Will EVs make our cities quieter?

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An initial assessment based on a limited comparative study and tyre statistics.

Introduction

E-mobility is gaining in importance worldwide. The European Parliament and the European Commission earlier this year formally approved a law to ban the sale of new gasoline and diesel vehicles in the European Union from 2035 [1], [2]. Legislation such as this will further accelerate the shift to electric vehicles (EVs). While EVs are known to have numerous positive effects on the environment, little is known on the impact of EVs on road traffic noise emissions. EVs are generally considered to be quieter than vehicles with combustion engines, as they produce virtually no engine noise [3]. However, the total noise emissions of vehicles are not only due to the engine noise: Several studies show that for passenger cars, tyre/road noise dominates already at a speed of 15 to 30 km/h [4], [5] & [6]. The question arises among noise abatement officials and noise plagued residents regarding the expected impact of EVs on noise emissions from urban roads. Systematic comparisons between electric vehicles and combustion vehicles are hardly available to date. Therefore, we attempt here to make an initial assessment of the noise impact of EVs on urban roads based on a limited comparative study and tyre statistics.

1. Noise emissions of EVs and combustion vehicles in direct comparison

To obtain an initial assessment about the impact of EVs on noise emissions in cities, we conducted a series of road tests with seven EVs and seven combustion vehicles (CVs). The vehicles were subjected to three different driving scenarios commonly encountered on urban roads.

1.1 The pairing of vehicles

To compare EVs with CVs, seven electric vehicles of different categories, ranging from small cars to delivery vans, were selected. Based on this selection, the corresponding vehicle counterparts with internal combustion engines were then searched for (see Figure 1). When selecting the vehicles, the pairing was chosen as best as possible, however, there were limitations in selection and availability. For example, a VW E-Golf would have been preferable as a counterpart to the VW Golf, instead of the VW ID.3. However, this vehicle was not available for the road tests.

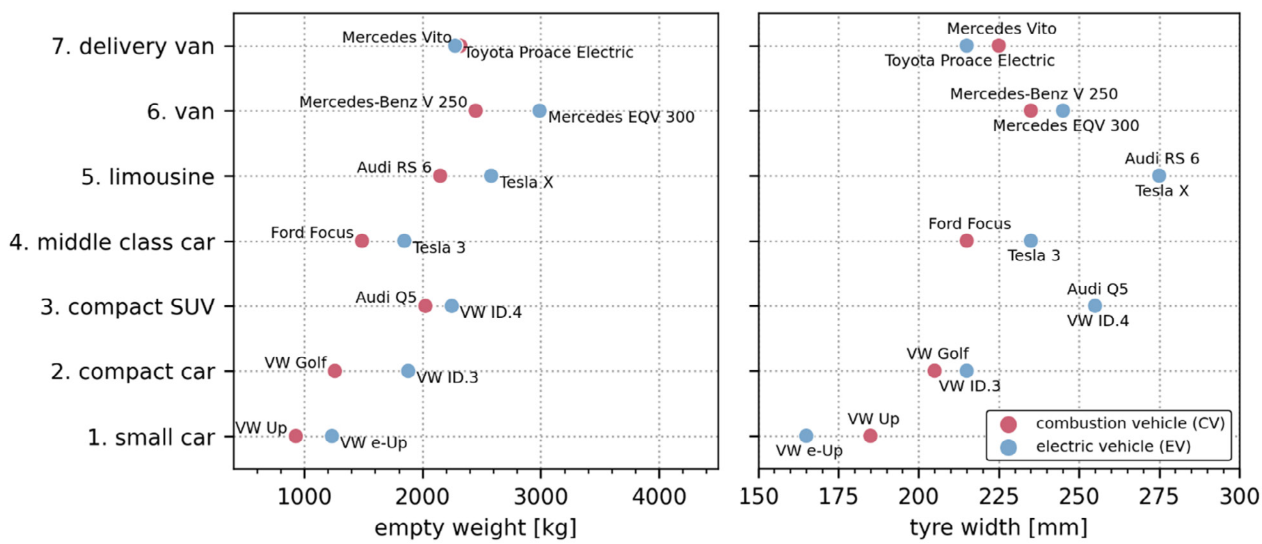

Figure 1: Empty weight and tyre width of the selected electric vehicles and their counterparts with combustion engines by category.

As can be seen in Figure 1, all EVs (except for category 7 "delivery van") have an empty weight 220 to 620 kg higher than the corresponding CVs due to their heavy batteries. In terms of tyre width, there is no systematic difference between the two vehicle types in the present sample.

1.2 The driving tests

To collect the noise emission data, pass-by measurements according to ISO 11819-1 [7] were performed at three microphone positions (A, B and C) placed at 25 m from each other on two different pavements – a conventional pavement and a low-noise pavement. In 7.5 m distance from the centre of the lane, the maximum sound level (LA, F, max) as well as the equivalent sound level (LA, eq) were recorded. The following three urban driving scenarios were simulated with all vehicles: 1) Constant velocity, the vehicles passed the three microphones at a constant driving speed of 20, 30, 40, 50 and 60 km/h; 2) Acceleration, the vehicles drove at 20 km/h to the first microphone "A" and then accelerated to 40 km/h and 60 km/h to microphones "B" and "C" respectively; and 3) Stop & Go, the vehicles drove past the first microphone "A" with 30 km/h, then slowed down, came to a complete stop at the second microphone "B" and then accelerated again and passed microphone "C" at a speed of about 40 km/h. The vehicles were driven by different drivers. Despite precise instructions, minor differences in personal driving behaviour were observed.

1.3 Noise emissions from EVs compared to CVs

To provide an overview, only the aggregated results across measurement positions (A, B and C) and vehicle categories (1 to 7) are presented in Figure 2. A detailed description of the measurements and the results can be found in the study [8].

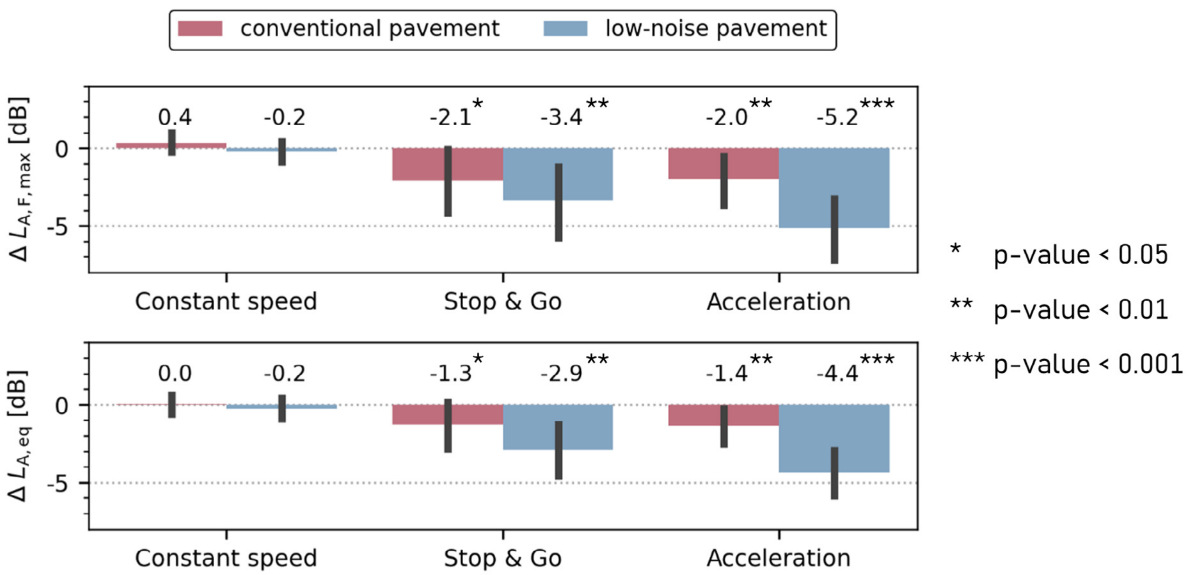

Figure 2: Mean difference values (EV - CV) and the corresponding 95 % confidence interval of LA,F,max and LA,eq for the three driving scenarios. All seven car categories are averaged without weighting.

Our limited vehicle comparison showed that the EVs used in this study are significantly quieter than their CV counterparts for the typical urban driving scenarios "acceleration" and "stop & go". Interestingly, the study shows that the effect of EV's is greater on low-noise pavements than on conventional ones. This can be explained by the reduced tyre/road noise on low-noise pavements which leads to a bigger influence of the propulsion noise component, causing the main difference in noise emissions between EVs and CVs.

At constant speed, however, the EVs used in this study did not show systematic differences in noise emissions compared to the corresponding CVs: At all tested speeds of 20, 30, 40, 50 and 60 km/h, no significant difference between EVs and CVs with regard to the noise emission was found, regardless of the road surface.

2.What happens when EV's higher weight and torque require wider tyres?

In the limited comparison study, no significant differences in noise emissions were found between EVs and CVs at constant speed between 20 and 60 km/h. It must be emphasised that due to the small vehicle sample, the available data basis is rather small. Therefore, no clear conclusions about the differences in noise emissions between EVs and CVs can yet be derived from the measurement data. However, it appears that at constant driving speeds, other factors such as unladen weight or tyre specifications play a greater role than the propulsion type.

Because the electric battery of EVs is quite heavy, other studies have found EVs to be about 200 to 300 kg heavier than their corresponding CV counterpart [9]. The increased weight and higher maximum torque of EV's and the resulting use of wider tyres with a higher load index may have a negative influence on the noise emission of an electric vehicle [10].

To find out how noise emissions may statistically change with increasing electrification of vehicles, we further analysed a database of all (C1) passenger car tyre products sold in Switzerland. On the one hand, we are interested in how the noise label statistically changes as a function of tyre width. On the other hand, we would like to know how the tyre load index affects the noise label. The tyre load index is a value ranging from 62 (=265 kg load per tyre) to 126 (=1700 kg load per tyre) and relates to the maximum carrying capacity of the vehicle. Understanding these trends may help us further assess the impact of the rapidly advancing electrification of vehicles on noise emissions.

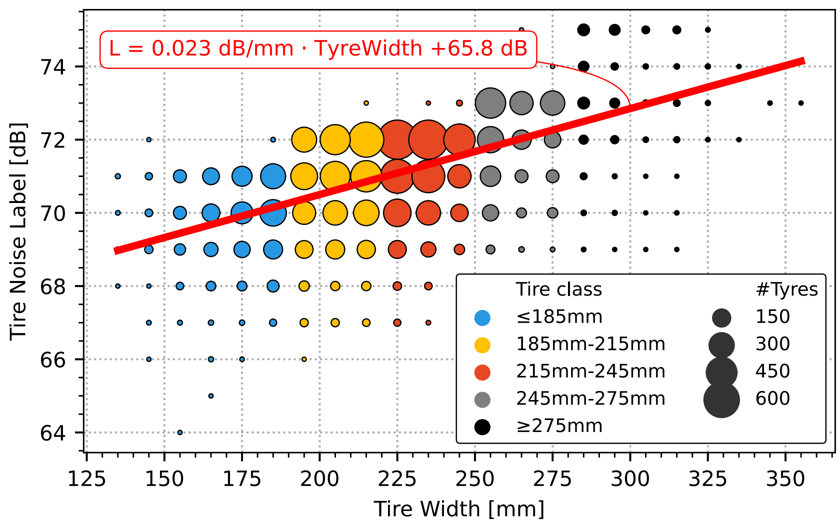

Figure 3: Relationship between tyre width and the tyre noise label based on the Swiss tyre product database.

Figure 3 shows that noise levels (noise labels) increase with tyre width by about 1 dB per 43 mm. So if EVs had to be fitted with slightly wider tyres than CVs due to their weight and torque, a slight increase in noise would have to be expected. A multivariate model between tyre width, load index and noise label, confirms the positive relationship between tyre width and noise while the load index again contributes to a noise increase of 0.05 dB per 10 units of load Index.

Table 1: OLS Regression Results of the model to predict the "Tyre Noise Label [dB]" based on variables "Tyre Width [mm]" and "Load Index [-]"

	Coefficient	Std. error	t-value	P > | t-value |
Intercept	65.57	0.108	608.88	0.000
Tyre Width	0.022	0.001	40.03	0.000
Load Index	0.005	0.002	2.75	0.006

As the above model shows, the load index seems to be significantly less decisive than the tyre width with regard to noise emissions. So, the mere increase in weight of EVs compared to CVs would not have to result in major increases in noise levels, unless wider tyres are fitted. It should be noted, however, that the above correlations were not determined directly based on measurements but were established indirectly via the tyre noise label. Given the relatively high uncertainties determined for the EU tyre noise label [12], the correlations between tyre width, weight index and acoustics may even be stronger in reality

3. Conclusions

In this article, based on a limited comparative study, an attempt was made to estimate the influence of the rapidly advancing electrification of vehicles on noise emissions in urban areas. The good news for residents is that significantly lower noise emissions can be expected for the driving scenarios "acceleration" and "stop & go", which are common on urban roads. Depending on the dominant driving behaviour on a road section and the road surface, noise reductions of 0 to a maximum of 5 dB can be expected. The more unsteady driving behaviour there is on a road section and the quieter the road surface, the greater the noise-reducing effect of electrification. The bad news, on the other hand, is that at constant driving speeds, no significant reduction in noise emissions was found for EVs at speeds between 20 and 60 km/h. If we assume that EVs tend to be equipped with wider tyres and higher load indexes due to their higher weight and torque, we even have to expect a slight increase in noise pollution on roads with constant driving speeds. It should be stated that only a very small sample of pairs of EVs and CVs could be studied. Further research is needed to reliably predict the change in noise emissions as a result of vehicle electrification. Moreover, in future studies, other vehicle types e.g. heavy trucks, the impact of AVAS, as well as the effect of EVs at the high speed road network should be investigated.

4. Acknowledgments

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