Effects of electric vehicles on air quality in street canyons

T. Schöllnhammer[1], F. Lommes[2], T. Schulz[3], H. Hebbinghaus[3], and S. Wurzler[3]

[1]Department of Civil and Environmental Engineering, Ruhr University Bochum, Bochum, Germany
[2]Meteorological Institute, University of Hamburg, Hamburg, Germany
[3]North Rhine Westphalia State Agency for Nature, Environment, and Consumer Protection, Recklinghausen, Germany
Keywords: electric vehicles, air quality, street canyon.
Presenting author email: sabine.wurzler@lanuv.nrw.de

Road traffic is one of the main causes of poor air quality in European cities. Electric vehicles (EV) are often presented as solution for air quality problems in cities. In addition they are claimed to be a climate friendly means of transport owing to their non-existent exhaust emissions. The German government has formulated the ambitious goal to increase the amount of electric vehicles in Germany to 1 million in 2020 and 6 million in 2030. The aim of this paper is to investigate how much of this claim is true. While traffic is a major source of air pollutants in street canyons, it is often forgotten that electricity production nowadays is a significant source of air pollutants on the regional scale.

Focus of the present study is the air quality in street canyons, to be more precise the PM10 and NO_2 concentrations. We concentrate our investigation on road traffic, taking the fleet composition into account. We have investigated the following questions:

- Is the goal of the German government effective with regard to an improvement of the air quality?
- What share of electric vehicles would be needed to
a) significantly reduce the annual immission load (5 µg/m³ for NO_2 and 3 µg/m³ for PM10)?
b) comply with the EC limit values?
- Which vehicle type is most promising with regard to an efficient immission reduction? E.g., passenger cars? Busses? Heavy duty vehicles?
- What is the impact of the reduced traffic emissions on the regional background concentration of PM10 and NO_2?
- How much electricity is consumed by the vehicles? What is the resulting effect on power plant emissions?

We present results for two street canyons in Germany with moderate EC air quality limit value exceedances: Gladbecker Street in Essen, and Friedrich-Ebert-Street in Mönchengladbach. The air quality analyses were carried out using the canyon plume box model Immis^{Luft} for the contribution of local traffic, combined with field observations of air quality and model results of the chemical transport model EURAD (Memmesheimer et al., 2004). The change in power plant emissions was estimated based on the emission inventory of LANUV NRW. The energy consumption by the vehicles was estimated based on values from the recent literature, such as product information (Schöllnhammer, 2012).

As already mentioned the German government wants to increase the amount of electric vehicles in Germany. An example of the effects of this program on the air quality is shown in Table 1 for the annual average PM10 concentration. Reference year is 2009. We have assumed that the replacement of vehicles with combustion engines by electric vehicles would happen instantaneously. The proportion of electric vehicles in our street canyon was assumed to be the same as for the vehicle fleet in Germany. The findings are rather daunting for PM10, the results for NO_2 are somewhat better. The good news for these scenarios is that the effect of the increased electricity production on the regional air quality is leveled out by the emission reduction by the vehicle fleet on the regional scale.

Table 1: PM10 annual average concentration in µg/m³ in Friedrich-Ebert-Street for different scenarios: no electric vehicles (None), 1 or 6 million electric vehicles (EV) of the different vehicle types in Germany. HDV = heavy duty vehicles; LDV = light duty vehicles.

PM10 annual average concentration in µg/m³					
EV	None	Cars	HDV	Busses	LDV
1 mio.	29,6	29,6	29,5	29,4	29,6
6 mio.	29,6	29,4	29,5	29,4	29,6

One general finding of our study is that electric vehicles can reduce the NO_2 burden but are not the right measure to significantly influence the PM10 concentration in a street canyon. Only a minor share of the PM10 emissions is caused by vehicle exhaust. The lions share is produced by friction and abrasion processes. Those are present anyhow no matter of the engine type.

What amount of electric vehicles would be necessary to find a major impact on air quality will be addressed further in the presentation. The tradeoff between local emissions by the vehicles and the more regional emissions by the power plants will be critically discussed.

Major parts of this work were performed as diploma thesis at the Department of Civil and Environmental Engineering, Ruhr University Bochum, with the advisors Prof. R. Höffer and C. Wevers.

Memmesheimer, M., Friese, E., Ebel, A., Jakobs, H. J., Feldmann, H., Kessler, C., Piekorz, G. (2004), IJEP, **22**, 108 – 132.

Schöllnhammer, T. (2012): Wirkung der Elektromobilität auf die Luftqualität im innerstädtischen Gebiet. Diploma Thesis, Ruhr University Bochum, 95pp.