

LIFE CYCLE ASSESSMENT OF RAILWAY INFRASTRUCTURE IN BELGIUM

ANALYSE DU CYCLE DE VIE DE L'INFRASTRUCTURE FERROVIAIRE EN BELGIQUE

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Abstract

In the framework of the BRAIN-TRAINS project, the environmental impact of rail freight transport in Belgium has been analysed using the Life Cycle Assessment (LCA) methodology. The rail freight transport system has been divided in three sub-systems: rail transport operation, rail equipment (locomotives and wagons) and rail infrastructure. For the sub-system rail infrastructure, a detailed study of the life cycle phases of construction, maintenance and disposal of infrastructure has been conducted. We have collected specific information related to the Belgian railway infrastructure from both literature sources and directly from Infrabel (the Belgian railway infrastructure manager) through the use of questionnaires.

The purpose of this paper is to give an overview of the methodology used to analyse the LCA of the railway infrastructure in Belgium as a part of the rail freight transport system.

Keywords

Railway infrastructure, Life Cycle Assessment.

INTRODUCTION

The European Commission's White Paper on transport (2011) aims to shift the 30% of road freight over 300 km to other modes of transport more energy-efficient such as rail or waterborne transport by 2030 [1]. The increased demand for rail transport promoted by the public authorities may represent a challenging target to the rail freight sector due to the high amount of goods that this implies. Moreover, the growth in rail freight transport could lead the need for the expansion of the railway network, which encompasses a range of environmental effects that should be studied.

The improvement of rail infrastructure might influence the development of rail freight transport. Therefore, the standardisation in Europe of different elements such as the track gauge, the loading gauge of tunnels and bridges and the electrification systems would enhance the interoperability of rail freight transport in long distances. Furthermore, greater availability of intermodal terminals would improve the lack of direct rail links and the weak access to the rail network. These enhancement in the flexibility of the rail transport would stimulate a modal shift from road transport to rail transport.

In order to analyse the environmental impact of rail freight transport, it is necessary to consider all the sub-systems that compose it and not only the final energy consumption and the exhaust emissions produced during the transport activity. Therefore, the rail transport operation accounts for 19% of the total energy consumption (European average with a mixed use of electricity and diesel), the production of electricity and diesel used in the transport activity is responsible for the 50%, and all the processes related with the rolling stock and the railway infrastructure represents the 12% and the 19% of the total energy consumption, respectively [2].

METHODOLOGY

In order to analyse the environmental impact of rail freight transport in Belgium, the Life Cycle Assessment (LCA) methodology has been used. The system perspective of the LCA methodology implies the need to analyse not only the direct processes related with the transport activity such as energy consumption and exhaust emissions of the sub-system rail transport operation, but also the processes related with the sub-systems rail equipment and railway infrastructure.

Focusing on railway infrastructure (see Figure 1), the LCA takes into account the raw material extraction and manufacturing of products such as sleepers or ballast; the construction of the railway infrastructure including tracks, tunnels and bridges; the processes of maintenance and material renewal during the lifespan of the railway infrastructure; and finally, at the end-of-life of the railway infrastructure, most of the elements are recycled such as the ballast that is reused as material for backfill and the wooden sleepers that are incinerated with energy recovery.

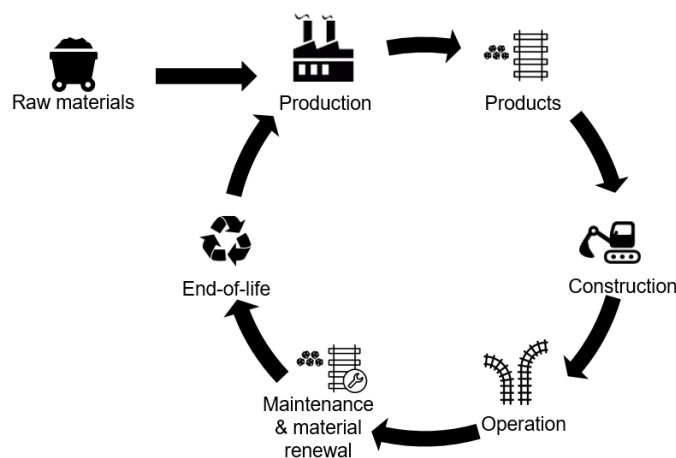


Figure 1: Life Cycle Assessment of the railway infrastructure

Since the railway infrastructure is shared between passenger and freight transport, an allocation of the environmental impacts related with the construction, maintenance and disposal of infrastructure has to be performed. On the one hand, the allocation of construction and disposal of the rail infrastructure has been calculated using the transport performance (tkm) and operating performance (Gtkm) for goods and passenger transport in Belgium. It should be noted that data on traction performance (GGtkm) is not available. On the other hand, the allocation of operation and maintenance of the rail infrastructure has been calculated using the transport performance (tkm) and kilometric performance (train-km) for goods and passengers transport in Belgium.

According to Eurostat, the Belgian railway network is classified in both one track railway lines and two or more tracks railway lines. The length of one track lines have been converted in two tracks lines, and adding the length of two or more tracks lines have been obtained the total length of the Belgian railway network in two tracks lines. All the processes included in the sub-system rail infrastructure have been calculated using a two tracks line as reference.

RESULTS

The Life Cycle Inventory of the Belgian railway infrastructure includes tunnels, bridges, rails, sleepers, fastening system, switches and crossings, track bedding and the overhead contact system. The maintenance of the Belgian railway infrastructure has been analysed as well. Therefore, the maintenance works such as rail milling, ballast tamping, ballast profiling, ballast stabilisation, ballast cleaning and wood control are taken into account. We have considered in the maintenance of railway infrastructure both the fuel consumption and exhaust emissions from the machinery used in the maintenance and the new materials used in the track renewal.

Tunnels and bridges

The Belgian railway network has 132 tunnels, being the total length of tunnels 95 km. The share of tunnels in the total Belgian railway network has been obtained by dividing the length of tunnels by the total length of the Belgian railway network. The Belgian railway network has 4800 bridges. The total length of bridges is unavailable, thus it has been used a share of bridges of 2.2% [3]. The material demand from tunnel and bridge construction in the Belgian railway network has been calculated multiplying the share of tunnels and bridges by the obtained material demand of tunnel and bridge construction.

Rails, sleepers, fastening system and track bedding

We have considered two main types of rails profiles in our study, the rail 50E2 and the rail 60E1, with an average share in Belgium of 53% and 47%, respectively. Moreover, we have included the use of 3 splice bars per km, considering the use of continuously welded rails of 300 m long.

The distance between sleepers stated by Infrabel for the Belgian railway network in continuous welded rails 50E2 and 60E1 in main lines is 0.6 m, thus an average of 1.67 sleepers per metre is used. For continuous welded rails 50E2 in side lines, the sleepers are installed at 0.75 m spacing, thus an average 1.3 sleeper per metre is used [4]. The Belgian railway network presented in the year 2010 a ratio between wooden and concrete sleepers in the main tracks of 21% and 79%, respectively. For side tracks, the rate was a 65% of wooden sleepers and a 35 % of concrete sleepers. In the switches, the distribution was a 95% of wooden sleepers and a 5% of concrete sleepers [5]. The greater use of wooden sleepers in the switches is due to the flexibility of wooden sleepers to create custom-made sleepers [6].

Infrabel uses several techniques to fix the rails to the sleepers. The most representative elements of the fastening system have been identified for every method, such as clips for attachment, bolts, screw spikes and base plates for wooden sleepers, and rubber pad for concrete sleepers.

We have assumed the use of only ballasted tracks throughout our study.

Switches and crossings

Switch and crossing systems play a key role in the connections between different tracks, establishing a railway network that allows the rail transport. The switches and crossing used by Infrabel are manufactured in Belgium. The most relevant parts of the switch and crossing system considered in our study are showed in Figure 2. The annual material demand due to the switch and crossing system has been calculated. The number of switches per metre has been calculated based on the total number of switches in the main and side lines and the total length of the main and side lines.

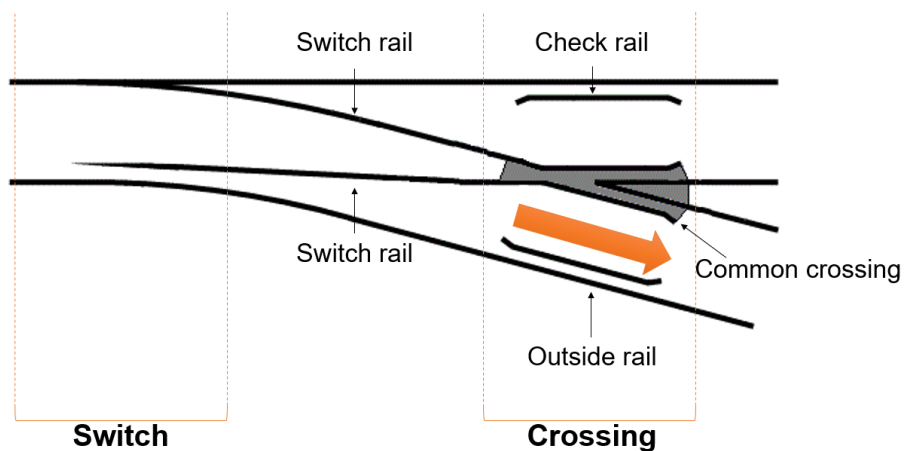


Figure 2: Switch and crossing system

Overhead contact line

Three main types of overhead contact line systems have been identified in the Belgian railway network. The main overhead contact lines have a power supply of 3 kV DC, which includes the type compound and the type R3. The overhead high speed contact lines have a power supply of 25 kV AC.

The most relevant parts of the overhead contact lines considered in our study are showed in Figure 3. A mast with a length from 7 to 15 meters and made of galvanised steel supports the overhead contact line. The bracket system is attached to the mast supporting the catenary wire. An earth wire is attached to the mast. The feeder supply the electricity to the overhead contact line. The catenary wire supports the contact wires through the use of droppers. The contact wires are composed of two wires, which transmits the electricity to the trains by the pantograph fixed on the top of the train. The insulators isolate the electric parts from the structural elements such as the mast.

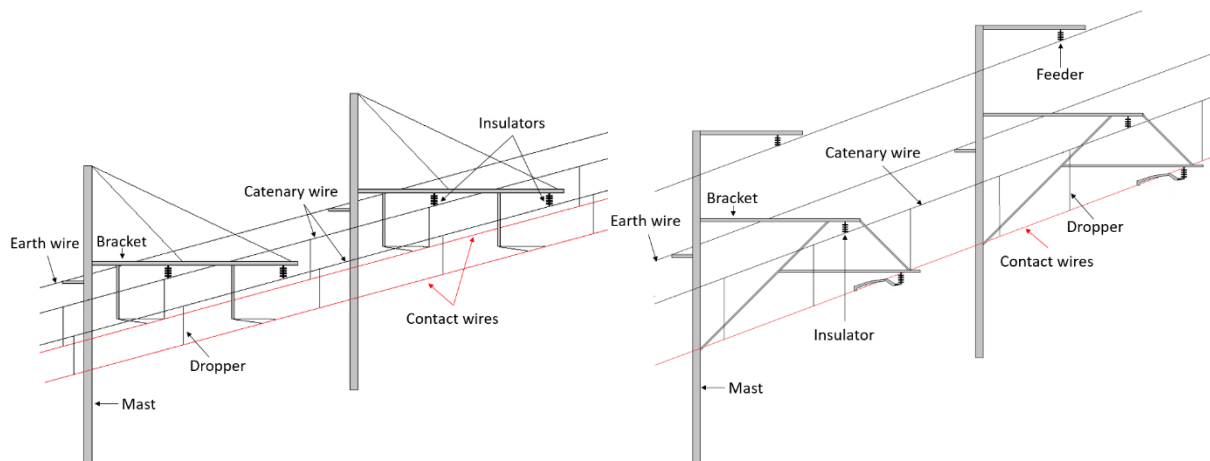


Figure 3: Examples of overhead compound lines (left) and overhead R3 lines (right)

CONCLUSIONS

A study on the environmental impact of the Belgian rail freight transport is being carried out, which entails a detailed analysis of the rail infrastructure in Belgium. The main elements of the infrastructure have been identified, as well as the main maintenance works.

ACKNOWLEDGEMENTS

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