# Introduction to electrification

11/05/2023

# Background

- Worldwide, governments are introducing more restricted regulation on emissions
- New engine technologies that include downsizing and specific devices to reduce emissions, are not considered anymore sufficient for the new regulation and it is necessary the introduction of electrified vehicles.
- To introduce the emerging worldwide scenario, let's see:
  - Survey on Regional regulations
  - Electrified vehicle definition, taxonomy and trend for the next future
  - Technical solutions defined and included in Global rollout plan by FCA Electrification team
  - Components of electrified vehicle and make possibility

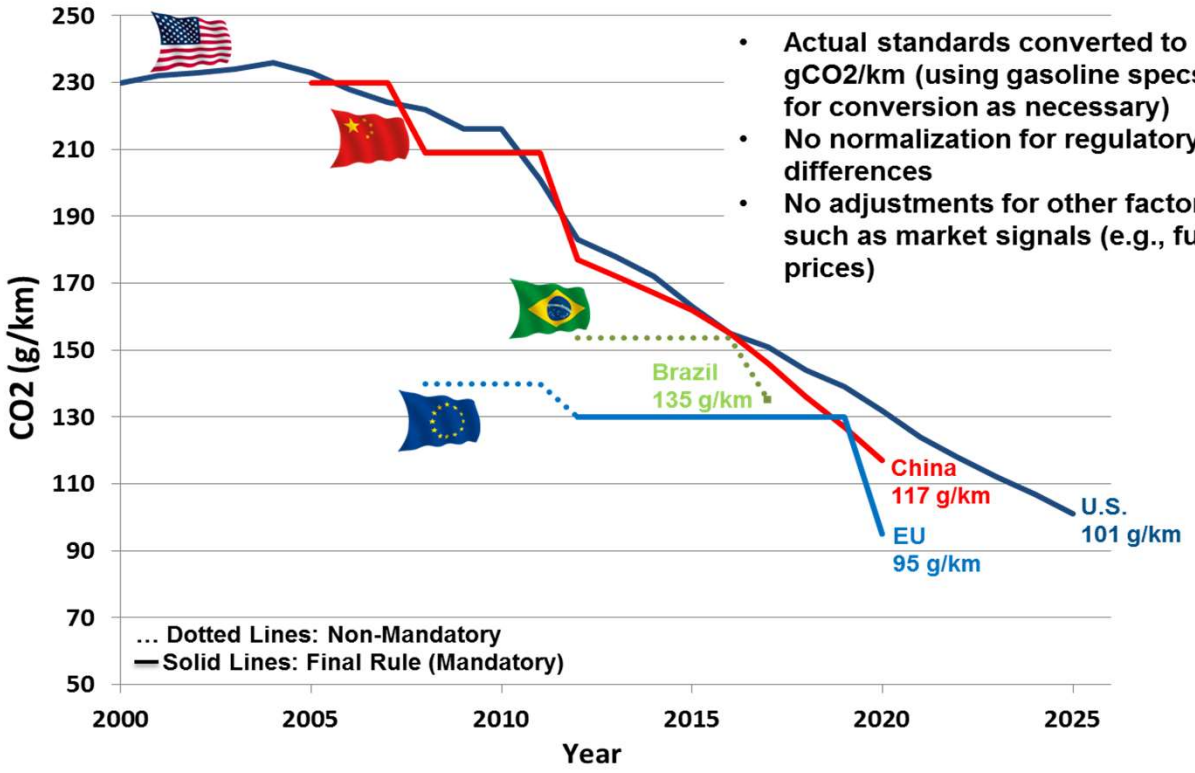

REQUIREMENTS
RULES
LAW
STANDARDS
COMPLIANCE
POLICIES
GOVERNANCE
TRANSPARENCY
REGULATIONS

# Regulatory Differences Add Complexity

| | United States | Europe | China | Brazil |
|---|---|---|---|---|
| **Compliance Method** | Fleet Average | Fleet Average<br>EU28+Norway+Iceland<br>(Switzerland specific fleet) | Fleet Average<br>& Per Vehicle Limits | Fleet Average |
| **Attribute** | Footprint | Mass | Mass | Mass |
| **Regulated Segments/ Scope** | • Domestic Car<br>• Light-Duty Truck<br>• Import Car (CAFE) | • Passenger Car<br>• Light Commercial Vehicles | • Domestic Car<br>• Import Car | • One fleet |
| **Banking, Transfers and Trading** | • 5 year carry forward, 3 year carry back<br>• Fleet transfers<br>• Trade with other OEMs | • Annual phase-in to final standards from 2012CY to 2015CY and in 2020CY<br>• No carry forward or back<br>• OEMs can pool | • 3 year carry forward<br>• Cannot transfer between import and domestic fleets<br>• Cannot trade with other OEMs | • Essentially measured in one stand-alone year |
| **Penalties** | • Must comply w/GHG<br>• CAFE penalties | • Penalties | • Must comply (threat of pulling certificates) | • Must comply or pay 30% tax per vehicle for last 5 years |
| **Window** | thru 2025MY | from 2012CY to 2021CY | thru 2020CY | 10/1/16– 9/30/17 |
| **Drive Cycle** | FTP City<br>FTP Highway | NEDC<br>(likely shifting to WLTP) | NEDC | FTP City<br>FTP Highway |
| **Units** | g/mi and MPG | g/km | L/100km | MJ/km |

# Reducing $CO_2$ is a Global Trend

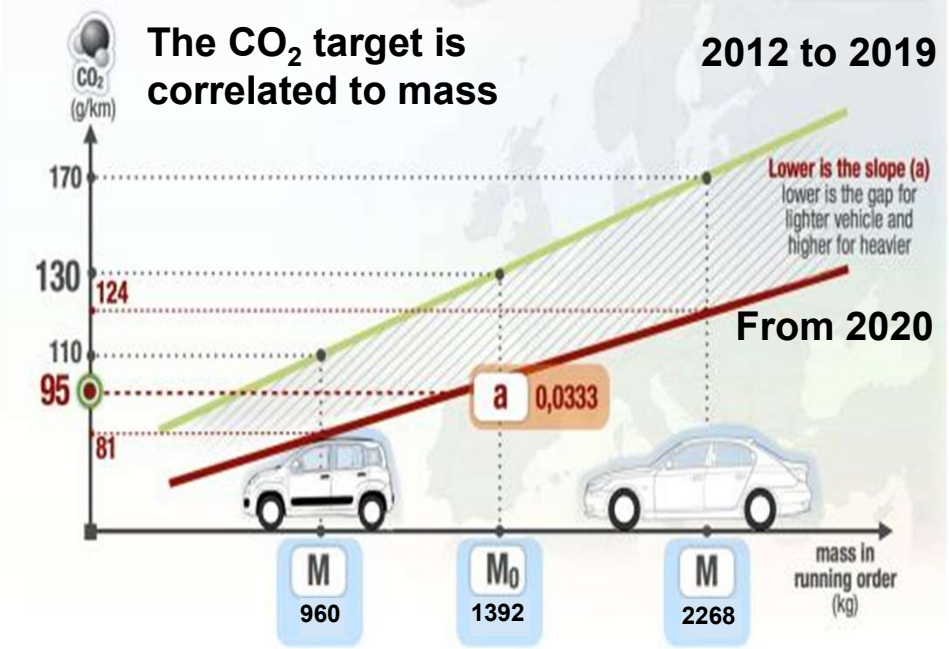
- Regulations will require 30% - 45% reduction in GHG by 2025 in major markets
- Expected to continue towards overall goal of ~80% reduction in the U.S. by 2050



# EUROPE: Emissions requirements from 2020

**MAIN RULES**

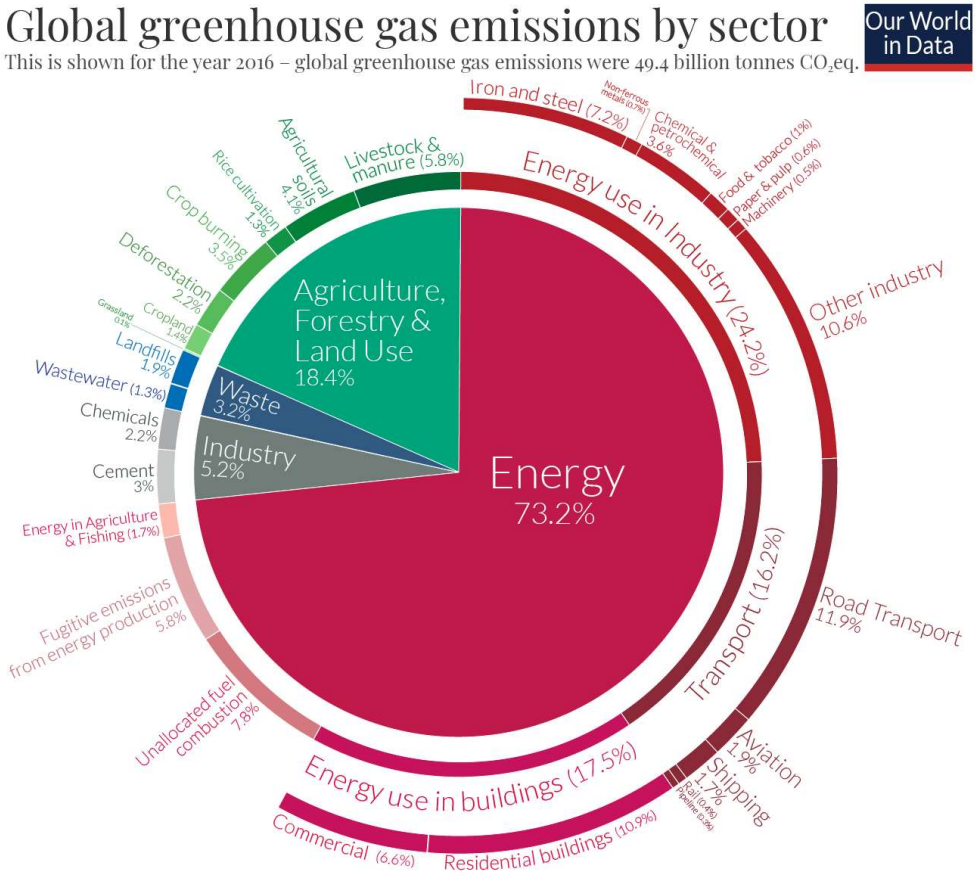
- Average target $CO_2$ emissions defined for new passenger car registrations is based on average mass: **95 $gCO_2$/km: from 2020 on**
- $CO_2$ target for each manufacturer is based on its own fleet **«average mass»**



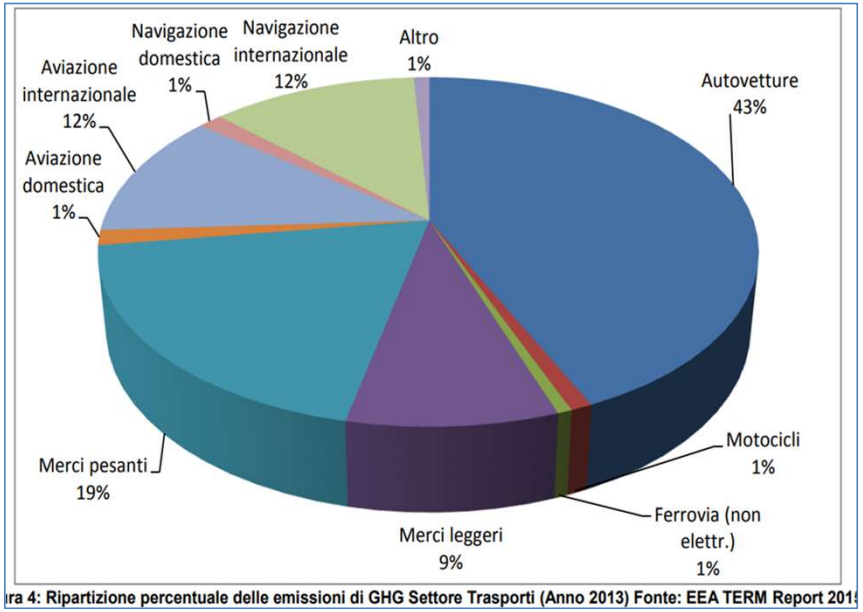
# General comments to regulations

- $CO_2$ emissions: Greenhouse effect and Urban environment pollution – Regulation are not making difference but the technical consequences could be huge in case.
- Emissions = consumptions
- Factors influencing consumptions hence emissions:
  - Powertrain emission profile
  - Vehicle weight and CX
  - Atmospheric weather: temperature, humidity …
  - Urbanistic (traffic fire, queues.)
- Necessity to refer to a standard evaluation of consumption
- General scenario of $CO_2$

# Global CO2 emission by sector

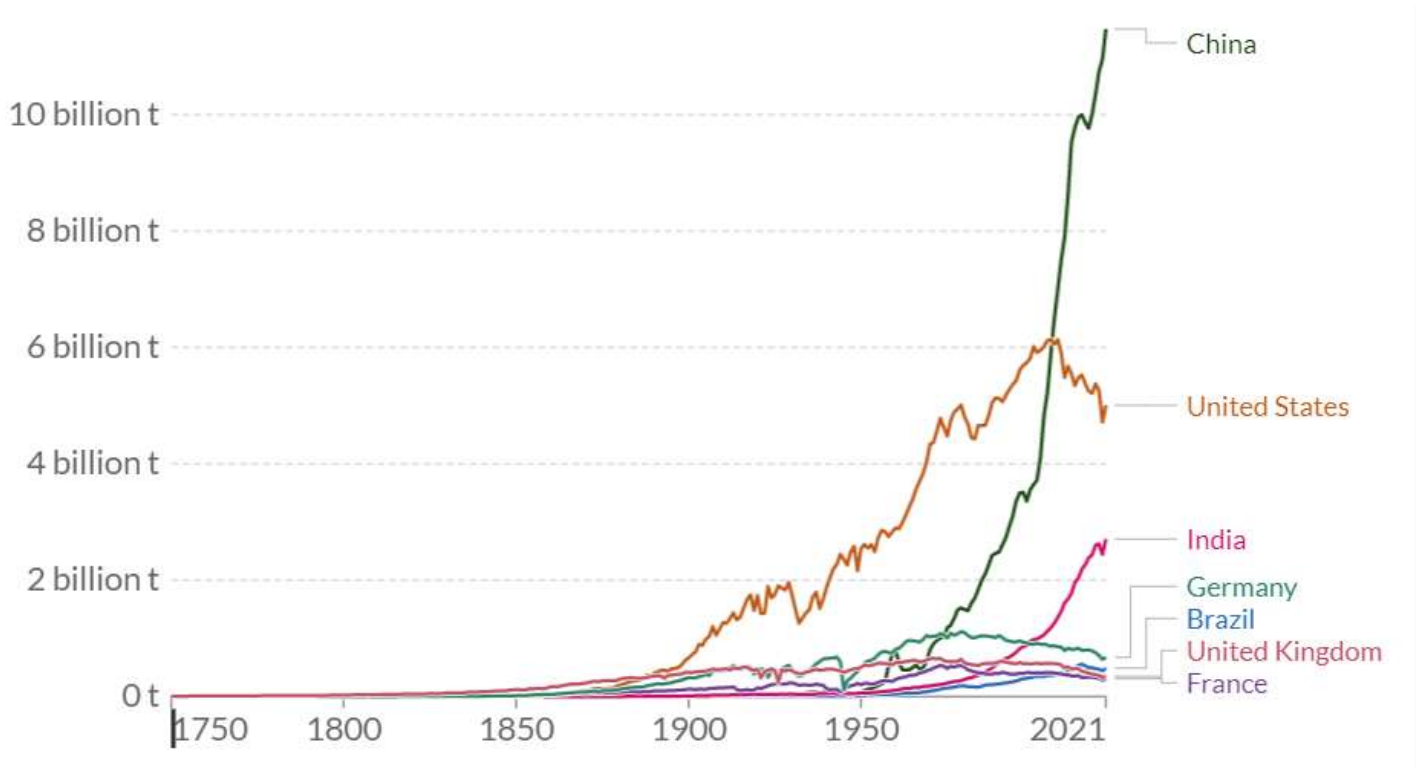



## Detail of transport

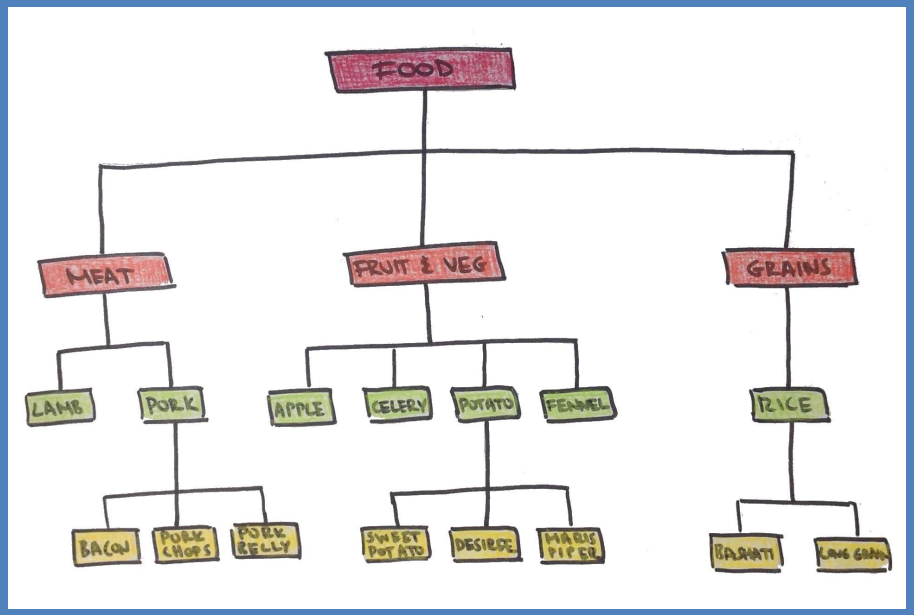



ra 4: Ripartizione percentuale delle emissioni di GHG Settore Trasporti (Anno 2013) Fonte: EEA TERM Report 201

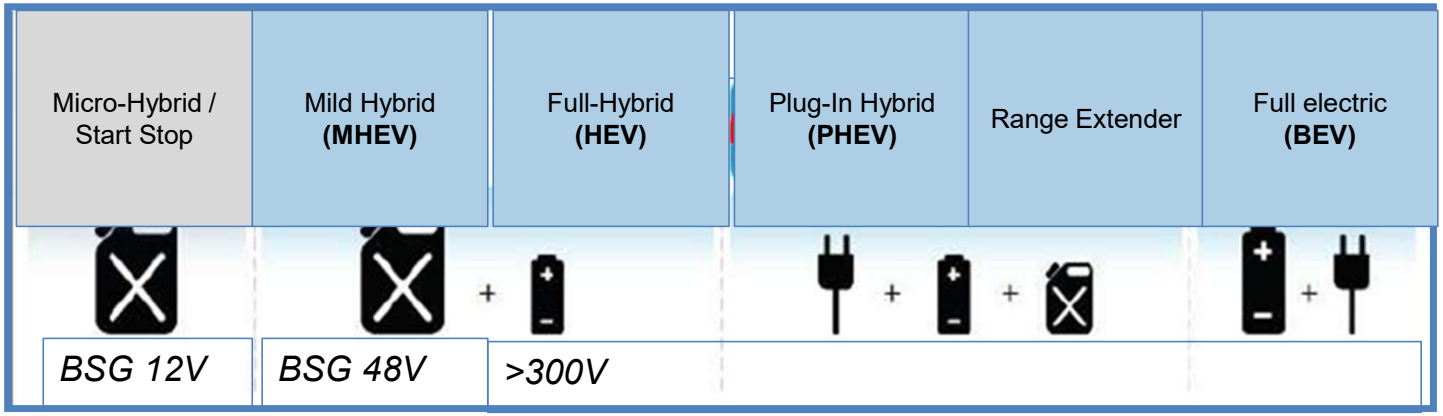
# $CO_2$ emissions by region



# *Electrified vehicle taxonomy*



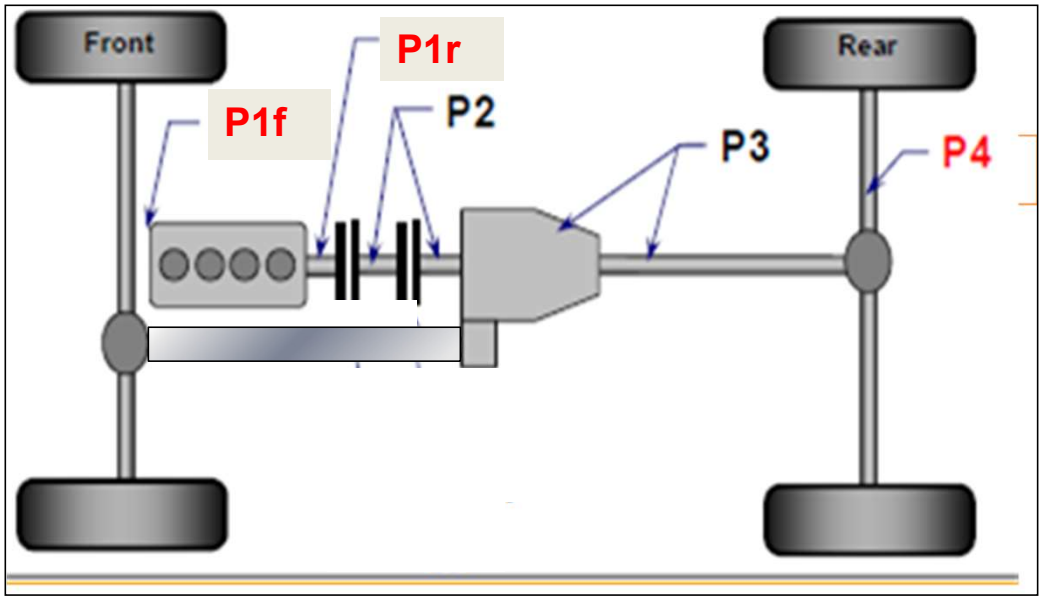
# Electric vehicle glossary

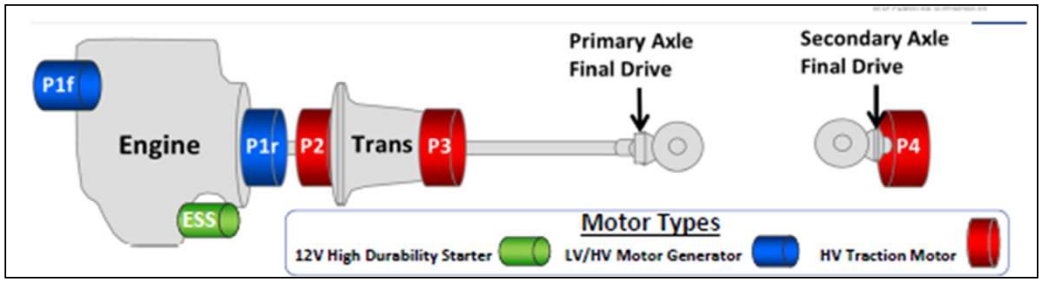



**CRITERIA OF CLASSIFICATION**

- **Voltage**: range of autonomy is proportional to voltage level
  - Losses proportional to electrical current ***P*** $= RI^2$ ***squared***
  - To generate the same power current decrease while the tension increase ***P= VI***
  - ***Ex.: 140HP = 100Kw***
    - *High tension 340V → I = 100k/340= 300A*
    - *Low tension 48V → I = 100k/48= 2000A (6,6 times higher, losses are* $6,6^2$ *→ 45 higher)*
- **External charging:** plug in system allows a clean recharge
- **Structure of electrical motor and traditional engine**: parallel/series

# Hybrid types named by electric machine position

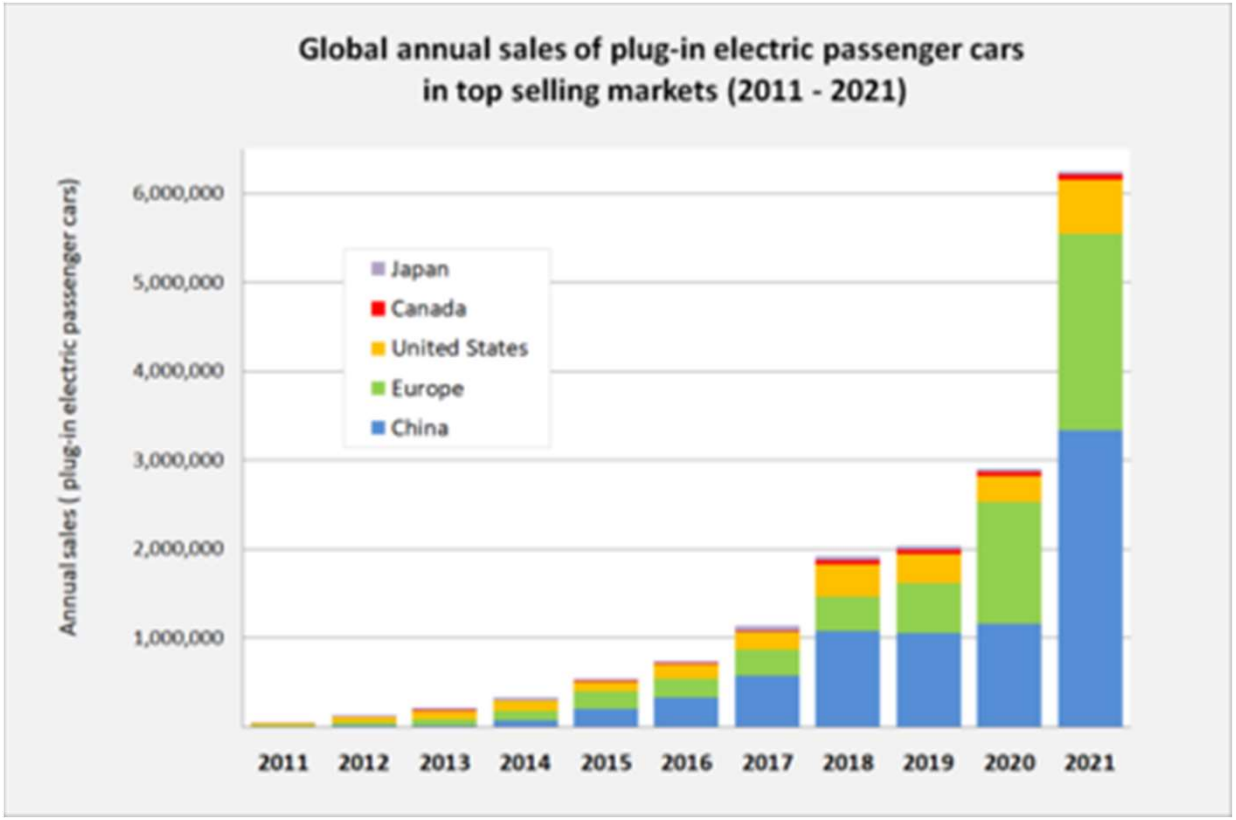



| DEFINITION |
|---|
| **ESS**<br>The high durability starter machine replaces the conventional starter |
| **P1f**<br>The e-machine is mounted on the front end accessory belt corresponds to the belt-mounted starter (BSG) |
| **P1r**<br>The e-machine is mounted on the crankshaft corresponds to the Flywheel Alternator Starter (ISG) and is equivalent to P1f |
| **P2**<br>The e-machine is mounted on the Transmission input it can be decoupled from engine and or transmission |
| **P3**<br>The e-machine is mounted on the Transmission output it can be decoupled from the driveline |
| **P4**<br>The e-machine is mounted on the non drive axle it acts as a separate powertrain and can be decoupled from the driveline. For BEV this is the primary drive system |

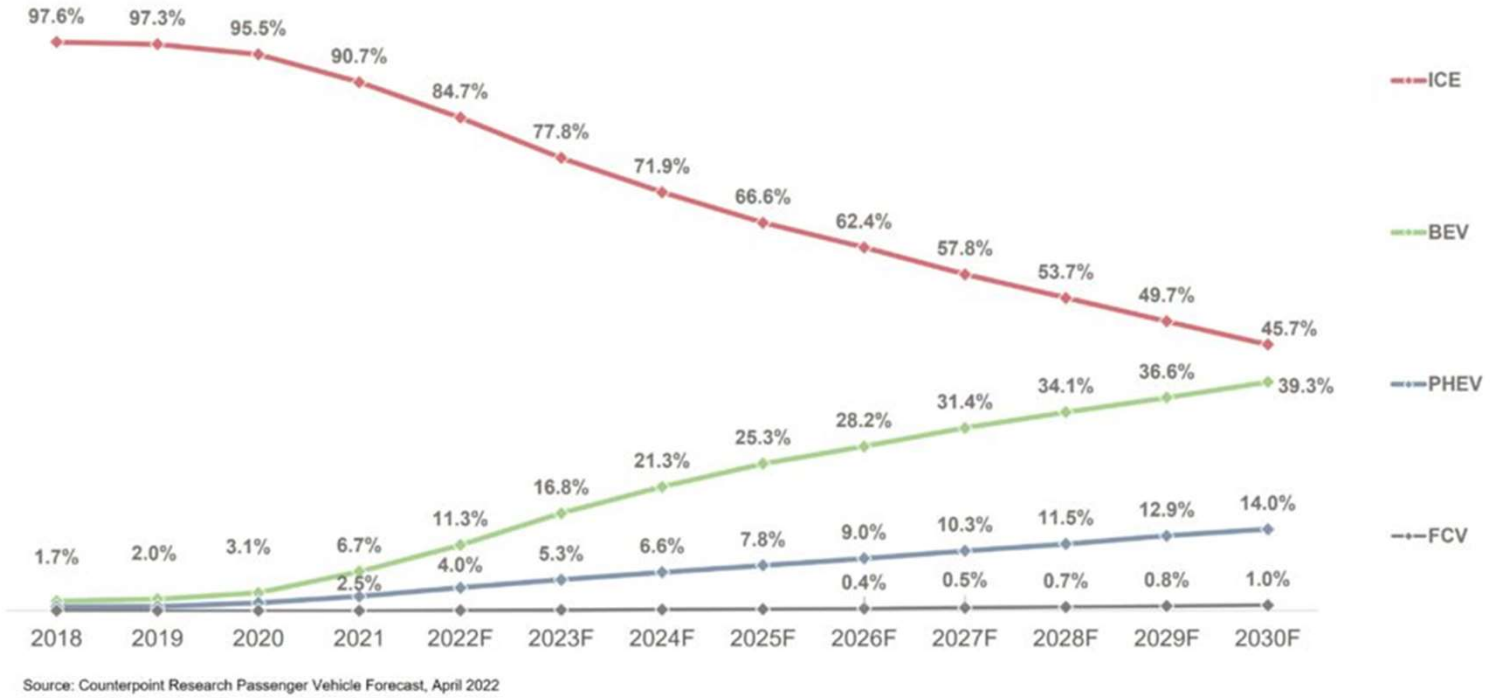
# *Powertrain trends*

# Trend in electrification: share per region




Around
10% of total
sales

# Trend in electrification: global share evolution



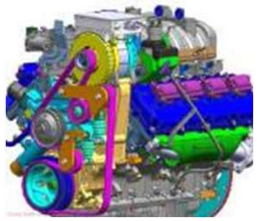

Source: Counterpoint Research Passenger Vehicle Forecast, April 2022

# *Electrified vehicle*

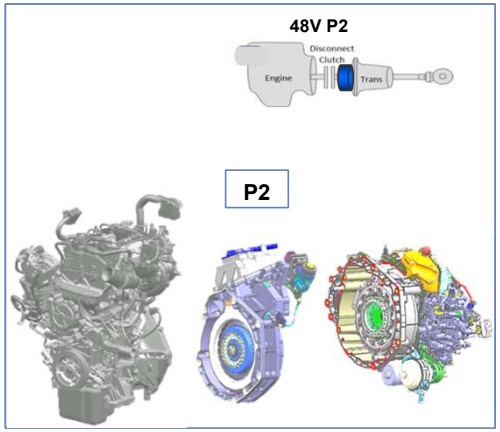
# Powertrain Electrical architectures

## Mild Hybrid BSG 48V

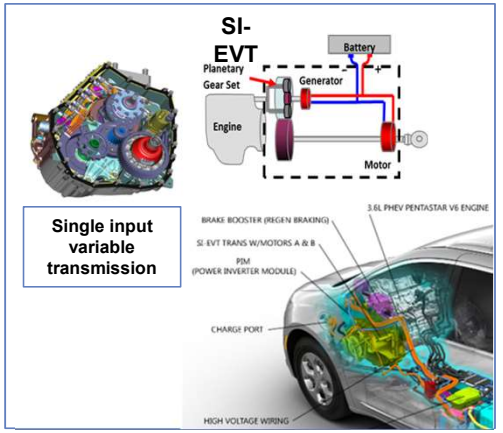
Modified Engine



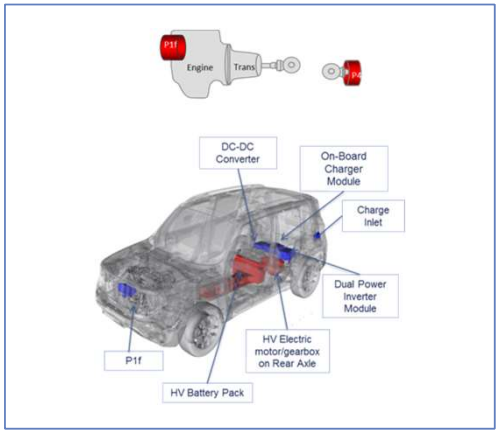

## Mild Hybrid P2 48V



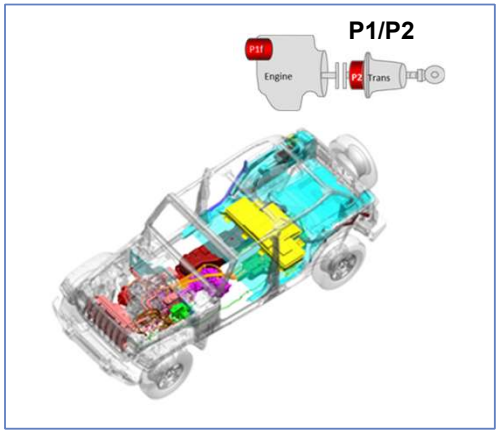

## PHEV P2/P3



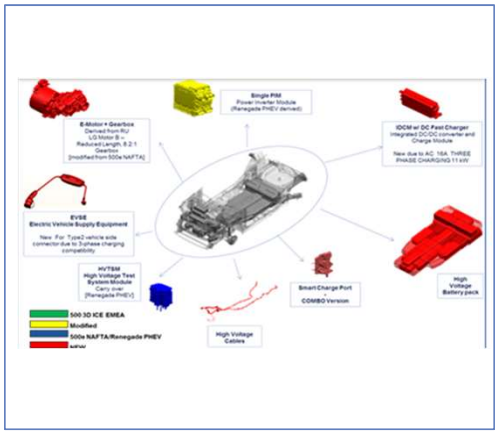

## PHEV P1/P4




## PHEV P1/P2




## BEV



# *Electrified vehicle components*

# Main electrified components partitioning

**Battery pack**

**Electric Drive Motor**

**Battery module**

**Electric Motor**

*VEHICLE Perimeter*

*POWERTRAIN Perimeter*

# Electrification Landscape by CoC

Electrified propulsion system components align to core powertrain  manufacturing competencies.




| Traditional Powertrain Center of Competence | Electric Drive Module | Electric Motor | Battery Pack Assembly | Battery Module Assembly |
|---|---|---|---|---|
| Casting | X | X | X | |
| Prismatic | X | X | X | X |
| Rotating | X | X | | |
| Assembly | X | X | X (*) | X |

(*) Battery Pack Assembly @ Vehicle plant

## Summary

- Regulations are evolving quickly
- There is a high-risk situation for development:
  - NOT defined a global standard
  - Competitors are exploring different solutions
- Traditional powertrains (ICE) with a support of Mild Hybrid solutions are still an important asset of Car portfolio as the Full Hybrid (HEV) but BEV are gradually progressing
- IN 2030 is expected hybrid cars out of production to be 100% BEV from 2035 (Europe first)
- Next future: e-fuel and Hydrogen

# BACKUP

# Top ten countries per CO2 emissions