Market Impact and Potential Impact on Consumers

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BEVs and Environmental-Societal Challenges

Complete **environmental solution at local level** (TtW - Tank to Wheels):

- zero **noxious** emissions
- zero **carbon dioxide** emissions
  WtT - Well to Tank emissions depend on the electricity production pathway
  extra WtW emissions (including the recycling phase) depend on the under definition processes for high volumes production
- very high **energy efficiency**
- low **acoustic emissions**

BEVs and Environmental-Societal Challenges

From the **OEM perspective**, BEVs are the solution for/answer to:

- tailpipe noxious emissions homologation
- CO_2 fleet based penalties
- green credit based “bonus-malus” policies

BEVs and Environmental-Societal Challenges

From the **user point of view**:

- outstanding performance (acceleration, gradeability, elasticity…)
- driving comfort
- effective functional integration (acceleration and braking functions)
- easy “performance” configurability (at driver level)
- lower TCO (Total Cost of Ownership):
  - depending on the electricity price
  - if the batteries have not to be replaced during the vehicle life or the costs of their replacement is not in charge of the customer

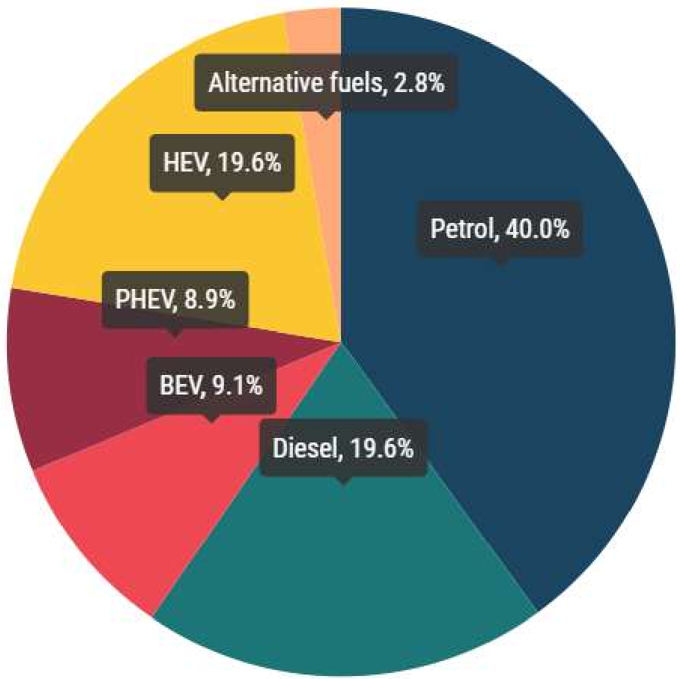
Market Penetration and Customer Acceptance

- From 2018 to 2021 BEV EU market share has increased from 1 to around 9% (near one order of magnitude)
- In 2022, at last up to Q2, this trend is largely slowing down (from 9,1 to 9,9%)

It seems that today BEVs are not yet able to completely replace the petrol cars becoming the larger volumes market solution.

Why?

EU 2021 Market share:

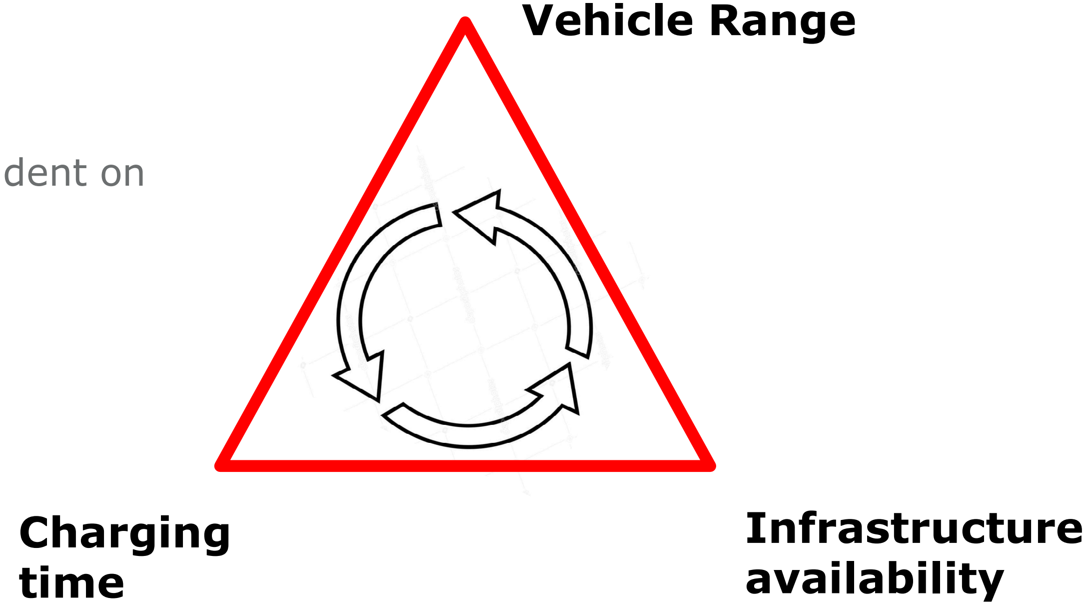


Source: ACEA

Battery Electric Vehicles: Roadblocks/Challenges

From the end user point of view, the weak points in respect of the traditional engine-based vehicles are:

- **Vehicle Range**: lower than the one of ICE-based vehicles and highly dependant on the ambient conditions, driving style, auxiliaries connected…
- **Battery Charging**:
  - Charging **Time**
  - Charging **Infrastructure diffusion**
- **Purchasing price** (at least today largely dependent on the batteries (technology and installed energy)



Battery Electric Vehicles: Range and Charging

Up to now the main answer to the range issue has been **increase more and more the on-board installed energy** also taking advantage of the Li-ion battery technology improvement (from Gen1 to Gen 2b/3a).

Fiat 500 NA (2013): 24 kWh

Fiat 500e High Range (2020): 42 kWh

Each battery new generation means:

- (at least at the beginning) **higher battery specific costs** [€/Wh]
- higher **charging times** or higher **charging power levels**

Battery Electric Vehicles: Range and Charging

Increasing more and more the expected range, this “sizing for the worst case” negatively impacts on:

- the **vehicle weight**
- the vehicle **cost/purchasing price**
- the **charging time/costs**

To try to tackle at least part of these issues, there are many investigations in progress:

- **hyper-DC fast charge** (toward MW levels…)
- **battery swapping** (it is back…) at module/block level
- **dynamic** wireless (cars) or wired (trucks) **power transfer** (charging in motion as a train)
- …

all of them asking for **higher complexity** and/or **infrastructure large investments**

The Customer Centric Approach

The large-volumes customer first request is to **get from A to B in an efficient, safe, comfortable and low-cost way**

Stating from this statement, in CEVOLVER we have deeply investigated **low-cost solutions** enabling functionalities supporting this goal both for **passenger** (CRF) **and commercial** (Ford) vehicles

According to this philosophy, the validators have **battery systems sized for the typical mission** (the so called "**right sizing**") and the management of limited frequency longer trips is made possible acting on the use of **cloud-based data coming from the environment** (temperature, info of the road scenario (e-horizon) etc.) to enable:

- advanced **eco-driving**
- **eco-charging**: advanced eco-routing combined with charging station localization and **battery thermal preconditioning** before the stop
- **vehicle thermal** and **powertrain energy optimization**

Possible Next Steps

Starting from the CEVOLVER experience, it is possible to investigate how to take advantage of the **Vehicle to Cloud interaction** and the **calculation capabilities at cloud level** to largely improve the battery management in multiple directions.

For instance:

- being a right sized battery doing in its life more charge-discharge cycles of a larger size battery for the same vehicle range, it is important to correctly **predict its SoH** (State of Health) evolution vs. time
- in the coming **V2H** (Vehicle to Home) / **V2G** (Vehicle to Grid) scenario, the SoH evolution prediction can be also a key element to allow to the vehicle end user/customer to **reach a proper mix between motion and energy exchange ageing**
- enabling an effective battery **predictive maintenance/prognostic**
- having a right sized battery a lower installed energy in respect of a larger sized battery, a DC fast charging at the same power level means a higher power on energy ratio (higher stress) and a precise **cloud based anode potential estimation** allows to have a **better charging** and a **lower impact on the battery ageing** (controlling the lithium plating effect)
- ….
- …