ON THE FUTURE RELEVANCE OF ELECTRIC VEHICLES: PRO'S AND CON'S

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Overview

Over the last few decades sales of battery electric vehicles (BEVs) have been growing continuously especially in China, Europe and the USA. Despite the global COVID crisis the market share of electric cars in 2021 was four times higher than in 2019 reaching a global stock of more than 16 million electric cars. [IEA] There are different reasons for the increasing use of electric vehicles such as supporting policy framework, decreasing battery prices, as well as development of the charging infrastructure.

However, the main driver for the increasing number of electric vehicles are still monetary and non-monetary supporting policies. Over the last years many countries have significantly increased public spending on subsidies and incentives for electric vehicles. In addition, many countries have already announced ban of internal combustion engine vehicles in the future, e.g. in Norway already starting from 2025. Due to this announcement many car manufactures have started with the electrification of their car fleets, so that number of new electric vehicle models is rapidly increasing. Currently there are about 450 electric vehicle models available on the market but a very concerning aspect is that the vast majority of these models is in the category large cars and sport utility vehicles (SUV), see Figure 1. Electric vehicles are, due to the battery packs, usually much heavier than corresponding conventional vehicles. Figure 2 shows the weight of some electric vehicle models. Their weight is in the range from 1200 kg (Mitsubishi i-MiEV) to 2720 kg (Audi e-tron).

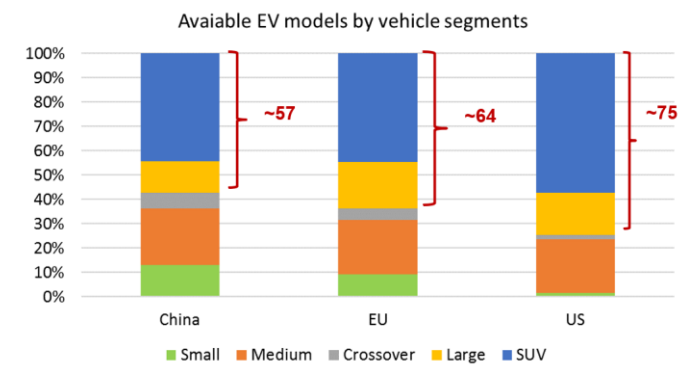

Fig. 1. Avaiable electric vehicle models by vehicle segments in China, the EU and US [1]

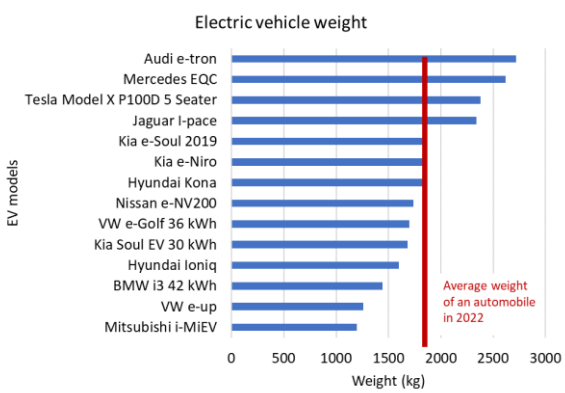

Fig. 2. Weight of electric vehicles for selected electric vehicle models [2]

The major reason for the promotion and support of BEVs is their potential to contribute to the reduction of CO2 emissions caused in the transport sector. Their full environmental benefits could be reached only in combination with the use of electricity produced from renewable energy sources. However, worldwide, the carbon intensity of electricity is in the range from about 25 gCO2e/kWh in Paraguay to 795 gCO2e/kWh in Botswana. [3]

The core objective of this paper is to analyze the benefits and challenges of electric vehicles considering their driving costs and their contribution to the reduction of emissions with special focus on the size of vehicles and the costs of charging.

Method

For the economic analysis of the electric vehicles different size chategories of electric vehicles are considered as well as different electricity costs for charging. In detail this analysis includes investment costs (IC) of vehicles, corresponding operating and maintenance costs ($C_{O\&M}$), specific number of kilometres driven per car per year (skm), the energy/electricity price (P_f), and specific energy consumption (FI). The formal economic analysis starts with the calculation of the total driving costs (C_{drive}) per year (all cost values in this paper refer to EUROs of 2020) for different size chategories (small, medium and large) of electric vehicles:

$$C_{drive_i} = IC_i\alpha + P_f FI_i skm + C_{O\&M_i} \quad [€/car/year] \qquad (1)$$

i…car caregory

For the environmental assessment carbon content of electricity mix in different countries is considered. Moreover, comprehensive discussion on energy and material consumption for car production in relation to environmental impacts is provided.

Results

Figure 3 shows a comparison of the total driving costs for different electric car categories currently available on the market. The cost structure is shown for two different charging options: car charging at home as well as using publicly available fast charging points. It can be noticed that the cost of fast charging is about four time higher than those of home charging. Investment cost of electric vehicles are increasing with the maximal driving range, which is correlated with battery capacity. However, increase in battery capacity lead to increase in raw material consumption and consequently to the environment. Most of electric vehicles which have similar driving range to conventional cars require larger batteries. This has as a consequence also high purchase prices of electric cars. More affordable electric vehicles have short driving range and they are suitable for daily use in urban areas, which should be replaced with electrified public transport. Environmental benefits of electric vehicles are very dependent on electricity generation mix and they are currently very different across countries.

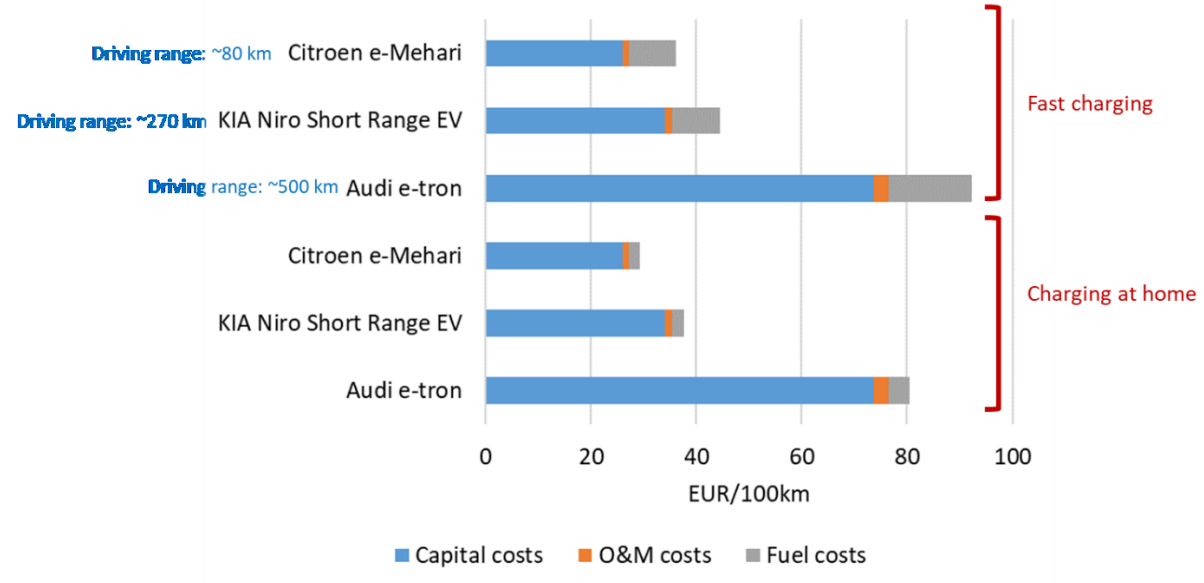

Fig. 3. Total driving costs of selected electric vehicles (Assumption: 15000 km driven per year)

Conclusions

The major conclusions of this analysis are:

Electric vehicles in combination with electricity from renewable energy sources can reduce CO2 emissions in transport considering well-to-wheel emissions. However, the problem is the increasing size of the vehicles. There is still huge uncertainty about negative environmental impact of raw material mining as well as regarding the environmental impact of battery recycling.

Although, the performance of electric vehicles is rapidly improving, electric vehicles are still less convenient for use in comparison to conventional cars. Especially, charging time and infrastructure should be improved, as well as the balance between car price and driving range.

In the future, electric vehicles could play a significant role only if (i) the proper mix of different supporting policy measures is implemented, (ii) battery performance is improved and costs are reduced, (iii) the size of the BEVs promoted is strictly limited and (iv) it is ensured by highly credible sources that the electricity used comes from renewable energy sources.

References

[1] IEA, Global EV Outlook 2022

[2] TBTP - Weight Distribution Test Results Overview, available on: https://tbtp-ev.github.io/tbtp-results-weight.html

[3] Our Word in Data, Carbon intensity of electricity, available on: https://ourworldindata.org/