Clean Electro-mobility Solutions only using Green Energy Input

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Abstract

The utilization of electric vehicles (EVs) is considered as the new tool against the serious problems resulting from the oil products consumption in the transportation sector. In this context, the current work first estimates the real world electricity consumption of commercial EVs, including charging and discharging losses, using long term experimental measurements. Accordingly, on the basis of the total electricity consumption and using the electricity generation fuel mix (mainland vs. remote islands), the corresponding air pollutants are predicted. On the other hand, one may estimate the air pollutants' emissions of contemporary EVs using experimental measurements and data provided by the EV manufacturers and other external accreditation bodies. According to the results obtained one should point out that current EVs may surcharge the environment with a higher volume of pollutants than the corresponding ICE-based ones, especially when coal-based and oil-based electricity is used to charge the batteries of the EV. On the other hand, if using renewable energy sources to charge the batteries of EVs, it is evident that the environmental impact of EVs -due to air pollution- is minimal.

Keywords: Renewable Energy; Energy Storage; Transportation Sector; Air Pollution; Greenhouse Gases

1. Introduction

The European Commission has set the rules towards a cleaner and more sustainable environment. Considering that the transportation sector is not only a great GHG but also an important air pollutants' emitter, renewable energy sources (RES)-based electro-mobility is strongly promoted by EU countries. According to the latest available data (International Energy Agency (2017) and electric vehicle (EV) volumes (2018)), the global electric car stock (i.e. Battery Electric Vehicles (BEVs), Plug-in Hybrid EVs) surpassed two million vehicles in 2016 (Figure 1).

In this context, the current work first estimates the real world electricity consumption of commercial EVs, including charging and discharging losses, using long term experimental measurements (Kostopoulos et al., 2018). Accordingly, on the basis of the total electricity consumption and using the electricity generation fuel mix (mainland vs. remote islands), (Kaldellis and Zafirakis (2007) and Kaldellis et al. (2009)), the corresponding air pollutants are predicted.

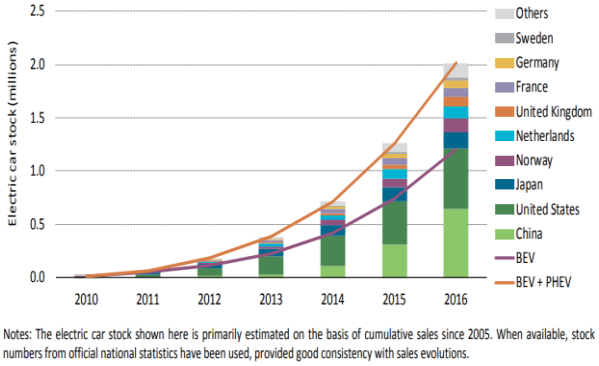

Figure 1. Global electric car stock, 2010-2016, EV volumes (2018).

Figure 2. UNIWA solar EV charging station.

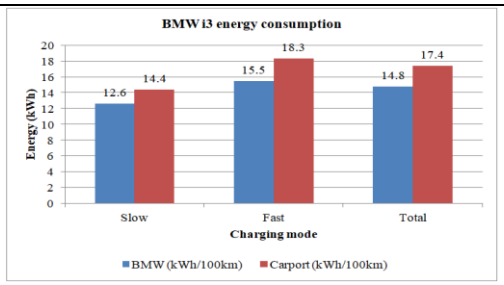

Figure 3. Energy consumption values for slow and fast charging.

2. Methodology

In order to experimentally verify the real energy (electricity) consumption of commercial EVs, the

autonomous / grid connected solar EV charging station (Figure 2) of the Soft Energy Applications and Environmental Protection Laboratory of the University of West Attica (UNIWA) has been used. During "normal" charging, high power via a P-charge Wallbox Mono (of up to 22kW) incorporated in the solar EV charging station is provided. During "slow" charging, the vehicle is connected with a conventional AC 230-volt (16A) household power socket, incorporated also in the solar EV charging station. According to Figure 3, 15% higher energy consumption is recorded during the charging phase when using the fast charging mode. Moreover, due to charging losses, the final energy absorbed by the EV is found to be higher in comparison with the pure EV energy consumption by approximately 20%, which can result from appropriate calculations. On the other hand one may use the existing experience concerning the air pollution related with the current electricity generation power stations.

3. Results

On the basis of long-term measurements, charging losses have been found to be ~15%, taking into account both the winter and summer period, as well as both slow and normal charging modes; thus the energy that a EV consumes reaches 17.4kWh/ 100km.

Subsequently, using published work concerning the CO_2 emissions of the electricity generator sector one may state that the corresponding emissions vary from almost 1500gr/kWh_e for the lignite based old power stations of W. Macedonia down to 750gr/kWh_e for oil-based and 450gr/kWh_e for natural gas based electricity generation plants (Kaldellis and Kapsali, 2014). Furthermore the corresponding NO_x, SO_2, HC and PM specific emissions (gr/km) are summarized in Table 1, using available official data for Greece (Kaldellis et al., 2004 and Kaldellis et al., 2005). Thus, on the basis of the total electricity consumption and using the electricity generation fuel mix (mainland vs. islands) the corresponding air pollutants are predicted.

Table 1. Specific emission factors

Air Pollutant (gr/km)	ICEV	Mainland Grid	Island Grid
CO_2	100-200	80-200	120-160
NO_x	0.06-0.15	0.15-0.25	0.04-0.10
HC	0.1-0.2	0	0.05-0.08
SO_2	0	0.2-0.35	n/a
PM	0.005-0.015	0.001-0.003	0.005-0.01

4. Discussion

Consequently using the above briefly described methodology, one may estimate the air pollutants emissions of the contemporary EVs using experimental measurements and data provided by the EV manufacturers and other external accreditation bodies. For this purpose several internal combustion engine-based vehicles (ICEV) are analyzed according to the technology used. Moreover the engine size and the year of construction are also embodied in the proposed analysis. According to the results obtained one may clearly state that the current electrical cars may surcharge the environment with a higher quantity of pollutants than the corresponding ICE-based ones, especially when coal-based and oil-based electricity is used to charge the batteries of the EV. For example, for an EV used by the average European driver (i.e. covering 15000km per year), the annual CO_2 emissions are comparable. Actually, the corresponding annual emissions for utilization of mainland electricity vary between 250 and 600kg, while the corresponding value for the islands is approximately 450kg. On the other hand the annual carbon dioxide emissions for contemporary ICEVs range between 300 and 600kg, values that are similar to the ones related with the above mentioned EVs. Finally, by applying solar based charging, the resulting CO_2 emissions are less than 20kg per year.

5. Conclusions

Recapitulating, in order to improve the air quality of our environment and minimize the transportation sector impact on the climate change it is more than necessary to avoid the utilization of fossil fuels for providing electricity at the EVs charging points. On the other hand, if using renewable energy sources to charge the batteries of EVs, the environmental impact of EVs -due to air pollution- is minimal.

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