Forecast Models for Road Traffic Noise in The Year 2050 as a Basis for the Development of Measures to Reduce Noise in Urban Areas

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Abstract

The German Climate Protection Act aims to reduce greenhouse gases. The focus is on harmful emissions, while noise, which can also lead to physiological and psychological disorders, has been neglected. An effective transformation of the transport sector requires long-term developments in the economy, society, politics and technology. The complexity of these future developments leads to high planning uncertainty. Therefore, the scenario technique is used as a method of futurology. The aim of this research is to analyse the development of urban noise for the year 2050. The purpose is to provide an instrument for future planning of noise abatement in road traffic. As a basis, key factors are identified, described and analysed, whereby a long-term horizon and megatrends are considered. Taking into account greenhouse gas reduction measures, national transport scenarios and socio-economic scenarios are included in order to forecast the development of road traffic noise up to 2050. Reference and stability scenarios are developed and the qualitative data from these scenarios are converted using statistical analysis into quantitative forecasts. The average traffic volume is calculated using multiple regression equations from the forecasts of traffic performance and traffic volume. The developments of the settlement-structural district types are determined by logarithmic trend lines. Based on these forecasts, planning situations are created. They deal with typical situations in the development of residential areas. These situations are combined with various road traffic noise sources to form an application case and presented graphically for the future scenarios. These are fictitious development plans in the sense of urban planning, which can be traced back to real planning cases in the future. For each planning situation, a noise immission plan is also simulated and the noise level differences compared. The noise immission plans for the year 2050 shows that without additional noise reduction measures, no significant reduction in noise levels can be expected. Despite the achievement of climate protection targets in the stability scenario, there are no perceivable differences in noise levels compared to the reference scenario. Therefore, noise reduction measures need to be increasingly considered in mobility concepts and transport development planning, as well as in spatial development planning.

Keywords: *road traffic noise, urban noise, forecast models, noise immission plans, scenarios*

1. Introduction

Global warming causes climate change, whereby the transport sector with its CO2 exchange is one of the most important factors. Therefore, the German Climate Protection Act stipulates that greenhouse gases in the transport sector must be reduced by at least 70% by 2030 and by at least 90% by 2045 compared to 1990 levels. According to the German government's 2021 reports, the current measures will not achieve the climate target for greenhouse gas emissions from the transport sector by 2030. Transport is the only sector that has not yet managed to reduce its emis¬sions, particularly with road transport being the largest emitter [1].

The main focus of climate protection targets is on the reduction of emissions from the transport sector due to their harmful effects on human health. However, the impact of noise on physiological and psychological well-being is often overlooked. Especially if noise exposure is prolonged, it can lead to chronic diseases such as hypertension, cardiovascular disease and weakening of the immune system [2]. According to a 2020 survey, three quarters of the population are not only affected by traffic-related pollution, but they also feel annoyed or disturbed by road traffic noise [3].

To address these issues, an extensive transformation of the transport sector is urgently needed. An effective implementation of the respective climate protection targets in the future must be achieved in particular through long-term developments and changes in all areas of the economy, society, politics and technology. Consequently, future developments will always be characterised by complexity, which in turn can lead to a high degree of uncertainty in planning future measures.

Against this background, the scenario technique is a method of futurology in both business and government organisations. It is one of the main techniques of futurology and an effective tool for decision making under uncertainty.

Scenarios do not represent a single future end state but show possible paths into the future that can be influenced by different factors. This means that there are multiple alternative paths and visions of the future [4].

There is already a significant amount of future research in all sectors of the economy. With regard to noise protection, there is a lot of research into noise reduction. However, there are only a few explorations on the long-term horizons for road traffic noise, so the presented research focuses on the development of road traffic noise for the year 2050. The purpose is to provide an instrument for future planning of road traffic noise control.

2. Method

As a basis for the forecast models, on the one hand the time horizon "2050" is chosen, whereby this is not meant in the calendar sense. Rather, it is a time period that takes into account currently discussed political, economic and social planning and decision-making processes. On the other hand, megatrends are selected as key factors that have a high impact on road traffic noise and are

considered likely by experts.

These megatrends are analysed using an influence matrix. From the passive sum of this analysis, an indicator sequence is determined. Taking into account current data and the coronavirus pandemic, existing national transport scenarios and socio-economic scenarios corresponding to this determined indicator sequence are integrated into the exploration. These scenarios also take into account greenhouse gas reduction measures that forecast the development of road traffic noise up to 2050.

The reference scenario describes the future development if no new decisions are made, and no measures are taken. Meanwhile, in the stability scenario, ambitious measures are implemented to achieve the climate protection target.

Finally, the qualitative data from these scenarios are converted through statistical analysis into two quantitative forecasting models. Based on these forecast models, planning situations are developed in the form of fictitious development plans, which in turn form the basis for the development of various noise reduction measures.

3. Scenarios

According to the 13th population projection, variant 2, the German population is expected to fall to 77 million by 2050. This is based on an annual net immigration of 200,000 people. The gross domestic product is expected to grow by 1% by 2025 and by 0.8% in the following years. In 2050, the percentage of electrified vehicles is projected to be 75% for passenger cars, 73% for light commercial vehicles, and 9% for heavy commercial vehicles.

In the reference scenario, it is predicted that the climate protection targets will not be met by 2050 and will be significantly delayed. Due to demographic trends, passenger transport will decrease. Freight traffic, on the other hand, will increase, primarily through globalisation and e-commerce. Shifting freight Transport to the railways will only be possible to a limited amount. The goal of reducing land utilisation cannot be achieved.

The stability scenario assumes the implementation of ambitious measures. With measures to avoid and shift traffic as well as to increase efficiency, the climate protection targets will be achieved in 2050. Transport will become greenhouse gas-neutral, and the transport infrastructure will be strengthened. Public awareness of the use of public transport and environmental protection will also increase. Motorised private transport will decrease, and public transport will increase. A significant amount of freight can be shifted to rail. Furthermore, unused areas of settlement will be repurposed to meet the land utilization goal by 2050.

4. Noise Immission Plans 2050

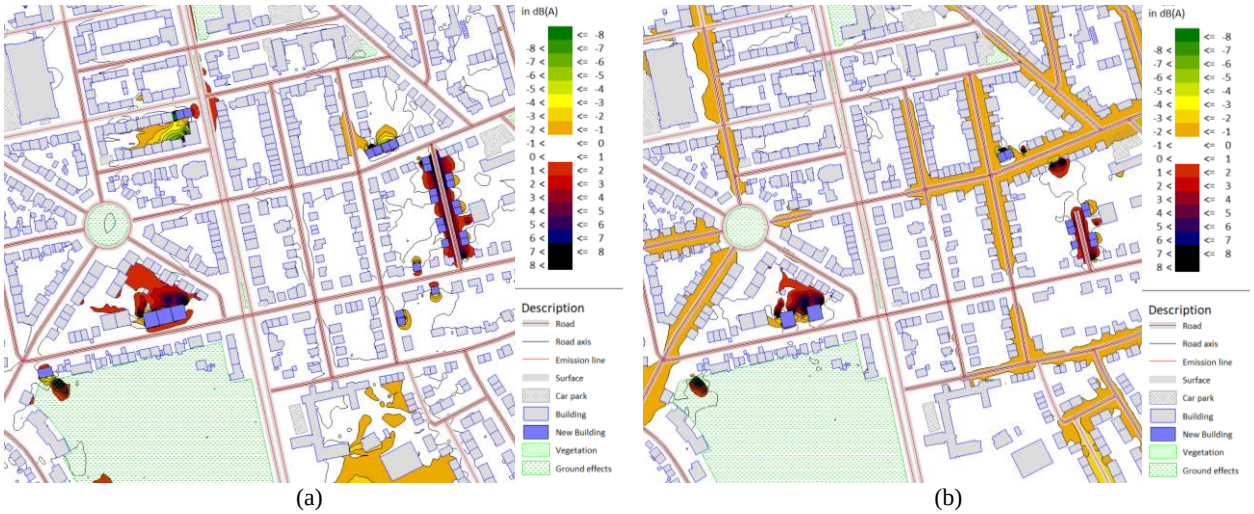
The qualitative data from the scenarios are converted using statistical analysis into quantitative forecasts. The average traffic volume is calculated using multiple regression equations from the forecasts of traffic performance and traffic volume. The developments of the settlement-structural district types are determined by logarithmic trend lines. Thereby, the proportion of electrified motor vehicles depending on urban and suburban driving is included in the calculation of the length-related sound power level and the noise reduction potential is calculated in each case.

Based on these forecasts, planning situations are created. They deal with typical situations in the development of residential areas in large cities, urban districts, and rural districts. These situations are combined with various road traffic noise sources (DIN 18005) to form an application case and presented graphically [5]. These are, in the sense of urban planning, fictitious development plans that can be traced back to real planning cases in the future. For each planning situation, a noise immission plan is simulated and the noise level differences compared. For better comparability of the noise reduction effects, a qualitative assessment is made using a scale.

5. Results

The forecast models for road traffic noise up to 2050 provide significant insights for the development of urban noise reduction measures. The vision for the future is a greenhouse gas-neutral transport sector with lower emissions of air pollutants and noise. If measures are not taken to reduce greenhouse gases, Germany will not achieve its climate protection targets in 2050. However, it is possible to reduce greenhouse gases by avoiding and shifting transport, as well as increasing efficiency.

The noise immission plans for the year 2050 indicate, however, that even with successful implementation of climate protection measures, road traffic noise will remain a problem area. Neither the reference scenario nor the stability scenario shows significant reductions in sound pressure levels compared to the current situation.



(a) (b)

Fig. 1. The level difference between the current noise immission plans and the reference scenario(a) and the stability scenario(b), taking into account the development of residential areas in large cities with noise sources from national and local roads (scale 1:10000).

In the reference scenario (Figure 1a), the sound pressure as compared to today remains unchanged. There are only differences in the sound level distribution due to structural changes. This is due to the low reduction potential of the length-related sound power level of the electrified vehicle share, while at the same time the freight transport share increases.

In the stability scenario (Figure 1b), the sound pressure level on roads with speeds below 30 km/h improves by a maximum of 2 dB. This improvement is partly due to the possibility of shifting some freight traffic to the railway.

6. Conclusion

The results of this research show that in 2050, without additional noise abatement measures, no significant reduction in noise levels can be expected compared to today. Therefore, noise reduction measures need to be increasingly considered in mobility concepts and transport development planning, as well as in spatial development planning.

The authorities should develop and implement noise action plans in a timely manner, whereby the development and application of new, low-noise road surfaces as well as noise barriers, walls and absorbing façades play an increasingly important role. In addition, road space needs to be redesigned, including the creation of cycle lanes, minimizing braking and acceleration as well as reducing the speed limit. Implementing of the compact city concept also reduces road traffic noise, whereby the distances between the various places in a city are minimized and walking and cycling are made possible.

At the same time, it is important to continue research into noise reduction in urban areas. Setting legal limits could be another measure to reduce noise pollution. A holistic approach to road traffic noise can improve the quality of life in urban areas and protect the health of residents.

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