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Railway specific environmental performance indicators

*Indicateurs de performances environnementales, spécifiques aux Chemins de fer
Bahnspezifische Indikatoren für die Umweltleistung*



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Contents

Summary	1
1 - Introduction	2
1.1 - Background - why introduce environmental performance indicators?	2
1.2 - Purpose and scope of leaflet	2
2 - Methodology	5
2.1 - Environmental performance indicators on three levels	5
2.2 - Stepwise approach to data collection	6
3 - Overview of the environmental key performance indicators	8
3.1 - Indicator 1: Energy consumption	8
3.2 - Indicator 2: Share of renewable energy	8
3.3 - Indicator 3: CO ₂ emissions	9
3.4 - Indicator 4: Local air pollution	9
3.5 - Indicator 5: Noise emission	10
3.6 - Indicator 6: Land take	10
4 - Detailed description of the environmental key performance indicators	11
4.1 - Indicator 1: Energy consumption for traction	11
4.1.1 - Definition	11
4.1.2 - System boundaries	12
4.1.3 - Data processing	12
4.1.4 - Data interpretation	15
4.2 - Indicator 2: Share of renewable traction energy	16
4.2.1 - Definition	16
4.2.2 - System boundaries	17
4.2.3 - Data processing	17
4.2.4 - Data interpretation	19
4.3 - Indicator 3: CO ₂ emission	19
4.3.1 - Definition	19
4.3.2 - System boundaries	20
4.3.3 - Data processing	20
4.3.4 - Data interpretation	22

4.4 - Indicator 4: Local Air Pollution	22
4.4.1 - Definition	22
4.4.2 - System boundaries	23
4.4.3 - Data processing	23
4.4.4 - Data interpretation	24
4.5 - Indicator 5: Noise emissions	24
4.5.1 - Definition	26
4.5.2 - System boundaries	27
4.5.3 - Data processing	27
4.5.4 - Data interpretation	28
4.6 - Indicator 6: Land take	28
4.6.1 - Definition	28
4.6.2 - System boundaries	29
4.6.3 - Data processing	31
4.6.4 - Data interpretation	32
5 - Reference variables	33
5.1 - Passenger-kilometres (pkm)	34
5.2 - Tonne-kilometres (tkm)	36
5.3 - Transport unit (TU)	38
Glossary	39
List of abbreviations	40
List of figures	41
Bibliography	42

Summary

This leaflet contains definitions for six environmental key performance indicators - or "KPIs" - for railway companies (operators, infrastructure managers or integrated companies) as well as explanations on how to produce them. The six indicators are:

- Energy consumption (traction only),
- Share of renewable energy (energy mix and bio-diesel),
- Greenhouse gas emissions (CO₂),
- Local air pollution (PM and NO_x)
- Noise emissions,
- Land take (area).

The chosen indicators serve to compare the environmental performance of railways and other modes of transport, and enable monitoring of rail transport's share of renewable energy sources, energy consumption, CO₂ emissions, air pollution, noise exposure and land take. This leaflet is valid for use by all UIC member companies. Due to the strict legislative framework in Europe, several references are made to EU legislation (e.g. for air pollution and noise).

Important system boundaries as well as explanations for data processing are defined for each indicator. Furthermore the reference variables needed to implement the key environmental indicators are specified in detail.

The data collection and data quality process is divided into three levels: basic, simple and advanced - enabling all railway companies to set up appropriate systems with environmental indicators to monitor their corporate environmental impact and demonstrate environmental improvements or advantages compared to other modes of transport.

It is recommended to gradually improve the data quality according to the principles in this leaflet - for the benefit of the individual railway company as well as that of the international railway community.

1 - Introduction

1.1 - Background - why introduce environmental performance indicators?

Society's expectations of companies' environmental and sustainability performance and behaviour have increased since the 1990s. Both the market and politicians increasingly demand sustainable products and services as well as proper documentation for performance and continuous improvement. Rail transport, being an environmentally-friendly transport mode with potential for improving still further, fully supports this development, since this enables the sector - as well as individual railway companies - to demonstrate its environmental assets.

This leaflet contributes to this goal by defining six functional environmental core indicators suitable to illustrate and continuously monitor the environmental improvements made in the rail sector. The indicators represent the rail sector's proposal for corresponding indicators to cover the transport sector as a whole. As such the indicators are developed to meet the needs of customers, society and politicians to enable comparisons between different transport modes in order to help fulfil society's overall expectations of the transport sector: to deliver and develop more sustainable transport in future.

The indicators in this leaflet deal with aspects of energy, emissions, noise and land take and cover the overall environmental performance of the railways as a transport mode. With this initiative the railways are meeting the need for useful indicators for rail transport, supporting the ongoing work underway e.g. the *TERM reports from the European Environmental Agency (EEA)* and the *Global Reporting Initiative (GRI)* (see [Bibliography - page 42](#)).

1.2 - Purpose and scope of leaflet

The main idea behind this leaflet has been to develop a small number of targeted, standardised and effective *functional indicators* able to be implemented by all railways.

A *functional indicator* measures performance compared to the function the service brings to customers/society: transporting people and goods over a distance. Functional indicators ensure comparability between modes of transport by using the same reference as a denominator: "passenger-km" and "tonnes-km" (see [point 5 - page 33](#)).

The key indicators describe the most relevant environmental impact of daily rail operations (traction including shunting) which can usefully be compared with other modes of transport (except for indicator "1.1 Specific final energy consumption" (see [Glossary - page 39](#)) which is only suitable for internal use). This leaflet, its methodology and chosen system boundaries reflect the fact that each indicator must be applicable for all transport modes in order to be compared.

Using this leaflet in connection with the *UIC Guidelines for environmental indicators* (see [Bibliography - page 42](#)) will give further details on indicators for other key environmental areas such as waste and material use as well as impacts which are not directly caused by traction (in stationary processes e.g. maintenance facilities).

The chosen approach in this document does not allow focus to be laid on those sustainable aspects relating to economic and social issues. The development of appropriate sustainability indicators for railways will be addressed in forthcoming publications in line with developments within the field.

The environment "pillar" of sustainable development in transport addresses mainly:

- Higher energy efficiency: decreased energy consumption per delivered transport unit (see Glossary - page 39),
- Increased use and share of renewable energy sources (for both diesel and electric traction),
- Decreased impacts from air pollution and greenhouse exhaust gas emissions,
- Decreased noise emission levels, with the main focus their impact on citizens,
- Reduced land take and reduced impacts on the natural environment.

Consequently six environmental themes have been identified, leading to the proposal of six core indicators covering the most important environmental areas for railway operations and for the transport system as whole (see also table 1 and Fig. 1 - page 4):

Table 1 : Overview of the six indicators described in this leaflet and their use

<i>UIC Leaflet 330</i>	Railway Operator	Infrastructure Manager	Integrated Railway
Energy consumption	●	○	●
Share of renewable energy	●	○	●
CO ₂ emissions	●	○	●
Local air pollution	●	●	●
Noise emissions	●	●	●
Land take	○	●	●

- = Relevant and important environmental factor
- = Relevant environmental factor

In Figure 1 - page 4, the scope of the leaflet is described in the form of a diagram showing that all the indicators relate directly to traction or railway production, and that no stationary processes are included. The four blue boxes contain all six indicators.

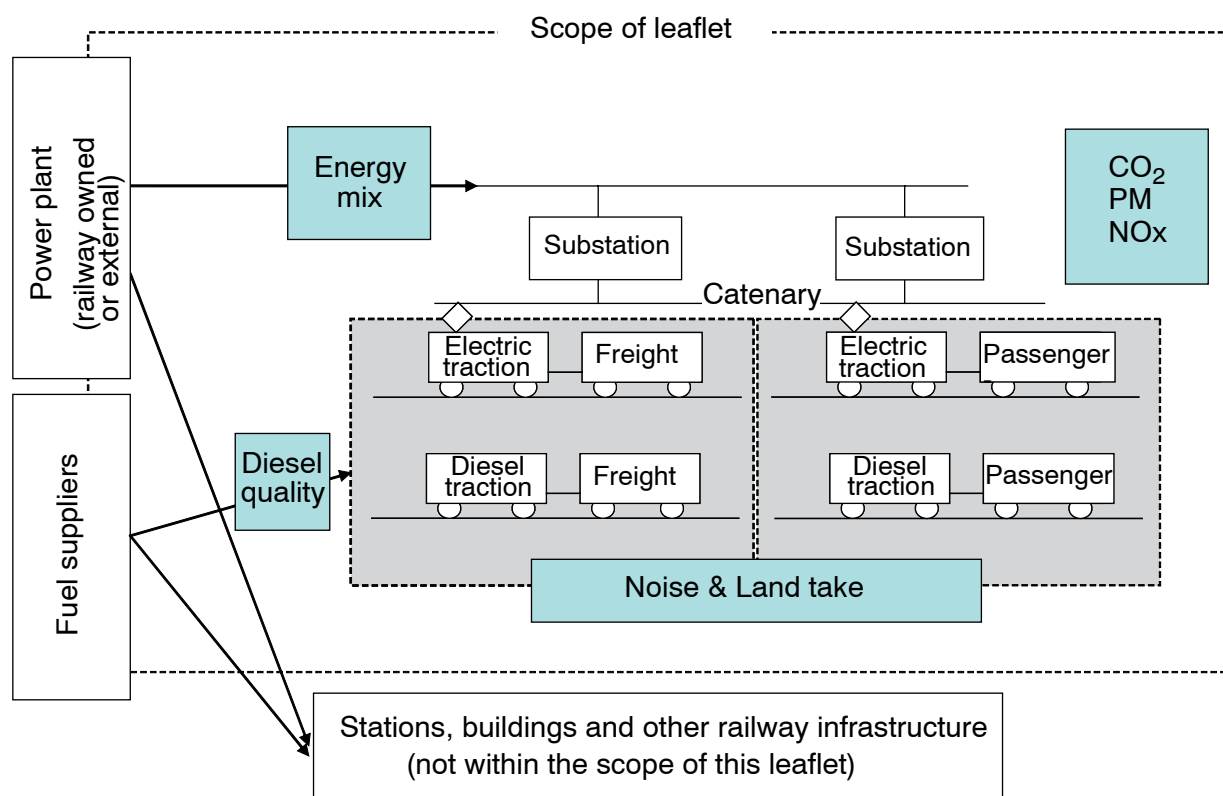


Fig. 1 - General scope of the leaflet with regard to the environmental issues considered

The following chapters provide the railways with user-friendly guide to producing these six environmental core indicators regardless of national peculiarities and different levels of experience in working with environmental indicators:

- Point 2 - page 5 presents the methodology and a practical stepwise approach, enabling the railways to handle data, procedures and quality aspects.
- Point 3 - page 8 presents an overview of the chosen environmental indicators for the railways.
- Point 4 - page 11 provides the railways with instructions on how to produce the relevant data for the numerator (environmental impact).
- Point 5 - page 33 gives instructions on how to produce the relevant data for the denominator (production of train services) as well as the various service types.

2 - Methodology

2.1 - Environmental performance indicators on three levels

The development of appropriate environmental performance indicators for the railways has been organised according to an overall structure shown in Fig. 2, where indicators are divided into three levels:

- **UIC Leaflet 330:** the indicators listed in this leaflet represent the most aggregated and generalised indicators. These indicators enable railways to monitor their environmental performance on a general level and to compare themselves to other modes of transport.
- **UIC Guidelines:** the UIC guidelines for environmental indicators for railways propose more detailed performance indicators to support and complement the indicator set from this leaflet. They include further explanations to assist data collection by the railways (see Bibliography - page 42).
- **Activity-specific & process-related indicators:** below the UIC guideline indicators is the operational level at each company (e.g. operations, procurement, maintenance) where activity-specific indicators are developed separately for reasons of environmental performance improvements or process optimisation.

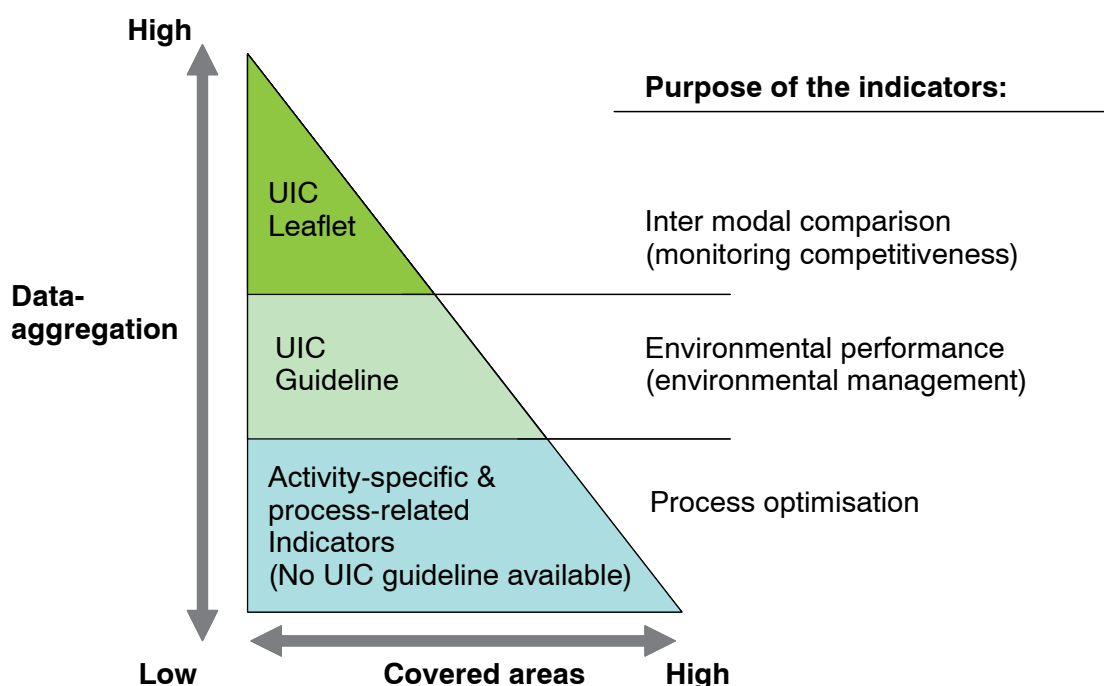


Fig. 2 - Framework of the UIC railway indicators at different levels of aggregation

2.2 - Stepwise approach to data collection

The stepwise approach applied in the development of the railway environmental indicators on all (three) levels is shown in Fig. 3, and more thoroughly described in the *UIC guidelines for indicators* (see Bibliography - page 42).

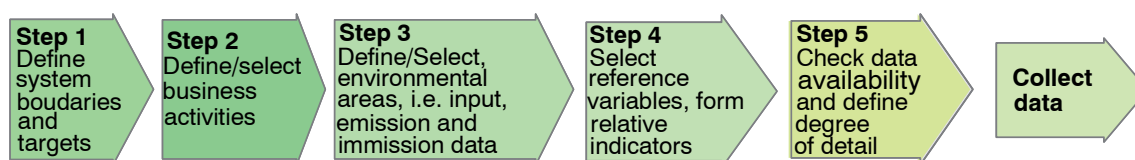


Fig. 3 - Stepwise development of environmental indicators

This leaflet lays down the principles for the aforementioned first 4 steps in order to obtain standardised results and figures from the railways. Following the step model, all that remains is step 5 - check the data availability and collect the proposed data.

The collection of data is then followed by data processing and quality control. In order to simplify this task and guide the railways through this work, this leaflet defines three different levels for this data handling: basic, the simple and the advanced as illustrated in table 2.

The reliability of the collected data depends on a combination of factors: the collection & calculation recordings, the process used to collect the data and the final review of the data and the collection process. Depending on the ambitions, resources and goals of each railway, different quality levels within these three aspects of the data handling process can be achieved as shown below.

Table 2 : Data handling process guidelines recommended by UIC

Process	Data handling - level of ambition (examples)		
	Basic	Simple	Advanced
A. Data categorisation	Estimated date (primarily)	Partly estimated, partly measured data	Measured data (primarily)
B. Data aggregation	Average figures for entire fleets (total data only)	Specific data for some service types (see tables 19 - page 35 and 21 - page 37)	Specific data for all service types (see tables 19 and 21)
C. Data collection cycles	Irregular collection cycles	Almost regular (annual) collection cycles	Regular and fixed annual collection cycles
D. Data collection procedures	No standardised collection procedures	Limited non-documented standardised collection procedures	Fully documented standardised collection procedures
E. Quality control (data and procedures)	Only partial internal verification and validation	Internal verification and validation only	Internal verification and validation followed by third party review

The basic, simple and advanced approaches represent the different levels of reliability, transparency and comparability of the indicators which the railways can achieve when handling their data. This description of the quality of data and procedures is crucial for drawing realistic and reliable conclusions from the data. Such data about the data is called "metadata" (see Glossary - page 39).

With regard to this UIC leaflet, the requirements outlined in the "basic" level (marked red) have to be fulfilled as a minimum. Many UIC members already use the "simple" level (marked yellow) or even the "advanced" level (marked green) in order to increase the benefit from the work done in collecting data. This offers them the opportunity to use the collected data for multiple purposes e.g. in environmental management or economic management systems.

The basic, simple and advanced approaches also represent different degrees to which the service types of the railway product are specified. The basic approach is typically aggregated values at company level and the advanced is specific to each product, e.g. urban traffic vs. high-speed trains and rolling road vs. mixed freight traffic to mention a few examples.

For some of the data - e.g. for land take - the indicator (numerator) will not show major variations from year to year (unless new lines have been built), meaning that the data to be collected will be limited.

3 - Overview of the environmental key performance indicators

The following six key indicators have been selected. The indicators measure specific performance as each is divided by the relevant transport volume. The standard UIC statistical nomenclature is used: Passenger transport = pkm or seat-km, freight transport = tkm or net-tonneskm, total transport (TU) = pkm + tkm (see also point 5 - page 33 and List of abbreviations - page 40).

3.1 - Indicator 1: Energy consumption

This indicator describes the specific final (1.1) and primary (1.2) energy consumption of passenger and freight transport. Depending on the aim this indicator may be used to compare rail passenger transport (1.1.a and 1.2.a) or rail freight transport (1.1.b and 1.2.b). The primary energy consumption (see Glossary - page 39) indicates to which extent rail is environmentally competitive with other transport modes whereas final energy serves more to enable internal comparison among either electric or diesel traction units. Further details are listed in points 4.1 - page 11 and 5 - page 33.

Final energy

ID	Indicator definition	Measuring unit
1.1.a	Specific final energy consumption of passenger transport	kWh/pkm (electricity) or L/pkm (diesel)
1.1.b	Specific final energy consumption of freight transport	kWh/tkm (electricity) or L/tkm (diesel)

Primary energy

ID	Indicator definition	Measuring unit
1.2.a	Specific primary energy consumption of passenger transport	kJ/pkm
1.2.b	Specific primary energy consumption of freight transport	kJ/tkm

3.2 - Indicator 2: Share of renewable energy

Indicator 2.1 covers the renewable energy used for electric traction only, i.e. electricity generated from hydro-electric power plants, wind farms, solar cells, etc. (for details see point 4.2 - page 16). Indicator 2.2 covers the share of bio-fuels i.e. the proportion of non-fossil fuels used in existing diesel engines.

ID	Indicator definition	Measuring unit
2.1	Share of renewable electric energy from total energy consumption	%
2.2	Share of bio-fuels as part of diesel fuel	%

3.3 - Indicator 3: CO₂ emissions

This indicator is calculated from the specific primary energy consumption of traction (indicator 1.2) and covers the direct emissions (from rail diesel engines) as well as indirect emissions (from power plants for rail electricity production using information from indicator 2.1). For details see points 4.3 - page 19 and 5 - page 33. No other greenhouse gases contributing to the global warming potential (GWP) (see List of abbreviations - page 40) are calculated into this indicator.

ID	Indicator definition	Measuring unit
3.a	Specific CO ₂ emission from passenger transport	g CO ₂ /pkm
3.b	Specific CO ₂ emission from freight transport	g CO ₂ /tkm

3.4 - Indicator 4: Local air pollution

This indicator is divided into the two main (relevant) constituents of local air pollution: NO_x and particle emissions. They are both estimated or calculated from the specific primary energy consumption of traction and technical assumptions for engines and power plant units. They cover the direct emissions (rail diesel engines) and indirect emissions (from power plants for rail electricity production). For details see points 4.4 - page 22 and 5.

It is very important to note that particle size differs between various types of exhaust gas emissions: particles from air, road and rail transport do not necessarily have the same size profile and thus are not equally harmful to human health (smaller particles are normally more toxic due to their ability to penetrate the lung tissue). This has to be taken into account before concrete benchmarking takes place between different sources.

Exhaust NO_x emissions

ID	Indicator definition	Measuring unit
4.1.a	Specific NO _x emissions from passenger transport	g NO _x /pkm
4.1.b	Specific NO _x emission from freight transport	g NO _x /tkm

Exhaust particle emissions

ID	Indicator definition	Measuring unit
4.2.a	Specific particle emissions from passenger transport	g PM ₁₀ /pkm
4.2.b	Specific particle emission from freight transport	g PM ₁₀ /tkm

3.5 - Indicator 5: Noise emission

This indicator describes the low-noise emission levels of the rolling stock (see Glossary - page 39) and compliance of the infrastructure with national limits. It is not suited to intermodal comparison. For details see points 4.5 - page 24 and 5 - page 33.

For any other intermodal comparison of noise exposure it is very important to note that for the same noise level produced by air, road and rail transport, rail is perceived as the least intrusive. This has to be taken into account before concrete benchmarking takes place.

ID	Indicator definition	Measuring unit
5.1	Proportion of low-noise rolling stock (weighted with wagon mileage)	%
5.2	Proportion of infrastructure lines meeting national limits	%

3.6 - Indicator 6: Land take

This indicator describes the area occupied by rail transport. As a consequence the land take is related to the performance of the entire transport system (passenger and freight). For details see points 4.6 - page 28 and 5.

ID	Indicator definition	Measuring unit
6	Specific land take of rail infrastructure (passenger and/or freight)	km ² /TU

4 - Detailed description of the environmental key performance indicators

This point presents the six environmental indicators in more details. Each environmental indicator represents the numerator in the specific indicator presented in the previous section.

4.1 - Indicator 1: Energy consumption for traction

Energy consumption is an important environmental issue, whether the energy comes from fossil fuels or renewable energy. The scarcity of fossil fuel reserves and its impact on economic aspects (rising energy costs) as well as security (foreign dependency) is among the main drivers behind the need for improved energy efficiency around the world.

The railways' environmental advantage compared with the other motorised modes of transport is based notably on their high energy efficiency. The objective of this indicator is therefore to monitor energy consumption, enabling the railways to maintain their lead despite the technological advances being made by competitors on the road and in the air.

Traction accounts for the bulk of the energy consumed by the railways (approximately 85 %), thus only traction energy consumption is considered in this indicator (normally including parking and shunting). Energy-saving measures are of interest to the railways given their great potential for cost savings.

4.1.1 - Definition

A basic distinction must be drawn between final and primary energy consumption (see Fig. 4 - page 12).

Indicator 1.1 - Final energy consumption

Final energy (diesel or electricity) is consumed directly by motive power units. This consumption includes auxiliary consumption for heating, air conditioning, lighting, on-board catering, etc. The final energy consumed shall be defined in terms of the fuel (volume of diesel) measured at the tank and electricity measured at the pantograph. The following point 4.1.2 - page 12 discusses this in detail.

Indicator 1.2 - Primary energy consumption

Primary energy covers - in addition to final energy - also the energy used "upstream" to make available the final energy on-board the train:

- Energy lost in conversion during the energy production process: energy consumed for the extraction, transport and transformation of primary energy carriers (e.g. crude oil, hard coal, gas, and uranium) into the final energy carriers: petrol, diesel and electricity.
- Energy lost in the distribution process: this includes the losses sustained and the energy consumed in conveying energy to the vehicle. In the case of electric traction, these losses occur in the supply network (often the public grid) and through transformation and losses in the electric railway infrastructure.

Final energy consumption figures are used as the basis for benchmarking and optimising within the railway system (not for direct comparison of diesel with electric, see Fig. 5 - page 13), whilst **primary energy** consumption is a good yardstick for comparing e.g. diesel and electric rail traction and rail transport with other modes (car, lorries and aeroplanes).