BATTERY VS HYBRIDS? FUTURE PERSPECTIVES OF ELECTRIC VEHICLES

Amela AJANOVIC
Energy Economics Group, Vienna University of Technology, 1040 Wien, E-mail: ajanovic@eeg.tuwien.ac.at

Overview

Electric vehicles have in recent years been considered as promising option for mitigating CO_2 emissions in transport. However, especially the high costs of battery electric vehicles as well as the limited driving range state major barriers for this pure technology. On the other hand, today various types of hybrids have emerged.

The core objective of this paper is to investigate the future market prospects of alternative powertrains like battery electric vehicles (BEV), hybrid vehicles (HEV) and fuel cell vehicles (FCV) in a dynamic framework till 2050 in comparison to conventional passenger cars for average conditions of EU-15 countries. We also consider different fuel mixes for electricity and hydrogen (H2) from fossil versus renewable energy sources (RES). This is relevant to identify the environmental performance which is further-on translated into corresponding costs of CO_2 of fuels by introducing a CO_2 based tax. Hence, in the economic analysis we also consider the potential effects of CO_2 taxes.

Methods

Our method of approach is based on a scenario with favourable conditions for the development of the energetic performance of conversion efficiencies in the whole mobility providing chain. We conduct a dynamic technical and economic analysis and investigate when in future HEV, BEV and FCV could become – under most favourable conditions – economically competitive compared to conventional gasoline and diesel cars.
To evaluate the economics we compare the transport service costs per 100km driven (C_{km}):
The costs per km driven are calculated as:

$$C_{km} = \frac{IC \cdot \alpha}{skm} + P_f \cdot FI + \frac{C_{O\&M}}{skm} \qquad [€/100\text{ km driven}] \qquad (1)$$

where:
IC……investment costs [€/car]
α……..capital recovery factor
skm…..specific km driven per car per year [km/(car.yr)]
P_f….….fuel price incl. taxes [€/litre]
$C_{O\&M}$…operating and maintenance costs
FI……..fuel intensity [litre/100 km]
To capture the dynamic effects of changes in investment costs of powertrains over time we apply the approach of technological learning (TL). We use eq. (4) to express an experience curve by using an exponential regression depending on investment cost of new technology components $IC_{New\_t(x)}$, the learning index b and the investment cost of the first unit a:

$$IC_{New\_t}(x) = a \cdot x_t^{-b} \quad [€/kW] \qquad (2)$$

Results

The expected historical developments of passenger cars' fuel intensities and assumptions for development in the scenarios up to 2050 (for average car size of 80 kW) are described in Fig. 1.Note, that the steepest decrease in fuel intensities took already place before 2011 as a first result of the efforts of European Commission to improve the efficiency of cars. In Fig. 2 the TL effect is applied to the base car, the battery and the engine specific components. But the costs of the overall efficiency are increasing. The later are revealed in better fuel intensities over time, see Fig. 1.
For the economic analyses we consider investment costs, operating and maintenance costs, fuel costs and the relevance of CO_2 taxes in the cost structure. Our analysis starts with the fuel costs. Fig. 3 compares the scenarios for the development of the fuel costs (incl. taxes) of the service mobility per 100km driven from 2010 to 2050.
In this scenario CO_2 taxes replace excise taxes starting from 2013 and increase up to 2050 by 1.5 cent/kg CO_2 and year. Fuel costs for driving remain cheapest for electricity but costs of hydrogen cars come closer and are remarkably cheaper than fossil fuels and biofuels. Due to the introduced CO_2 taxes price increases are highest for the fossil fuel driven vehicles.

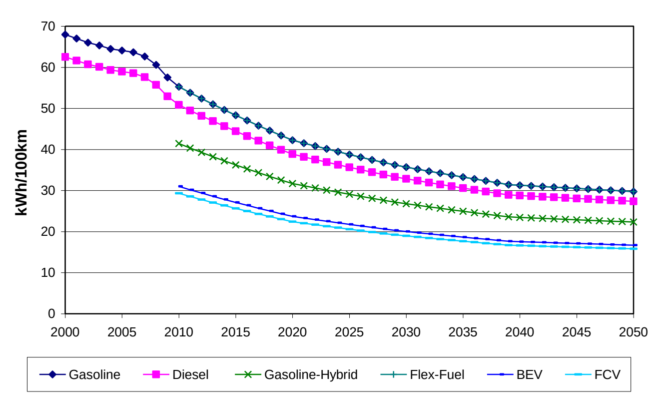

Fig. 1. Historical developments of passenger cars' fuel intensities and assumptions for development in the BAU scenarios up to 2050 (for average car size of 80 kW)

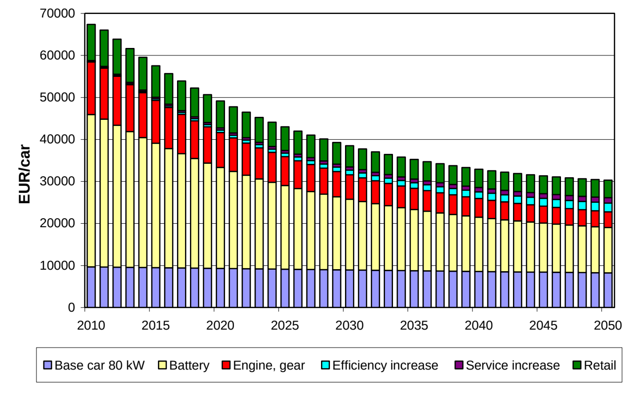

Fig. 2. Development of car investment costs of BEV (80 kW) considering TL and service increases 2010 -2050

The development of the total costs of service mobility per 100km driven of different types of passenger cars from 2010 to 2050 is compared in Fig. 4. We can see that total costs for conventional cars increase slightly – mainly because of the CO_2 taxes introduced and increases in fuel costs – while driving costs of BEV and FCV decrease significantly. This is mainly due to TL that reduces costs of batteries and fuel cells.

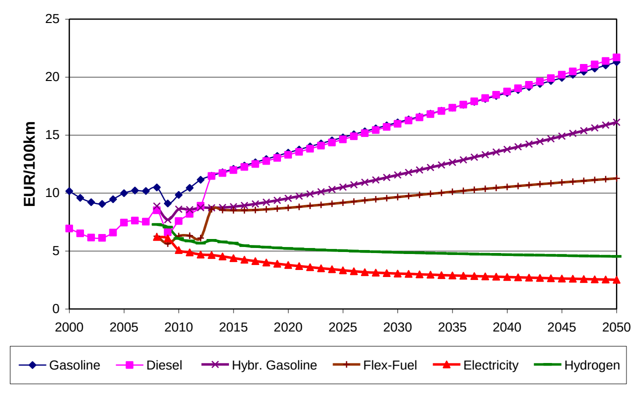

Fig. 3. Scenario of fuel costs incl. taxes per 100 km from 2010 -2050

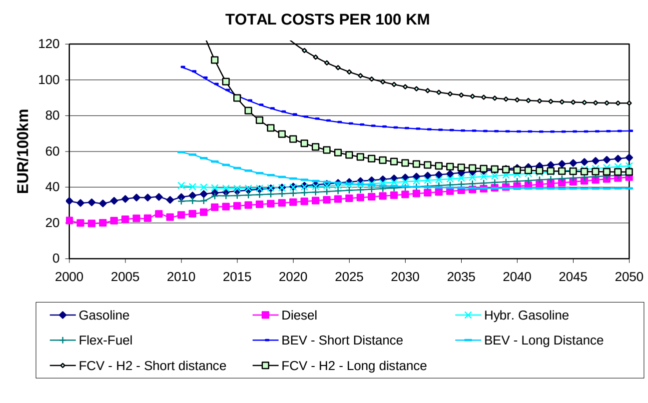

Fig. 4. Development of total costs of service mobility per 100km driven of different passenger cars in 2000- 2050

Conclusions

The major conclusions of this analysis are: From a technical point-of-view BEV and FCV are currently clearly preferable to conventional cars regarding ecological performance as well as energetic conversion efficiency. Yet, this applies only if electricity respectively hydrogen used is produced from RES.

With respect to the economic competitiveness of alternative powertrains compared to conventional vehicles in the most favourable – long distance driven – case BEV will enter the market by about 2025. FCV will become competitive even later, by about 2040. Also in this case optimistic assumptions are used in favour of this technology. HEV are already today a feasible technical option which combines the advantages of both electric drives and ICE-vehicles at rather moderate additional costs. Finally it is to note that by 2050 the total overall driving costs of most analysed fuels and powertrains will almost even out.

The major uncertainty remaining regarding BEV and FCV is how fast technological learning will take place especially for the battery and the fuel cells.

References

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