NOISE MAPPING 2021: HOW TO COMPARE RESULTS TO PREVIOUS ROUNDS?

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ABSTRACT

The environmental noise directive requires the assessment of noise from road traffic, railway traffic, airports and industrial activity sites in agglomerations as well as for major roads, major railways and major airports. This assessment is based on calculations where contours and noise levels on façades are determined. For the first time, the calculation method that must be used is proscribed in an EU directive. This method (CNOSSOS-EU) is different from previously used methods. For example, the propagation method, emission values and the method for determining the number of people exposed is different. The result is that a direct comparison of reported values to previous rounds has no meaning. To determine effectiveness of action plans and to monitor the effects of noise, a comparison between reporting rounds is necessary. Also, the European Commission has set a goal to reduce negative effects of transport noise by 30% in 2030. The baseline for this is 2016. How can this be assessed when numbers are incomparable? In this paper we will present the results of a study (road & rail) in the Netherlands where these differences are quantified. This allows us to compare results of the previous rounds to the current one. The outcome of the study will help municipalities to explain to the public why results are different this round of reporting.

Keywords: *CNOSSOS-EU, Action Plans, Environmental noise directive, Zero pollution action plan*

1. INTRODUCTION

As required by the environmental noise directive [1] noise maps for agglomerations, major roads, major railways and major airports were generated every five years starting with the situation in 2006. These noise maps can be used to define actions to reduce negative health effects of noise and they are also used to assess the effectiveness of action plans. Another use is the evaluation of the progress on the objectives of the zero-pollution action plan [2] and how far we have to go to reach these objectives.

Up until the noise maps over 2016 many different calculation methods were used across Europe. There were several interim methods, but countries were allowed to use their own national method as well. In the current round of noise mapping that changed. For the first time a Common Noise Assessment method (CNOSSOS-EU) [1] must be used when producing noise maps in the scope of the environmental noise directive. Due to the new calculation method, results of noise maps for the year 2016 will be incomparable to noise maps for 2021. This makes it difficult to assess effectiveness of action plans and evaluate the progress on the goals of the zero-pollution action plan.

A second consequence of changing the calculation method is the explanation to the public why there are these differences compared to what was published five years ago becomes more complicated.

In this paper we describe the results of a study where we quantified the differences between noise mapping rounds for road and rail traffic noise. We not only look at differences due to calculation method but also to other causes. In phase 2 of our study we will look in detail to each aspect of the method and how each aspect causes which

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difference. Finally, we will study how to account for that in action plans and informing the public. At the time of writing of this paper, phase 2 of the study was still in progress. In this paper we will present what trends we normally see (based on maps 2006-2016), and how that compares to the difference between the 2016 and 2021 maps. We will also show the influence of the new calculation method by studying the differences of calculations with both CNOSSOS-EU and the Dutch method.

2. DIFFERENCES IN NOISE MAPPING

2.1 Differences due to approach

Even using the same calculation method, noise maps will give different results that are not caused by any physical change in the environment or change in traffic. Results depend on data used in the models or choices made by the modeler. Or for example, a difference can occur due to a change in the size of an agglomeration. A clear example, shown in Figure 1, is the city of Groningen. Due to rearrangement and merging of municipalities, the city has increased in size between 2016 and 2021.

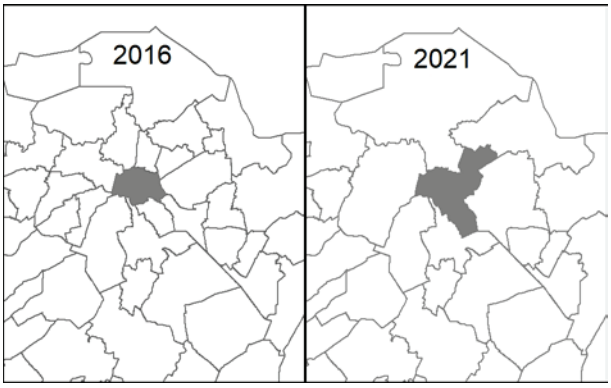

Figure 1. Borders between municipalities in 2016 and 2021. Due to merging of municipalities and different borders the agglomeration of Groningen (shown in grey) has changed in size from 83 km^2 in 2016 to almost 200 km^2 in 2021.

Another example that causes a difference is that more and more detailed (3D) data is available and is easily used in noise models. Finally, different or updated traffic models may be used. This will especially effect low intensity roads where the uncertainties in number of vehicles is large. Another difference might have been because of exceptional traffic intensities due to the COVID pandemic. In the Netherlands this is expected to play a negligible role. The reason is that most agglomerations used traffic models that did not take the effect of measures due to the COVID pandemic into account. This is also the case for major roads and railways. There representative traffic data was modelled as if there were no COVID measures. This was deliberately done to make it easier to assess trends and effectiveness of action plans.

2.2 Differences due to CNOSSOS-EU

Differences due to CNOSSOS-EU can be caused by a number of things. That is the emission model, the propagation model, and the method of determining exposure to noise. An example for a difference due to the emission model is the difference in source heights. This is shown in Table 1. The low source height for road makes the CNOSSOS calculation model especially sensitive to small height variations around the road and thereby may introduce higher barrier effects in the calculations.

Table 1. Source heights CNOSSOS-EU and Dutch method

Source	Dutch method	CNOSSOS-EU
Road	0.75 m	0.05 m
Rail	0, 0.5, 2, 4 & 5 m	0.5 & 4 m

The propagation model is also fundamentally different. Especially at larger distances the difference in ground attenuation [3, 4] is large. In the case of CNOSSOS under favourable conditions there is no ground absorption at large distances. In ISO 9613-2 [5] and the Dutch method [6] there still is some ground absorption at these distances. An example of the ground attenuation for both CNOSSOS-EU and ISO 9613-2 in a model with absorbing ground and a source height of 0.5 meter is shown in Figure 2. We have assumed 30% favourable conditions in CNOSSOS. For ISO 9613-2 we added the dashed line where the meteorological correction was added to the ground attenuation. This dashed line should be compared to the CNOSSOS-EU line to observe the difference between CNOSSOS-EU and ISO 9613-2.

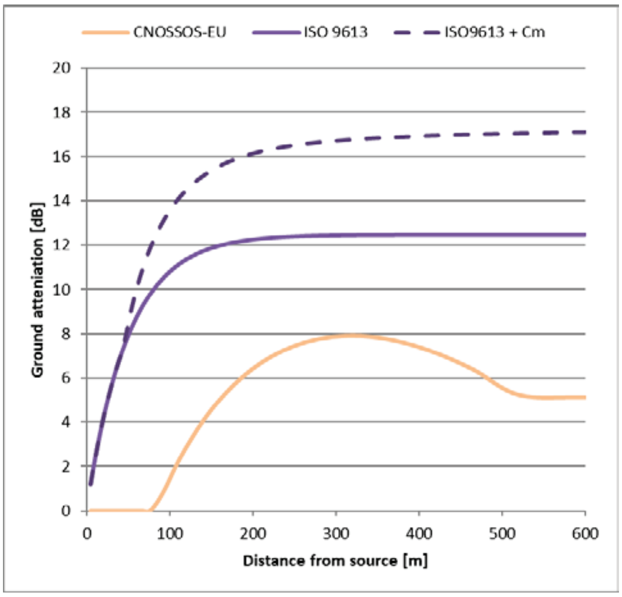

Figure 2. Ground attenuation at 500 Hz for CNOSSOS-EU (30% favourable conditions) and ISO 9613-2 (with and without meteorological correction). Calculated for a source height of 0.5 meters, receiver height of 4 meters and absorbing ground (G=1).

From Figure 2 it is clear that due to the different ground attenuation a difference in calculated levels is expected between the Dutch method/ISO 9613-2 and CNOSSOS-EU. This difference can be more than 10 dB at 500 Hz. A significant difference occurs even at short distances.

The third difference introduced with CNOSSOS-EU is the method of assigning the number of people living in dwellings to calculated noise levels. In 2016 and before, the highest calculated noise level (L_{den} and L_{night}) on the façade of a building was assigned to all the people living in that building. It did not matter if there was a single dwelling in that building or if there were multiple dwellings. With CNOSSOS-EU a new, more detailed method is introduced for buildings with multiple dwellings. In that case, the noise levels of all receivers (or, depending on layout of the dwellings within a building, the upper half of the receivers) are distributed equally over all the people living in such a building. A calculation [7] of a city in Europe with both methods show that the new method can lead to a decrease of 22% of reported people exposed to levels above 55 dB L_{den}. This aspect will be further addressed in phase two of our study.

3. MAPPING 2006 - 2016

We studied differences that occur with mapping using the same calculation method. For this, data on noise exposure from 2006-2016 was collected for the Netherlands from the datahub [8] that is hosted by the European Environment Agency (EEA). The EEA collects this data from all member states and publishes it in a uniform way. In Figure 3 the relative changes in number of people exposed for all agglomerations are presented.

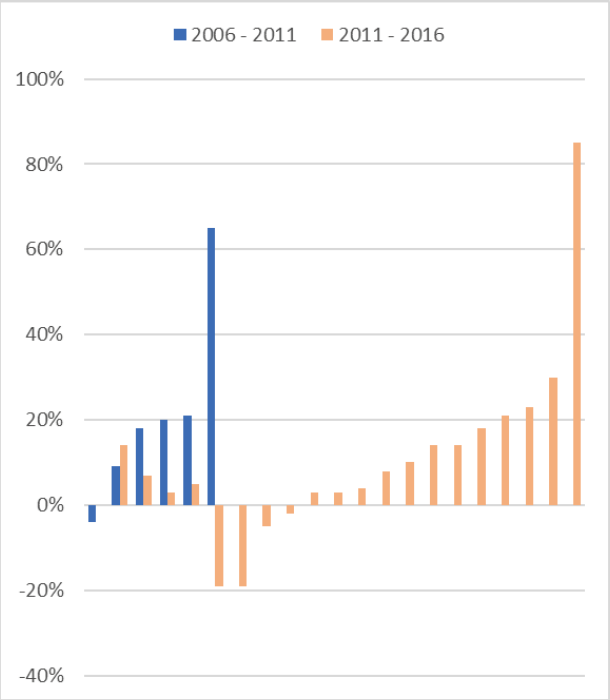

Figure 3. Relative change in number of people exposed for road traffic noise in all 21 agglomerations in the Netherlands from 2006 to 2011 and 2011 to 2016. In 2006 six agglomerations were required to report.

It is shown in Figure 3 that there mostly is an increase in the reported number of people exposed due to road traffic noise in agglomerations. In total, the increase was 19% from 2006-2011 and 6% from 2011-2016. The growth may be partially explained because the number of people living in agglomerations grew with approximately 4% every five years. Although it is unknown where this increase occurs (above or below the reporting threshold) one can assume that this population growth has led to an increase in number of people exposed.

In some cases, there is a very strong increase in reported number of people exposed. It is still unclear why these differences occur. It could be caused by a different approach in assigning noise levels to population (difference between noise level on façade or noise levels based on contours). However, in general, one would expect fluctuations of around 10 percent due to factors not related to calculation methods or changes in the environment.

That is also detailed in Figure 4, where we present averaged results for road and rail traffic noise for the situations with and without correction for population increase. It should be noted that the corrected values are a rough estimate as we do not know if population increase has mainly occurred above or below the reporting threshold.

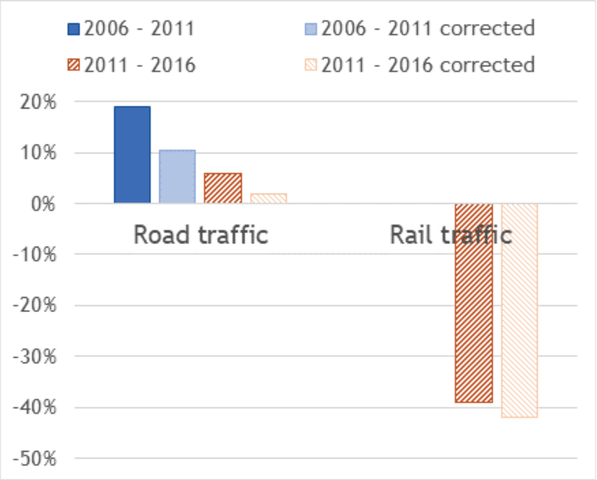

Figure 4. Relative change in number of people exposed to noise levels in L_{den} of 55 dB or higher by road and rail traffic. Numbers corrected for population growth are included. No values for rail traffic were available for 2006.

It is shown that especially between 2011 and 2016 for road traffic noise the average number of people exposed has been relatively constant (not taking increase in population into account). For major railways the number of people exposed to noise has dropped dramatically between 2011 and 2016. This is partially due to local measures like noise barriers and rail dampers but the main case is the decommissioning of noisy passenger trains, retrofitting of cargo trains (and some passenger trains) and the influx of new quieter passenger trains.

4. MAPPING 2016-2021

4.1 Differences 2016 and 2021

In this part of the study, we look at the differences between reported data for 2021 and 2016. This gives us information on how the change to the new methodology compares to fluctuations we normally see. For this part of our study we used data from 23 municipalities that reported their noise data to the Dutch central noise data repository [9, 10]. We performed two types of analysis: the first was to visualize where increases or decreases occur and the second was to compare the number of people exposed.

To visualize the differences in noise levels in an area, a method was developed based on hexagons. For each hexagon a value is calculated that describes how noisy it is in that hexagon. By using this method for both 2016 and 2021 a difference can be calculated. It is then easy to visualize where it has gotten noisier or quieter. This method was developed because calculating a difference between contours can give very messy results, that are difficult to interpret. In the method we created a grid of hexagons (4 acres each). For each hexagon a value, that we call dB/acre, is calculated. This is calculated by using the center value of each contour band and an area weighted average of the overlap of de hexagon with these contours. As we use existing contours starting at 55 dB L_{den} and 50 dB L_{night}, noise levels below 55 dB L_{den} or 50 dB L_{night} do not have a contribution on the dB/acre. An example is a hexagon that overlaps for 1.5 acres with a 55-60 dB contour and 0.5 acres with a 60-65 dB contour. The rest of the hexagon is lower than 55 dB. That means that only half the hexagon actually has an overlap with a contour. In this case the calculated dB/acre for this hexagon is determined according to equation 1.

$$\text{dB/acre} = (1.5\text{x}57.5+0.5\text{x}62.5)/4=29.4 \qquad (1)$$

Because we have identical grids of hexagons, we can calculate the relative difference in dB/acre between 2021 and 2016. This allows us to visualize were on average noise levels are higher or lower in 2021 compared to 2016. This method allows us to easily perform a first assessment as to where higher, lower, or similar noise levels are calculated. It is not meant to find hotspots or to assess absolute levels. An example is shown in Figure 5.

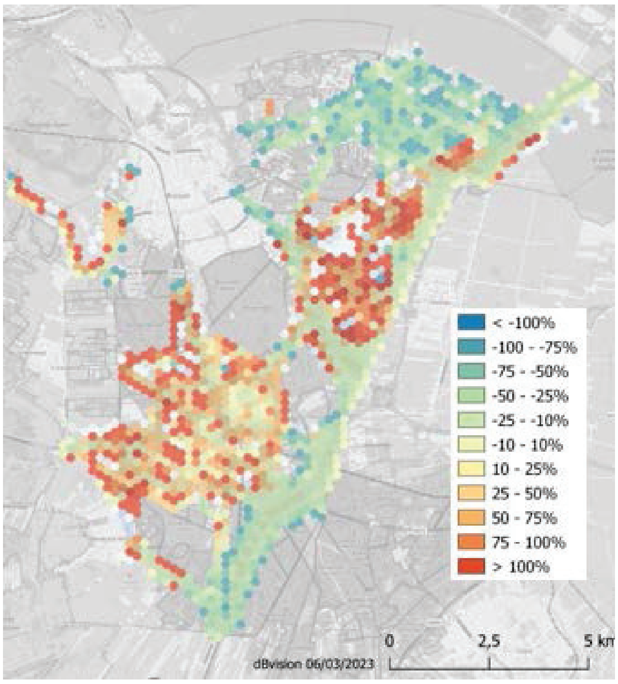

Figure 5. Relative difference between 2021 and 2016 based on dB/acre for road traffic noise in L_{den}

In Figure 5 it is shown that an increase in noise levels mainly occurs within the city. An exception is at the top middle part of the map. This municipality included fewer roads in the model for 2021 compared to 2016. The major road on the right of the map was reconstructed between 2016 and 2021. This explains the reduction in noise in that area. In Figure 6 we show the absolute values in dB/acre for 2021. It shows that areas with the largest increase are not necessarily the areas with the highest exposure to noise.

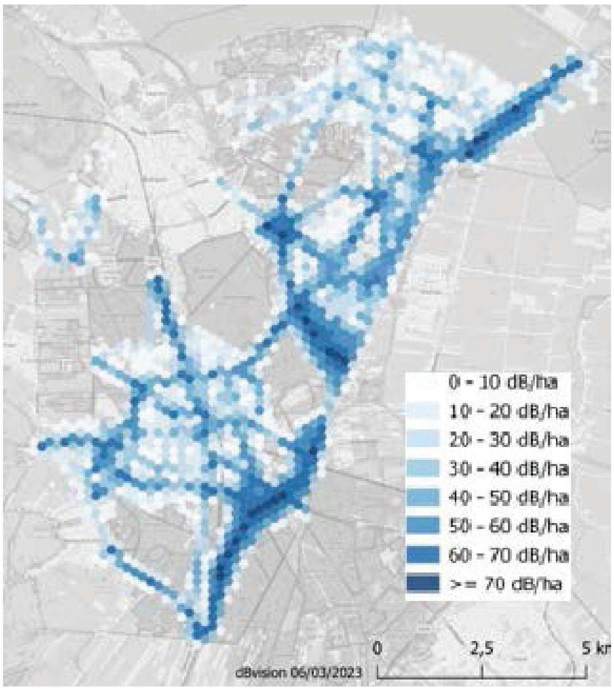

Figure 6. Absolute values of dB/acre for road traffic noise in L_{den} for 2021

With the help of these visualizations, we have information on where to zoom in to understand where the differences come from.

A second part is to look at the number of people exposed. We see the following for rail and road noise.
Figure 7 shows the difference in reported number of people exposed in 2021 and in 2016.

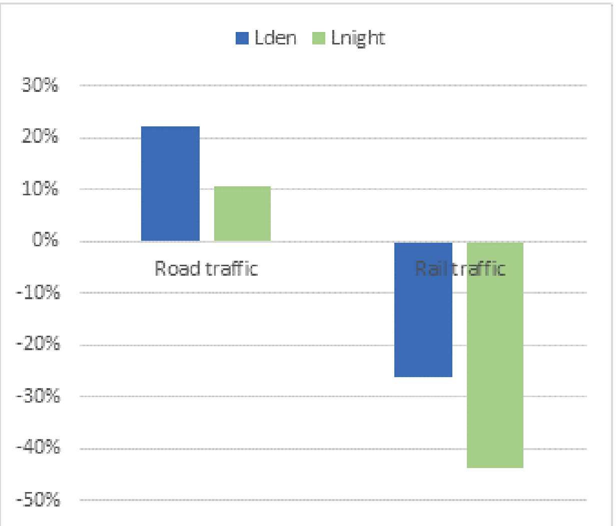

Figure 7. Relative difference between reported number of people exposed in 2021 and 2016. A positive value means that the numbers were higher in 2021 compared to 2016.

For road traffic the number of people exposed to L_{den} noise levels of 55 dB or higher is on average about 20% larger in 2021 compared to 2016 (and about 10% larger for 50 dB or higher in L_{night}). In comparison, the increase between 2011 and 2016 was 5%. For rail traffic we see a decrease in number of people exposed. This decrease is substantial, but smaller that the decrease reported between 2011 and 2016.

4.2 Differences due to CNOSSOS-EU

We also studied how the calculation method (we focused on emission and propagation) influenced results. This was done by calculating the exact same noise models with CNOSSOS-EU and with the Dutch road or rail methods. This comparison was made for 10 municipalities and 2 provinces. Provinces map major roads that they are the competent authority for.

Because the models contain the same data, a direct comparison can be made between CNOSSOS-EU and the Dutch methods. However, not every aspect can be copied between the two methods. For example, in the Dutch method an earth berm has 2 dB less barrier attenuation compared to a noise barrier. In CNOSSOS-EU there is no difference. One can have two approaches when making a comparison. That is to change the models to accommodate the other calculation method or keep the models the same. In this case two companies did the comparison independently. They each had a different approach. One company included the 2 dB correction in the Dutch method while the other company did not. It was found that for the end result these different approaches had very limited influence.

We focus here on the difference due to the emission and propagation model. That means that in each model the same method proscribed by CNOSSO-EU for the distribution of receiver points on dwellings and how people are assigned to these receiver points was used.

In Table 2 the difference in number of people exposed between CNOSSOS-EU and the Dutch models is shown.

Table 2. Relative difference in number of people exposed between CNOSSOS-EU and Dutch method. A positive value means that there are more people exposed using CNOSSOS-EU compared to the Dutch method.

Source	L_{den}	L_{night}
Local roads	38%	57%
Major roads[1]	81%	86%
Major rail	53%	55%

As shown in Table 2 there is a large increase in the calculated number of people exposed when CNOSSOS-EU is used.

The reported differences between 2021 and 2016, presented in section 4.1 are smaller than these differences are shown here and they are due to the calculation method. This will partially be caused by the different method used for 2016 to assign noise levels to people living in dwellings compared to 2021. Another difference is that in 2016 rounding was used on noise levels, but not in 2021. This means that in 2016, a range of 55-59 dB has noise levels from 54.50 till 59.49 dB whilst in 2021 that same range has noise levels form 55.00 till 59.99 dB.

The differences shown Table 2 are an average over 10 municipalities. In Figure 8 we show the average difference for each municipality separately. This gives information if the same conclusions can easily be made for all municipalities including those that were not used in this study.

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[1] Does not include provincial major roads

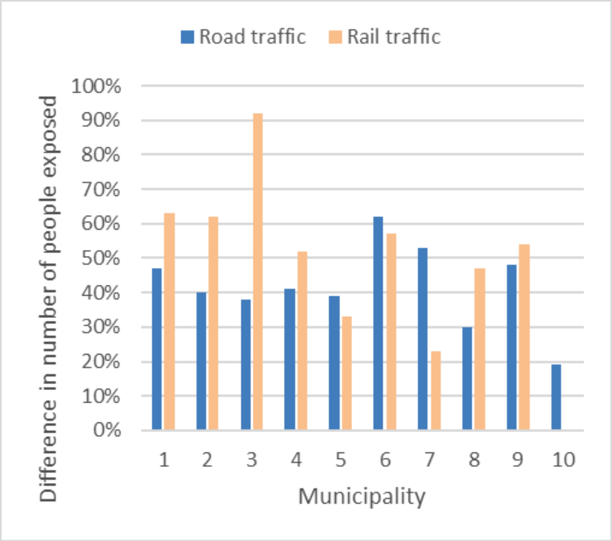

Figure 8. Relative difference in number of people exposed above 55 dB L_{den} between noise models with Cnossos and the Dutch methods for 10 municipalities. In municipality 10 there is no rail traffic noise.

We see that even though models may be similar, the effect of using CNOSSOS-EU is not constant. The very high difference for rail traffic observed in municipality number 4 is in a city with a very low amount of people exposed. A small difference one way or the other will always give a big difference in that case

Generally, it is shown that CNOSSOS-EU will lead a large increase in the number of people exposed to noise levels above 55 dB L_{den} compared to the Dutch method. In phase 2 of our study, we will use this data to help us to find the causes of these differences.

Finally, we studied the average difference in noise level for each dwelling separately. For road traffic noise the average difference is 3 dB and for rail traffic it is 2 dB. However, these differences were not the same for all municipalities and there are also large variations within municipalities. An example of the distribution of difference in noise levels for a large municipality is shown in Figure 9.

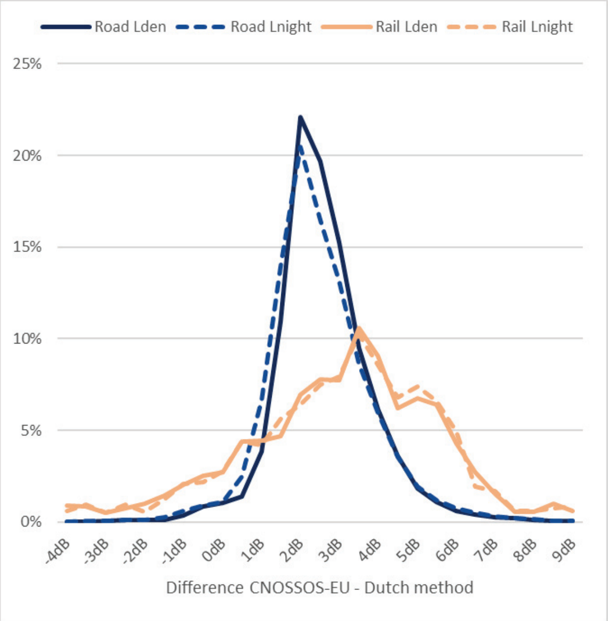

Figure 9. Distribution of difference of noise levels on dwellings between Cnossos and the Dutch methods for a single large city. The standard deviation is 1.3 dB for road traffic noise and 2.2 dB for rail traffic noise.

It is shown in Figure 9 that a dwelling can have a noise level that is up to 5 dB lower or up to 10 dB higher when CNOSSOS-EU is used instead of the national method.

In Figure 9 it is also shown that, especially for rail traffic noise there is a broader distribution of difference between the two methods. This may be caused by the many noise barriers along railroads in some cities. The different source heights between the methods will automatically lead to a different barrier attenuation. Also, in the Dutch method there is a correction of 5 dB to decrease the barrier attenuation of platforms. CNOSSOS-EU does not have that, but it does have retro diffraction. In the Dutch method retro diffraction cannot be calculated. It is also less relevant because in the Netherlands barriers along railroads are almost all made out of noise absorbing material.

5. CONCLUSIONS

Each round of noise reporting the reported number of people exposed varies. The reason is not always straightforward. It may be caused by different data used, choices a modeler makes or changes in the environment. Only substantial changes, like quieter trains, will be noticeable in these numbers. When actions in action plans constitute some measures for roads with people exposed to very high levels of noise it will be difficult to assess this based on reported numbers for an entire city. The variation between years may be larger than the effectiveness of a measure taken.

Compared to the previous years, the change of the reported number of people exposed in 2021 was very large. This is mostly due to the calculation method where on average 2 to 3 dB higher levels are calculated compared to the previously used Dutch methods. Further study is being done to see which aspects of the method lead to the different noise levels. With the result of both studies, we will set up a guidance for municipalities how to interpret these results and how to communicate results to the public. It will also help in assessing how noise levels have changed since 2017 and how this compares to the ambitions of the zero-pollution action plan.

6. REFERENCES

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