



TRAFIKVERKET
SWEDISH TRANSPORT ADMINISTRATION

Environmental Product Declaration for **railway tunnels on the Bothnia Line**



Title: Environmental Product Declaration for railway tunnels on the Bothnia Line
Publication number: 2016:047
ISBN: 978-91-7467-932-8
Date of publication: November 2014
Registration number: S-P-00197, UN CPC 53212
Publisher: The Swedish Transport Administration
Production cover: Grafisk form, the Swedish Transport Administration
Printed by: Ineko
Distributor: The Swedish Transport Administration



En EPD® (Environmental Product Declaration; miljövarudeklaration) är ett oberoende verifierat och registrerat dokument som ger transparent och jämförbar information om produkters miljöpåverkan i ett livscykelperspektiv.

Introduction

This Environmental Product Declaration (EPD), describes, from a lifecycle perspective, the total environmental impact of railway tunnels on the Bothnia Line. The EPD covers tunnel “substructure” only. Track, power, signalling and telecom systems in the tunnels are not included.

Within the International EPD system based on ISO standard 14025, this EPD was drawn up on accordance with Product Category Rules (PCR)) 2013:19 for Railways (see www.environdec.com for further information about the EPD-system).

The aim of this EPD is that it should provide experts and scientists (in the construction and infrastructure sectors) with objective and reliable information on the environmental impact of constructing, operating and maintaining railway tunnels.

This EPD was developed by Trafikverket (the Swedish Transport Administration). It has been certified by Bureau Veritas Certification AB and the certification is valid for three years (after which it can be prolonged).

Botniabanan AB has been responsible for the financing, detailed planning and building of the Bothnia Line. After completion, ownership of the infrastructure has been transferred to Trafikverket. Trafikverket has an implemented management system in accordance with the Swedish government’s regulation (SFS 2009:907) on environmental management in state agencies. One focus area for Trafikverket’s environmental work is to reduce climate gas emissions from construction, operation and maintenance of infrastructure and Trafikverket has therefore developed a tool for carbon footprint calculations for infrastructure projects (*Klimatkalkyl*, available at www.trafikverket.se). Inventory data for this EPD has been included in *Klimatkalkyl*, and the results for Global Warming and Energy Resources in this EPD is comparable to results in *Klimatkalkyl* for corresponding infrastructure parts.

This EPD describes the environmental performance of railways tunnels on the Bothnia Line. The following EPDs are also available for other Bothnia Line systems:

- EPD for the railway infrastructure on the Bothnia Line.
- EPD for railway track foundations on the Bothnia Line.
- EPD for railway bridges of the Bothnia Line.
- EPD for railway track of the Bothnia Line.
- EPD for power, signalling and telecom systems of the Bothnia Line.

As this EPD is based on data relating to Bothnia Line infrastructure, the results might not be representative of other railway tunnels. In order to decide if the result can be representative for other railway tunnels, the most important areas that should be checked to be comparable with the Bothnia Line are:

- Railway functionality (single or double track, axle load etc.).

- Construction methods (e.g. blasting or tunnel drilling)
- Mix of electricity for construction, operation and maintenance of the infrastructure.
- Origin of materials (mainly steel and concrete).

Comparison towards previous EPD

This EPD is an updated version of the original EPD from 2010. The reason for the update is that the PCR has been revised. In the revision, the declared unit was changed:

Old declared unit: *1 km railway (main line) over a calculation period of 60 years*

New declared unit: *1 km railway (main line) and year*

Inventory data for LCA-calculations have not been changed, but the change of declared unit gives results in other units compared to previous EPD. The declared environmental performance in this EPD is therefore not comparable to previous EPD since it is presented in other units.

Facts about the infrastructure of the Bothnia Line

The Bothnia Line is a new Swedish railway running from Nyland (north of Kramfors) to Umeå. It is routed via Örnsköldsvik and comprises 190 km of new single-track railway with 22 sidings (each 1 km long) and 7 travel centres/stations. The latter have good connections for pedestrians, cyclists, local and regional bus traffic and private vehicles. There is one large freight terminal in Umeå and a smaller container terminal in Örnsköldsvik.

The line has 90 railway bridges (total length of 11 km) and 16 tunnels (25 km main railway tunnels and 16 km service and access tunnels). Designed for combined passenger and heavy freight traffic the Bothnia Line offers maximum speeds of 250 km/h for passenger trains and 120 km/h for freight trains with a maximum axle load of 25 tonnes. The groundbreaking for the project took place on 14 August 1999, and the railway is operational since autumn 2010.

All tunnels on the Bothnia Line were built using conventional blasting technologies and preinjection with cement products. The inner surfaces of the tunnels are covered with shotcrete. Where necessary to prevent water dripping onto the track, the walls and roofs have drains. All tunnels are single-track tunnels with a design cross-sectional area of 70 m² and a ready-made area of 50 m². The allowed maximum distance to an emergency exit in a tunnel is 500 m. This means that all tunnels more than 1,000 m long have either an access tunnel in the middle or a parallel service tunnel with crossing tunnels.

Technical Data Infrastructure:

- Minimum radius of curvature: 3200 m
- Maximum gradient: 10 ‰
- Track gauge: 1435 mm
- Power-supply voltage: 15 kV, 16 2/3 Hz, AT-system

- Track: ballasted concrete sleepers, UIC 60 rail (continuous welded)
- Signalling system: ERTMS level 2
- Maximum axle load: 25 tonnes (30 tonnes on bridges)



Location of the Bothnia Line

Environmental performance

Resource use and emissions

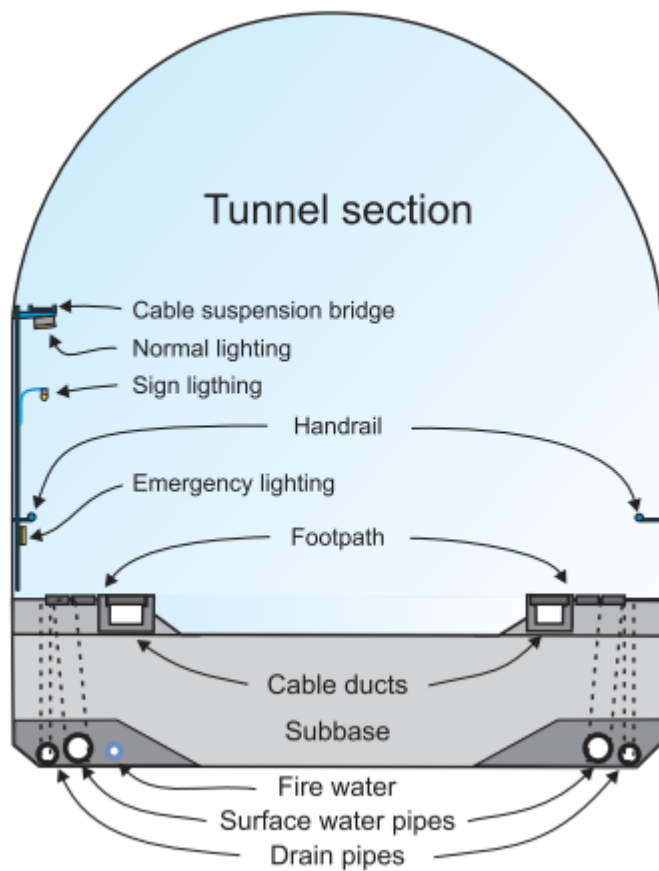
The environmental performance section of the declaration is based on a lifecycle assessment (LCA) carried out by WSP in 2014. The LCA was largely based on ecoinvent-data for materials and processes, and implemented in the software SimaPro. Inventory data was collected from the LCA for the Bothnia Line made by IVL Swedish Environmental Research Institute in 2009. An overview of system boundaries and included processes is given in the text, figures and tables below.

Extraction and production of raw materials, transport of materials and manufacturing of products were included in the LCA calculations. The data in respect of infrastructure-related processes and quantities of materials was collected from the building of the Bothnia Line. Selected generic data for material production was used according to the calculations rules in PCR 2013:19. The electricity used in construction processes and for production of materials was calculated as the average electricity mix for the countries hosting the processes.

Calculation of the environmental impact of railway tunnel construction was based on data from three selected “typical” tunnel contracts. As regards soil and rock excavation quantities, fuel and electricity consumption, etc., specific data was collected from these contracts and used as a basis for calculating the environmental impact of all the tunnels on the Bothnia Line.

The LCA calculations are based on the technical life times of all included components and results in a yearly contribution to all impact categories. All construction, reinvestment, operation and maintenance processes are included in that. All results are presented in the declared unit per kilometre of tunnel (main line) and year. As a complement, the impact from the construction phase is presented separately per kilometre of tunnel (main line).





All processes and elements needed to construct, operate and maintain the railway tunnels have been included in the LCA. However, note that track, power, signalling and telecom systems are not included. The figure shows some of the most important structural elements.

Overview of processes and elements included in the LCA for railway tunnels on the Bothnia Line.

Tunnel construction	Tunnel operation	Tunnel maintenance
Soil and rock excavation	Illumination of tunnels	Reinvestments according to life times of components/constructions
Tunnel boring	Frost protection for fire water in tunnel	

Deforestation	Operation of electrical and electronic systems	
Service roads		
Ventilation and pumping		
Injection of cement slurries		
Rock bolting		
Shotcrete		
Wall and roof drains		
Firewalls		
Tunnel portals		
Filling of crushed material		
Ducting (cable ducts and manholes)		
Firefighting water system		
Drainage and surface water piping		
Interior tunnel equipment		

As, under the rules in PCR 2013:19, waste handling processes make a negligible contribution to environmental impact categories (<1%), they were excluded from the LCA. For processes excluded by default, see PCR 2013:19.

Annual environmental impact for 1 km railway tunnel (main line) of the Bothnia Line. All construction, reinvestment, operation and maintenance activities are included for the tunnel infrastructure. Impact from construction phase is presented separately per km (not annually). Note that the track, power, signalling and telecom systems are not included.

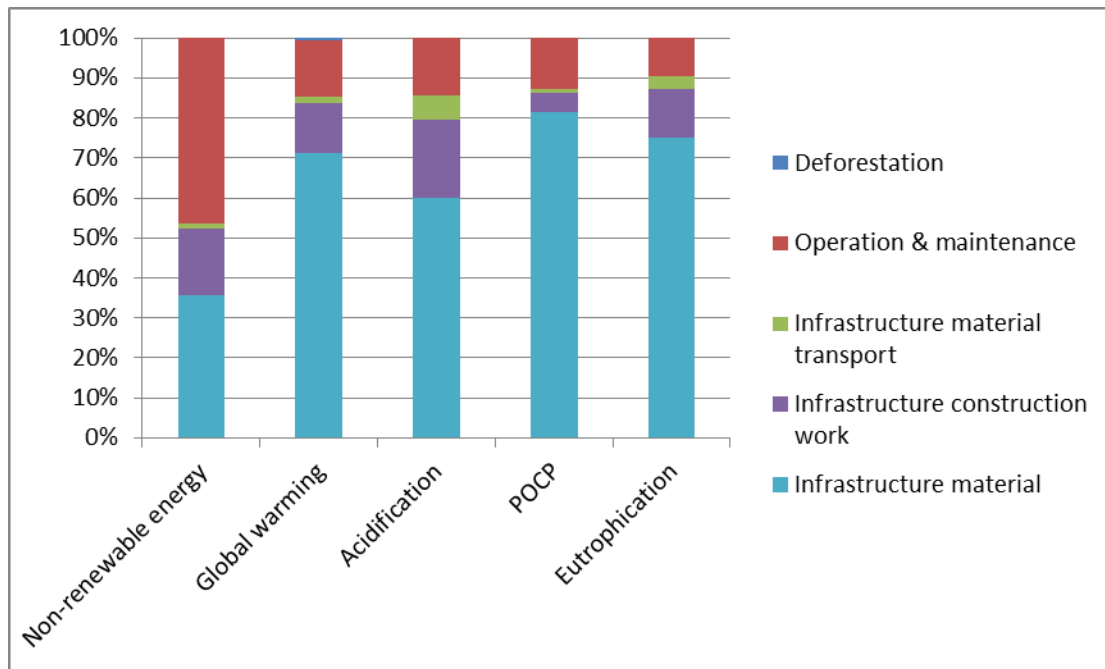
		Declared unit per km and year			
Impact category	Unit	Construction & reinvestment	Operation & Maintenance	Total	Construction per km
Use of resources					
Non-renewable materials	kg	2 182 465	958	2 183 423	258 400 127
Renewable materials	kg	0,27	0,018	0,28	25
Non-renewable energy	MJ	407 345	353 562	760 907	34 163 829

Renewable energy	MJ	35 491	95 484	130 975	3 628 871
Secondary materials	kg	85 465	0	85 465	6 925 656
Secondary energy	MJ	85 804	199 380	285 184	9 828 653
Water, total	kg	552 141	940 834	1 492 975	61 557 906
Water, direct	kg	249 466	0	249 466	29 935 962
Land use	m2	721	365	1 087	65 697
Potential environmental impacts					
Global warming	kg CO ₂ -eq.	29 973	4 915	34 888	2 599 910
Acidification	kg SO ₂ -eq.	88	15	102	7 480
POCP (Photochemical oxidant formation)	kg C ₂ H ₄ -eq.	5,2	0,76	5,9	349
Eutrophication	kg PO ₄ ³⁻ -eq.	38	4,0	42	3 241
Waste and outflows					
Output of materials for recycling	kg	1 954 148	0	1 954 148	228 368 715
Waste, hazardous	kg	1,3	0,15	1,5	127
Waste, excess soil	kg	33 397	0	33 397	3 970 984
Waste, other	kg	3 424	698	4 122	231 840

Specification of resources making the largest contributions to the different resource use categories

Resource use category	%
Non-renewable materials	
Rock, gravel	97%
Soil	2%
Calcite	1%
Renewable materials	
Wood	100%
Non-renewable energy	
Fossil	48%
Nuclear	52%
Renewable energy	
Hydropower	97%
Biomass	3%
Wind, solar, geothermal	1%

Dominance analysis



Emission impact categories and the relative contribution (in %) made by the process groups relevant to the Bothnia Line's railway tunnels. The process groups include all activities during the lifetime of the infrastructure. For example, "Infrastructure material" covers all materials used during construction, maintenance and reinvestment.

Upstream processes

Infrastructure material = Emissions from raw material acquisition and production of materials such as steel, concrete etc.

Infrastructure material transport = Emissions from vehicles (e.g. trucks and trains) used for transporting infrastructure material (e.g. concrete and reinforcement steel) from suppliers to the construction site.

Core processes

Infrastructure construction work = Emissions from machines (excavators, trucks, drilling rigs etc) used in constructing the infrastructure. This also includes transport of excavated soil and rock.

Deforestation = Net emissions of CO₂ resulting from forest land being permanently changed to railway land.

Downstream processes

Operation & maintenance = Emissions from production of electricity used for operation of the infrastructure (e.g. tunnel illumination) and from use of fuels for maintenance work.

Additional environmental information

The impact that the building and operation of the Bothnia Line has on land use, biodiversity and environmental risk-related issues has been analysed and is described in the EPD for railway infrastructure.

However, it is not possible or relevant to relate the results of the impact analyses to the individual infrastructure elements. Consequently, this EPD contains no such details.

Recycling declaration

The main infrastructure elements that are relevant as regards waste management and recycling are track, power, signalling and telecom equipment. Within Trafikverket, there is currently no general national strategy for recycling materials that are replaced during maintenance. Such materials often become the property of the contractor. Trafikverket's environmental strategy contains the following prioritised goals for the future:

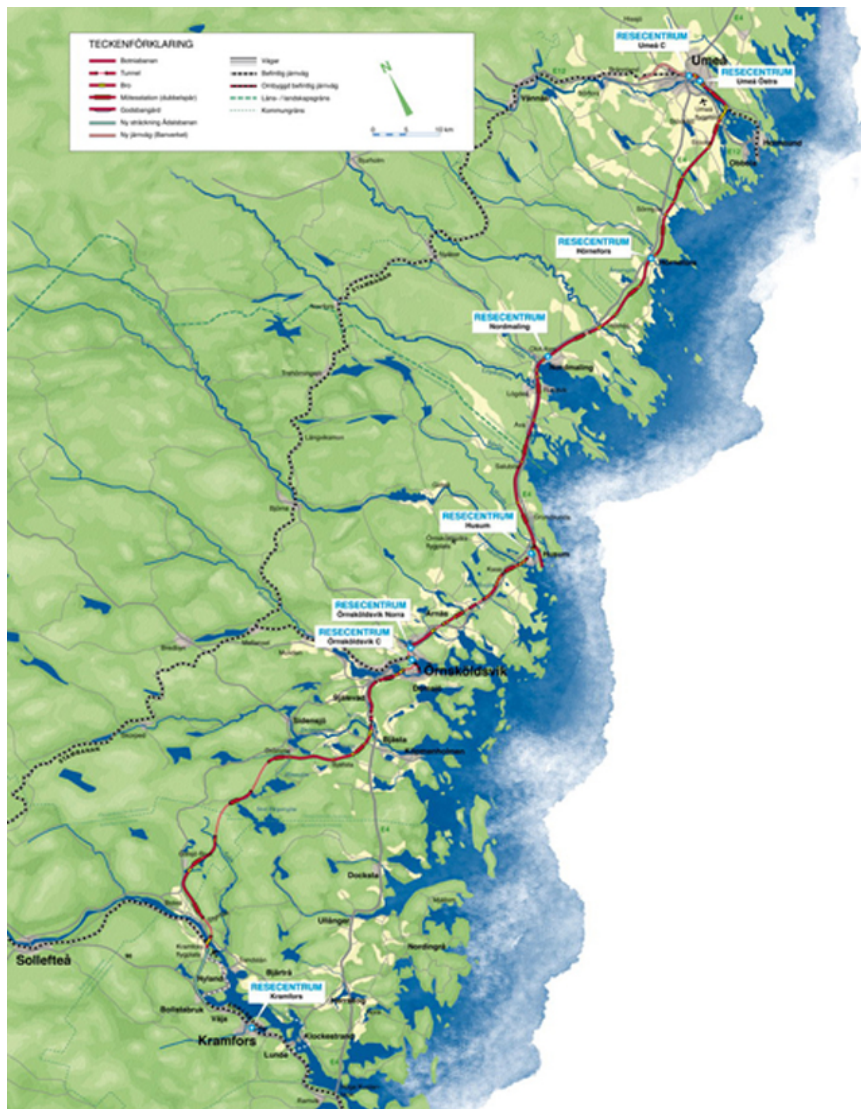
- Development, from an environmental perspective, of long-term reutilisation plans for strategic materials.
- Development of environmentally sound and effective management procedures for prioritised categories of waste.

Management of materials and substances

Throughout the construction of the Bothnia Line, all contractors have, as regards any chemical products and potentially environmental harmful materials they use, been required to obtain the approval of Trafikverket's Chemicals Board. Another requirement has been that PVCs and certain other materials (a number of specified harmful substances included therein) must not be used before the contractor has made an environmental risk assessment and Botniabanan AB has agreed with the use. If the use of any of these substances could not be avoided, the location of the components containing the substances has been documented by the contractor.

The satisfaction of these requirements has been checked in audits of all major contractors.

Hazardous waste generated in all contracts for the building of the Bothnia Line has been collected in environmental stations supplied by Botniabanan AB and managed by companies accredited for management of hazardous waste.



Route and travel centers/stations of the Bothnia Line (tunnels and bridges also shown)

EPDs from different programmes may not be comparable

See www.trafikverket.se for more information on the EPD and background material

PCR review was conducted by the Technical Committee (TC) of the International EPD Consortium (IEC).

See www.environdec.com for more information and contact for IEC.

Independent verification of the declaration and data, according to ISO 14025:

☐ Internal

☒ external

Third party verifier:

Bureau Veritas Certification AB

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Accredited by: Swedac



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