European Commission

Science for Environment Policy

Reducing railway noise and vibration: life-cycle assessments can help decide the best measures

27 July 2017
Issue 493

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Source: Tuler, M.V. & Kaewunruen, S. (2017). Life cycle analysis of mitigation methodologies for railway rolling noise and groundbourne vibration. *Journal of Environmental Management*. 191:75–82. DOI:10.1016/j.jenvman.2016.12.075

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To cite this article/service: "Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.

The measures available to reduce the noise and vibration produced by trains have been outlined in a recent study. The researchers say the most appropriate mitigation should be determined on a case-by-case basis and life-cycle assessments can help analyse the economic costs and carbon footprint of different methods.

Train noise, known as rolling noise, is the major source of railway noise in Europe. Ground vibration from trains produces a different effect and in extreme cases can damage structures around the track. Both rolling noise and ground vibration can cause considerable disturbance to residents around railway lines, wheras, for rural rail networks, disturbance mainly affects nearby ecosystems and pasture growth/production. The effectiveness of methods to reduce railway noise and vibration should be balanced with installation and maintenance costs. It is, therefore, important for the railway industry to consider whole-of-life costs when implementing measures. Railways can extend for long distances, meaning mitigation methods must also be practicable over many kilometres of track.

This study outlines key mitigation measures for rolling noise and ground vibration and their life-cycle performance. Information from worldwide field-based scientific studies was assessed and a life-cycle analysis was also carried out in terms of economic costs and the carbon footprint. Economic costs were based on cash-flow analysis and the carbon footprint assessed materials and emissions from fuel and energy used for construction and the maintenance of different mitigation measures.

Rolling noise, measured by using microphones at certain distances from the track, is influenced by train speed and design, track conditions and weather (indirectly: flooding of the track can lead to its oxidation, causing wheel noise; increased damping due to higher moisture could suppress overall sound radiation). Mitigation measures to reduce rolling noise include reducing track roughness, noise barriers and structural modifications or damping systems. The connection between train wheels and rails is one major source of noise and vibration; for example, deteriorating tracks are often rougher, which increases the sound pressure by up to 20 decibels (dB). Roughness can be reduced by grinding tracks to remove corrugated edges and by lubricating tracks. Walls and other barriers can reduce noise by between 5 dB and 15 dB, depending on the height, length and distance from the track.

The researchers say that making life-cycle comparisons for rolling-noise reduction is difficult, as some interventions comprise annual maintenance (e.g. rail lubrication), whereas others are single investments (e.g. barriers). However, noise barriers had higher carbon footprints and costs due to the materials used (e.g. high-density concrete), whereas track grinding and lubrication had lower costs. Grinding had the lowest carbon footprint of around 1.52 kilograms (kg) of CO_2 per kilometre (km).

Ground conditions, including the materials that provide the base of the railways, are a major source of vibration disturbance. Ground vibration can be in low frequencies on the surface (below 10 hertz (Hz)) or at higher frequencies (30–250 Hz) underground. Sleeper soffits, fixed to sleepers to absorb vibration, and ballast mats, which restrain the movement of the track, can both be used to reduce ground vibration. Ballast mats are much more expensive to install than sleeper soffits due to their size. However, they are better at reducing vibration.

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Reducing railway noise and vibration: life-cycle assessments can help decide the best measures *(continued)*

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Surface vibration is harder and more costly to mitigate, and technologies used include sleeper and ballast mats, trenches, buried walls and wave-impeding blocks. Wave-impeding blocks consist of soil that is compacted to reduce vibration. These are used where surrounding buildings or infrastructure prevents the construction of buried walls. Cost and carbon footprint are only incurred as a result of the fuel used when carrying out the work. It costs almost twice as much to install buried walls than trenches and the former also have a much higher carbon footprint. However, they are more effective at reducing vibration and require less maintenance.

The mitigation methods outlined show trade-offs between their effectiveness and economic and environmental costs, demonstrating how measures should be considered on a case-by-case basis. More expensive measures with a higher carbon footprint are often more effective (e.g. noise barriers and buried walls) and should, therefore, only be used in areas where noise and vibration is higher or where more people live near the train track. Less effective but cheaper and more environmentally friendly measures (e.g. trenches and wave impeding blocks) should be used in areas where train vibration does not cause large disturbance.

The researchers say the information summarised in this study may help engineers and managers to improve the environmental management of railways. They say the life-cycle assessment undertaken in this study is useful, as it considers both costs and carbon footprint, which is increasingly important to improve the sustainability of transport.