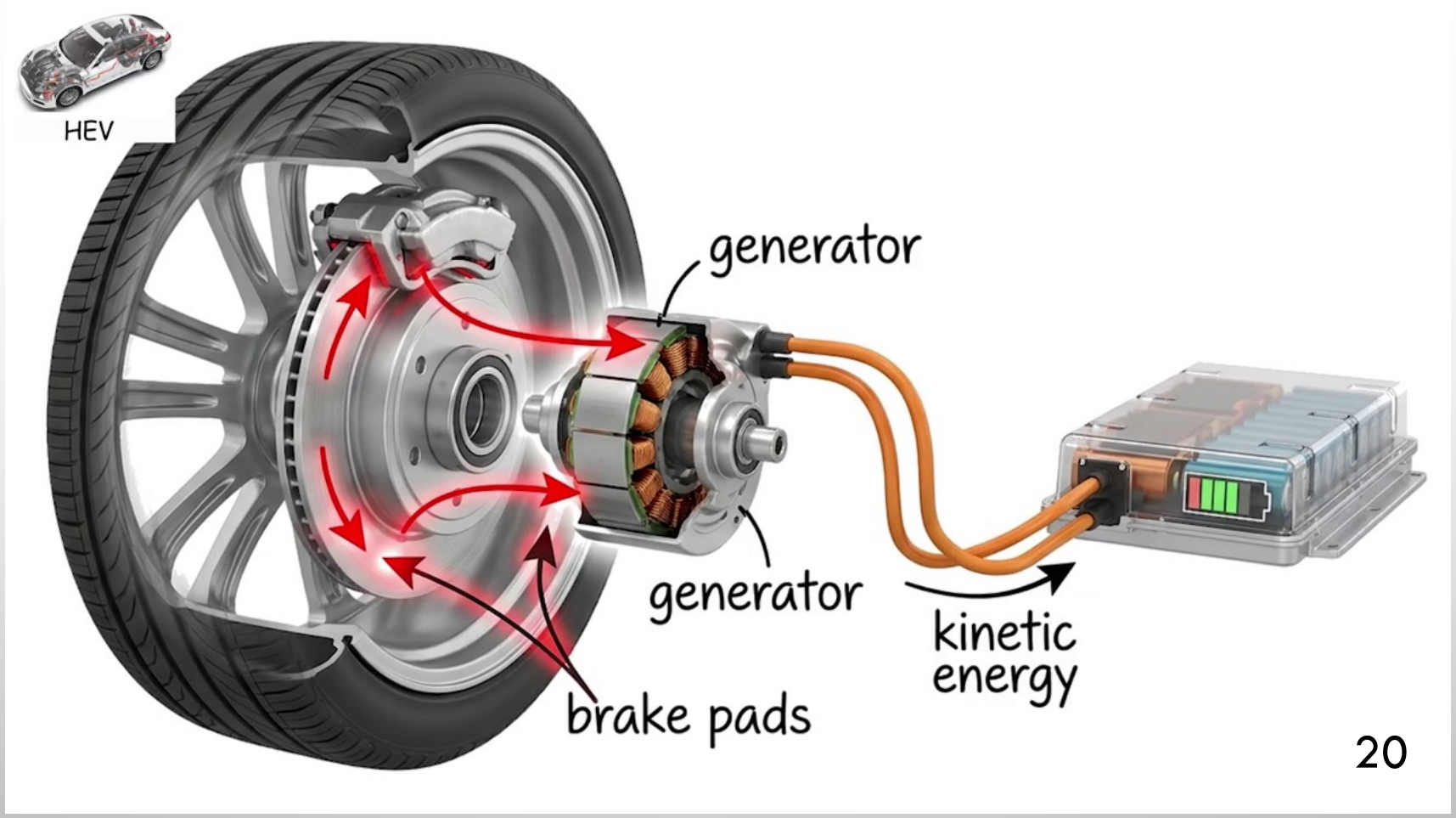
HYBRID ELECTRIC VEHICLE (HEV)



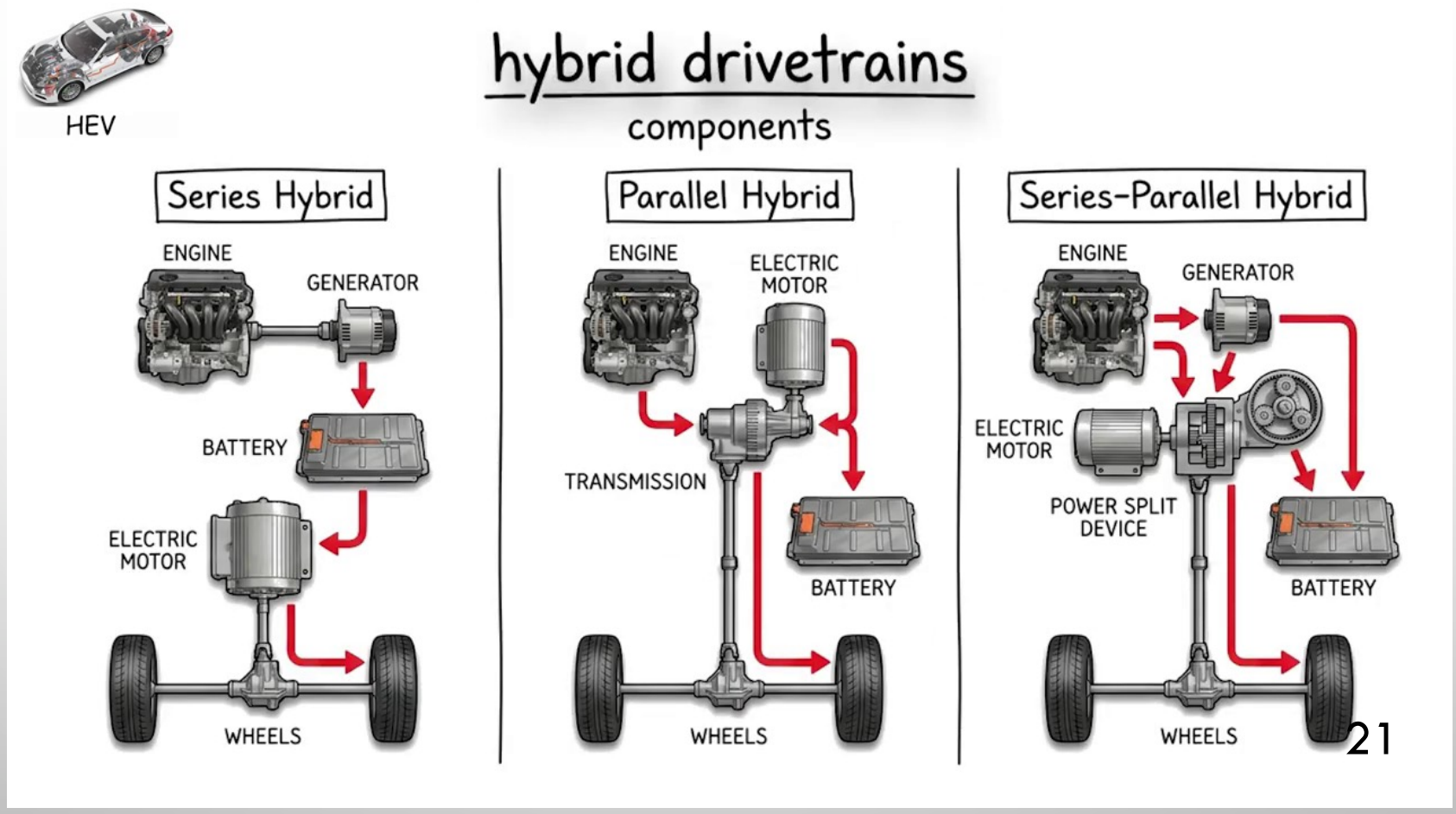
HEV – HYBRID ELECTRIC VEHICLE



HEV – HYBRID ELECTRIC VEHICLE



HYBRID DRIVETRAINS

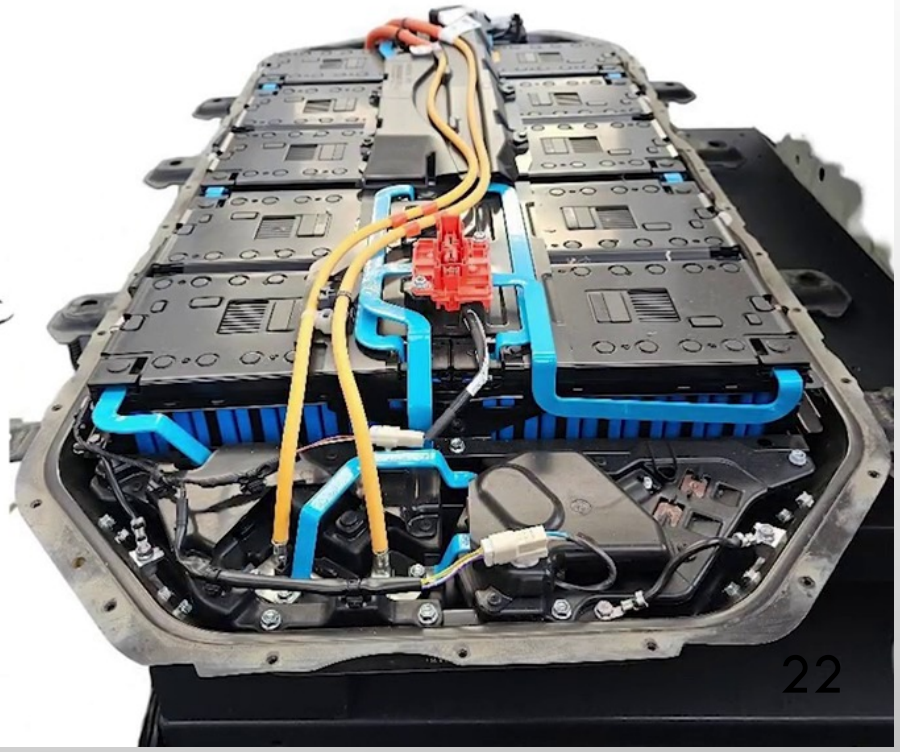


PHEV - PLUG-IN HYBRID ELECTRIC VEHICLE



PHEV

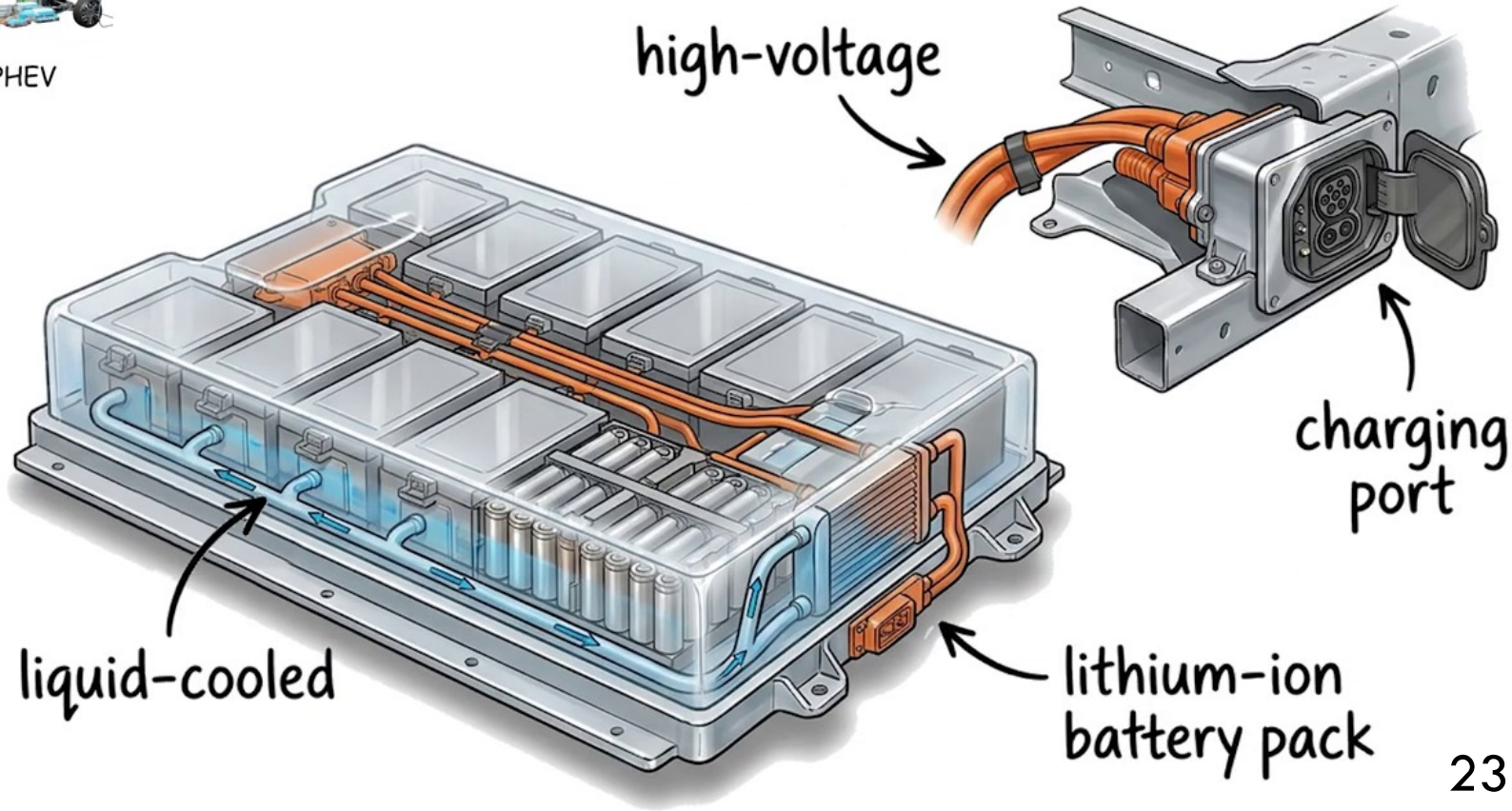




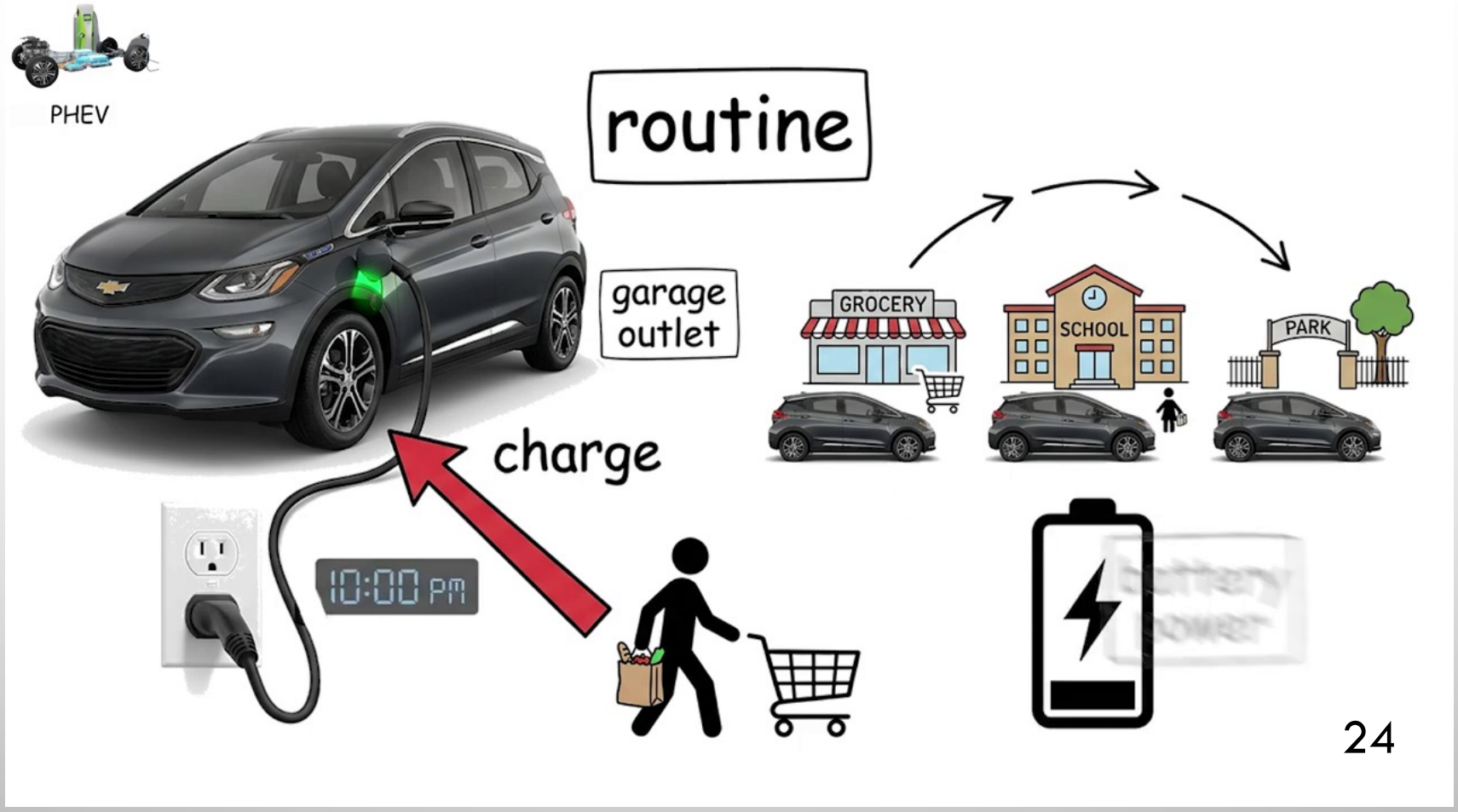
PHEV - PLUG-IN HYBRID ELECTRIC VEHICLE



PHEV



PHEV - PLUG-IN HYBRID ELECTRIC VEHICLE



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PHEV - PLUG-IN HYBRID ELECTRIC VEHICLE



PHEV - PLUG-IN HYBRID ELECTRIC VEHICLE



PHEV



charging routine



adaptive tool

mechanical



electrification

BEV - BATTERY ELECTRIC VEHICLE



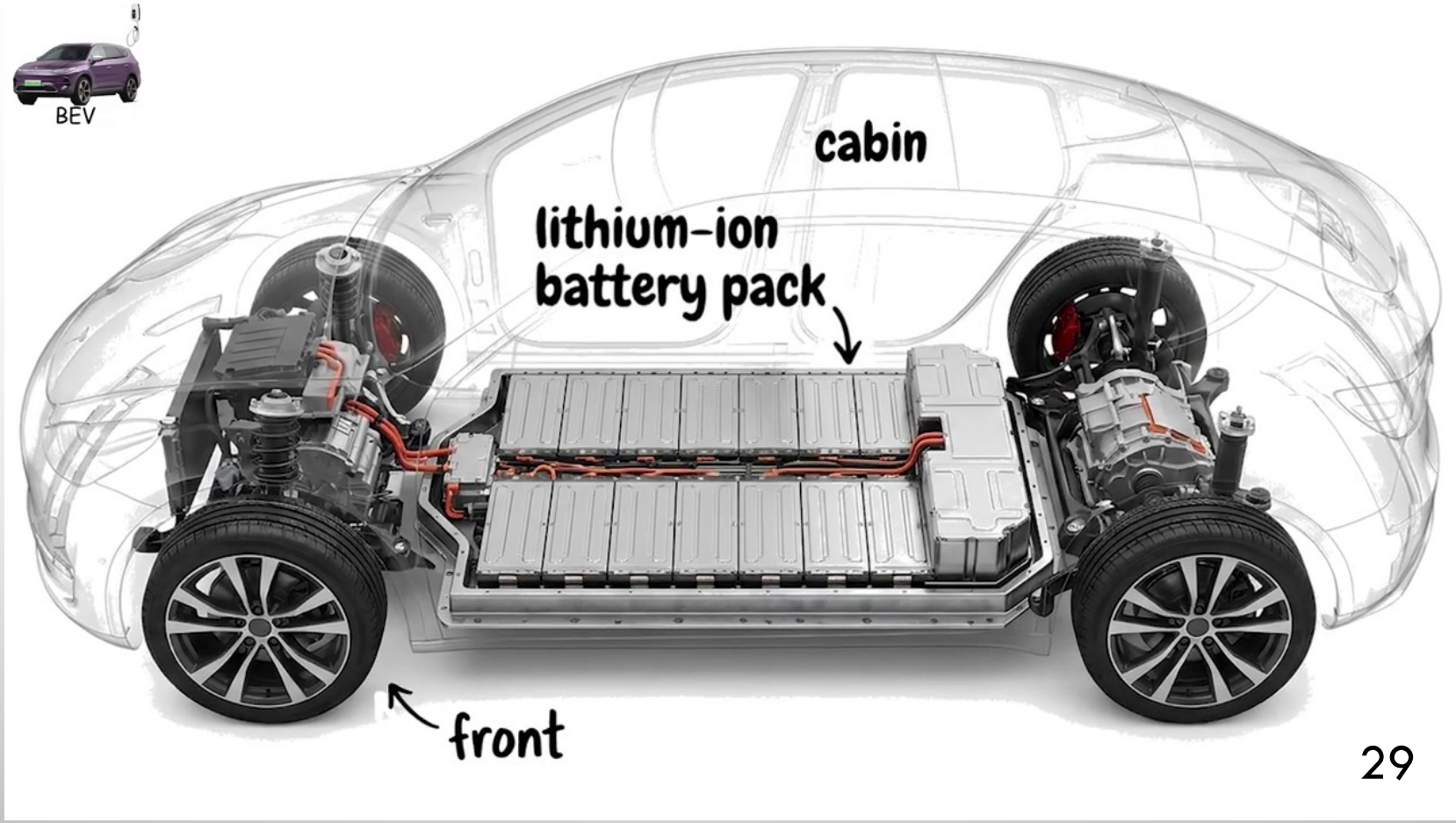
architecture



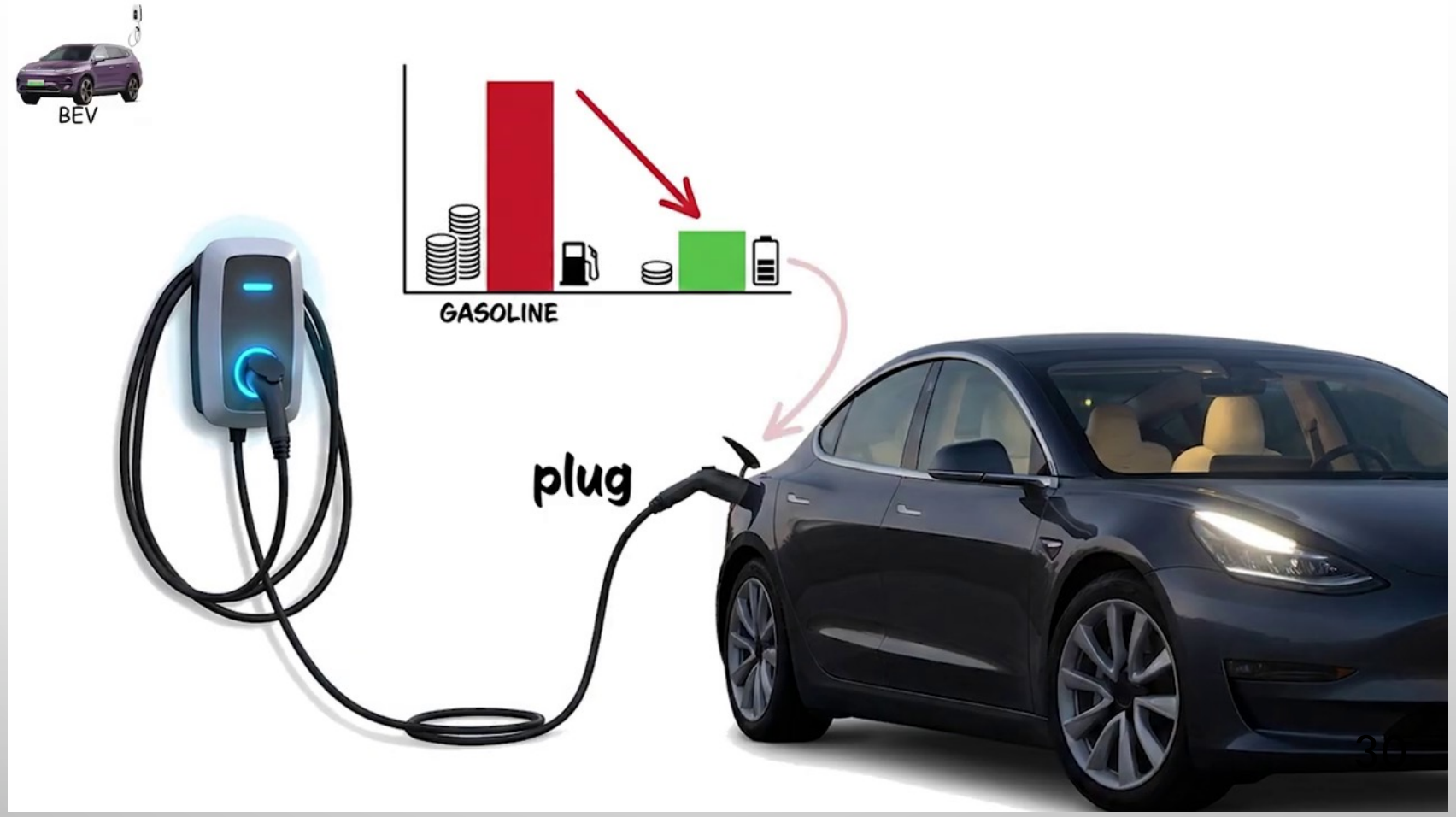
traditional



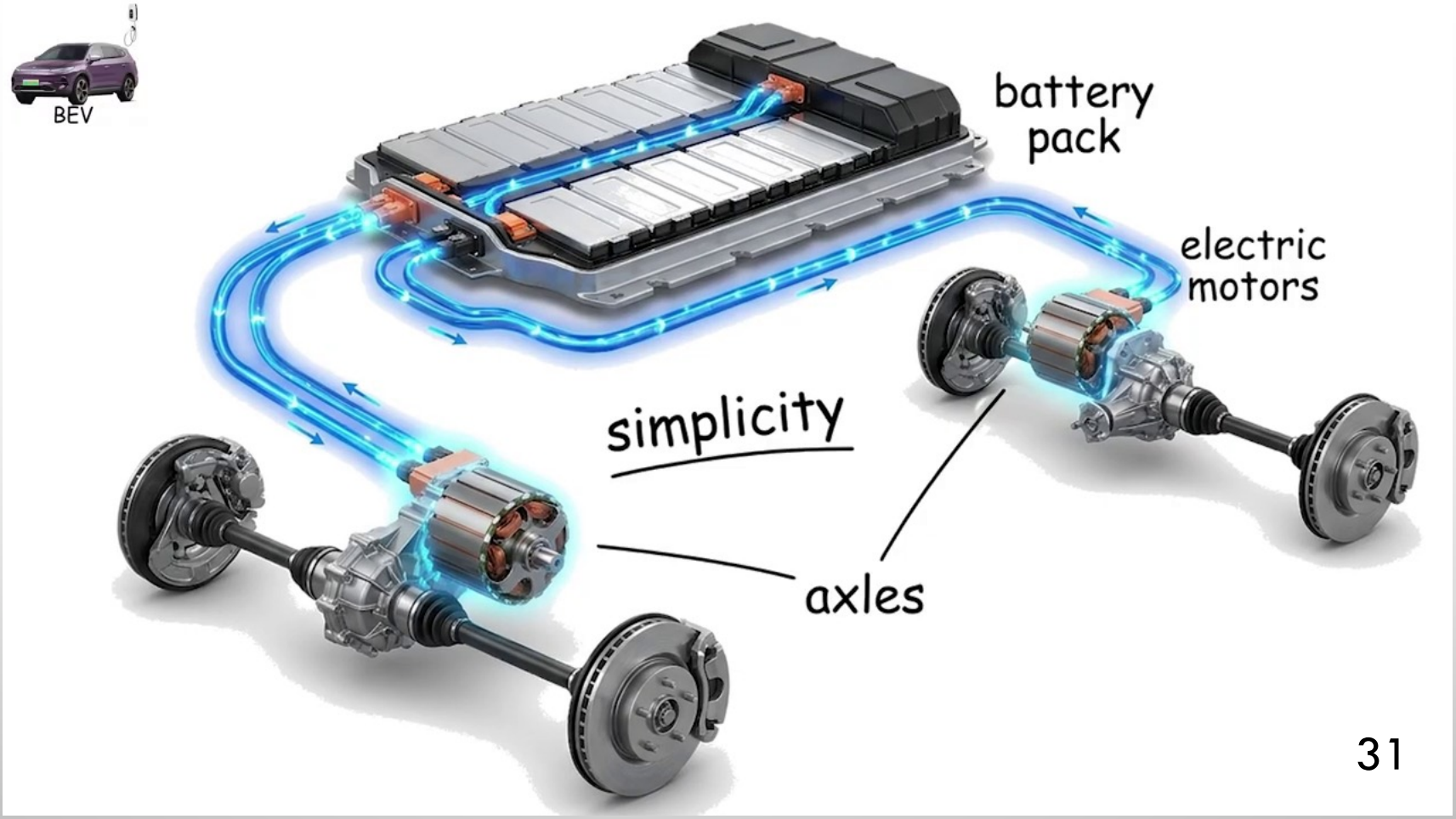
BEV - BATTERY ELECTRIC VEHICLE



BEV - BATTERY ELECTRIC VEHICLE

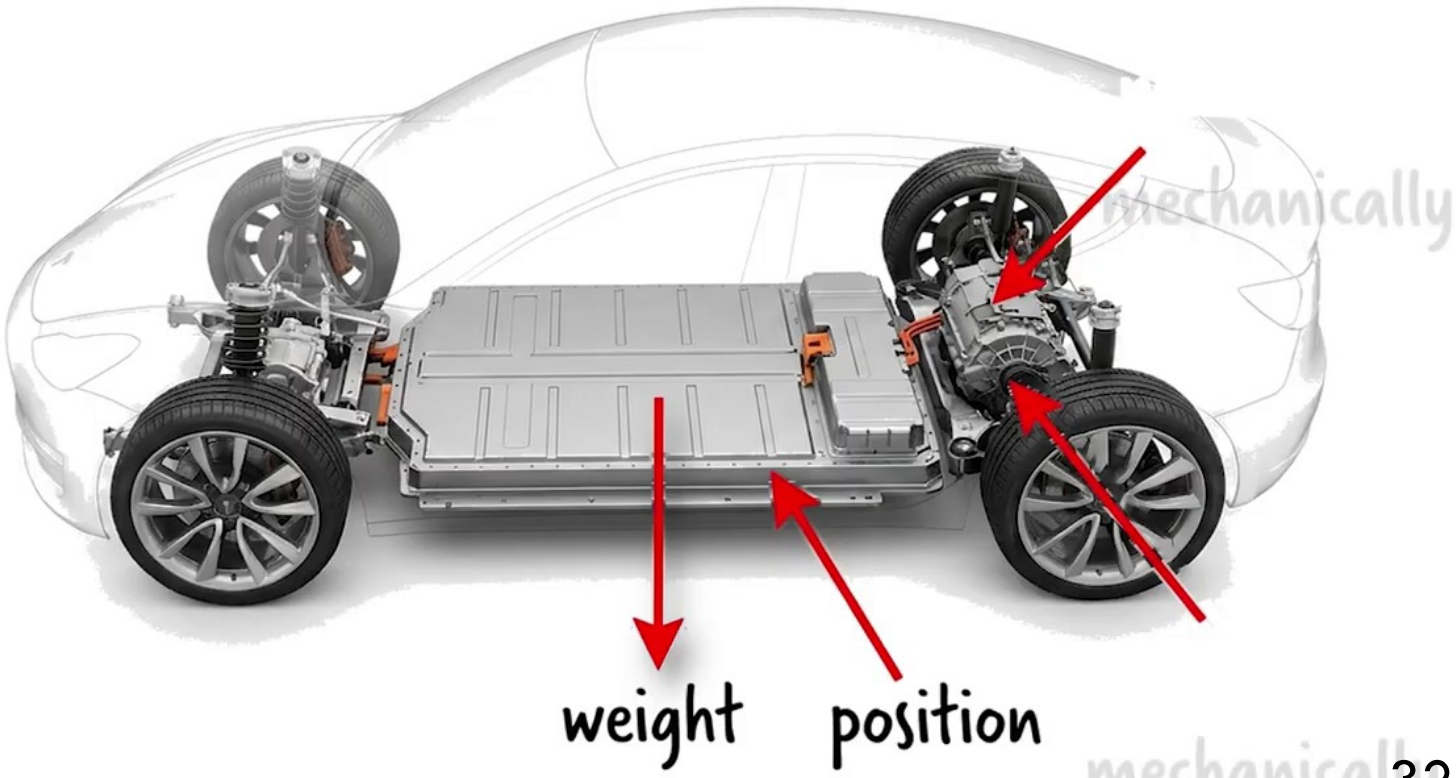


BEV - BATTERY ELECTRIC VEHICLE

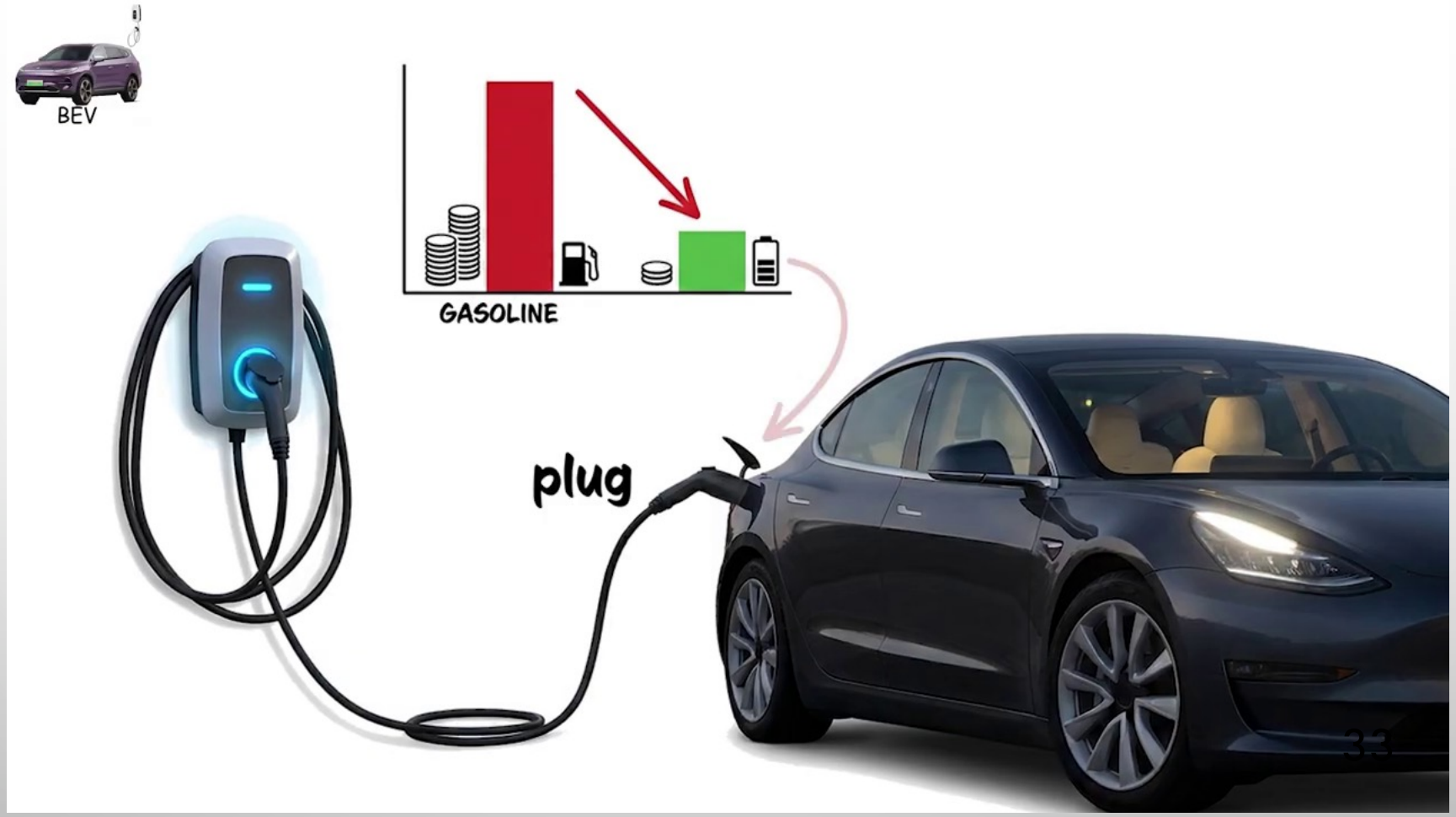


BEV - BATTERY ELECTRIC VEHICLE

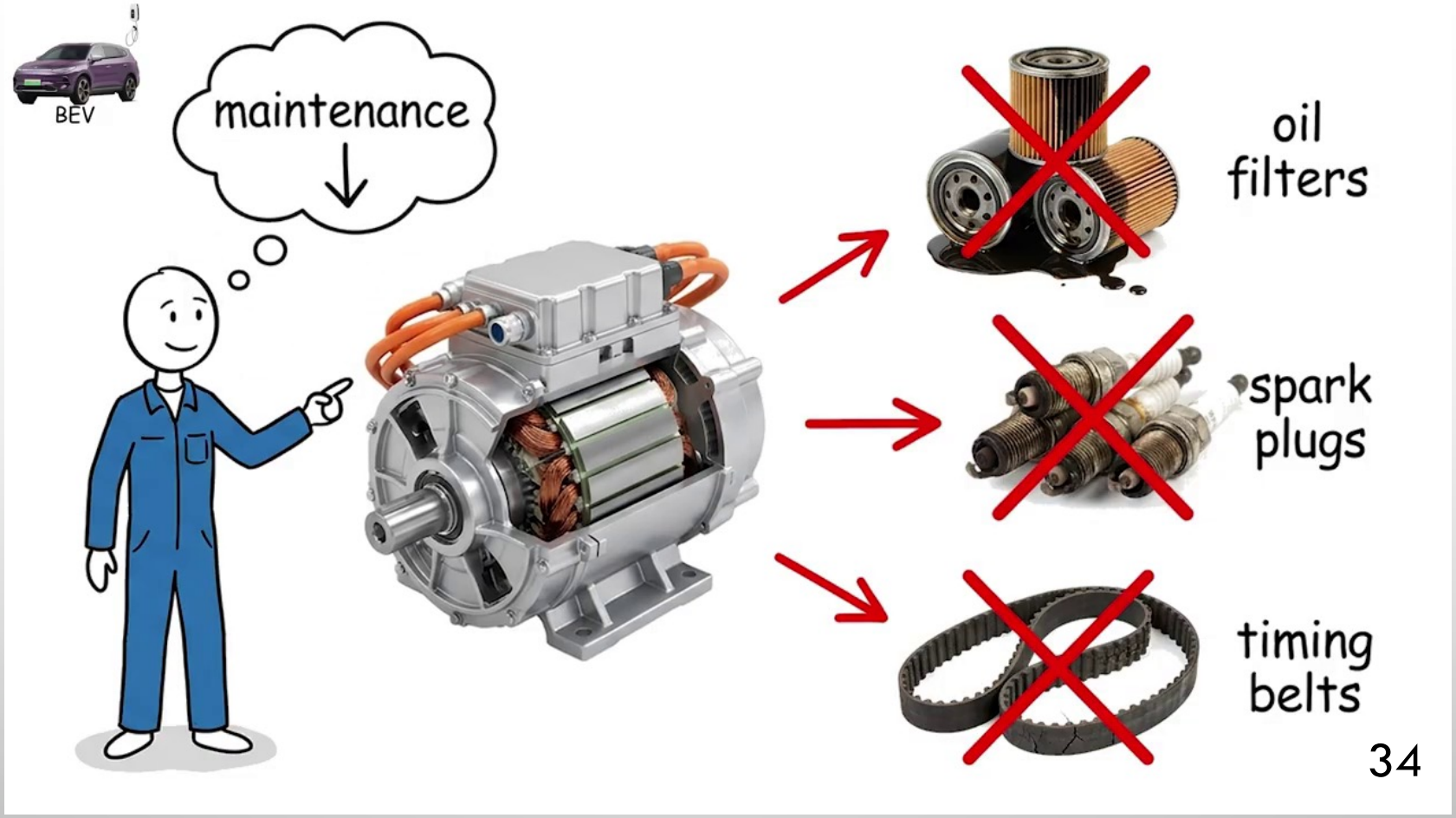




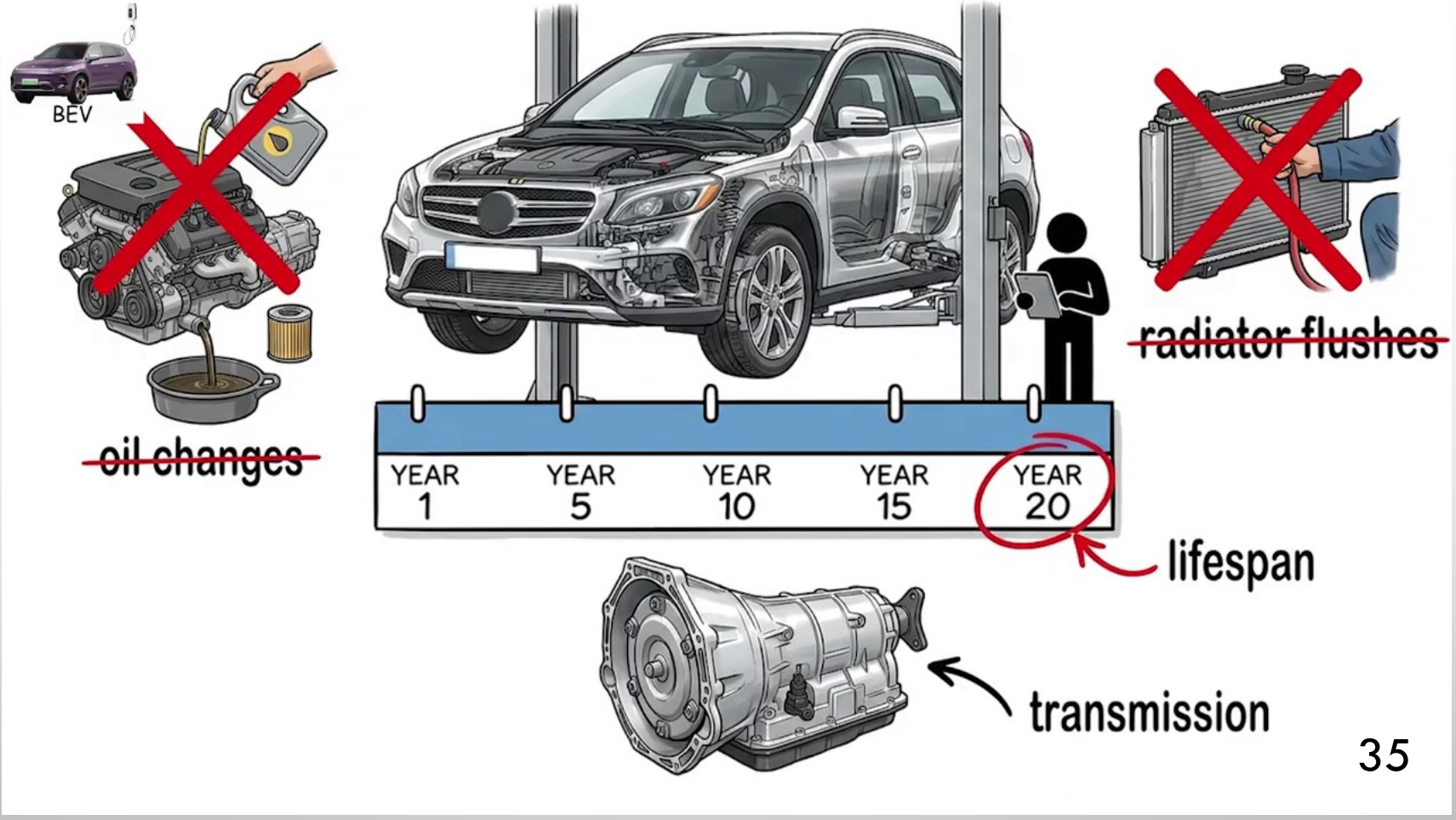
BEV - BATTERY ELECTRIC VEHICLE



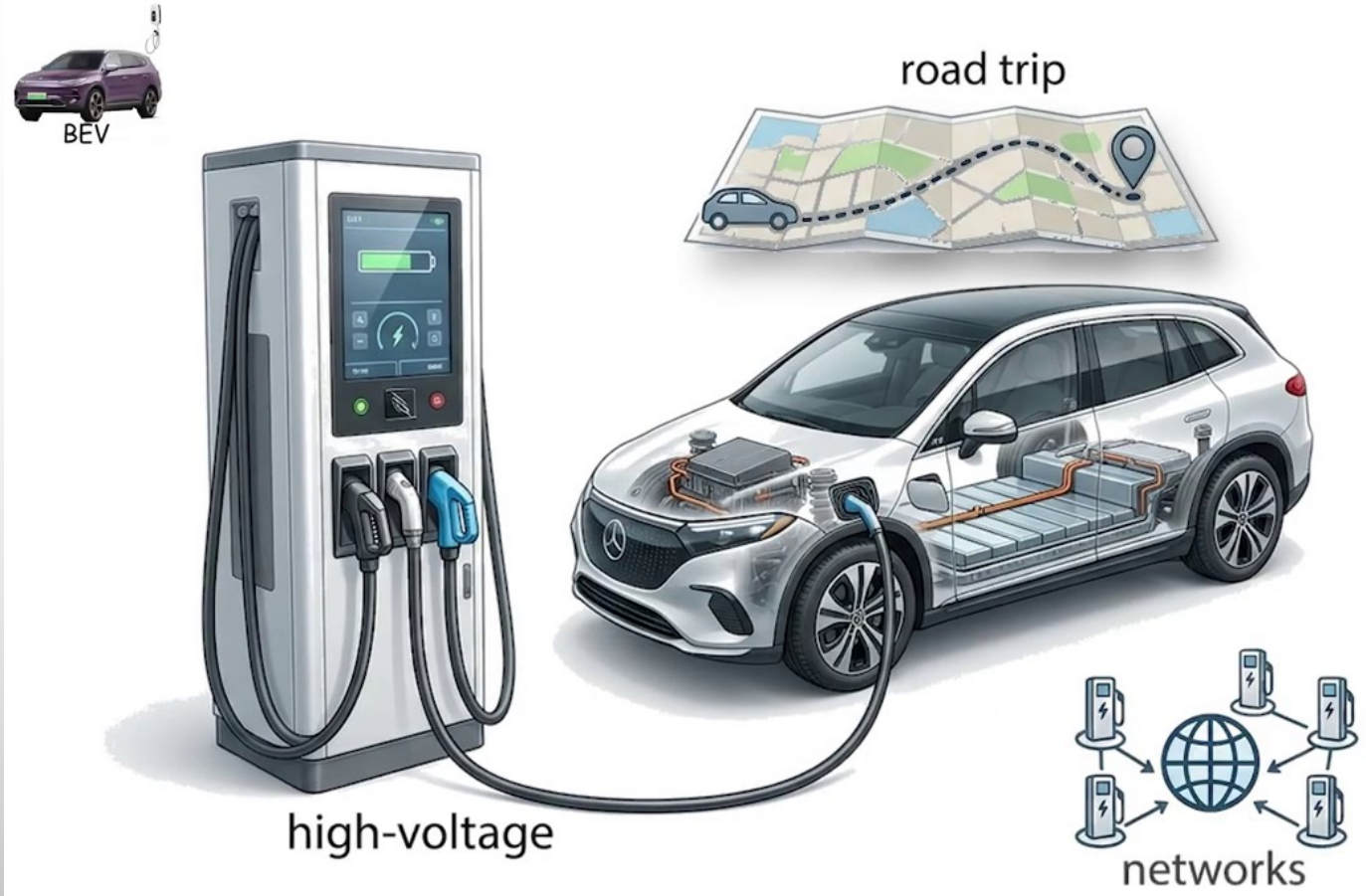
BEV - BATTERY ELECTRIC VEHICLE



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BEV - BATTERY ELECTRIC VEHICLE





Tesla
Model Y



BYD
Seal



Hyundai
Ioniq 5

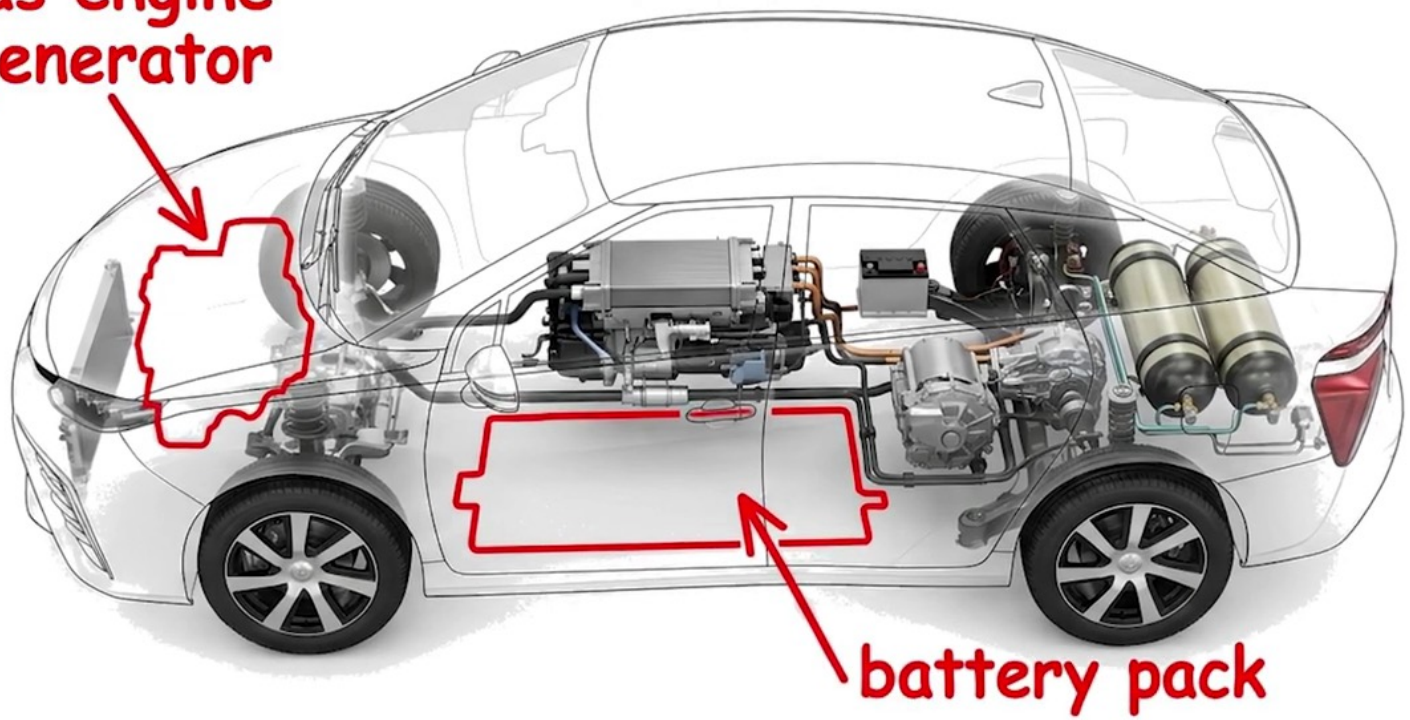


Kia
EV6

FCEV

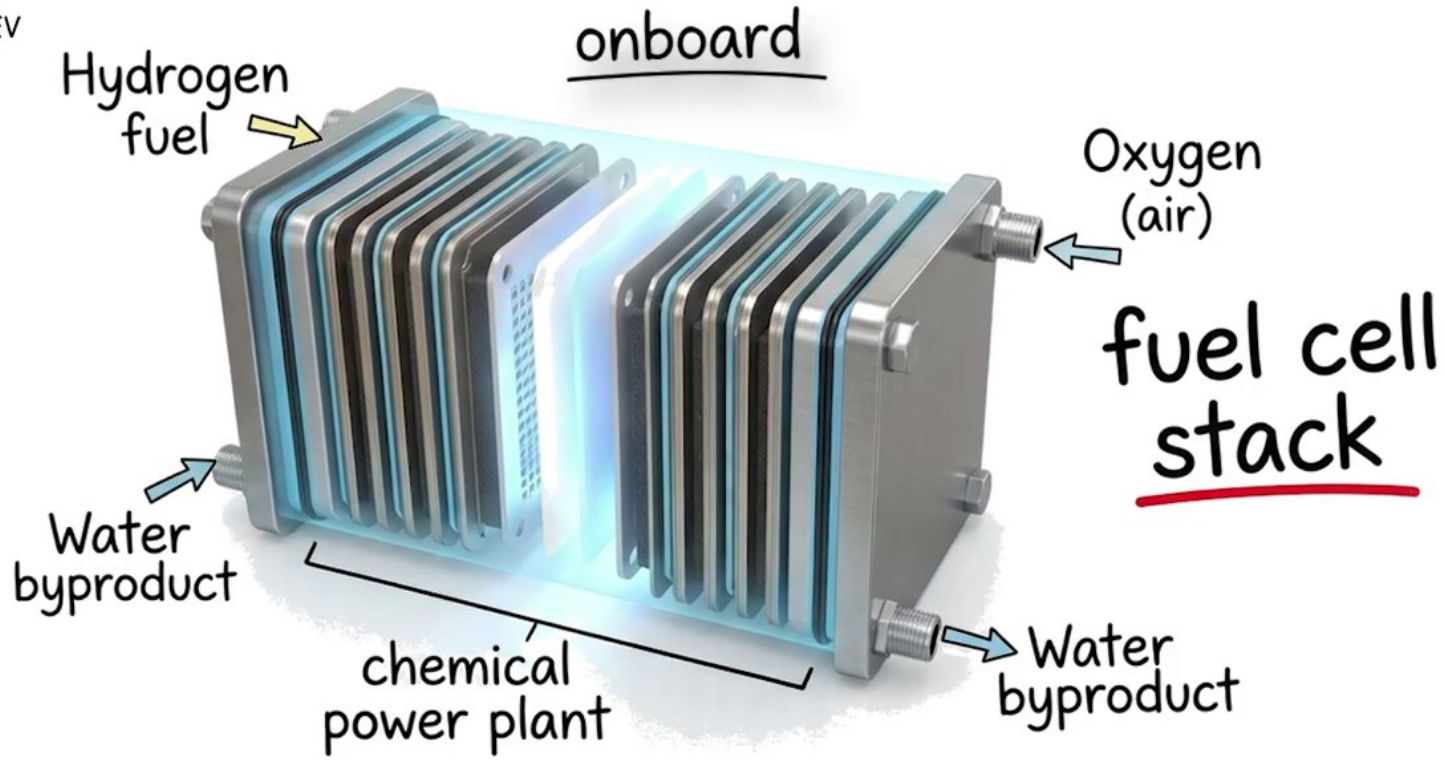


Fuel Cell Electric Vehicle
FCEV



FCEV- FUEL CELL ELECTRIC VEHICLE

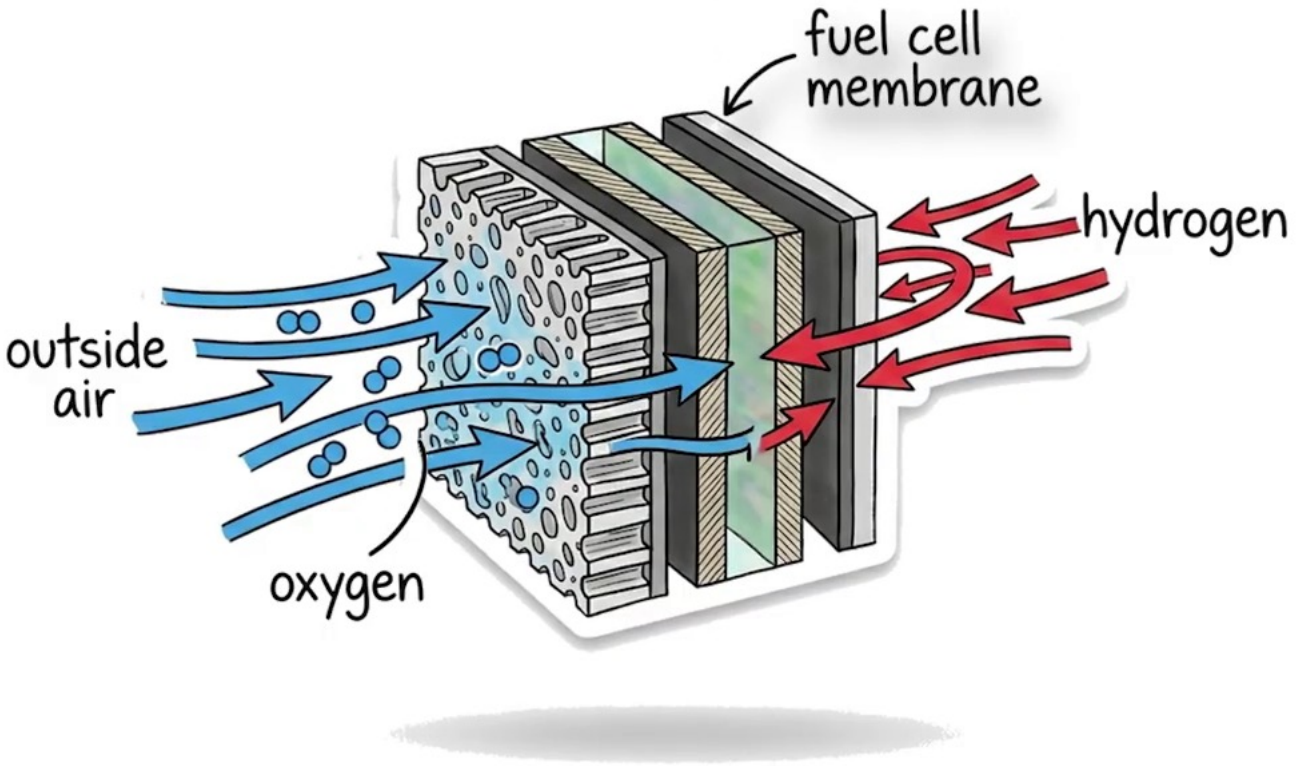




FCEV – FUEL CELL ELECTRIC VEHICLE



FCEV



FCEV – FUEL CELL ELECTRIC VEHICLE



FCEV – FUEL CELL ELECTRIC VEHICLE



FCEV

technology

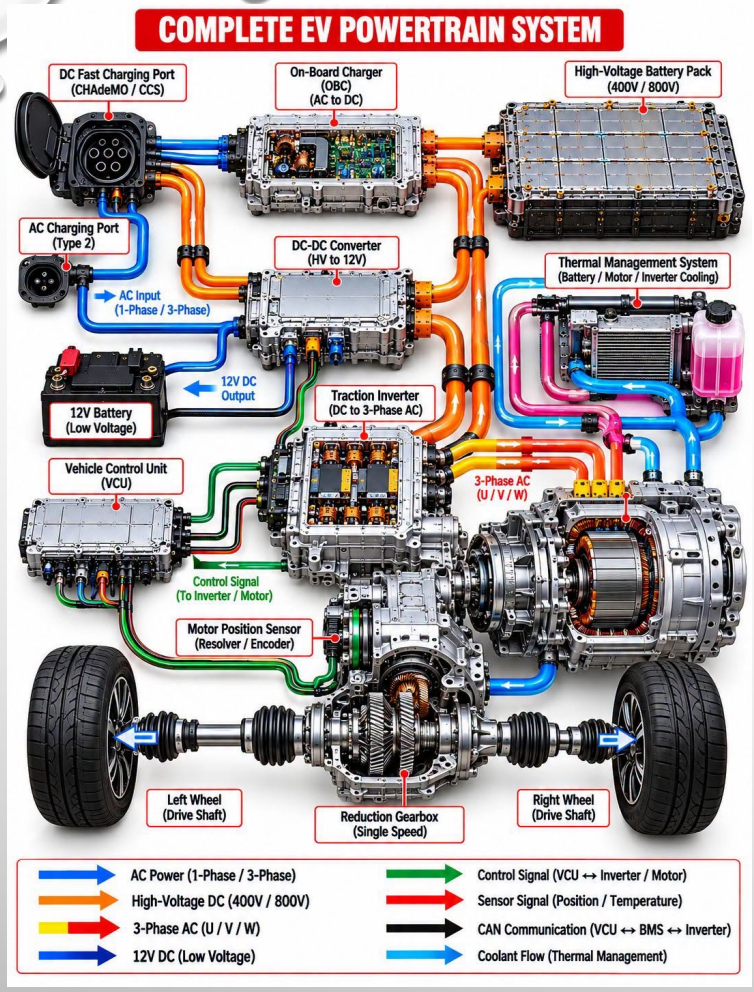
Toyota Mirai

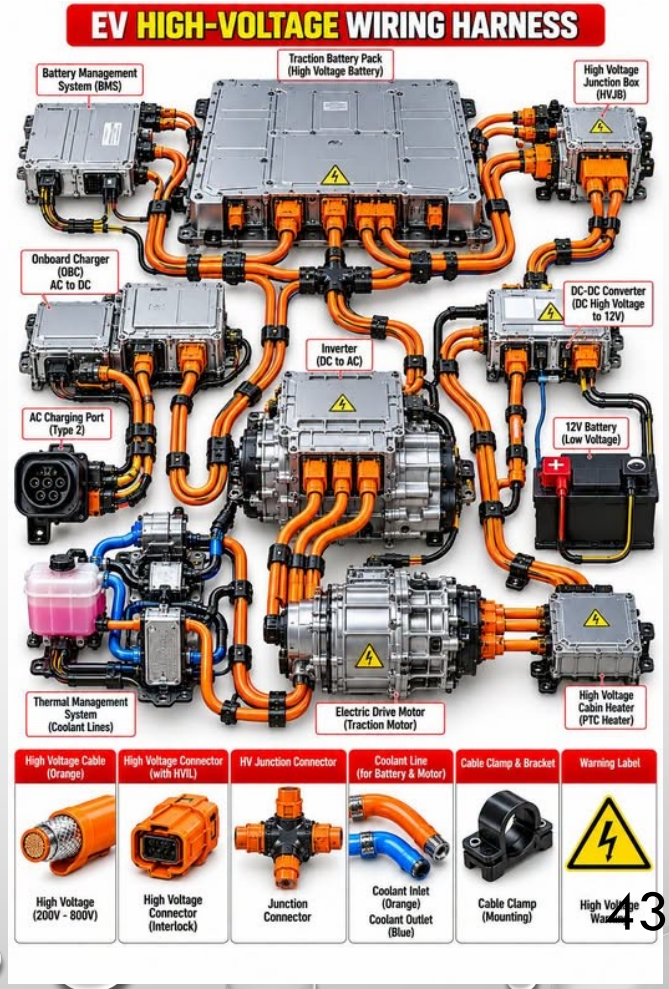


Hyundai Nexo

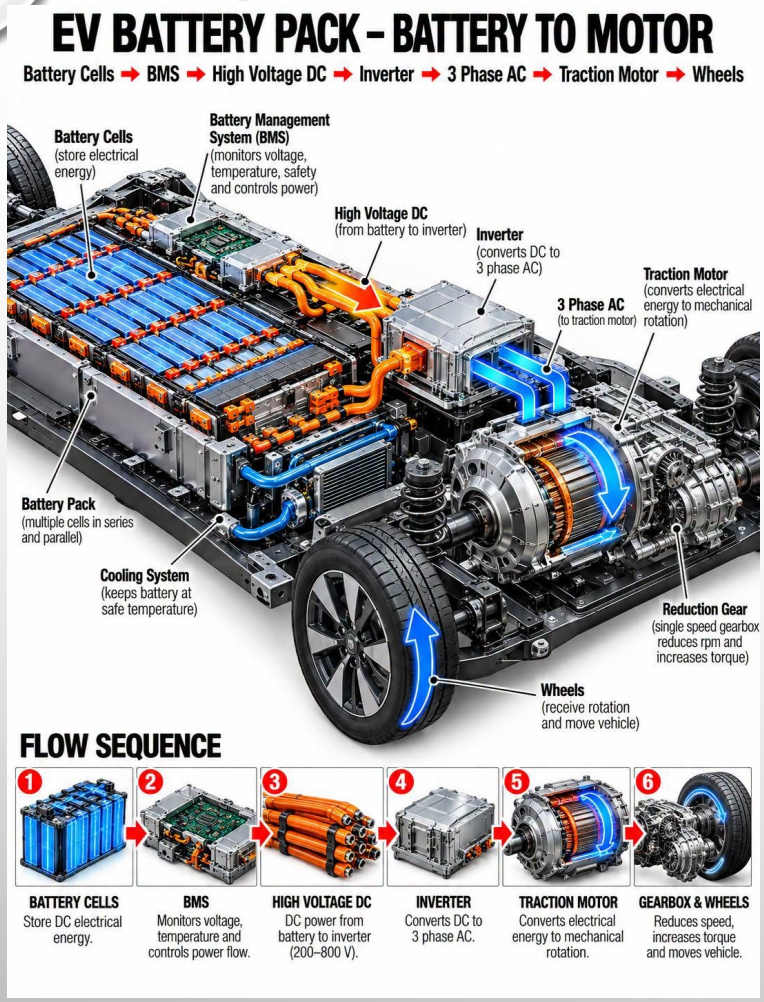


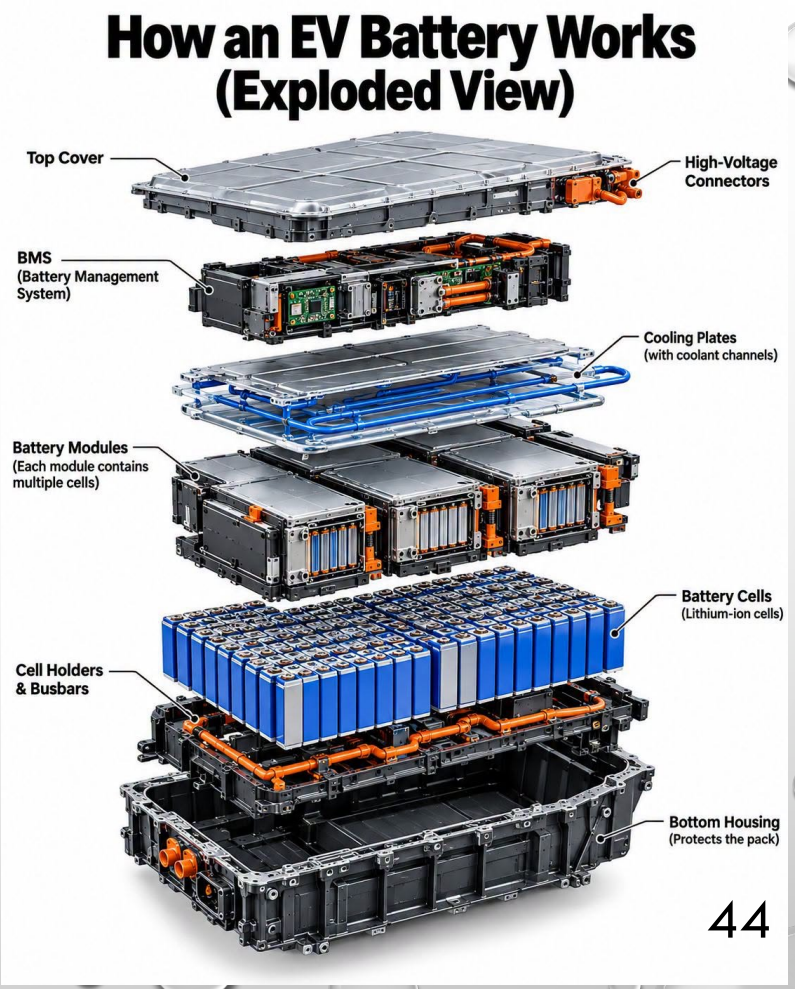
EV POWERTRAIN SYSTEM AND HIGH-VOLTAGE WIRING HARNESS



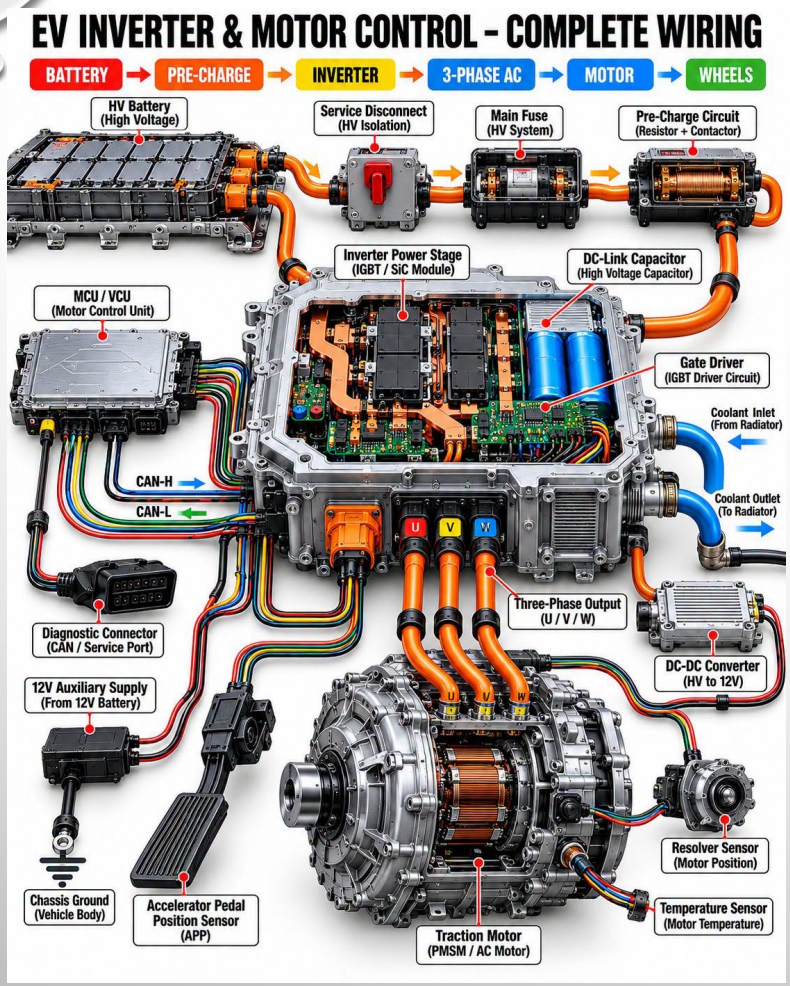


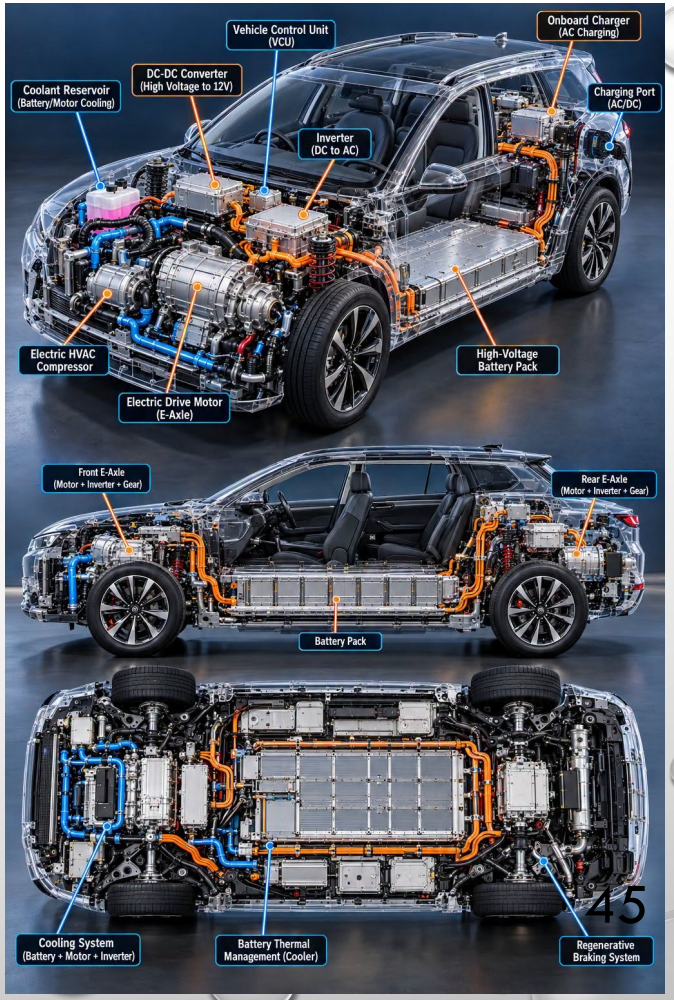
EV BATTERY PACK AND HOW AN EV BATTERY WORKS



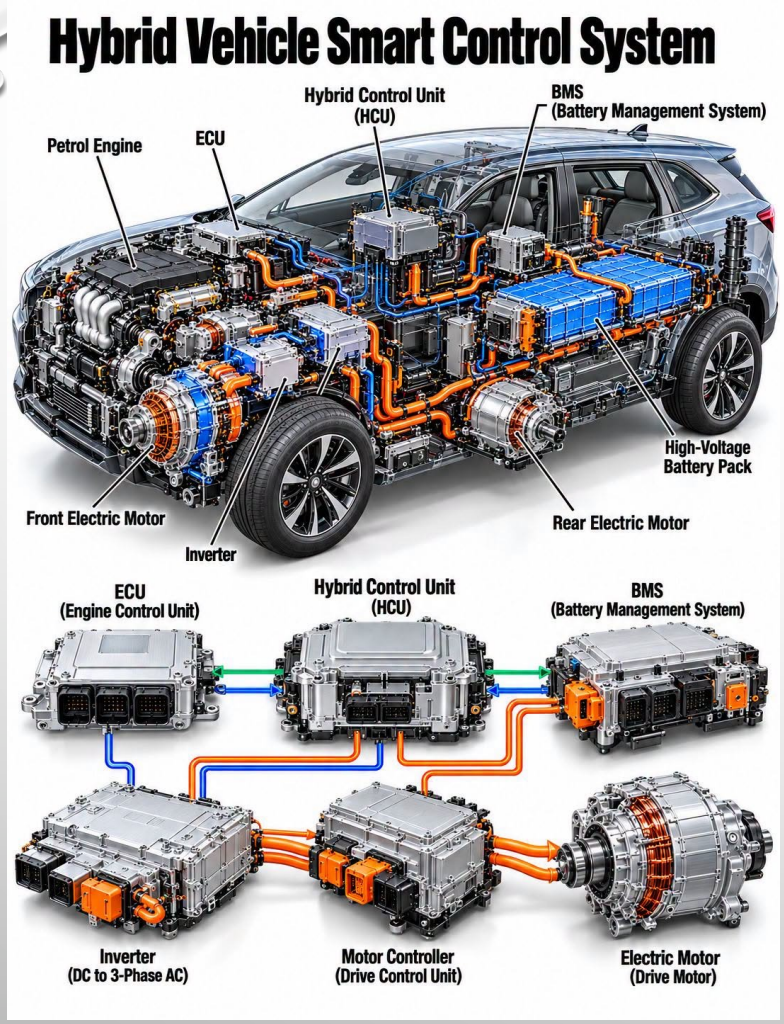


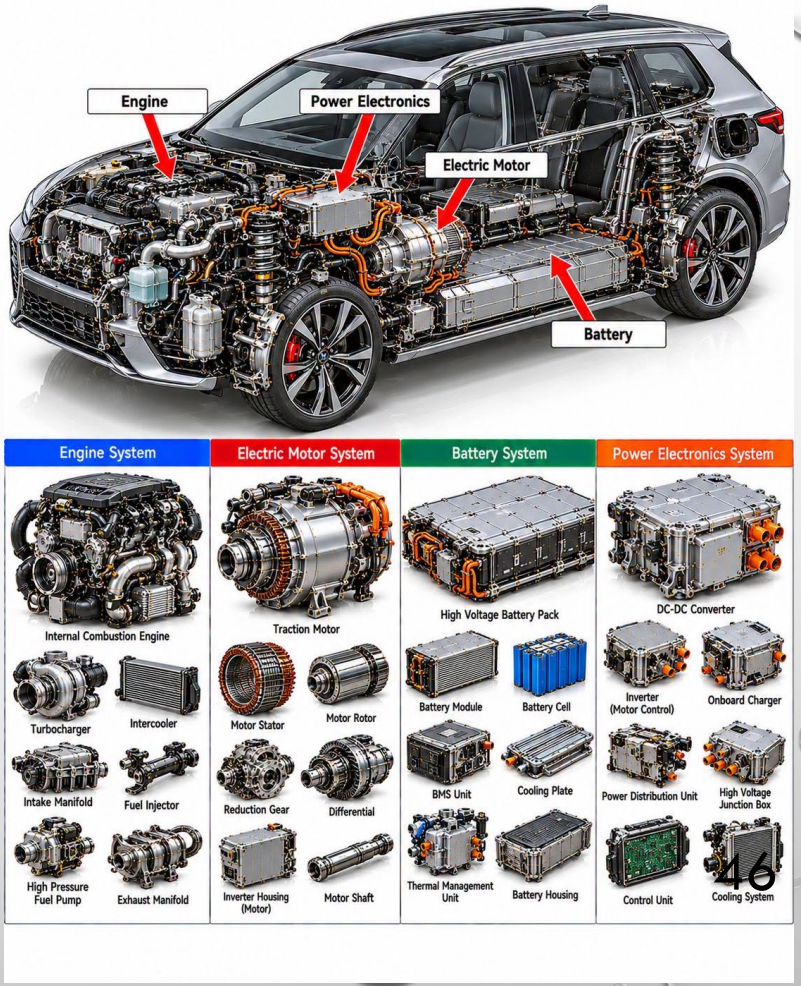
EV INVERTER & MOTOR CONTROL AND INTERNAL ARCHITECTURE



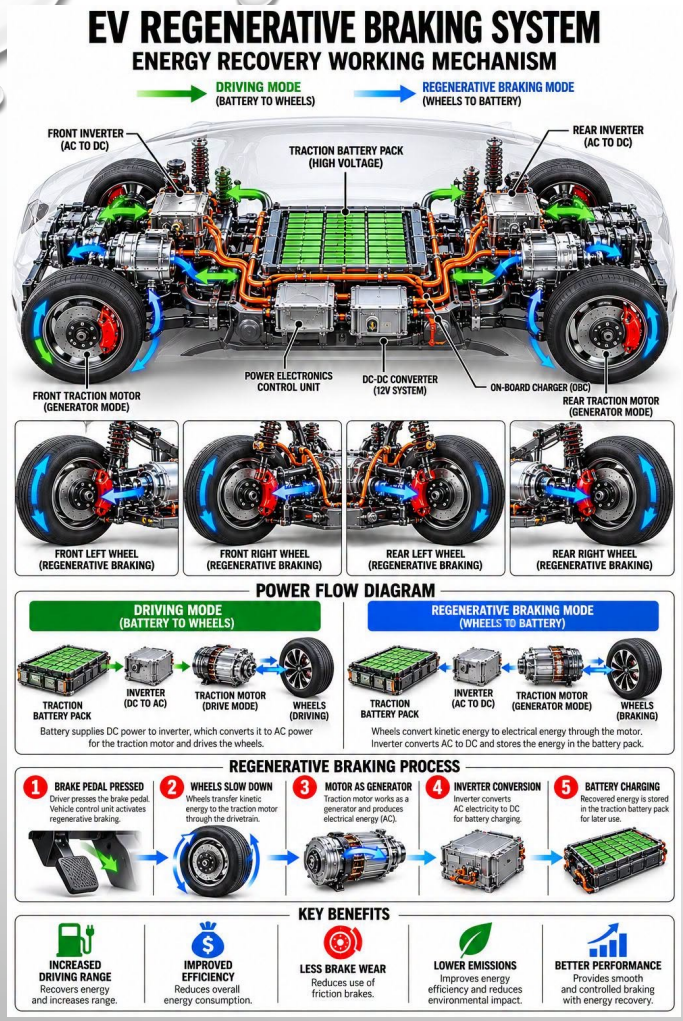


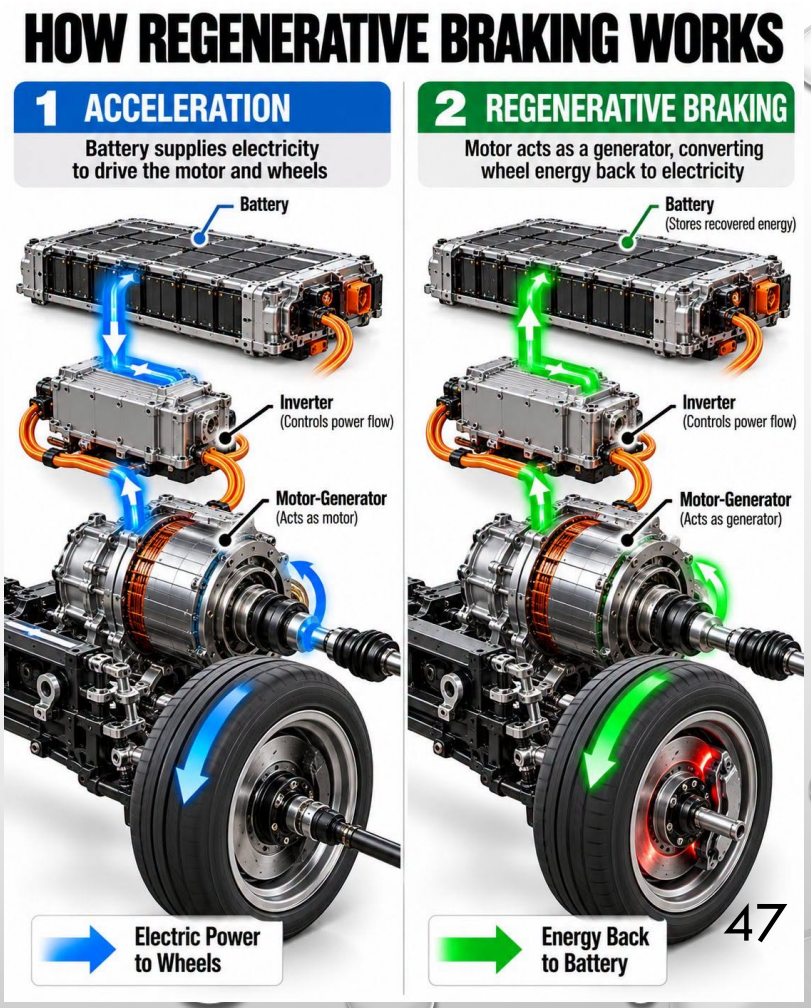
PLUG-IN HYBRID EV SYSTEM



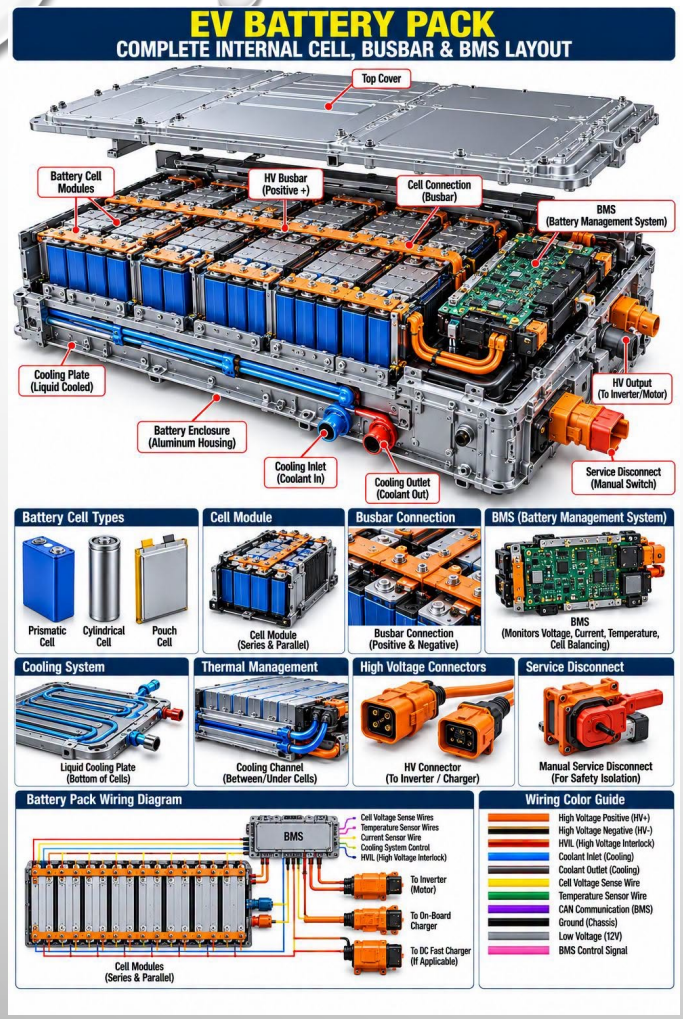


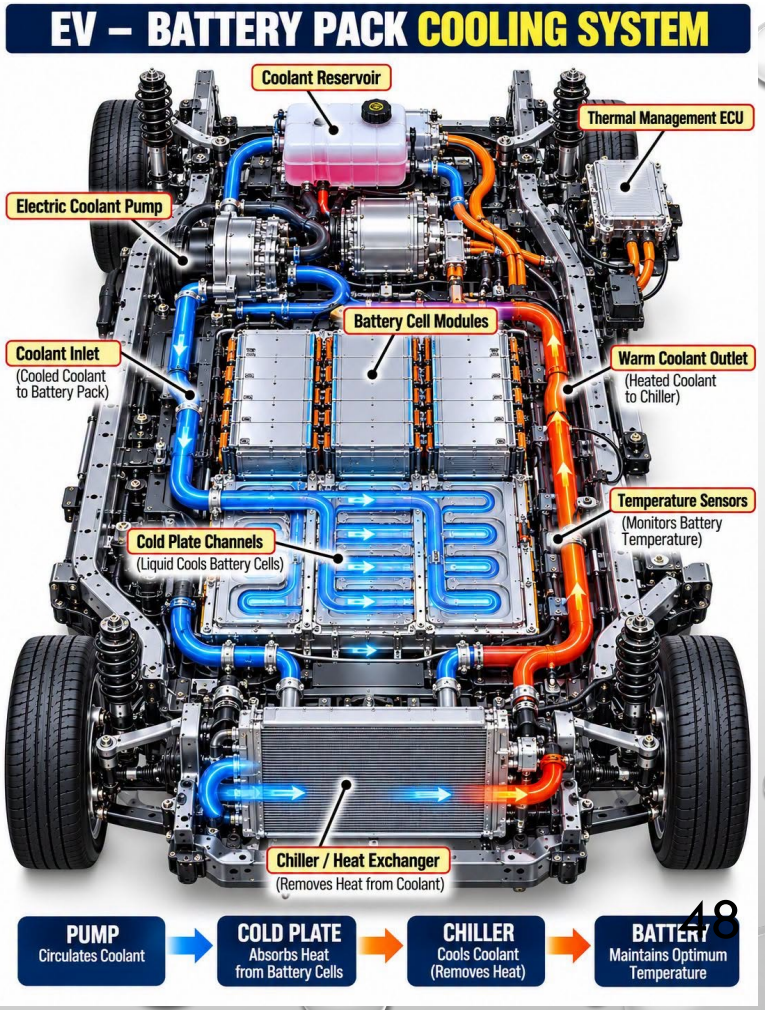
EV REGENERATIVE BRAKING SYSTEM



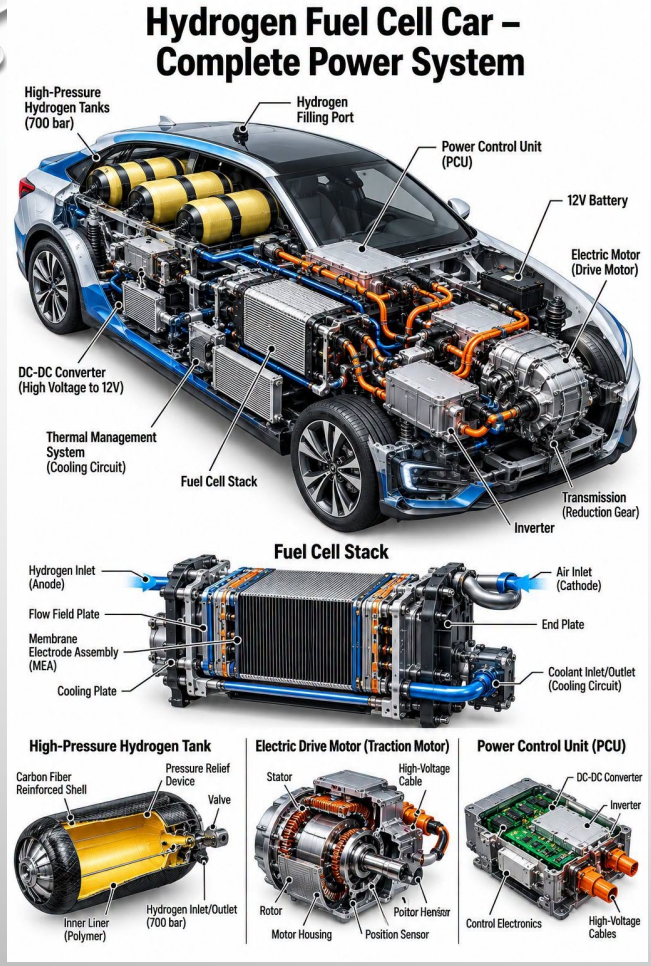


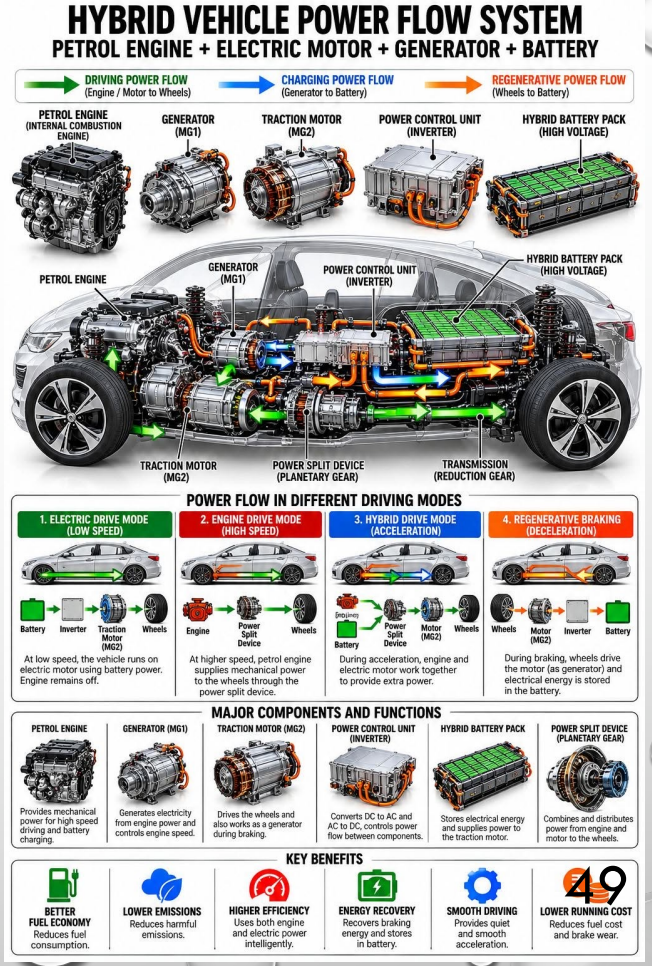
EV BATTERY PACK AND COOLING SYSTEM



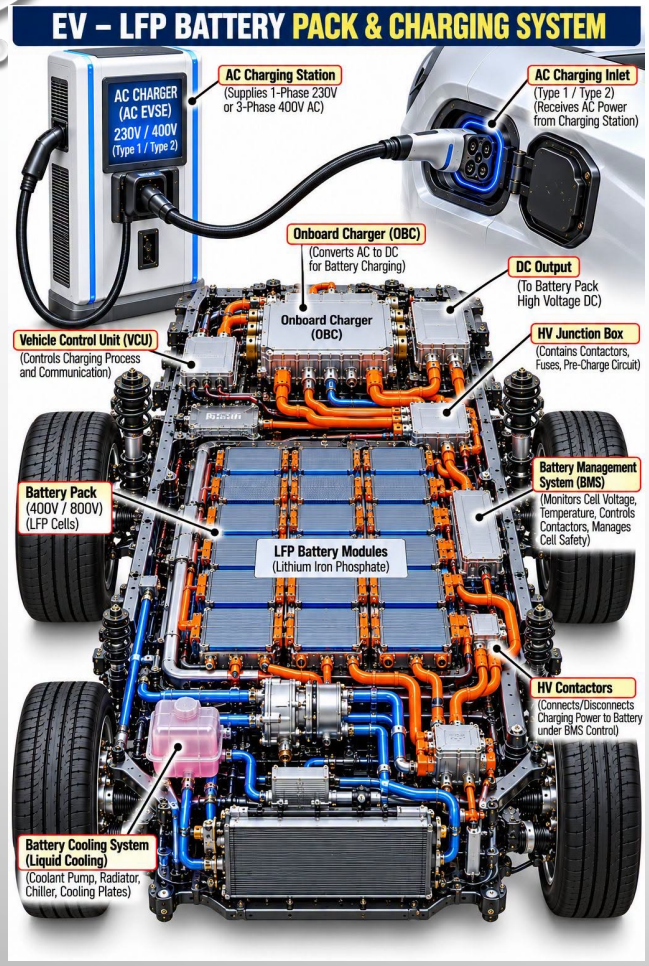


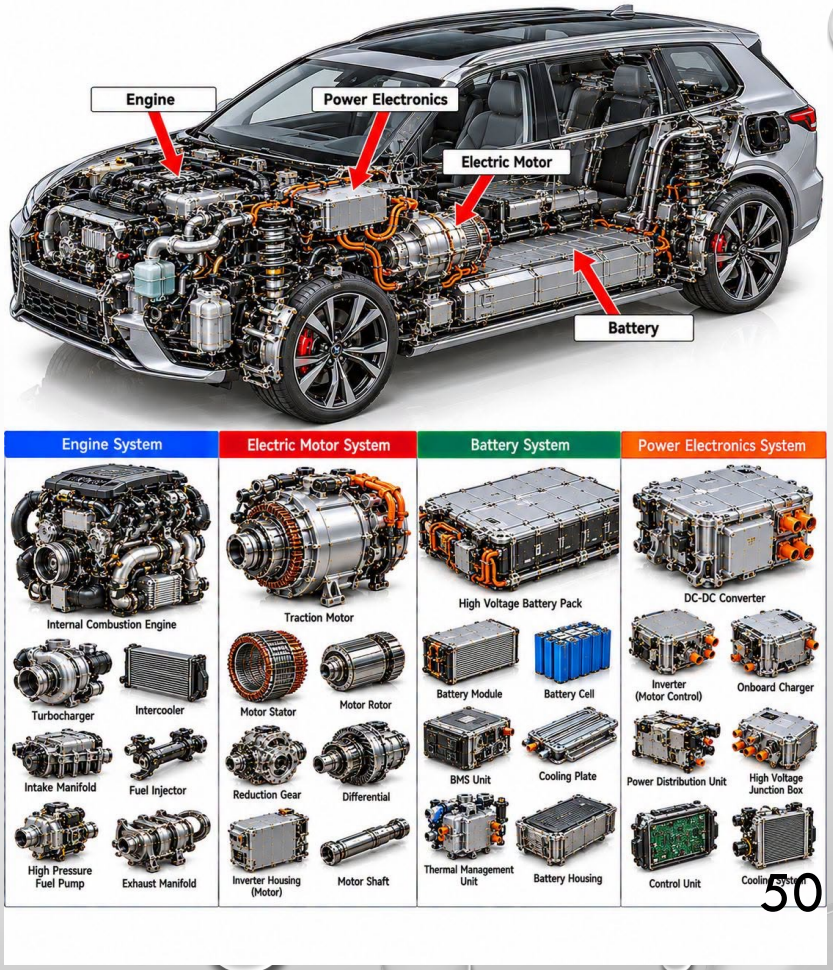
HYDROGEN FUEL CELL EV AND POWER FLOW SYSTEM



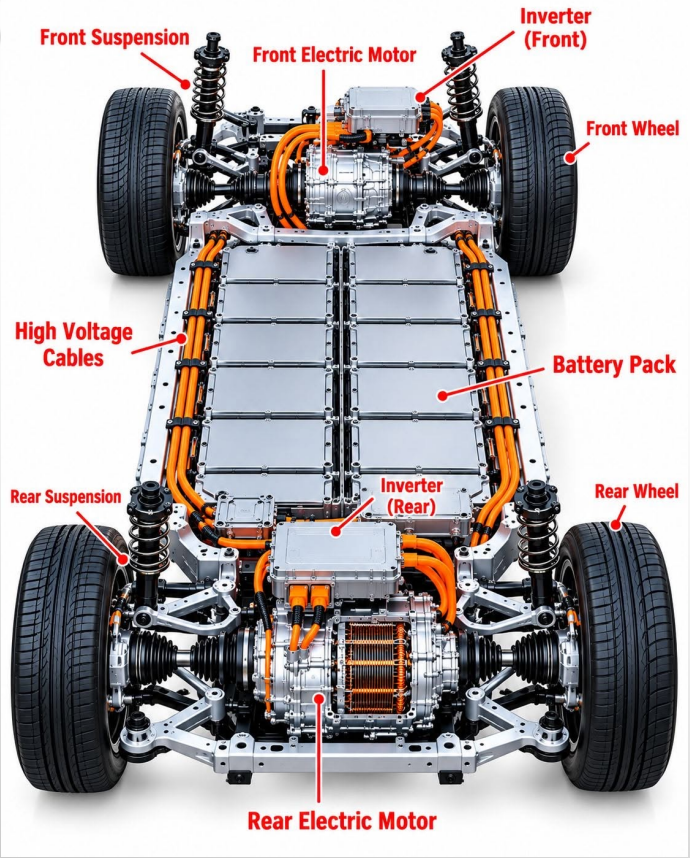


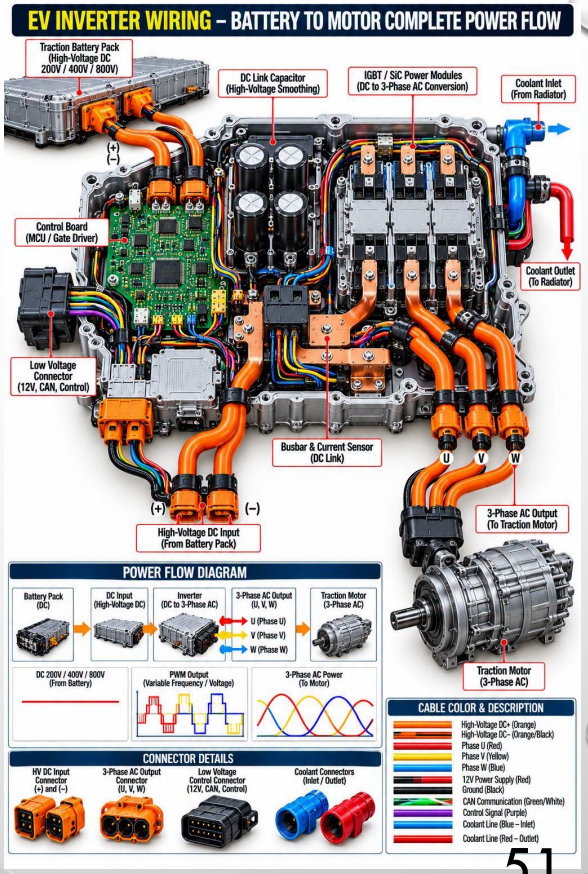
PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV)





DUAL MOTORS AND INVERTER WIRING







ကျေးဇူးတင်ပါသည်

ဦးခင်မောင်ဝင်း

ဒုတိယ ဥက္ကဋ္ဌ

မြန်မာနိုင်ငံအင်ဂျင်နီယာအသင်းချုပ်

၁၇ အောက်တိုဘာ ၂၀၂၆