Traffic and Transport in Environmental Management

Instructions for Company Recording of Transport-related Environmental Influences

A Guide prepared on behalf of the
Umweltbundesamt Berlin

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September 1999

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1. Introduction

Traffic and environment – a problem solved?

The environmental influences of transport are many and diverse. They comprise not only the direct effects of the means of conveyance during operation. Transport infrastructure, such as for example the road network, can also impair the environment substantially. Some of these effects are compiled in Tab. 1.

Not all these traffic-related environmental influences can be quantified. Many effects can only be described qualitatively since the interaction with biological and spatial systems is very complex. However, beyond any doubt they are connected with the "volume" of traffic. Thus the size of the road network or the vehicle km travelled on the roads can be considered as indicators for these many and varied effects.

Tab. 1: Effects of roads on flora, fauna and their habitats. From: Council of Experts for Environmental Issues (1994)

Environmental effects of roads
Effect of building site/construction bay/soil borrowing/ landfill
Direct loss of area
Direct change of area
Local climate changes
Emissions/air-borne pollution:
- Pollutants
- Dust
- Fertilising substances
- Light
- Noise
- Optical stimuli
Local changes in the water regime
Changes in surface water
Direct and indirect land fragmentation
Partition of sub-habitats
Barriers to dispersal
Animal losses (due to attractant effects too)
Interspecific competition
Structuring, creation of new habitats
Dispersal belts for species
Development functions and further consequential impacts such as land consolidation, development of bodies of water etc.

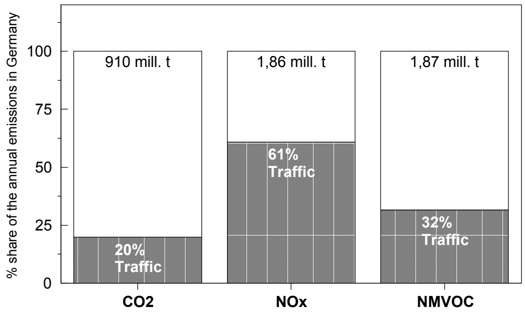


Fig. 1: Share of traffic in total emissions in Germany in the year 1996 for carbon dioxide (CO_2), nitrogen oxides (NOx) and high-volatile hydrocarbons without methane (NMVOC). Direct emissions only. Source: Verkehr in Zahlen [Traffic in figures], 1998.

However, some environmental influences can be quantified very well, especially the emissions of pollutants and consumption of (fossil) energy. Political discussion focuses on these, rightly so in some cases, since transport is still one of the largest polluters in Germany (see Fig. 1).

Admittedly the quantities of some major traffic-caused pollutants are sinking gradually as a result of major technical efforts. For instance nitrogen oxide emissions have been steadily reduced since the beginning of the nineties (see Fig. 2). However, the balance is less positive as regards the energy consumption or the emission of carbon dioxide (CO_2), which is relevant for the environment.

In the year 1996, 180 mill. t CO_2-emissions in Germany originated from traffic. This corresponded to approx. 20 % of all German CO_2-emissions. 15 years before the figure was less than 120 mill. t – for East and West Germany. Despite specific cuts in consumption this trend is continuing unabated. A further increase of approx. 20 % by comparison with the 1996 figures by 2010 must be expected. The direct CO_2-emissions from road transport alone will by then lie just below 200 mill. t per year. Freight transport accounts for a growing share of this (see Fig. 4).

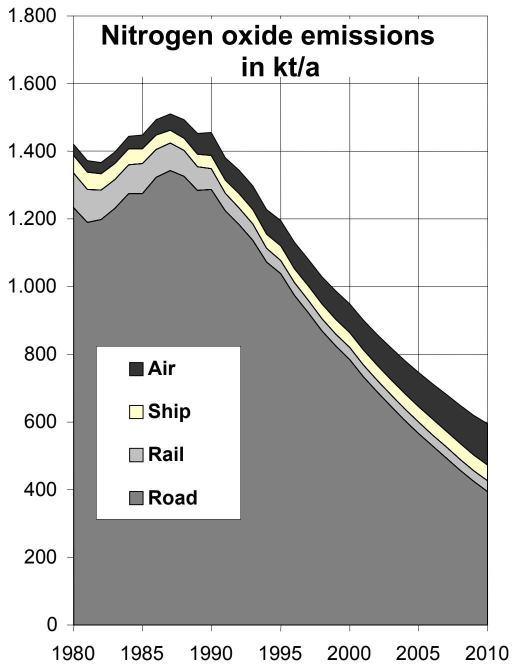


Fig. 2: Nitrogen oxide emissions by traffic in 1000 t per year. Real values up to 1997 (Road) and 1995 (other transport), after this trend scenario. Including energy prechain. Calculations with TREMOD. Source: Höpfner, Knörr 1999

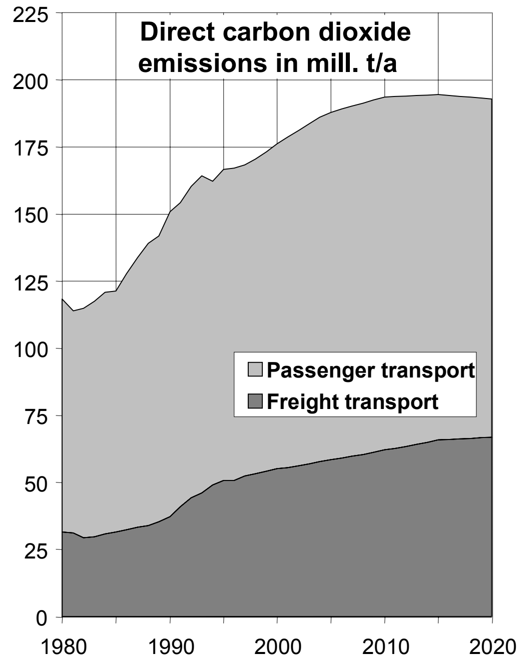


Fig. 4: Direct carbon dioxide-emissions by road traffic in 1000 t per year. Real values up to 1997, after this trend scenario. Excluding energy prechain. Calculations with TREMOD. Source: Höpfner, Knörr 1999

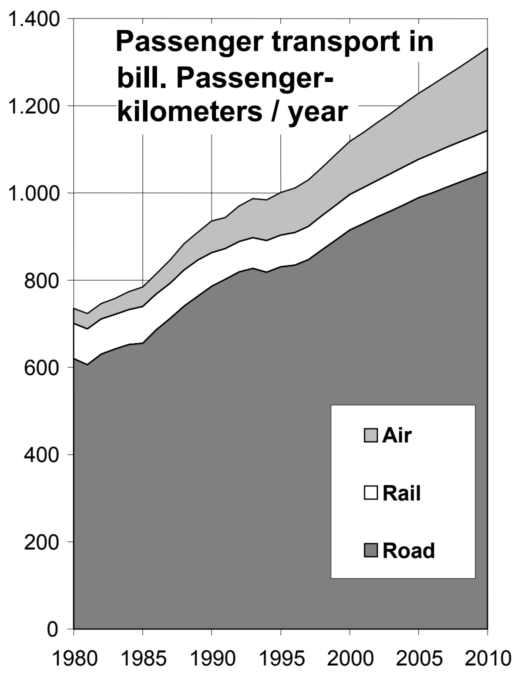


Fig. 3: Passenger traffic in billion person-km per year. Real values up to 1997 (Road) and 1995 (other transport), after this trend scenario. Source: Höpfner, Knörr 1999

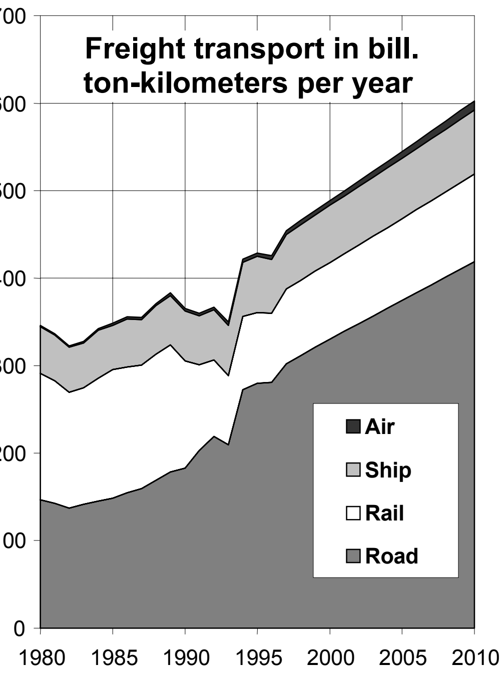


Fig. 5: Freight traffic in billion tonne-km per year. Real values up to 1997 (Road) and 1995 (other transport), after this trend scenario. Source: Höpfner, Knörr 1999

The reason for this lies in the continued strong increase in traffic volume, especially of road and air traffic. Fig. 3 shows the passenger traffic in person-kilometres from 1980 to 2010. The freight traffic, shown in tonne-kilometres, developed at an equally headlong pace. As is evident from Fig. 5, the value for e.g. road traffic has doubled within 20 years.

Noise pollution or land use by traffic is more difficult to document and to follow. Estimates by the Umweltbundesamt have revealed that in the year 1990 about 16 % of the population were exposed to road traffic noise levels above 65 dB (A) during daytime. At this noise level an increased risk of cardiovascular diseases is to be expected. The proportion of the population subject to such stress will only drop to 12.5 % by 2005. Further reductions will be prevented by the increase in traffic (UBA, 1997).

The situation is similar as regards land use. Traffic uses just under 5 % of the total area of Germany, and the proportion is growing. This figure does not include many areas such as dams, bridges, private parking lots or fuel filling stations.

Furthermore, areas constructed for traffic fragment ecological action connections and thus degrade the value of the entire affected area for other uses. Non-fragmented, low-traffic landscape regions of 100 sq.km and more formerly made up 22.6 % of the Federal Republic of Germany. Between 1977 and 1987 this share dropped by 18 % due to new fragmentation and the increase in traffic volumes (SRU 1994).

There is thus no doubt that transport is an activity area in our society with major impacts on the environment. That is why it is the subject of particular endeavours in the sector of protection of the environment. During the past years many improvements have been achieved by technical measures, e.g. by new vehicles with lower fuel consumption rates, or by exhaust emission control systems.

However, these measures are not sufficient. For example the mean fuel consumption of existing cars is only dropping gradually, despite the fact that new cars requiring only 3 litres for 100 km are now available. Starting with a basis of approx. 9 litres fuel per 100 km in the year 1990, even Shell AG still forecasts a value of approx. 7 litre/100 km for the year 2010 (Shell, 1999).

That is why discussion is focusing to a growing extent on how the problem can be tackled at source too – at the increase in motorised passenger and freight traffic performance. This presupposes a more comprehensive consideration of the procedures in the traffic and transport sector than simply casting a glance at the latest vehicle engineering. It must also be asked how much is transported, how far and with what means of conveyance. These aspects will be addressed in appropriate sections of this Guide.

To put it briefly

- Transport is and remains an environmentally relevant activity area.
- The environmental influences of transport are many and varied, and not always easily quantifiable.
- Transport makes a substantial contribution to pollutant emissions.
- Technical measures lead to a considerable reduction in emission quantities in some cases.
- However, energy consumption, noise, land use and emissions of the greenhouse gas CO_2 remain a central, traffic-related environmental problem.
- The traffic growth rates are very high and call for the causes of this growth to be tackled.

Transport and environmental management – a neglected issue

An analysis conducted by the University of the Ruhr, Bochum, revealed that only a few companies address the theme of transport within the scope of their environmental management system.

Tab. 2: Examination of random samples of company environmental reports and environmental statements for consideration of the transport aspect. Source: (Letmathe u. Steven, 1998)

	Environmental publications of the company	
	Quantity	In %
Total random samples	348	100
Transport aspects are addressed:	151	43
– only sporadically and unsystematically	108	31
– in guiding principles and company environmental policy	35	10
– in environmental objectives and/or measures	78	22
– by quantifying the environmental influences	43	12
– by Input/ Output balances	10	3

Survey within the scope of R+D Project No. 205 06 089

Although the transport of raw materials, products and wastes is listed in the EC EMAS Regulation as one of the aspects to be dealt with, many companies neglect the transport aspect in their environmental audit and in the environmental programme. Only a few per cent of companies list transport in their Input-/Output balance (see Tab. 2). Many of these balances show clear shortfalls in the determination of the energy consumption or of the pollutant emissions.

One reason for this is certainly the strong focusing of the EC EMAS Regulation on the site of companies. The essential transport inputs are provided *between* the sites and are then easily forgotten. Moreover quantifying the environmental influences of transport requires a not inconsiderable effort. Since protection of the environment in the transport sector is not regulated on the company side, and so there are no permit certificates or the like such as exist for plants subject to permits under the Federal Air Pollution Control Act, companies also encounter a data and method problem in their balancing.

Despite this, transport is a not inconsiderable aspect in a company's protection of the environment. Fig. 4 shows e.g. the growing significance of road haulage for the CO_2-emissions. In many product life cycle considerations the transport component makes an essential contribution to the ecobalance of the product.

That is why freight transport may not be left out of the environmental management system of a company. In the final analysis responsibility for these transport operations along the lines of allocation to the polluter and bringing influence to bear on development, purchasing, production and distribution must be sought within the companies and at the sites. Apart from this, the sites themselves generate a substantial volume of traffic, e.g. commuter traffic by the staff or visitor traffic.

And finally traffic is an important cost aspect for companies, especially within the scope of global markets. Transport costs in Germany account for approx. 2-5 % of turnover, while total logistics costs account for as much as 6-10 % (according to Pfohl, 1996). Reducing energy consumption, improving the vehicle load factor or cutting the transport volume can contribute to cost saving for the company – while at the same time reducing the burden on the environment.

Consequently considering transport in the environmental management can also benefit the general cost controlling of a company: the search for the necessary measure, the causes and the possible potentials for reduction in the use of resources or (transport) outlay for the production and accomplishment of the companies.

What is the purpose of this Guide?

The goal is that you give more consideration to the traffic and transport aspect in your environmental management system and in your company's eco-audit. The Guide is intended to assist you here. It should show what data are important at all, how the data are recorded and how information on the environmental influences can be derived from them.

The Guide provides tips and makes basic data available, e.g. emission factors in order to include transport in the company's eco-balance, roughly within the scope of a company environmental information system.

In the ideal case these data help you to appraise the importance of transport for your company's protection of the environment, to make comparisons on a time and material basis, to form ratios and to develop a need for action or fulfilment of goals from this. Interest is concentrated on the in-company decision-making process which you wish to support with qualified and target-oriented information.

It should be clear to all participants that the outlay for including the transport aspect must remain reasonable and manageable. You must be able to draw up balances relatively quickly, update them regularly and be able to fall back on as many already existing data as possible. The qualitative demands made of such a system are oriented to a pragmatic but accurate decision-support process and not to academic requirements relating to comprehensive balancing.

To whom is this Guide addressed?

The Guide addresses the practical officers in a company, e.g. the environmental protection officer who is building up or maintaining an environmental management system and needs a quantitative basis for this too. It is presumed that you are familiar with principles of environmental protection as well as with environmental management, but that you largely lack transport-specific information. This Guide should serve to close such a gap.

The Guide is *not* addressed to scientists who carry out studies, investigations or emission balances and need special vehicle-related emission factors or the like for this purpose. The procedure selected in this Guide and the definitions and aggregation of data are very strongly characterised by the controlling aspect and the decision-making process in the company.

That is why scientists, as well as users from other fields, e.g. from local authority transport and environmental planning departments, should preferably use other sources, such as the detailed Manual for emission factors (infras, 1999).

To put it briefly

- Helps companies to take the transport and traffic aspect into account in their environmental management.
- Quantitative considerations to support decision-making.
- Pragmatic approach instead of academically exact balances.
- Data not suitable for scientific investigations.

How is the Guide structured?

The Guide is divided into 3 parts:

	Chapter
Traffic in environmental management	2
Relevance assessment	3
Detailed balance	4

A first, general part discusses how transport can be taken into consideration in a company environmental management system, what role it plays there and what requirements result from this. In particular the concept of support for actions and decision-making by means quantitative information is dealt with. The second part presents the relevance assessment procedure. This is a simplified and fast balance of the environmental influences of transport and represents the basis for more in-depth considerations. Finally, the third part provides you with data needed for detailed balancing. It contains helpful hints for drawing up such detailed balances, indicating what ratios or indicators are used, etc.

Where do the data come from?

This Guide provides above all emission factors for various traffic and transport modes. These data originate from the computer model TREMOD, developed by ifeu-Institut since the beginning of the nineties on behalf of the Umweltbundesamt and in cooperation with the Federation of the German Automobile Industry, Deutsche Bahn AG and the Federation of the Mineral Oil Industry.

This model is updated constantly. It takes into account measurements on representatively selected vehicles and estimates by a committee of experts for future or new vehicles on the basis of boundary values and technologies probably deployed. In TREMOD the current stock of vehicles is taken into account, broken down by technical concepts, size categories etc., driving patterns and traffic situations, as well as real and forecast vehicle km travelled. It represents the currently best basis for traffic emission calculations in Germany.

Where do the examples come from?

Some of the examples presented are drawn from the research project on which this Guide is based. Several case studies were conducted in companies which want to integrate transport in their environmental management system. It was examined what data are available for this and what practical and methodological problems can occur. Some of the examples presented originate from the relevant literature or from company publications.

Where can further information be obtained?

If you are interested in details regarding the calculations of energy consumption rates and traffic emissions, you should study special publications. A very good overview is provided in the book:

- Borken, J. et al. (1999): Basisdaten für ökologische Bilanzierungen. Einsatz von Nutzfahrzeugen in Transport, Landwirtschaft und Bergbau. Vieweg Braunschweig

The CD-ROM drawn up on behalf of the Umweltbundesamt provides an important data collection for vehicle emission factors:

- infras (1999): Handbuch Emissionsfaktoren des Straßenverkehrs. Version 1.2. January 1999. Zurich/Berne

An overview of the current development of freight traffic-related emissions is provided by a current study by ifeu-Institut for the Federation of the German Automobile Industry (VDA):

- VDA (1999): Entwicklung der Fahrleistung und Emissionen des Straßengüterverkehrs 1990 bis 2015. Materialien zur Automobilindustrie 21. Frankfurt

2. Transport in the environmental management of a company

Requirements of the EMAS Regulation

The fact that transport is often neglected by companies in the eco-audit is partly due to the theme transport and traffic being mentioned only briefly and mostly indirectly in the text of the Regulations. In addition the special definition of site in the EC-Regulation plays a role.

Under Article 5 of the Regulation text an assessment of all the important environmental issues in connection with the company's activities at the relevant site is required for the environmental statement, as well as a summary of the numerical data regarding pollutant emissions, waste generated etc. There is no direct mention of the theme traffic or transport here.

However a reference to transport is made in Annex I C of the Regulation under the aspects to be dealt with. Within the scope of the environmental policy, the environmental programmes and the environmental audit, items to be considered include the transport of raw materials, wastes and products.

The other problem is the strong focus of the EMAS Regulation on the individual site. The site is considered as the territory on which the industrial activities subject to the control of the company are carried out. For instance the environmental review or the environmental programme relate to the site. However, the text of the Regulation states that the movable and immovable objects belonging to the company equipment and infrastructure used within the context of the activity also count as part of the site. This is made clearer within the scope of the German extension regulation, via which carriers can also participate in the Eco-Audit-System. In the explanations belonging to the Regulation the relevant means of conveyance are allocated to those company locations which are responsible for their use.

Transferred to the manufacturing industry, this would mean that a company should certainly include its works traffic with its own vehicles in the environmental management system. The question regarding consideration of forwarder's traffic etc. remains unclear, however.

A clearer ruling is becoming apparent in the new version of the EC EMAS Regulation (known as EMAS-2), which is currently available in draft form. It is stated in Annex VI that when describing the significant environmental influences, the company must take into account *all* environmental aspects of its activities, products and services. Both direct and indirect environmental aspects are to be included here.

These direct and indirect environmental aspects are described further in the Regulation. Direct aspects relate to company activities controlled by the company and which take place within the company. Indirect aspects relate to activities, products and services which the company cannot control or which only occur at a certain distance. Traffic and transport – as regards both goods/services and staff – is explicitly listed as an aspect to be taken into account.

Thus consideration of traffic and transport has become an integral component of the EC-Eco-Audits.

To put it briefly

- Consideration of traffic and transport is not clearly regulated in the old EMAS-Regulation.
- In the new EC Regulation draft traffic and transport form a fixed component of the environmental aspects to be taken into account.

What traffic is involved?

Basically every kind of traffic or transport resulting from company activities and which can lead to relevant environmental influences should be taken into account. For the manufacturing industry this will chiefly consist of goods traffic, for service companies it will consist of staff passenger traffic and where appropriate of customer traffic.

Goods traffic and passenger traffic can be classified on the basis of their various purposes, e.g. transport of products (distribution), wastes (disposal), raw materials (procurement) etc. It is also crucial what means of conveyance are used for this: motor vehicle, rail, ship, aircraft, pipeline etc.

One possible classification is shown in Fig. 6. You can use this scheme for instance to identify transport operations occurring in your company. You should not yet be guided by the question of what traffic the company is responsible for (e.g. works traffic) or not (e.g. suppliers' traffic). Nor is it yet of interest whether figures are available for such transport and whether they are quantitatively relevant. Instead it is important to obtain a general overview. The context is the company with its activities at the site to be validated.

☞**TIP**

- Observe what vehicles drive too and leave your company and whether you can classify all transport operations in the scheme.

Naturally you will not want or be able to balance all these transport operations. In a second step you should therefore consider

- whether relevant environmental influences really do proceed from the traffic concerned,
- who is primarily responsible for this traffic, i.e. who orders it and carries it out,
- whether your own company can influence the nature and manner of transport or traffic in any way.

This can be set out in a table to provide an overview.

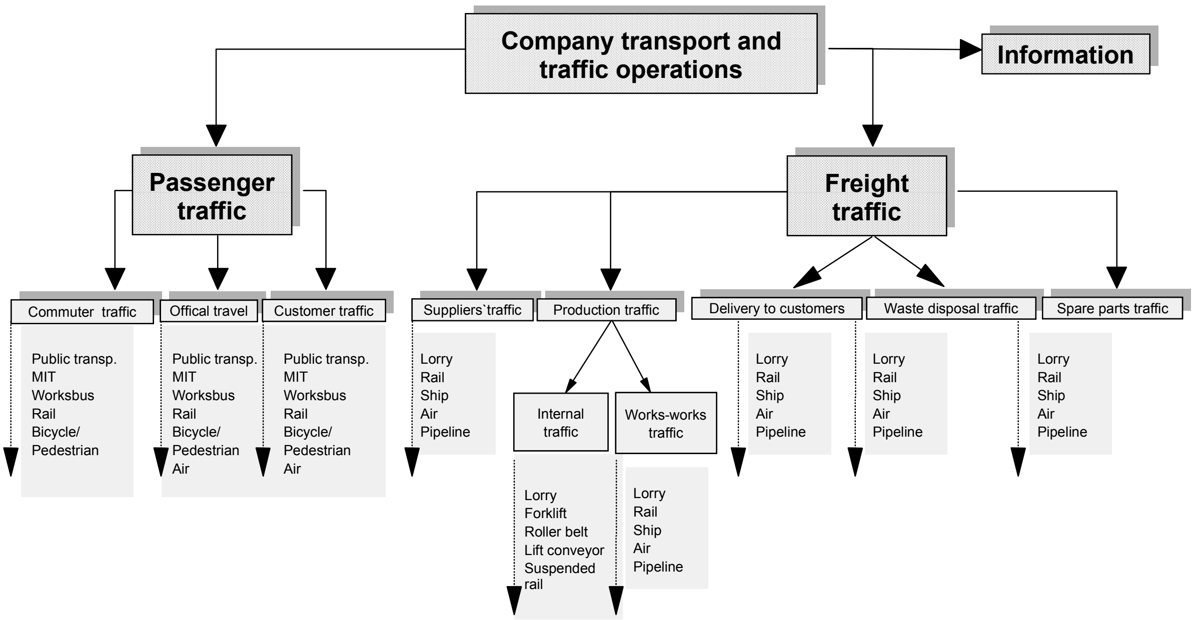


Fig. 6: Possible classification of company transport and traffic operations by purpose and means of conveyance

Selection of the balance limits

A core problem in balancing the environmental influences of traffic is the question of which traffic you allocate to your own company and which to the suppliers, other plants or even customers.

You can answer this question clearly for traffic at the site, e.g. forklift trucks, machines, light trucks etc. These belong to the site without any doubt. Strictly speaking, however, other traffic occurs outside the site. Consequently the boundary between what is to be considered and what is not to be considered can no longer be tied to the definition of the site, but must be based on other criteria.

Many companies decide only to take traffic produced by their own vehicle fleet into account. This also solves any data problems, since fuel reports, kilometre readings on the clock etc. are available for the company's own fleet.

However this approach does not go far enough. Companies also cause other transport operations as a result of their site activities, i.e. by production and subsequent distribution of the products, as well as by the consumption of raw, auxiliary and expendable materials, which are delivered. These transport operations are generally no longer carried out by the company itself, but mainly on its behalf by forwarders, possibly indirectly via the suppliers. This results in a complex interlinkage of delivery relations for which the company is responsible in the final analysis.

One possibility of balancing consistently and neatly here could be to consider only the departing traffic – assuming that the suppliers consider their own departing traffic. However, other defining boundaries are conceivable.

> **To put it briefly**
>
> - Do not select balance limits too tightly.
> - Orient yourself to the traffic actually caused by the company.
> - Check possibilities of influencing this!

The situation becomes particularly difficult if a plant to be audited only delivers goods as far as a central or delivering depot, but not to the actual customer. If the depots are not audited at the same time, essential transport operations are excluded and are not considered in an environmental management system.

However, these various approaches say nothing about whether the necessary information about the transport operations is available. This depends crucially on who carries out the transport, how it is invoiced, whether the forwarder is willing to cooperate, what customer and supplier information (e.g. distances) is available, etc.

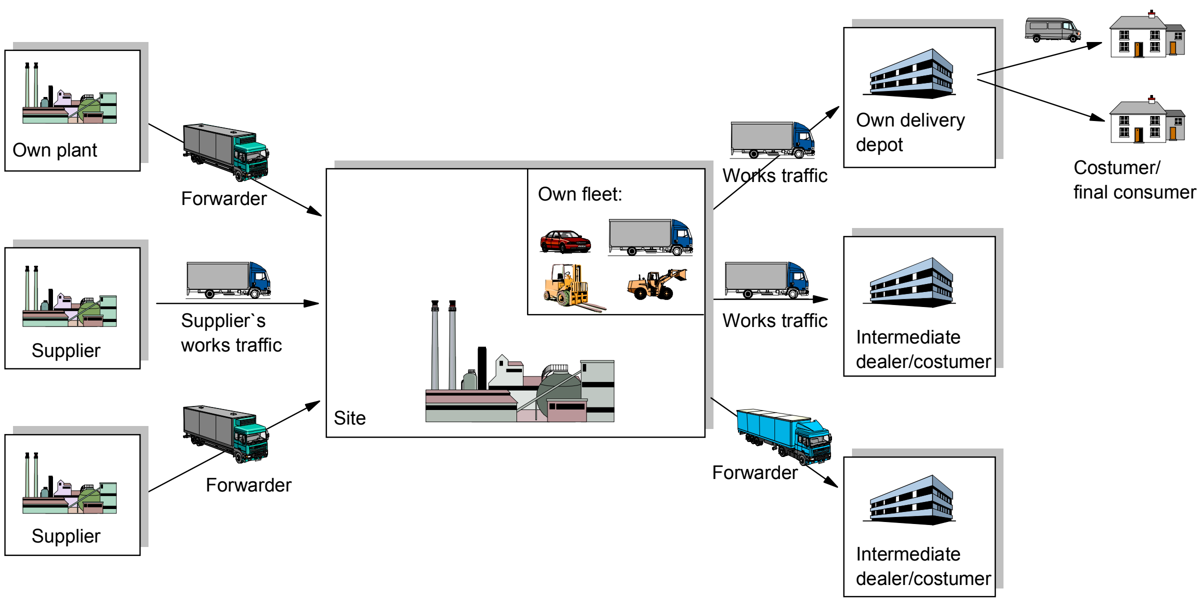


Fig. 7: Example of transpor relations between company site and supplier or customer

FOR EXAMPLE: Otto-Versand Hamburg

Otto Versand-Handelsgruppe with a turnover of about 25 billion Mark (1995/96) is the largest mail order group in the world. An environment management system was introduced at the Head Office in Hamburg in 1997. Within this scope a project aimed in particular at investigating trade and transport interlinks and their environmental influence was also implemented. The inventory was carried out in all logistic areas of Otto Versand. Not only the number of transport operations, the volume of transport and the proportions accounted for by the different transport modes were ascertained, but also the CO_2 emissions caused by these. These serve Otto Versand as a steering quantity for improving environmental protection. For a mail order organisation which orders merchandise from all over the world, it was natural to balance the incoming goods flows from the various countries (markets) and the associated CO_2 emissions. Otto Versand normally assumes responsibility for carriage of all goods produced abroad.

The following questions were involved:

- How much air freight does Otto Versand cause per season?
- What purchasing sectors cause most air freight?
- What programme ranges does this affect?
- What purchasing sectors cause 60 per cent of the air freight?
- Which operative teams does this concern?
- Cooperations talks with representatives of various airlines and shipping lines.

Otto Versand distributes more than 60,000 articles. That is why it was necessary to focus on a not excessively large number of programme groups. The incoming goods flows were considered altogether, broken down by supplier or by purchase area.

First of all the main markets Hong Kong and India were balanced, since this is where the greatest potential for reduction was expected. The airports of departure in the markets and Frankfurt in Germany were defined as the system limit. From there goods are flown on to Hamburg. The upstream transport from the producer to the airports and transport to the Otto Versand warehouses was not taken into account. The necessary data originated from internal and external sources. The compilation of the goods imported by airfreight from the markets had to be carried out via the forwarder, since no information on this was stored in the Otto Versand systems.

Results:

Imports from overseas caused about 60 % of the CO_2 emissions of Otto Versand with a current figure of 110,000 t a year. The Hong Kong market dominated with a share of 52 per cent. Airfreight from the Indian market to Hamburg emitted approx. 2,600 t carbon dioxide. 64 per cent of this alone was caused by two management teams of Otto Versand.

Reduction scenarios were designed on this basis. For incoming goods transport from overseas sea transport and a combination of sea and air transport are alternatives to air transport. For the Indian market especially there are good possibilities for shifting to intermodal transport sea/air. Instead of being flown directly from Bombay to Germany, the goods are first shipped by sea to Dubai and from there by airfreight to the destination. If all transport operations from this market were transferred to intermodal transport, it would be possible to achieve carbon dioxide emission reductions of about 6,000 t a year.

Source: Dr. M. Arretz, Otto-Versand Hamburg; UBA-Texte 78/98

A further problem is interrupted traffic with handling operations, concerning rail, ship or aircraft. There is frequently a total lack of information regarding transport procedures. However, this does not mean that such transport is not important for environmental management. This is where the actual environmental influences on traffic by the company occur (see example Otto-Versand).

The Guide will show how the boundary limits of the balance are to be selected – depending on the requirements in the company and the problem context. This will be steered essentially by the controlling concept and the sphere of influence of the company.

Taking the prechain into account

The topic of the boundary limits of the balance also involves the question of what to do with the prechains. What do we mean by a prechain?

Some means of conveyance (lorry, ship) emit pollutants directly during traction. Others (electrically powered railways) are free of pollutants during the actual traction. Here the emissions are generated at an earlier stage in the chain, during provision of the secondary energy, i.e. of the electric power.

If one were to compare only the direct emissions of such systems, the electrically powered transport systems would always be considered environmentally sounder. However, this need not be the case if the indirect transmissions in the "prechain", i.e. in the power station and the electricity distribution, are taken into account as well.

There is also a prechain for fuel-powered means of conveyance (lorry, car, diesel-powered railways, ships, aircraft) in which – comparatively slight – emissions occur, i.e. the refinery for providing refined mineral oil products. A serious comparison of the environmental influences of different means of conveyance is only possible if these prechains are considered too.

This consideration of the prechains represents a difficult task for a company wishing to balance the environmental influences of its transport operations. In addition to the actual consumption and emission data of the means of conveyance, emission data from power stations, refineries etc. are also required.

To put it briefly

- If possible always take the indirect environmental influences from the prechain into account.

That is why the values of the means of conveyance are frequently already stated including the indirect emissions in the prechain (cf. Fig. 2). In this Guide too, many emission factors are stated "incl. prechain". However for non-experts these different reference systems can cause great confusion and lead to incorrect calculations. They should therefore be used very carefully.

In some cases it is possible to do without the "prechain". The essential effects are then caused e.g. by the direct emissions of the vehicles. For instance the prechain is relatively insignificant for questions of emission reduction by means of new engine or pollutant reduction concepts. Here it is sufficient to work solely with the direct emissions or with other quantities that are easy to survey.

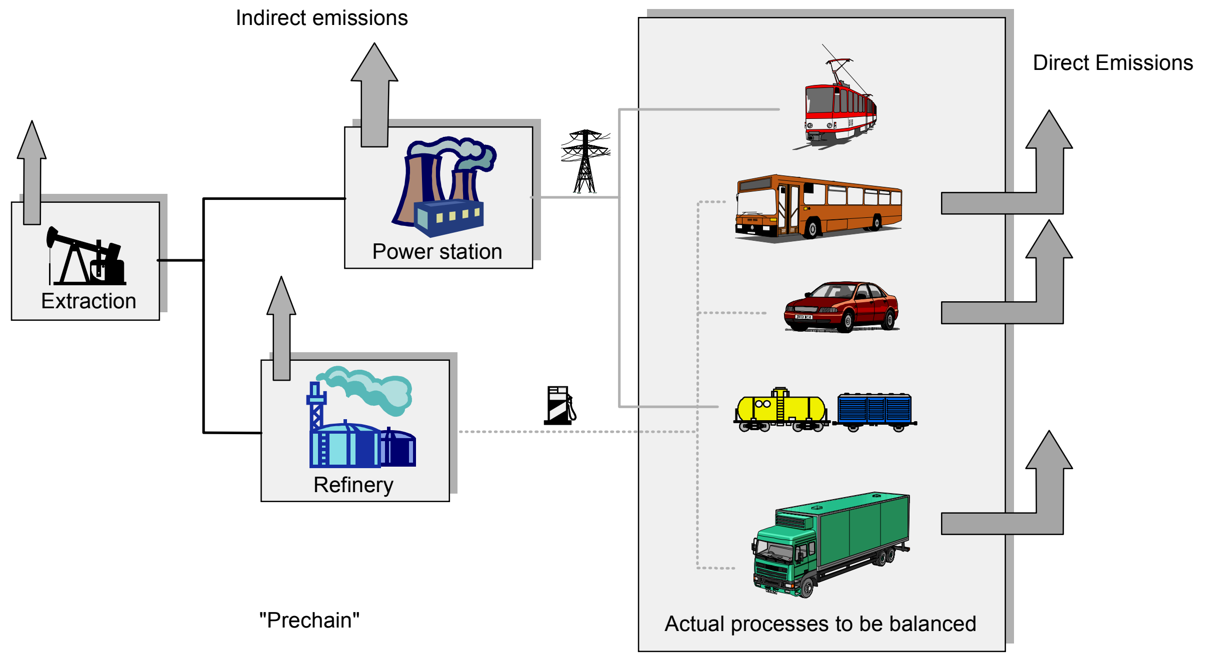


Fig. 8: Diagram of the balancing of direct emissions in transport operations and indirect emissions in the prechain.

Which environmental influences are to be balanced?

The EMAS Regulation requires assessment of all important environmental issues or – in the new draft – a description of the significant environmental influences. It must be decided from case to case what environmental issues are relevant for the company. This also depends critically on the local situation. For example delivery traffic – although it is to be considered as slight regarding the emission quantities – may be very environmentally relevant if neighbouring residential areas are impaired by noise pollution. The company must deal with these special environmental aspects and review whether it is possible to relieve the burden on the environment.

Furthermore, a company should orient itself to the catalogue of environmental influences of traffic which enjoy a high priority in social terms too. The draft of an environmental policy key programme of the Federal Ministry of the Environment of 1998 can serve as a reference here. In the "Environmental barometer Germany" key indicators and environmental objectives are stated for six environmental areas (see right).

These objectives at national level can be partly transferred to the company-specific level. A central indicator for the environmental influences of traffic is formed by the CO_2-emissions. The emissions of NO_x and VOC are also important. The pollutants SO_2 and NH_3 are quantitatively insignificant as regards transport.

For the sectors Land and Nature a company can show its land requirement and the increase in land. Traffic is taken into account via the parking space. However, vehicular traffic also needs land outside the site. An indirect indicator for this would be the vehicle km travelled (in car-km or lorry-km per year), caused by the company.

The water sector has no significance for traffic. However, the resource sector is relevant for traffic due to energy consumption. Presentation of money-valued productivities for traffic proves to be difficult, though.

✓ **CHECK**

- Does the noise pollution caused by traffic at the site play a special role for local residents?
- Does the traffic connected with the company lead to an unusually high land requirement, for instance due to large parking areas or handling facilities?

Environmental barometer: Climate

The annual CO_2-emissions serve as an indicator. By the year 2005 these emissions are to be reduced by 25 % by comparison with the 1990 status.

Environmental barometer: Air

Sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3) and volatile organic compounds (VOC) serve as indicators. A reduction by 70 % compared with 1990 is aimed at by 2010.

Environmental barometer: Land

The daily increase in land for settlement and traffic in Germany serves as an indicator. In 1997 the value was 106 hectares/d. By 2020 this increase is to be reduced to 30 hectares per day, i.e. by more than 70 %.

Environmental barometer: Nature

The ecological priority areas serve as an indicator. By the year 2020 altogether 10-15 % of the non-settled area existing in 1998 is to be secured as ecological priority areas. The current value is about 5 %.

Environmental barometer: Water

The proportion of flowing water with chemical quality class II for AOX and total nitrogen was selected as indicator. A figure of 100 % by 2020 is aimed at.

Environmental barometer: Resources

The energy and raw material productivity (=Gross Domestic Product / energy or raw material consumption) were selected as indicators. These values are expected to rise to 2.5 times the values in the year 1993 by 2020.

Orientation to the controlling process

When carrying out such investigations be careful not to lose sight of the actual purpose. On the one hand this is to determine the relevant environmental influences. This can be achieved by a single quantitative inventory and a qualitative assessment. On the other hand the Eco-Audit stands under the motto of "continuous improvement of protection of the environment by the company".

Measures are necessary for this improvement process. You must identify the possible measures. And finally the success of the measure must be checked and if appropriate measured against preselected objectives.

It is for this specific purpose that you need the quantitative information. That is why balances are drawn up. The surveys must be so precise and comprehensive that the result of the measure is measurable and can be substantiated for instance in the next environmental statement by a reduction in emissions. Consequently it must be possible to update the balances and they must comply with certain systematics. The basic data of the balance must originate from your company.

It is presumed here that measures are possible and that your company can initiate them. Thus within the framework of the management system there should be possibilities for influencing the company's traffic and transport. Only then does the improvement process actually have a chance. Only then does a detailed balancing system make sense.

Balancing the scope for action

This solves the problem of the boundary limits of the balance for traffic in a pragmatic fashion. The "limits of action" of your company are selected as "boundary limits of the balance". These definitely include your own works traffic. If your company has substantial influence on its suppliers, the delivery of raw materials is included. If products are delivered to customers via forwarders and if nothing can be changed here for reasons of cost, distribution is not recorded. However, if your company can bring influ-

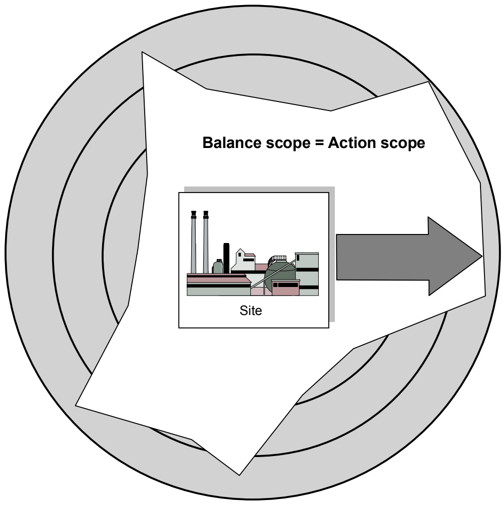


Fig. 9: The company balances the traffic up to the lim-

ence to bear on what vehicles the forwarder uses and whether these comply with the new exhaust regulations, distribution should be taken into account.

Despite all pragmatism, however, you must retain the boundary limits and nature of balancing once you have selected it. Otherwise the balances drawn up each year cannot be compared with one another. Improvements would not be clearly visible. That is why it is very important to consider carefully at the beginning what is to be included in the balance.

To put it briefly

- Identify and assess the relevant environmental influences due to the company's traffic.
- Check what traffic sectors the company can influence.
- Introduce a regular and systematic traffic eco-balance.
- Retain boundary limits of the balance in the following years.
- Balance in as much detail as necessary to be able to represent the success of measures.
- Balance as simply as possible and restrict yourself to those areas that can be influenced by the company.

Indicators and ratios – for what?

The requirements made of an environmental management system stipulate at least two tasks that have to be fulfilled:

- identify and quantify the company's traffic-related environmental influences,
- support the continuous improvement process with data.

It is advisable to proceed separately here and to select differing indicators or ratios. In the following a fundamental distinction is made between the task of impact assessment and controlling support.

Impact and relevance - assessment

This serves to ascertain what environmental influences are caused by the company's traffic and whether these are relevant. The environmental barometer (see page 16) can be taken as a guide for the environmental sectors selected. Appropriate indicators for the description would then be:

- Vehicle km travelled in lorry-km and/or pers.-km
- CO_2-emissions
- NO_x-emissions
- VOC-emissions
- local demand for areas constructed for traffic

Some of these indicators can also be considered as a reference for other environmental influences of traffic which are difficult to quantify. For instance, noise pollution increases in a first approximation with the vehicle km travelled.

The calculation will roughly assume all-in values and estimates. Precise computations can follow when you have ascertained that this environmental sector is relevant and your company can bring influence to bear here too. Only then does the question arise as to where the emissions originate from in detail, i.e. from what means of conveyance, for what transport purposes, what actors are involved.

Indicators for relevance...

The relevance for the company can be attached to a variety of matters. First of all the question arises as to whether the traffic makes e.g. any notable contribution at all to the CO_2-emissions of the company. If this is not the case, reduction measures should preferably be oriented to production, provision of energy etc. This aspect can be checked on the basis of percentage ratios. How many per cent do e.g. the traffic-related CO_2-emissions account for in the total emissions of the company?

Secondly you can check whether your company's contribution to the relevant environmental influence in Germany is important. How much NO_x does e.g. the company's traffic release by comparison with NO_x-emissions in Germany?

Naturally this contribution will always be small by comparison, so that the results are not very illustrative. That is why the eco-balance theory includes the mean value per inhabitant (MVI) approach. How much NO_x is emitted in Germany per inhabitant and year? The NO_x value of the company is divided by this MVI. This value provides e.g. information about whether a company makes a large contribution to the relevant environmental pollution or not.

FOR EXAMPLE: NO_x-MVI

In 1996 altogether 1.86 mill. t NO_x were emitted in Germany. That is equivalent to 22.7 kg NO_x per inhabitant. The MVI of NO_x is 22.7 kg.

The company Anyfirm Ltd. causes about 7.5 t NOx-emissions a year due to delivery transport of raw materials, distribution of products and staff traffic. The other NOx-emissions of the company are negligible. This value corresponds to 330 mean value per inhabitant units, i.e. Anyfirm Ltd. emits as much NO_x as 330 average inhabitants in Germany. For Anyfirm Ltd., with a workforce of 80 persons and a comparatively low level of merchandise production, this is a relatively high value.

... and for controlling

The ratios formed for the appraisal of impact and relevance need not necessarily be suitable for demonstrating the continuous process of improvement. What is important here is to have indicators and ratios that support the decision-making process in a target-oriented manner, can be surveyed easily and regularly, and illustrate the real development in the company.

For this reason possible fields of action for the traffic of a company are compiled on the following pages. A distinction should be made between freight traffic and passenger traffic on the one hand, and responsibility for the transport on the other.

For almost every action different actors or partners within and outside the company have to be addressed. In the final analysis there must be a ratio for these actors to monitor the results achieved. The ratio should therefore be simple and as closely oriented to the question involved as possible.

Pay attention to details...

A company wants to reduce its traffic emissions by changing over to the latest models in its vehicle fleet. Only lorries complying with the EURO III-Standard or higher are to be procured. This results especially in emission reductions for nitrogen oxides and diesel particles.

The emissions are calculated on a fuel-related basis as the consumption quantities are known from the fuel filling records. The emissions are calculated with emission factors in g NOx per kg diesel fuel, which were taken from a publication.

However, the reduction effect resulting from the new vehicles is not mapped at all since the emission factors in this case do not make distinctions on the basis of the EURO-Standard. The calculated emissions remain constant – with the same diesel consumption. A percentage entry stating how many lorries belonging to the company are subject to the new standards would be more informative here. Or else more detailed emission factors must be used.

FOR EXAMPLE: "Juice" Rally for lorry drivers

Driving smoothly and at low engine speeds leads to lower fuel consumption and thus also to lower emissions. This applies for both passenger and road freight traffic. Individual investigations document the fact that appropriate regular coaching in a company can lead to reductions in CO_2-emissions of up to 10 %.

However, the CO_2-emissions should not be used as a ratio. It would be too costly to calculate these for the various vehicles or drivers. Instead, the mean fuel consumption values of the individual drivers are compared on the basis of fuel filling records.

Getränke-Wüllner Bielefeld...

Such a system has been implemented by the firm Getränke Wüllner GmbH & Co. KG in Bielefeld. The company runs a mineral water spring (Carolinenbrunnen) and a beverage wholesale business and employs a staff of altogether approx. 400. The company delivers about 800 beverage products to customers, partly with its own fleet and partly via the forwarder Spedition Krumme, which is located in the company yard, as well as partly with other subcontractors. All vehicles fill up at the company's own filling station. About 1.2 mill. litres diesel fuel are used each year. The vehicles are filled with a filling card system, which enters the number of the vehicle and the number of the driver.

The data are analysed monthly within the context of the fleet controlling in an Excel file and form the basis for the "Juice Rally". Each driver is notified of his mean consumption rates. It was ascertained that poor driving can lead to an increase in fuel consumption of 10-15 %. The objective of the action was to reduce the consumption of the 40-t lorries to below 35 l/100 km. Drivers who reduce consumption over 6 months are given a voucher (value approx. 100 DM). Wüllner spends altogether approx. 1000 DM per year on this. At the same time meetings of the drivers are held 2 – 3 times a year to discuss driving behaviour and to strengthen environmental awareness.

Sources: CO_2-Minderungsstudie Verkehr Grossraum Hannover; Wüllner GmbH & Co. KG Bielefeld

Possible fields of action

Field of action		Cooperation/ contact person		Possible indicators, ratios for monitoring results
FREIGHT TRAFFIC				
Transport under the company's responsibility				
Training of drivers	➔	Logistics, personnel department	➔	Analysis of fuel filling records by driver
Use of newest, low-pollutant and low-noise vehicle technology	➔	Vehicle fleet/ logistics, workshop	➔	Share of vehicles with EURO I/II/III etc.; emissions
Improvement of load factors, avoidance of unladen runs	➔	Logistics, distribution	➔	Load factors
Improvement of the logistic concepts	➔	Logistics, distribution	➔	Load factors; vehicle km travelled
Diversion to environmentally sound means of conveyance	➔	Logistics, distribution, possibly purchasing	➔	Modal Split (freight traffic.); emissions (w. prechain)
Transport under external responsibility				
Packaging of orders or deliveries for better loading; review of necessary delivery periods	➔	Purchasing, distribution, suppliers, customers	➔	Vehicle km travelled; emissions
Influencing suppliers and forwarders as regards vehicle technology and means of conveyance	➔	Purchasing, distribution, suppliers, forwarders	➔	Share of vehicles with EURO I/II/III etc.; emissions
Selection of suppliers and preproducts with consideration given to transport distance	➔	Purchasing, suppliers	➔	Distances; transport performance
Fundamental options				
Site location to avoid traffic, oriented to markets and sources of raw materials	➔	Management, purchasing, distribution	➔	Transport performance
Reduction of product weight with same benefit	➔	Product development	➔	Transport volume; transport performance
Reduction of raw material inputs, avoidance of residues	➔	Production planning, controlling	➔	Transport volume; transport performance; waste quotas
PASSENGER TRAFFIC				
Improvement of public transport offers for staff and customers	➔	Personnel department, staff representatives	➔	No. of Job-Ticket or similar; modal split (pers. traffic.); emissions (w. prechain)
Parking space management	➔	Personnel department, Controlling	➔	Parking space
Preference given to rail for official travel	➔	Personnel department	➔	Modal split (pers. traffic); no. of short distance flights

These are the essential modules for the "Environmental Management System Traffic". First of all a simple impact and relevance appraisal is carried out. This indicates whether traffic is an important action sector for the company and whether measures should be taken

You should then clarify what action sectors can lead to a suitable reduction of the traffic-related environmental influences and whether your company can initiate these measures.

In order to support and control these measures detailed balances and specially developed ratios can be introduced, that are updated regularly.

The action-oriented indicators and ratios serve to monitor the improvement process. The impact-oriented indicators improve the balance of the environmental influences and ideally also map the results of the measures.

The degree of detail in which you differentiate the data in such a detailed balance depends not least on the data situation in the company and the work involved by this. The basic data for a relevance appraisal and for the detailed balance are set out in the following chapters.

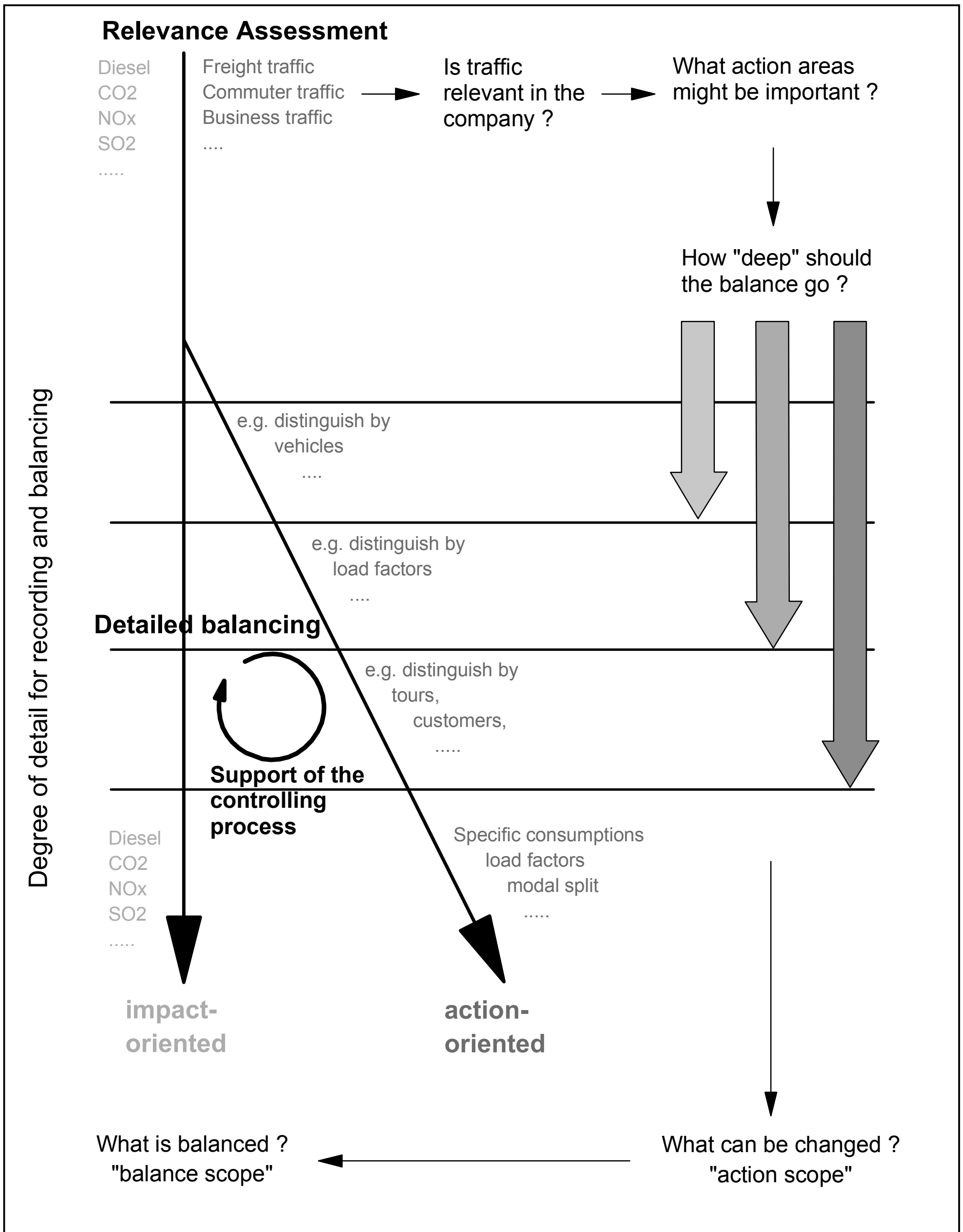


Fig. 10: Procedure for balancing the environmental influences of a company's traffic

3. Impact and relevance assessment

The procedure presented for the impact and relevance assessment serves as a start to balancing. It is intended to provide you with orientation for ascertaining whether the company's traffic leads relevant environmental influences and your company should pay more attention to appropriate measures. The calculations are therefore "quick and dirty". This must be taken into account when using the given basic data for other purposes.

Freight transport

In order to obtain an overview of what transport the company causes at all, you should start from an Input-/Output balance of the company. What goes into the company, what comes out of it? The quantities for this in kg or t are generally surveyed within the scope of the first environmental review in any case.

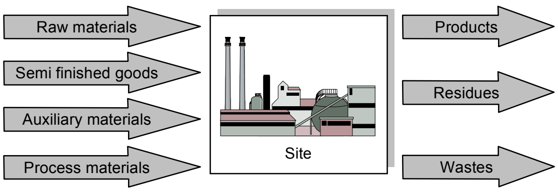


Fig. 11: Die Input-/Output balance of the site serves as a context for assessing the relevance.

However, additional information is now required. Where do these material flows actually come from? What is the distance from the supplier? Where do the products go to? What is the average distribution distance? And finally, what means of conveyance are generally used, or how is the transport split between lorry, rail, aircraft etc.?

You can spend a great deal of time on answering these questions "exactly". However, you can also try to assess the answers roughly. Most raw materials are generally purchased from a handful of suppliers. The Purchasing Department knows the distance, at least roughly. Otherwise use an atlas or travel route software. If the distance is several hundred km, it does not matter if the figure is say 50 km out.

The question of where to start and finish when calculating the distance often presents difficulties. What do you do if intermediate dealers are involved? You should be guided by where the raw materials actually come from, or where the products go to for further processing or consumption. In the detailed balance you can then address the question of how far to balance, i.e. how far the company's scope for action extends.

The share of materials conveyed by road, rail etc. should also be roughly assessed. For example: 30 % by rail and 60 % by road and 10 % by air. Transport by rail, air and ship is generally intermodal transport, i.e. you will have to take into account road transport at each end. This is insignificant for this first appraisal. The figures for the transport mode in the main transport leg are sufficient here.

Pay attention to details...

Many computer programs from the Purchasing or Distribution sectors already supply lists of annual distribution quantities, purchased quantities etc.

Some of these programs also contain the distances from the suppliers. If you want a summary analysis for all raw materials, the following often happens in practice:

Raw material1	2,345 t	234 km
Raw material2	540 t	87 km
Raw material3	1,230 t	673 km
...		
Total	4,115 t	994 km

This distance information is worthless. In particular the transport performed does NOT result from the product of 4,115 t and 994 km! Instead the individual items have to be multiplied and THEN added.

Such an analysis can be carried out with most computer programs. If appropriate you need the help of your computer department. However, this will save you a lot of work and manual calculations.

☞TIP

- Talk to your colleagues in the Purchasing and Distribution Departments and ask them about their experience. What means of conveyance are generally used? Where do the raw materials come from? Where do the products go to? Who disposes of the wastes and where? Even if your company is not directly responsible for the transport, this information is generally available somewhere.

The transport performance in tkm is calculated from the quantities in t and the transport distances in km. The calculation can be carried out in accordance with the prepared form on page 25.

The transport performance is broken down into the most important transport modes and the individual items in the Input-/Output balance. This facilitates the subsequent analysis of where the largest contributions come from.

With the transport performance figures it is then possible to roughly calculate the emissions caused by the individual transport modes. For this the calculated tkm are multiplied with the factors from Tab. 3. These values are stated in g per tkm. The result must then be converted into kg or t if appropriate.

This calculation has been prepared as an example in the form on page 25. You only need to enter the estimated figures or the calculated intermediate results in the grey fields.

Tab. 3: Emission factors in g per tkm for various freight transport modes including supply of fuel or energy (= Prechain). Source: TREMOD 1999; Borken et al. (1999).

Pollutant	Lorry	Rail	Aircraft	Barge	Sea Ship
CO_2	147.3	32.2	903	35.4	17.5
NO_x	1.21	0.12	4.24	0.61	0.42
NMVOC	0.17	0.01	0.50	0.05	0.02
Particulate	0.050	0.005	0.13	0.017	0.030
CO	0.23	0.04	0.97	0.11	0.046

Note.: Lorry: mean of vehicle fleet as of year 2000; Rail: intermodal transport; Aircraft: long-distance flights; Sea-going Ship: general cargo freighter.

FOR EXAMPLE: Oberland-Glas AG in Bad Wurzach

Oberland Glas AG is one of the leading manufacturers of container glass in Germany. The company employs just under 2000 persons and has an annual turnover of DM 670 mill. It has altogether 4 sites, including Bad Wurzach in Baden-Württemberg with 2 plants.

The most important "raw material" for container glass production is recycled glass. If one asks where this recycled glass comes from, the answer is easy: from the lot next door. This is the seat of the recycling firm Süddeutsche Altglas Rohstoff GmbH (SAG), which is a subsidiary of Oberland Glas AG. SAG recycles the waste glass collected in the South German region. For this the waste glass is broken and cleaned of impurities in two plants with a performance of 900 t per day

For the transport balance of the glassworks it is naturally useless in this case to enter just 50 metres as transport distance for the raw material. SAG investigated where the waste glass comes from. Depending on the collection point the waste glass is transported directly to SAG on lorries (from within a radius of about 100-150 km) or it is trans-loaded at intermediate depots. In major conurbations in Baden-Württemberg and Bavaria decentral intermediate stores with rail connections have developed in cooperation with disposal firms too. This makes it possible to use high-capacity goods wagons for delivering the waste glass. However, about 90 % of the waste glass is still delivered by lorry.

Tab. 4: Form for rough calculation of the annual freight transport performance and the associated CO_2-emissions by different transport modes. Values from Tab. 3

Goods ↓	Quantity ↓		Distance ↓		Transport performance ↓		Emission factor for CO_2 ↓	Emission-quantity of CO_2 ↓	
ANNUAL TRANSPORT OPERATIONS BY LORRY:									
Raw materials		t/a *		km =		tkm/a	* 0.147 kg/tkm =		kg/a
					+			+	
Fuels etc.		t/a *		km =		tkm/a	* 0.147 kg/tkm =		kg/a
					+			+	
Auxiliary materials		t/a *		km =		tkm/a	* 0.147 kg/tkm =		kg/a
					+			+	
Products		t/a *		km =		tkm/a	* 0.147 kg/tkm =		kg/a
					+			+	
Residues		t/a *		km =		tkm/a	* 0.147 kg/tkm =		kg/a
					=			+	
Annual transport performance by lorry:						tkm/a			
					÷ 9 t =				
Estimated annual km driven by lorry:						Lorry-km/a			
ANNUAL TRANSPORT OPERATIONS BY RAIL:									
Raw materials		t/a *		km =		tkm/a	* 0.032 kg/tkm =		kg/a
					+			+	
Fuels etc.		t/a *		km =		tkm/a	* 0.032 kg/tkm =		kg/a
					+			+	
Auxiliary materials		t/a *		km =		tkm/a	* 0.032 kg/tkm =		kg/a
					+			+	
Products		t/a *		km =		tkm/a	* 0.032 kg/tkm =		kg/a
					+			+	
Residues		t/a *		km =		tkm/a	* 0.032 kg/tkm =		kg/a
					=			+	
Annual transport performance by rail:						tkm/a			
ANNUAL TRANSPORT OPERATIONS BY AIRCRAFT:									
Raw materials		t/a *		km =		tkm/a	* 0.90 kg/tkm =		kg/a
					+			+	
Fuels etc.		t/a *		km =		tkm/a	* 0.90 kg/tkm =		kg/a
					+			+	
Auxiliary materials		t/a *		km =		tkm/a	* 0.90 kg/tkm =		kg/a
					+			+	
Products		t/a *		km =		tkm/a	* 0.90 kg/tkm =		kg/a
					=			=	
Annual transport performance by aircraft:						tkm/a			kg/a
								÷ 1000 =	
							Total CO_2:		t/a

Tab. 5: Form for rough calculation of the annual NO_x-emissions by different transport modes. The required transport performance is transferred from the preceding table. Values from Tab.3

Goods ↓	Transport performance ↓		Emission factor for NO_x ↓	Emission-quantity of NO_x ↓	
ANNUAL TRANSPORT OPERATIONS BY LORRY:					
Raw materials		tkm/a	* 1.21 g/tkm =		g/a
				+	
Fuels etc.		tkm/a	* 1.21 g/tkm =		g/a
				+	
Auxiliary materials		tkm/a	* 1.21 g/tkm =		g/a
				+	
Products		tkm/a	* 1.21 g/tkm =		g/a
				+	
Residues		tkm/a	* 1.21 g/tkm =		g/a
				+	
ANNUAL TRANSPORT OPERATIONS BY RAIL:					
Raw materials		tkm/a	* 0.12 g/tkm =		g/a
				+	
Fuels etc.		tkm/a	* 0.12 g/tkm =		g/a
				+	
Auxiliary materials		tkm/a	* 0.12 g/tkm =		g/a
				+	
Products		tkm/a	* 0.12 g/tkm =		g/a
				+	
Residues		tkm/a	* 0.12 g/tkm =		g/a
				+	
ANNUAL TRANSPORT OPERATIONS BY AIRCRAFT:					
Raw materials		tkm/a	* 4.24 g/tkm =		g/a
				+	
Fuels etc.		tkm/a	* 4.24 g/tkm =		g/a
				+	
Auxiliary materials		tkm/a	* 4.24 g/tkm =		g/a
				+	
Products		tkm/a	* 4.24 g/tkm =		g/a
				=	
					g/a
				÷ 1000 =	
			Total NO_x:		kg/a

Passenger transport

It is more difficult to assess passenger transport. How many customers or visitors come per day on average, and where do they come from? For some companies this will be insignificant. However, for service companies or wholesalers/retailers this is important.

Here too the rule applies – assess the values roughly. Commuter traffic can be ascertained from the number of staff and the approximate catchment area. The Personnel Department can generally supply appropriate information. In addition the approximate split between the different transport modes is stated. The number and regular occupancy of the car parks is, by the way, an indication of how many staff come to work by car.

The number, distance and transport mode must also be estimated for customer visits. In some companies the works security team has suitable information or can provide empirical values.

Tab. 6: Emission factors in g per pers.-km for various passenger transport modes including supply of fuel or energy (= Prechain). Source: TREMOD 1999

Pollutant	Car	Rail	Aircraft
CO_2	159.2	45.0	207.1
NO_x	0.38	0.13	0.83
NMVOC	0.32	0.01	0.06
Particulates	0.01	0.03	0.003
CO	2.69	0.04	1.33

Note: Car: 1.3 pers./car, stocks as of year 2000; Rail: long-distance traffic; Aircraft: short-distance flight.

Information on official travel or business travel traffic is more problematical. Here you will have to fall back on the experience of the Personnel Department. Basically all official travel is recorded, but simply on a cost basis. Details of the transport mode selected or the distance are very rare. Only a rough estimate helps here. If official travel proves to be relevant, you may need an assistant to analyse the travel expense sheets.

Tab. 7: Emission factors in g per pers.-km for various passenger transport modes in local traffic including supply of fuel or energy (= Prechain). Source: TREMOD 1999

Pollutant	Car	Rail	Fixed route bus	Tram/light rail rapid transit
CO_2	198	118	80.1	72.5
NO_x	0.41	0.66	0.93	0.05
NMVOC	0.72	0.05	0.11	< 0.01
Particulates	0.01	0.04	0.03	-
CO	4.6	0.16	0.31	0.02

Note: Car: 1.3 pers./car, stocks as of year 2000; Rail: local traffic

For passenger transport the annual traffic determined. This can then be aggregated to annual emissions with the emission factors compiled in Tab. 6 and Tab. 7. The forms drawn up on the following pages can serve as a reference here.

FOR EXAMPLE: Wilkhahn

The medium-sized firm Wilkhahn in Bad Münder produces quality office furniture. The company has been conducting an eco-balance regularly since 1993 in which all Input and Output flows are recorded. The fuel consumption for business trips by car is ascertained via fuel invoices.

For the other business travel the Controlling Department draws up an Excel-List from the SAP-System containing travel expenses, flights and rail travel. Parking fees, accommodation and the like must be cancelled.

A distinction is then made between domestic flights, European flights and overseas flights, as well as domestic rail travel and foreign rail travel. Average prices per air-km and rail-km are ascertained, taking into account discount arrangements for the company. With these average prices the approximate distances travelled can be derived from the travel costs listed.

Tab. 8: Form for rough calculation of the annual passenger transport volume and the associated CO_2-emissions from different transport modes. For medium distances enter the single distances.

Transport mode ↓	No, of persons ↓		medium distance ↓		Return workday ↓	Passenger transport volume ↓	Emission factor for CO_2 ↓	Emission quantity of CO_2 ↓	
COMMUTER TRAFFIC:									
Car		P. *		km/d	* 2 * 200 d/a =		* 0,198 kg/Pkm =		kg/a
								+	
Rail (local)		P. *		km/d	* 2 * 200 d/a =		* 0,118 kg/Pkm =		kg/a
								+	
Fixed route bus		P. *		km/d	* 2 * 200 d/a =		* 0,080 kg/Pkm =		kg/a
								+	
Tram		P. *		km/d	* 2 * 200 d/a =		* 0,073 kg/Pkm =		kg/a
								+	
CUSTOMER TRAFFIC (LOCAL):									
Car		P./d *		km	* 2 * 250 d/a =		* 0,198 kg/Pkm =		kg/a
								+	
Rail (local)		P./d *		km	* 2 * 250 d/a =		* 0,118 kg/Pkm =		kg/a
								+	
Fixed route bus		P./d *		km	* 2 * 250 d/a =		* 0,080 kg/Pkm =		kg/a
								+	
Tram		P./d *		km	* 2 * 250 d/a =		* 0,073 kg/Pkm =		kg/a
								+	
BUSINESS TRAVEL:									
Car		P./a *		km	* 2 =		* 0,159 kg/Pkm =		kg/a
								+	
Rail (long dis.)		P./a *		km	* 2 =		* 0,045 kg/Pkm =		kg/a
								+	
Aircraft		P./a *		km	* 2 =		* 0,207 kg/Pkm =		kg/a
								+	
VISITOR TRAFFIC (LONG DISTANCE):									
Car		P./d *		km	* 2 * 250 d/a =		* 0,159 kg/Pkm =		kg/a
								+	
Rail (long dis.)		P./d *		km	* 2 * 250 d/a =		* 0,045 kg/Pkm =		kg/a
								+	
Aircraft		P./d *		km	* 2 * 250 d/a =		* 0,207 kg/Pkm =		kg/a
								÷ 1000 =	
							Total CO_2:		t/a

Tab. 9: Form for rough calculation of the annual NO_x-emissions by different transport modes. The required transport performance is transferred from the preceding table.

Transport mode ↓	Passenger transport volume ↓	Emission factor for NO_x ↓	Emission quantity of NO_x ↓	
COMMUTER TRAFFIC:				
Car		* 0.41 g/Pkm =		g/a
			+	
Rail (local)		* 0.66 g/Pkm =		g/a
			+	
Fix route bus		* 0.93 g/Pkm =		g/a
			+	
Tram		* 0.05 g/Pkm =		g/a
			+	
CUSTOMER TRAFFIC (LOCAL):				
Car		* 0.41 g/Pkm =		g/a
			+	
Rail (local)		* 0.66 g/Pkm =		g/a
			+	
Fix route bus		* 0.93 g/Pkm =		g/a
			+	
Tram		* 0.05 g/Pkm =		g/a
			+	
BUSINESS TRAVEL:				
Car		* 0.38 g/Pkm =		g/a
			+	
Rail (long dis.)		* 0.13 g/Pkm =		g/a
			+	
Aircraft		* 0.83 g/Pkm =		g/a
			+	
VISITOR TRAFFIC (LONG DISTANCE):				
Car		* 0.38 g/Pkm =		g/a
			+	
Rail (long dis.)		* 0.13 g/Pkm =		g/a
			+	
Aircraft		* 0.83 g/Pkm =		g/a
			÷ 1000 =	
		Total NO_x:		kg/a

Indicators

The results for freight transport and passenger transport can now be aggregated. The values for the relevant pollutant emissions caused by freight and passenger transport are entered and added in the following schema. The value is then divided by the total quantity of emissions. This results from the transport emissions and the emissions from production, supply of energy etc. The latter values should be known from the environmental review.

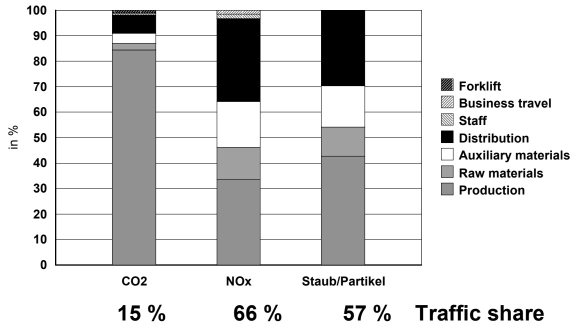
The result is ultimately the percentage share of transport in the relevant emissions caused by the company. The calculation is repeated for each pollutant.

Tab. 10: Calculation schema for determining the percentage share of transport emissions in the total emissions of the company, taking CO_2 as an example.

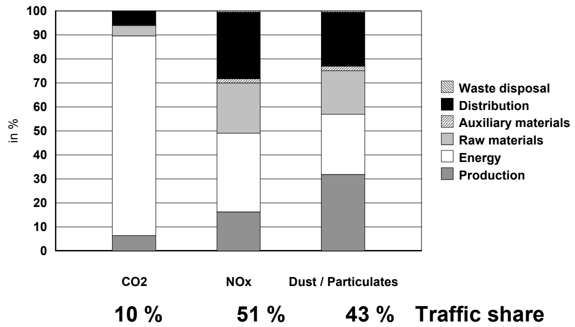
Freight transport				$t\ CO_2/a$	
			+		
Passenger transport				$t\ CO_2/a$	
			=		
Total transport				$t\ CO_2/a$	
			÷		
Emissions (total)	(		+		$t\ CO_2/a$)
		Transport (s. above)		Prod. + Energy	
			=		
			÷ 100 =		
Percentage share of transport:				%	

You can of course carry out this analysis more precisely. In Fig. 12 the shares of the emission-causing sectors in the total emissions of the relevant company are shown for four different types of company/ organisation. The shares can differ widely depending on what the company produces. Taking CO_2 as an example one can see that the contribution by transport can fluctuate between 3 % and 28 %. If the contribution is slight, it is better to orient CO_2-reduction strategies to production or to the provision of energy for the company.

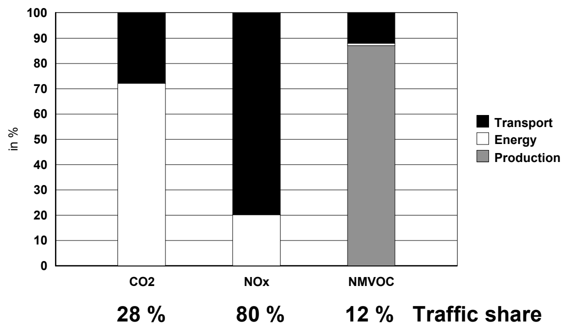
Manufacturing company (bulk goods):



Manufacturing company (bulk goods):



SME from manufacturing industry:



Public authorities / service companies:

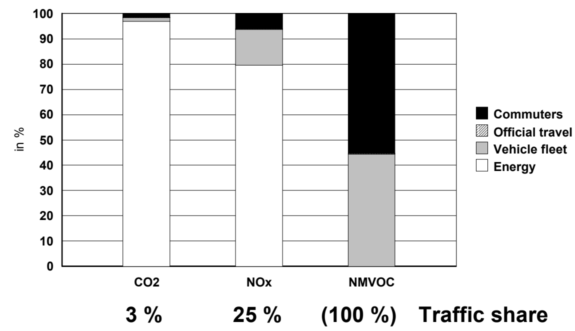


Fig. 12: Four examples of relevance analyses: shares of company sectors in the pollutant emissions (T=Transport)

The examples in Fig. 12 show that the transport-related shares in the same company can vary depending on which pollutant is considered. Thus, for instance, in the second company transport-related CO_2 accounts for only 10 % of the company's total CO_2-emissions, but the transport-related NO_x share makes up more than half the total.

This finding should have impacts on the environmental programme. If the NO_x-emissions of this company are to be reduced, one must certainly start in the transport sector. It is possible that the measures are needed to reduce the NO_x differ from those needed to reduce CO_2-emissions.

The various contributions calculated with Tab. 4-5 and 8-9 now serve to ascertain which transport sector causes the high shares. In the example cited this is transport for distribution and raw materials. It should be reviewed here what possibilities the company has for influencing the transport of raw materials and transport for distribution. If influence can be exerted, these sectors should be considered with more exact figures in the detailed balance. The transport of auxiliary materials, wastes or even business travel can be left out of consideration in this example in future, which saves a considerable amount of work.

By contrast the transport of the auxiliary materials is an even more important aspect for the first company in Fig. 12 than the transport of raw materials. In this company an analysis of the raw materials will be important, reviewing where they come from and how they are delivered.

☞TIP

- Enter a column with the percentage contributions of the individual transport sectors to the total pollutant emissions on the right next to Tab. 3 and 4. This will give you an immediate overview showing you where to start.

Other environmental influences

In the impact and relevance assessment do not forget to ask whether there are other environmental influences caused by the traffic of the company too. For example, what parking or goods-handling space is available to the company and how does the company use it? If there are large parking areas, are they all paved? Does special noise pollution occur and are there complaints from local residents?

If this – often also qualitative – discussion leads to relevant results, measures for the environmental management must be derived from it. For the detailed balance it should then be considered what quantitative support can be provided for the action sector.

Mean values per inhabitant

The question as to whether an environmental influence caused by a company is relevant can hardly be answered in general terms or be tied to general criteria. Starting with Fig. 12 it would be a good idea to define thresholds for the percentage contributions of transport above which measures are to be recommended.

One possibility would be: if individual transport-related pollutant-emissions account for 30 %, measures should be examined. If the level of 30 % is exceeded for all pollutants, measures should definitely be initiated.

The problem: percentage observations say nothing about how the absolute quantity of the emitted pollutant is to be evaluated.

This question cannot be answered in general terms either. The mean values per inhabitant (MVI) already mentioned provide a further aid for interpretation here. For example a small company can emit just as much NMVOC as 1000 inhabitants – which might appear to be a lot and should be checked. For the site of a large chemical group this MVI would probably be unspectacular.

Tab. 11: Calculation schema for creating mean values per inhabitant, taking CO_2 as an example

Total emissions		t CO_2/a
	÷	
Value per inhabitant for CO_2 from Tab. 12	11,1	t CO_2/a
	=	
MVI value for CO_2		MVI_{CO2}

The basic data for creating the MVI are compiled in Tab 12. The following procedure should be followed. For each pollutant divide the total quantity emitted or caused by the company by the value per inhabitant from Tab. 12. The result is the MVI for the relevant pollutant, i.e. the company causes as many emissions as the corresponding number of average citizens.

Tab. 12: Basic data for creating mean values per inhabitant (MVI).

Environmental influence	Total Germany 1996	per inhabitant
CO_2-emissions	910 mill. t	11.1 t
NO_x-emissions	1.86 mill. t	22.7 kg
NMVOC-emissions	1.87 mill. t	22.8 kg
Dust emissions	0.52 mill. t	6.3 kg
SO_2-emissions	1.85 mill. t	22.6 kg
CO-emissions	6.71 mill. t	81.8 kg
Vehicle km travelled lorry + tractor unit	64 bill. vkm	780 vkm
Vehicle km travelled car + estate car	520 bill. vkm	6330 vkm
Built up area (1990)	26,716 km^2	326 m^2
Increase in area	387 km^2/a	4.7 m^2/a

Note: Inhabitants 1996: 82 mill. pers. emissions acc. to UBA 1997. vehicle km acc. to Verkehr in Zahlen 1998. Built-up area acc. to Stat. Jahrbuch 1998. Increase in area assessed acc. to Fed. Min. of the Environment 1998.

Preparing the detailed balance

With the impact and relevance assessment you know,

- whether the traffic of the company leads to relevant environmental influences and
- what environmental influences are affected by this.

The next question is what measures or measure sectors can lead to a reduction of the environmental influences and whether the company has any influence on these and can initiate this measure.

The following overview (pages 34 and 35) provides indications of what measures are expedient. The context is the objective of reducing a certain environmental influence.

The measures can essentially be put together in the following groups:

- technical measures, addressing the vehicle engineering in particular
- improvement in loading with the same traffic performance
- changeover to more environmentally sound transport modes
- reduction of the transport distances by changes in delivery relations
- reduction of transport quantities and volumes by improved products

The measure sectors affect the environmental influences to different extents. A reduction of the transport performance naturally leads to reductions of all environmental burdens or pollutants. The measure is said to have a broad-based impact. However, the potentials for this are generally limited. Technical measures generally address much more specific aspects, e.g. only particulate emissions, but are then very effective.

The reduction effects shown in Tab. 13 are only estimated.

The selection of transport mode in the company is essentially determined by the quality of the transport (punctuality, reliability, costs, security etc.). The real potential for changing a transport mode is therefore limited. For the assessment it was assumed that 50 % of the transport operations can be diverted from road or air to rail and the like. The reduction effect reflects the low influence of such a change.

Improvements in the load factor, tour planning etc. are also limited. Generally reductions of 10-20 % are considered possible here. This results in a reduction of the vehicle km travelled and of the environmental influences.

The reduction of transport distances can be influenced strongly when a company decides on a new site, but this does not happen very often. Closeness to the market and possibly to sources of raw materials and the like play a crucial role here. During ongoing operations the supplier structure can be influenced within certain limits. The closer the suppliers are, the better. Here too, reductions are integrated directly in the environmental influences. The same applies for an improvement of products in the direction of lower product weights with the same useful function.

Data structure

The company examines in which of these measure sectors possibilities exist for bringing influence to bear. For the monitoring within an environmental management system and the quantifying of results, it is relevant who is responsible for this measure – whether this person is located within the company or whether external actors (forwarders, suppliers, customers) are involved.

This question of responsibility also determines which data can be selected most expediently for a continuous surveying system:

- Data related to vehicle km travelled (lorry-km, car-km, possibly broken down by vehicle type) can practically only be surveyed within your own company. For instance the vehicle km driven by company cars can easily be evaluated via the kilometre readings and fuelling records. However, corresponding data from external actors cannot always be allocated to transport of your own merchandise. That is why data related to vehicle km driven by external actors can be problematic for a survey system.
- Transport performance-related data (t-km, pers.-km) can be ascertained in your own company with a reasonable work input from the Purchasing, Distribution and Personnel Departments, even if external actors carry out the transport. If appropriate certain supplementary surveys will be necessary among the external actors. However, this information (e.g. distances) can generally be procured since it also forms the basis for cost calculations. The transport performance-related data map a whole series of action sectors, e.g. changeover to other transport modes, and react sensitively to reductions of transport quantities and distances. However, direct links with the vehicle technology used are difficult here. Precise information is rarely available on this and is hard to survey.
- Simple balances can be drawn up on the basis of the fuel consumption. Figures are available for your own company's fleet (in the case of official travel or business trips with private cars fuelling expenses are available). The fuel consumption acts sensitively on a whole series of measures. It reflects e.g. reductions in the km travelled or improved driving behaviour. Since you are considering the fuel consumption of your *own* vehicle fleet and the company is responsible for the vehicle technology used, the influence of vehicle types, new technical reduction concepts etc. should be taken into account in the consumption figures.

In the following chapter emission factors are offered for the major pollutants and the various transport modes. Data based on vehicle km travelled are not provided. Vehicle-specific data are provided on the basis of the fuel consumption. Otherwise the figures relate to the transport performance.

Tab. 13: Overview with examples of action targets, possible measures for this and the potential reduction effects. Ratios are developed from the measures and serve either to steer the measure (action-oriented) or to examine the reduction effect (impact-oriented).

Action target	Possible measures	Possible effects	Necessary indicators ✏ impact-oriented ☞ action-oriented
Reduce particulate emissions	New lorry technology EURO 3, EURO 4/5	Over 80 % reduction	✏ Emissions with EF für lorries broken down by size and EURO 3, EURO 4/5, fuel-related, without prechain ☞ Share of new lorries with EURO 3, EURO 4/5
	Divert from road to rail	Depending on diversion potential up to 50 % reduction conceivable	✏ Emissions with EF, broken down only by means of conveyance, transport performance-related, with prechain ☞ Modal Split acc. to transport mode from transport performance
	See measures for reducing vehicle km travelled		
Reduce NMVOC-emissions	New lorry technology EURO 3, EURO 4/5	Up to 40 % reduction	✏ Emissions with EF für lorries broken down by size and EURO 3, EURO 4/5, fuel-related, without prechain ☞ Share of new lorries with EURO 3, EURO 4/5
	Divert from road to rail	Depending on diversion potential up to 50 % reduction conceivable	✏ Emissions with EF, broken down only by transport mode, transport performance-related, with prechain ☞ Modal Split acc. to transport mode from transport performance
	Divert from car to rail and public transport	Depending on diversion potential up to 80 % reduction conceivable	✏ Emissions with EF, broken down only by means of conveyance, vehicle-km-related, with prechain ☞ Modal Split acc. to transport mode from traffic generated
	See measures for reducing vehicle km travelled		
Reduce NO_x-emissions	New lorry technology EURO 3, EURO 4/5	Up to 60 % reduction	✏ Emissions with EF für lorries broken down by size and EURO 3, EURO 4/5, fuel-related, without prechain ☞ Share of new lorries with EURO 3, EURO 4/5
	Divert from road to rail	Depending on diversion potential up to 50 % reduction conceivable	✏ Emissions with EF, broken down only by transport mode, transport performance-related, with prechain ☞ Modal Split acc. to transport mode from transport performance
	Change over from car and aircraft to rail	Depending on diversion potential up to 30 % reduction conceivable	✏ Emissions with EF, broken down only by means of conveyance, vehicle-km-related, with prechain ☞ Modal Split by means of conveyance from traffic generated
	See measures for reducing vehicle km travelled		

Tab. 13 cont.: Overview with examples of action targets, possible measures for this and the potential reduction effects. Ratios are developed from the measures and serve either to steer the measure (action- oriented) or to examine the reduction effect (impact-oriented).

Action target	**Possible measures**	**Possible effects**	**Necessary indicators** ✏ impact-oriented ☞ action-oriented
Reduce CO_2-emissions	Divert from road to rail	Depending on diversion potential up to 350 % reduction conceivable	✏ Emissions with EF, broken down only by transport mode, transport performance-related, with prechain ☞ Modal Split acc. to transport mode from transport performance
	Change over from car and aircraft to rail and public transport	Depending on diversion potential up to 30 % reduction conceivable	✏ Emissions with EF, broken down only by means of conveyance, vehicle-km-related, with prechain ☞ Modal Split acc. to transport mode from traffic generated
	Change dynamics of driving	Up to 10 %	✏ Emissions with EF für lorries fuel-related, without prechain ☞ Fuel consumption
	See measures for reducing vehicle km travelled		
Reduce vehicle km travelled	Increase load factor	Can account for up to 20 %.	✏ Emissions with EF für lorries fuel-related, without prechain ☞ Fuel consumption ☞ Load factor
	Improve tour planning	Can account for up to 10 %.	✏ Emissions with EF für lorries fuel-related, without prechain ☞ Fuel consumption
	See measures for reducing transport performance		
Reduce transport performance	Reduce distances to suppliers, customers etc.	Is included in linear fashion	✏ Emissions with EF, broken down only by means of conveyance, vehicle-km-related, with prechain, or ✏ Emissions with EF für lorries fuel-related, without prechain ☞ Transport performance, or ☞ Fuel consumption
	Reduce weight of products, raw materials etc.	Is included in linear fashion	✏ Emissions with EF, broken down only by means of conveyance, vehicle-km-related, with prechain, or ✏ Emissions with EF for lorries fuel-related, without prechain ☞ Transport performance, or ☞ Fuel consumption
Reduce local noise pollution	New lorry technology		☞ Share of new lorries with noise reduction concept
	Introduce time restrictions		☞ Keep time logs
	Measures for reducing vehicle km travelled		
Reduce local land used	Parking space management		☞ Area constructed for traffic ☞ Number of job tickets etc. ☞ Modal Split

4. Detailed balance

Fundamental approach

Conduct a new *relevance assessment* every 3 years. Admittedly the absolute values calculated between the survey periods are not directly comparable with each other, since the nature of the survey, the boundary limits of the balance or the company's field of activity have probably changed. However, the assessment is sufficient to ascertain whether there have been any changes regarding the needs for action. Perhaps production of a new product has been taken up, or business divisions have been outsourced. The relative figures, the shares of the sectors, are therefore of interest.

The new assessment will serve as a signpost to you, indicating what you must pay special attention to in future in the *detailed balance*, whether you can carry on with the continuous survey in this way, whether you may have to collect additional information, or whether you should expand your balance to be able to initiate and monitor measures.

The purpose of the *detailed balance* is to provide comparable and absolute figures over periods of time. This is what you need to measure the success of measures. As far as possible the period covered by the balance and the survey method should not be changed, or only if this is vitally necessary. However you should then make it clear which values are still comparable and which are not.

Together this results in informative reporting that continuously collects only as much information as is needed, but regularly reviews the relevance of this information.

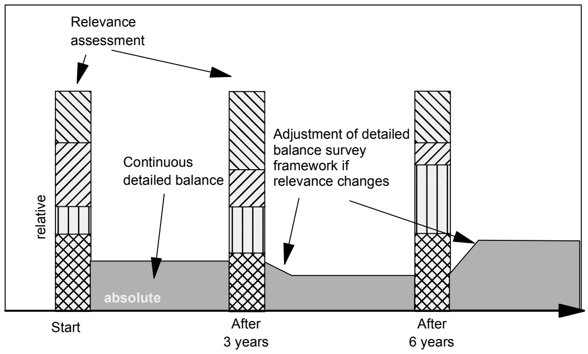


Fig. 13: Schematic example showing how the relevance assessment and detailed balance complement each other. The detailed balance is updated regularly for a shorter period covered by the balance. The relevance assessment is conducted roughly but comprehensively every 3 years in the validation cycle and serves to correct the balance framework of the detailed balance if appropriate.

FOR EXAMPLE:

The Swabian company Anyfirm Ltd. introduces an environmental management system. For this purpose a transport and emission balance is also drawn up. A first relevance assessment is carried out.

The results show that 30 % of the CO_2-emissions are caused by traffic delivering raw materials, 20 % by expendable supplies (fuels etc.) and 30 % by distribution. 10 % are caused by commuter traffic. Internal transport and business travel each account for 5 %. These two will not be considered to have priority in future and will not be included in the balance. A reduction in commuter traffic is not probable, since in view of the rural structure staff depend on their cars. It also turns out that Anyfirm Ltd. does not have any influence on the raw material deliveries. These are made by a large group with integrated logistics.

Anyfirm Ltd. therefore first concentrates on the procurement of expendable supplies and on distribution. Here precise figures relating to quantities, distances and means of conveyance are surveyed and regularly updated. By concentrating orders, runs can be saved for the expendable supplies. In the case of distribution the tour planning is optimised. The works drivers are coached regularly. The measures produce results. This can be documented in the detailed balance with the aid of the CO_2-emissions calculated.

After 3 years a new relevance assessment is conducted. In the meantime the company has been bought by a group and restructured. Distribution has been taken over by another firm. In future Anyfirm Ltd. has no more influence on distribution, even though it still accounts for 35 % of the CO_2-emissions. These surveys are therefore no longer continued in the detailed balance. However, the relevance assessment shows that business travel has now risen steeply to 20 %. This is due to the fact that Anyfirm Ltd. has taken on additional maintenance and service tasks.

For the future detailed balancing a system is being developed for recording field staff traffic continuously and for regularly awarding premiums to the staff whose traffic behaviour is thriftiest and most environmentally sound.

Consideration of noise pollution and land use

Various transport-related environmental influences are very difficult to quantify. For this reason they are often forgotten. These include in particular noise pollution and land use. You should therefore take these points into account separately.

Noise

In the case of noise pollution you can distinguish between the direct, local stresses at the site and the general stresses resulting from the traffic caused by the company.

Investigate whether there are complaints from residents due to delivery or commuter traffic. Rail-bound traffic also causes noise pollution. Are residents affected by the company's own sidings?

The local noise pollution can be quantified and assessed by a number of different characteristic quantities: by the number of complaints in a year, by annual noise level measurements at sensitive points, by the number of lorry-movements per day/ per hour at the site etc. Select a suitable quantity which describes the problem of noise pollution and which you can also influence by appropriate measures.

The general noise pollution depends on the one hand on the total traffic quantity. The lower the number of vehicle km travelled, the lower the noise pollution will be. On the other hand the noise pollution also depends on the vehicles used.

Since 1995 new EU boundary values have applied for new vehicle types and since 1996 for all new vehicles when they are first licensed. For example a car may only cause a max. noise level of 74 dB(A) when accelerating past at a distance of 7.5 m, and a lorry >150 kW rating may still cause 80 dB(A). However, there are naturally differences between the vehicle types as regards noise emissions. When procuring new vehicle you should therefore take the aspect of noise emissions into account.

Tyres have a clear influence on the noise development of vehicles. Winter tyres can account for up to 5 dB(A), and summer tyres for up to 3 dB(A). Tyres with lower noise development often have a lower rolling resistance and are therefore fuel-saving too.

The Umweltbundesamt has therefore introduced the Blue Angel environmental symbol with the legend "for low-noise and fuel-saving features". So far, however, this Blue Angel has not yet been awarded, even though many tyres would already satisfy the requirements today. If your company has a large tyre requirement, for instance because you have a large vehicle fleet, ask the tyre manufacturers about the rolling resistance and whether the tyres satisfy the requirements of the Blue Angel. Include this aspect in your company's procurement guidelines.

☞TIP

- Consider the procurement of low-noise vehicles and of tyres with low rolling resistance in your company's procurement guidelines.
- Reduce the parking space available when new offers, e.g. job tickets, new public transport links etc. are created.

Land

As regards land use check how much land is used for traffic at the site. Clarify how much of this is actually necessary for delivery and distribution traffic and for handling goods. One interesting quantity is the number of parking spaces available for staff, customers and visitors. Determine how high the load factor or the change is. Calculate how much the parking area is worth at the standard local land prices.

Measures in the sector of passenger transport should generally have an effect on the parking space requirement. If your company creates offers e.g. in the form of Job-Tickets etc., reduce the amount of parking space available at the same time, or at least regulate staff entitlement to a parking space.

Important basic information about balancing

When emission balances are drawn up in the traffic sector, there is a repeated ´need for various conversion factors and computing regulations. A few of these factors are compiled in the following.

Tab. 14: Net calorific value and densities of energy sources. Source: ifeu-Institut 1999

	Net calorific value MJ/kg	Density kg/l
Mineral oil (crude)	42,61	
Diesel fuel	42,96	0,832
Petrol/gasoline	42,96	0,742
Kerosene	43,00	0,795
Heavy oil	40,58	0,970
Natural gas	44,01	0,792 g

In Germany the factor 3.175 kg CO_2/kg fuel is used for calculating the direct CO_2-emissions from the combustion of petrol and diesel. This factor 3 can also serve you for a rough check of whether the CO_2-balance agrees with the fuel input. Deviating values depending on the carbon content must be used for fuels other than petrol and diesel.

By the way, with the CO_2-emissions you generally also have a suitable indicator for the consumption of fossil energy!

If you are interested in the direct sulphur dioxide emissions (SO_2), i.e. from the combustion operation during traction, you can calculate these from the sulphur content of the fuel. The sulphur contained is converted almost completely to SO_2 during combustion. Thus on the basis of the molecular weight 1 g S thus becomes 2 g SO_2. The percentage S-content is set out in Tab. 15. Example of a calculation for diesel in the year 2000:

	kg/a Diesel
x 0,030 / 100 x 2 =	
	kg/a SO_2

Tab. 15: Sulphur content in the fuel in % by weight. Source: ifeu-Institut 1999

	2000	2005
Diesel	0.030	0.004
Petrol	0.014	0.005

Most emissions are stated with the prechain already included. In this case you do not need to carry out any further calculations regarding the prechain.

In the event that the data explicitly only cover the direct emissions from traction or in the company, the prechain, comprising e.g. mineral oil extraction, refining and fuel distribution, must be considered separately. The prechain can have a distinct influence on the emission balance. For instance fuel distribution plays a major role in the NMVOC-emissions of petrol-fuelled vehicles.

Tab. 16 shows the prechain for the reference year 2000 for the fuels petrol and diesel. These data are always related to kg fuel consumption. You must therefore calculate these in addition to the direct emissions from traction and you can derive them from the fuel consumption of the traction.

Tab. 16: Emissions from the prechain for the provision of 1 kg fuel in the year 2000. Source: ifeu-Institut 1999

per kg	Petrol/gasoline	Diesel fuel
Primary energy input in MJ	50,7	48,3
Emissions:		
CO_2 in g:	561	491
NO_x in g:	1,34	1,16
NMVOC in g:	2,19	0,65
Particulates in g:	0,08	0,08
CO in g:	0,33	0,30
SO_2 in g:	2,14	1,69

A special feature must be taken into account in the case of railways. Railways are partly operated with diesel fuel, but mainly with electric power. Deutsche Bahn has special power stations available for this. If you want to calculate the prechain, i.e. the provision of electricity via extraction, power station etc. separately, you need data regarding the provision of this special "railway electricity".

Tab. 17 shows the emissions of the prechain for railway electricity. By way of comparison the "normal" data for the provision of electricity by the power supply companies in Germany are also shown. These data can be used for example if electrically powered vehicles are used in the company and you only know their electricity consumption.

Tab. 17: Emissions caused by the provision of 1 kWh railway electricity in the year 2000. Source: Borken et al. 1999

per kWh	Power supply comp. free industry	Rail Mix free overhead line
Primary energy input in MJ	11.05	10.60
Emissions:		
CO_2 in g:	668	581
NO_x in g:	0.58	0.57
NMVOC in g:	0.017	0.017
Particulates in g:	0.0058	0.0078
CO in g:	0.17	0.19
SO_2 in g:	0.47	0.45

Decimal conversions:

Prefix:		Conversion factor:		Multiples:
Peta	P	1,000,000,000,000,000	10^{15}	Quadrillion
Tera	T	1,000,000,000,000	10^{12}	Trillion
Giga	G	1,000,000,000	10^{9}	Billion
Mega	M	1000000	10^{6}	Million
Kilo	k	1000	10^{3}	Thousand
Hecto	h	100	10^{2}	Hundred
Deca	da	10	10^{1}	Ten
Deci	d	0.1	10^{-1}	Tenth
Centi	c	0.01	10^{-2}	Hundredth
Milli	m	0.001	10^{-3}	Thousandth
Micro	µ	0.000001	10^{-6}	Millionth
Nano	n	0.000000001	10^{-9}	Billionth
Pico		0.000000000001	10^{-12}	Trillionth

Energy units:

	kJ	kcal	kWh
1 Kilojoule (kJ) =	1	0.2388	0.000278
1 Kilocaloy (kcal)=	4.187	1	0.001163
1 Kilowatt hour (kWh)=	3600	860	1

Distance :

	km	Mile	Naut. mile
1 Kilometer (km) =	1	0.6214	0.5400
1 Mile =	1.609	1	0.8690
1 Nautical mile (nm)=	1.852	1.1508	1

Lorry

In the following this term is understood to mean not only lorries, but also lorry-trailer combinations and tractor-semi-trailer combinations. These are combined to form one group.

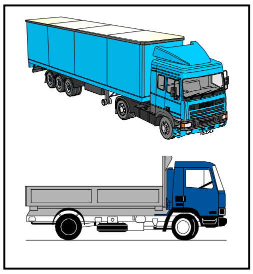
Tab. 18 shows the emission factors which are only distinguished by lorry size. They already contain the prechain and are related to the transport performance, i.e. to tonne kilometres. These values are suitable if no detailed fuel consumption rates of the vehicles or a list of the vehicle technology used is available. This is generally the case if only the transport quantity and transport distance are known from the waybills, but the actual transport is carried out by a forwarder or the supplier.

In this case it is simply necessary to estimate with what vehicles - judging by the admissible total weight - transport is carried out. This is generally reduced to a few size classes, e.g. lorry-trailer combinations or tractor-semi-trailer combinations > 32 t. If no data are available on this, it is also possible to calculate using a mean value. In this case the values are weighted with the vehicle km travelled of the individual vehicle size categories on German roads.

Tab. 18: Pollutant emissions of lorry traffic incl. prechain in g per tkm. Ref. year 2000. LT=lorry-trailer combination, TST=tractor-semitrailer combination. GVWR=gross vehicle weight rating. Source: ifeu. TREMOD 1999

GVWR	CO_2	NO_x	NMVOC	Part.	CO
Lorry <7,5t	452	2,98	1,10	0,23	1,35
Lorry 7,5-14t	294	2,24	0,57	0,16	0,68
Lorry 14-20t	294	2,47	0,42	0,12	0,56
Lorry >20t	218	1,92	0,28	0,07	0,38
LT <20t	161	1,13	0,24	0,10	0,54
LT 20-28t	133	0,88	0,17	0,07	0,26
LT 28-32t	128	1,14	0,12	0,05	0,25
LT >32t	128	1,11	0,11	0,04	0,15
TST <32t	114	0,91	0,11	0,05	0,21
TST>32t	111	0,96	0,08	0,03	0,09
Mean	147	1,21	0,17	0,05	0,23

The values thus calculated are suitable e.g. for comparing various transport modes (rail, aircraft). The influence of the size categories on the emissions can thus then be checked. For instance a clear reduction in emissions per tonne-kilometre is shown if large vehicles (e.g. > 32 t) are used. Average loading has naturally been assumed here.



If the influence of differing load factors or of the driving behaviour is to be considered, these emission values are no longer of any assistance. You should then use fuel-related calculations instead. However, this requires knowledge of the real fuel consumptions. If the company has its own vehicle fleet, the consumption values for diesel fuel are generally available. These consumption figures should be broken down by vehicle. The vehicles can be distinguished by size category and if appropriate by pollutant reduction standard (EURO 2, 3 ..).

The emissions are then calculated with the emission factors from Tab. 19. They are related to one kg diesel consumption and are distinguished by pollutant reduction standard.

It is clear from the table that in some cases substantial emission reductions are connected with the various EURO-standards. This reflects the process of technical innovation in the coming years. As of the year 2000 new vehicles licensed in Germany will be subject to the EURO-3-Standard. It is expected that as of the year 2005 they will be subject to the EURO-4 or 5-Standard. However, corresponding vehicles will already be available on the market at an earlier date. With this information a you can review, for instance, what reduction effect is connected with the use of the latest vehicles.

The direct CO_2 emissions are calculated directly from the fuel consumption using the conversion factor 3.175. Only the direct emissions, i.e. those generated during driving mode, were taken into account in Tab. 19. If the emissions of the prechain are to be included as well, these must be calculated separately via the fuel consumption and the factors from Tab. 16.

FOR EXAMPLE: Stora Enso Sachsen GmbH

Stora Enso Sachsen GmbH near Leipzig is one of Europe's most modern newsprint factories. The company belongs to the Swedish-Finnish Stora-Enso-Group and has a workforce of approx. 350. Each year approx. 450,000 t waste paper is processed to over 300,000 t newsprint and approx. 60,000 t market de-inking material.

Transport of the raw and auxiliary materials, as well as of the products and the wastes generated, plays an important role for the eco-balance. That is why a detailed transport balance was drawn up. One objective is to procure the waste paper from catchment areas which are as close as possible to the factory. If it is necessary to transport these over a long distance, this should preferably be done by rail.

In the case of transport by road Stora Enso Sachsen brings influence to bear on the carriers, persuading them to use only the most modern, low-emission and low-noise vehicles. This is checked and recorded on delivery. To support this a vehicle data base for suppliers and forwarders has been set up. The vehicle data are recorded on first delivery by a specific vehicle. Later allocation is then possible via the vehicle plate number.

One difficulty consisted in reading the pollutant reduction standard from the vehicle papers. It is concealed in a code number which Stora Enso Sachsen decoded with the support of the technical surveillance organisation TÜV Leipzig (see below). For lorries > 3.5 t, S1 corresponds to the EURO 1 standard, S2 to EURO 2 etc.

Code number	Clear text
----00	no classification
----01	NCL: G1
----02	NCL: G1 east
----10	PCL: S1
----11	PCL: S1, NCL: G1
----12	PCL: S1, NCL: G1 east
----20	PCL: S2
----21	PCL: S2, NCL: G1
----22	SKL: S2, GKL: G1 Oest

GKL:Geräuschklasse; SKL: Schadstoffklasse

Tab. 19: Pollutant emissions lorry traffic without pre-chain in g per kg fuel consumption. LT=lorry-trailer combination, TST=tractor-semitrailer combination. GVWR=gross vehicle weight rating. Source: ifeu. TREMOD 1999

GVWR	EURO1	EURO2	EURO3	EURO4	EURO5
CO in g per kg diesel					
Lorry <7,5t	8.0	4.5	3.6	2.7	2.7
7,5-14t	6.3	3.5	2.8	2.1	2.1
14-20t	5.3	2.9	2.3	1.7	1.7
LT <20t	9.1	5.0	4.0	3.0	3.0
LT 20-28t	5.4	3.0	2.4	1.8	1.8
LT 28-32t	5.5	3.1	2.4	1.8	1.8
LT >32t	3.7	2.0	1.6	1.2	1.2
TST <32t	5.0	2.8	2.2	1.6	1.6
TST>32t	3.6	2.0	1.6	1.2	1.2
NMVOC in g per kg diesel					
Lorry <7,5t	7.8	5.6	4.5	3.9	3.9
7,5-14t	6.2	4.5	3.6	3.1	3.1
14-20t	4.5	3.2	2.6	2.2	2.2
LT <20t	4.6	3.3	2.6	2.2	2.2
LT 20-28t	4.1	3.0	2.4	2.0	2.0
LT 28-32t	2.8	2.0	1.6	1.4	1.4
LT >32t	2.6	1.9	1.5	1.3	1.3
TST <32t	3.0	2.2	1.7	1.4	1.4
TST>32t	2.5	1.8	1.4	1.2	1.2
NOx in g per kg diesel					
Lorry <7,5t	20.5	17.6	11.7	8.8	4.4
7,5-14t	23.9	20.5	13.6	10.2	5.1
14-20t	26.6	22.8	15.2	11.4	5.7
LT <20t	21.9	18.8	12.5	9.4	4.7
LT 20-28t	27.0	23.0	15.3	11.4	5.7
LT 28-32t	28.1	24.1	16.1	12.0	6.0
LT >32t	28.4	24.3	16.2	12.1	6.1
TST <32t	24.8	21.3	14.2	10.6	5.3
TST>32t	31.4	26.9	17.9	13.4	6.7
Partikel in g per kg diesel					
Lorry <7,5t	1.78	0.80	0.53	0.14	0.14
7,5-14t	1.96	0.88	0.59	0.15	0.15
14-20t	1.49	0.67	0.45	0.12	0.12
LT <20t	2.26	1.01	0.68	0.18	0.18
LT 20-28t	1.39	0.63	0.42	0.11	0.11
LT 28-32t	1.45	0.65	0.44	0.11	0.11
LT >32t	1.16	0.52	0.35	0.09	0.09
TST <32t	1.57	0.70	0.47	0.12	0.12
TST>32t	1,21	0,54	0,36	0,09	0,09

Delivery van

For delivery vans with an admissible total weight ≤ 3.5 t it is important to distinguish whether these have a diesel engine or an internal combustion engine. The engine type influences the emissions.

Tab. 20 shows the emission factors for the reference year 2000 for delivery vans powered by diesel and internal combustion engines. No further distinction by size category is made. If it is not known whether the delivery van has a diesel or an internal combustion engine, calculate on the basis of a diesel engine.

The data are given in gram per vehicle kilometre. The reference to the transport performance is difficult for delivery vans, since the loading fluctuates substantially. That is why transport performance-related values were stated assuming an estimated average load of 300 kg per vehicle. These values must be adjusted depending on the application.

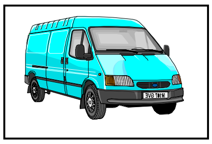
Tab. 20: Pollutant emissions of delivery vans incl. prechain in g per vehicle-km or tkm. Reference year 2000. Source: ifeu. TREMOD 1999

GVWR	IC g/Fz.-km	IC* g/t-km	Diesel g/Fz-km	Diesel* g/t-km
CO2	315	1.050	346	1.153
NOx	1.26	4.2	1.03	3.43
NMVOC	1.03	3.43	0.15	0.50
Particulate	-	-	0.15	0.50
CO	11.3	37.7	0.75	2.50

* with 300 kg average payload

When comparing the emission factors for lorries, it is noticeable that the values are very high related to the transport performance. For the emission appraisals you should therefore only fall back on such values if no other data are available, e.g. related to the vehicle km travelled or the fuel consumption.

If the delivery vans belong to the company's own vehicle fleet, fuel consumption figures are generally available. These consumption figures should be broken down by diesel/petrol and per vehicle. If appropriate the vehicles can then be distinguished on the basis of the pollutant reduction standard (EURO 2.3..).



The emissions are then calculated with the emission factors from Tab. 21. They are related to one kg diesel consumption and are broken down by pollutant reduction standard.

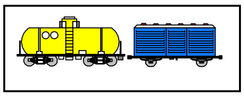
New vehicles licensed in Germany will be subject to the EURO 3 standard from 2000 onwards. It is expected that as of the year 2005 they will be subject to the EURO 4 standard. However appropriate vehicles will be available on the market already at an earlier date. Thus a company can review, for example, what reduction effect is connected with the use of the latest vehicle models.

Calculation of the direct CO_2 emissions results directly from the fuel consumption with the conversion factor 3.175.

In Tab. 21 only the direct emissions, i.e. those emitted during vehicle operation, were taken into account. If the emissions of the prechain are also to be considered, these must be calculated separately via the fuel consumption and the factors from Tab. 16.

Tab. 21: Direct pollutant emissions by delivery vans (diesel-engine/I.C. engine) without prechain in g per kg fuel consumption. Source: ifeu. TREMOD 1999

	EURO1	EURO2	EURO3	EURO4
	CO in g per kg fuel			
Diesel	8.9	3.9	2.3	2.2
I.C.	90.5	65.3	46.7	35.5
	NMVOC in g per kg fuel			
Diesel	1.02	0.75	0.46	0.43
I.C.	4.10	2.45	1.25	0.94
	NOx in g per kg fuel			
Diesel	9.4	8.3	6.3	3.9
I.C.	11.4	5.3	2.2	1.3
	Particulates in g per kg diesel			
Diesel	1.18	1.02	0.46	0.28



Rail (freight)

In the case of freight transport by rail the values of Deutsche Bahn AG are taken as a basis. A distinction is made between 3 kinds of train types:

- Individual wagon loads
- Trains for intermodal cargo transport
- Complete train-loads

The train type is generally determined by the goods to be transported. Bulk goods such as ores or coal are generally conveyed in complete train-loads, containers by intermodal transport, and general cargo in individual wagonloads. The degree of utilisation of these train types varies considerably. For complete train loads a loading factor of approx. 44 % can be assumed, for trains in intermodal transport 37 %, and for individual wagon loads only 30 %. This also has impacts on the energy consumption and the emissions.

The emission factors must be distinguished on the basis of the type of traction: electrically powered traction and diesel powered traction. The data are broken down in such a way that the traction for the main run is the crucial value. The incidental services necessary during rail transport are taken into account implicitly. These are transfer trains for the wagons, shunting runs or empty runs by locomotives. Some of these services are carried out with different kinds of traction, for instance electric traction or diesel-powered traction.

If it is not known what kind of traction is used to transport the goods in the main run (not at transfer!), the mean value (mix) should be used for the calculation. This is assumed to be 90 % electric traction and 10 % diesel traction.

All data in Tab. 22 already include the pre-chain, especially the power station for electrical power and the refinery for diesel.

Tab. 22: Emission factors of the rail in g per tariff-t-km for various train types including provision of the fuel or energy (= Prechain). Source: Borken et al. 1999

Traction in the main run:	Electric	Diesel	Mix
Individual wagon loads			
CO_2	46.0	76.0	49.0
NO_x	0.16	1.18	0.26
NMVOC	0.015	0.14	0.027
Particulates	0.0061	0.055	0.011
CO	0.048	0.36	0079
Intermodal cargo transport			
CO_2	30.4	48.9	32.2
NO_x	0.043	0.77	0.12
NMVOC	0.0024	0.090	0.011
Particulates	0.0011	0.036	0.0045
CO	0.013	0.23	0.035
Complete train loads			
CO_2	19.2	32.4	20.6
NO_x	0.033	0.51	0.081
NMVOC	0.0023	0.059	0.0080
Particulates	0.0009	0.024	0.0032
CO	0.010	0.15	0.025

The transport performance is generally related to the tariff-tonne-kilometres, i.e. those tonne-kilometres which are invoiced by the rail company. However, the number is smaller than the number of tonne-kilometres actually carried out in the rail network. If a company only knows the values from the waybills or the rail company invoices, it can calculate with the tariff-tonne-kilometres given in the following tables. However, if exact train runs with the various transfers, traction values etc. are known, use of the cited emission factors will presumably lead to an over-estimation. In this case reference is made to detailed representations (e.g. Borken et al.).

Ship

In the case of ship transport a distinction is made between inland vessels (barges) and sea-going vessels. The data available here are poorer in quality than those for other transport modes.

The companies generally only have the tariff-kilometres or transport performance in tkm. Calculations on the basis of a known fuel consumption or the like are not customary.

Barge

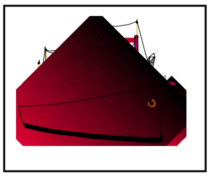
The energy consumption and emissions of barge transport depend essentially on the barge size, whether it is travelling upstream, downstream or along canals, and on the loading of the vessel. On average a diesel consumption rate of 10 g/tkm can be assumed. The emission factors shown as flat rates in Tab. 23 are based on this value.

Tab. 23: Emission factors for barges in g per t-km and in g per kg diesel (both including the provision of fuel). Source: Borken et al. 1999

Pollutant	Barge on average in g / tkm	Barge in g per kg diesel-consumption
CO_2	35.4	3.540
NO_x	0.61	0.06
NMVOC	0.051	0.005
Particulates	0.017	0.002
CO	0.11	0.011

Tab. 24: Energy consumption in g diesel per t-km for a barge with 50 % loading. Source: ifeu. Borken et al. 1999

GVWR	Free-flowing		Canalised	
	Down-stream	Upstream	Down-stream	Upstream
800 t	7.7	20.0	9.3	12.8
1.250 t	6.8	17.7	8.1	11.2
1.750 t	6.3	16.3	7.4	10.2
2.500 t	5.1	13.0	6.1	8.4



If more precise data are available about the voyage, individual values can be calculated with the aid of the energy consumption data in Tab. 24 and the fuel-related factors. In this case the dead-weight of the vessel must be known, as well as the nature of the waterway (canalised, flowing water) and the direction. Tab. 24 only shows values for 50 % loading. For other load factors detailed information should be taken e.g. from Borken et al.

Sea-going ship

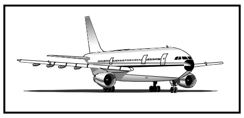
For sea-going ships a distinction is made between the following categories:

- General cargo freighters, Ro-Ro freighters and container carriers with a dead-weight between 9,000 t and 23,000 t and relatively good load factors.
- Bulk carriers with dead-weights of on average approx. 40,000 t and often with a high load factor in one direction only.
- Tankers with dead-weights between 50,000 and 200,000 t.

The emissions for these categories are compiled in Tab. 25. They already contain the prechains for the fuel, whereby heavy fuel oil is generally used here. Once again calculation is carried out on the basis of the transport performance, with the nature of the transported goods indicating which ship category should be selected.

Tab. 25: Emission factors of sea-going ships in g per t-km including the provision of fuel (= prechain). Source: Borken et al. 1999

Pollutant	General cargo freighter	Bulk cargo carrier	Tanker
CO_2	17.5	8.73	4.36
NO_x	0.42	0.21	0.042
NMVOC	0.015	0.0076	0.0019
Particulate	0.030	0.015	0.0038
CO	0.046	0.023	0.0047



Aircraft (freight)

In the case of air transport this guide only distinguishes between short/medium distance and long-distance flights. The differences lie essentially in the influence of the starting phase on energy consumption and emissions, in the differing load factors and in the use of differing aircraft types for the various tour distances.

The technology of the aircraft used naturally has a large influence on the energy consumption and emissions. Some airlines (e.g. Lufthansa) advertise specifically with the claim that they are continuously lowering their consumption figures and thus making a contribution to a continuous improvement process in their organisation. This means that the values are currently changing substantially due to material changes in the aircraft fleets.

The emission factors are compiled in Tab. 26. They relate to the status at the end of the nineties and assume a kerosene consumption of 381 g/tkm for short and medium distance flights and 253 g/tkm for long-distance flights. The values in Tab. 26 already contain the prechain for provision of kerosene.

Tab. 26: Emission factors for freight transport by air in g per t-km including the provision of fuel (=prechain). Source: Borken et al. 1999

Pollutant	Short-/ medium-distance flight	Long-distance flight
CO_2	1.355	903
NO_x	6.36	4.24
NMVOC	0.75	0.50
Particulates	0.20	0.13
CO	2.14	0.97

Pay attention to details...

The real values can differ substantially, depending on which airline and which aircraft fleet is used.

For example Lufthansa states for the reference year 1997 that its freight transport operations only have a specific consumption of 243 g/tkm. The emissions are correspondingly low (but the values do not include the prechain):

Carbon dioxide:	762 g/tkm
Nitrogen oxides	4.1 g/tkm
NMVOC	0.22 g/tkm
Carbon monoxide	0.62 g/tkm

These values already represent an average of short/medium distance and long-distance flights.

Where older aircraft types are used consumption values of approx. 550 g/tkm can certainly apply for short-distance flights. A good mean value is approx. 300 g/tkm. Modern aircraft (e.g. Airbus 340) on long-distance routes can even drop below a value of 200 g/tkm.

On most computer programs it is possible to carry out such an analysis. If appropriate you might need the help of your computer department. This will save you a great deal of work and manual calculations.

If you want to be absolutely certain in your calculations, make enquiries of your airline and call up the current values for consumptions and emissions.

Source: Lufthansa Umweltbericht 1997/98

Forklifts and other machines

Forklift trucks, cargo-handling equipment and other machines can be powered with different energy sources in the companies: by electric energy, diesel fuel or gas. It is advisable to calculate the emissions of these machines via the energy consumption. Calculations via other characteristic quantities, e.g. lifting work performed etc., involve substantially more input and are generally less precise too.

If machines are powered by electric energy, you must record the consumption for these machines. For this it is advisable to install corresponding consumption meters. It is easier but less precise to appraise the values via the connected load of the machines. For this the nominal rating is multiplied by the operating hours and an estimated utilisation (e.g. 0.7). You can also verify such an estimate by corresponding consumption measurements at the beginning. From this you can determine a load factor and then use this for future calculations.

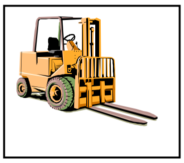
If the consumption figures for electric power are available or have been appraised, the emissions for provision of the electricity can be calculated with the aid of Tab. 17. This calculation is very simple.

The emission factors for forklifts powered by a liquefied gas mixture of butane and propane are shown in Tab. 27. They can be used as indicative values for gas-powered machines.

Tab. 27: Emission factors for forklifts in g per kg gas consumption. Only direct emissions without the provision of the gas. Source: TNO Delft, 1992, personal notification.

Pollutant	Gas-powered forklift g/kg
CO_2	3042
NO_x	40
NMVOC	25
CO	145

Only rough values can be stated here for diesel-powered machines. Starting from the diesel consumption, the emissions can be estimated roughly using the factors in Tab. 28. These are emission factors of machines with a rating of approx. 55 kW. However these emissions must be supplemented by the prechain for provision of the diesel fuel.



In future European emission boundary values will be important for mobile machines powered by diesel engines too. The operation of diesel-powered cargo handling equipment in closed rooms represents a problem, however. The Technical Rule for Hazardous Materials TRGS 554 for reducing health hazards at the workplace applies here. Particulate emissions, which may not exceed certain concentrations in room air, are particularly important in this case. However, this must be checked from case to case, if appropriate via room air measurements. The measures are then to be checked in individual cases.

Tab. 28: Emission factors for light duty machines in g per kg diesel consumption. Direct emissions only, without the provision of fuel. Source: Estimates acc. to Borken et al. 1999

Pollutant	Diesel-powered light-duty machines g/kg
CO_2	3175
NO_x	35
NMVOC	6
Particulates	3
CO	10

Source: TNO Delft, 1992, personal notification.

Pipelines

Transport by pipeline plays as essential role chiefly for mineral oil and natural gas, but can also be an interesting alternative for other goods too. The energy input for pipeline transport depends on a large number of factors, for instance the material being transported, the pipeline diameter, the flow speed, the pressure difference or differences in height.

Values for natural gas and mineral oil are given here as reference values (Borken et al. 1999). In the case of natural gas pipelines the compressors are operated with gas turbines. The energy consumption can be assumed to be 0.75 MJ/tkm. For oil pipelines the pump need electric energy of about 0.02 kWh/tkm.

FOR EXAMPLE: Pipelines at BASF

Within the BASF plant in Ludwigshafen 5.6 million tonnes are transported each year, mainly in the 2000 kilometre long, above-ground pipelines and along the 211 kilometres of rail tracks.

The Ludwigshafen site was structured as a compound site. This means that residual materials from one plant are used as raw materials in another plant. Furthermore, sites which are connected by the composite system can also be placed together spatially. This makes it possible to avoid many transport operations, especially in the sector of waste disposal and raw material supplies.

Instead transport operations are required in internal traffic, but distances are relatively short here and many transport operations can be handled via pipelines. Transport using pipelines avoids above all return trips.

Passenger cars

Passenger traffic presumably plays a role in various places in your organisation. On the one hand some of the staff will travel to work by car. Consequently data on the traffic performance (in person-km) is available for commuter traffic. On the other hand there is business travel with company-own or private vehicles, for which generally only fuel consumption can be determined.

Tab. 29 shows the emissions of car traffic related to the traffic performance, i.e. to person-km. An average occupation rate of 1.3 persons per car is assumed here. If you want figures related to vehicle km travelled here, then multiply the value from Tab. 29 with the factor 1.3, e.g.:

6,0	g/pers.-km CO
x 1,3 =	
7,8	g/car-km CO

In the case of commuter traffic there are rarely precise data of the car types used. You will have to work with mean values covering the entire car stocks. At best you can state whether travel is largely within town limits or outside town limits. If your company is located in the town and some of the staff come from a radius of e.g. 5 km, you can assume urban traffic for this run.

FOR EXAMPLE: Commuters

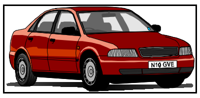
Your company has 3000 employees, 50 % of them come by car. One third of them commutes from the nearby town XY, the rest come from the town in which your company is located. For travel within town, estimate a mean distance of 6 km one way, i.e. 12 km outward and return travel. This distance is driven within the town. The town XY is 20 km away, 15 km of which are Autobahn, 5 km within town. Assume 200 workdays a year. If you want to calculate the CO_2 emissions of the commuter traffic:

500 x 200 x 30 km x 158.2 g/Pkm = 475 t/a

500 x 200 x 10 km x 198.3 g/Pkm = 198 t/a

1000x 200x 12 km x 198.3g/Pkm = 476 t/a

Total CO_2-emissions: 1149 t/a



Tab. 29: Pollutant emissions of car traffic in the year 2000 with prechain in g per person-km; broken down by car displacement volume and road category (IO=urban, AO= outside built-up areas, AB= autobahn). Source: ifeu. TREMOD 1999

	IO	AO	AB	Mean
	CO_2 in g/Pkm			
< 1,4 l	175.1	114.3	147.9	142.6
1,4 – 2,0 l	198.0	129.6	150.2	156.9
> 2,0 l	244.5	157.3	186.0	192.7
Mean	198.3	128.8	158.2	159.2
	NO_x in g/Pkm			
< 1,4 l	0.38	0.35	0.49	0.39
1,4 – 2,0 l	0.38	0.28	0.41	0.35
> 2,0 l	0.44	0.30	0.34	0.36
Mean	0.41	0.32	0.43	0.38
	NMVOC in g/Pkm			
< 1,4 l	1.02	0.21	0.22	0.50
1,4 – 2,0 l	0.50	0.10	0.11	0.23
> 2,0 l	0.49	0.09	0.09	0.20
Mean	0.71	0.14	0.13	0.32
	Particulates* in g/Pkm			
1,4 - 2,0 l	0.013	0.07	0.014	0.011
> 2,0 l	0.031	0.020	0.026	0.025
Mean**	0.012	0.007	0.014	0.010
	CO in g/Pkm			
< 1,4 l	6.0	1.9	6.0	4.2
1,4 – 2,0 l	3.9	1.0	2.0	2.2
> 2,0 l	3.5	0.6	0.7	1.4
Mean	4.6	1.3	2.6	2.7

* mean value from I.C. and diesel-engine cars together
** incl cars < 1.4 l

The values in table 29 are broken down into urban, out of town and autobahn, as well as by the displacement of the car engine. Mean values are stated in each case. Therefore if you do not know the size of the cars used, use the mean values from the last line for each pollutant. If you do not know what road categories are used, take the mean values from the last column. The completely aggregated mean values are set out here. If you do not know either the car size or the road category, take e.g. the value 159.2 for the CO_2 emissions per pkm.

If your company has its own vehicle fleet, you will have information about fuel consumption. This also applies if private cars are used. In this case you will have fuel invoices etc. available. These consumption figures are real and always more reliable than the estimates on the basis of distance travelled. The CO_2 emissions can be calculated very precisely with these figures.

To calculate the other emissions, such as the nitrogen oxides or particulate emissions, it is necessary to know something about the vehicle technology used. The emission factors necessary for this are listed in Tab. 30. They are distinguished on the basis of type of engine, engine size and reduction standard.

This table also helps you to recognise what emission reductions would be connected with a change to other or more modern vehicles. The higher fuel consumption for larger vehicles must be taken into account. That is why the average consumption per car-km is stated here.

FOR EXAMPLE:
Car pools

In the example on the preceding page, of the 500 commuters from the town XY 120 persons have already driven with colleagues so far. This corresponds to the mean car occupancy rate of 1.3, which was also assumed for the values in the table.

Together with the work's council the company promotes car pools. This is interesting for commuters from XY. Monthly premiums are drawn for persons changing over to this system. As a result of this action the number of people using a car pool is now 240 persons. Thus the average occupancy rate is now 1.9.

You can now calculate with lower emission factors:

158.2 * 1.3 / 1.9 = 108.2 and

198.3 * 1.3 / 1.9 = 135.7

and further:

500 x 200 x 30 km x 108.2 g/Pkm = 325 t/a

500 x 200 x 10 km x 135.7 g/Pkm = 136 t/a

This saves 212 t CO_2 a year, equivalent to 18 % of the commuter traffic emissions.

An interesting side effect: you save parking space for 120 cars and instead you can plan a pavilion for a product show of your organisation - without having to buy any new land.

Tab. 30: Direct pollutant emissions of car traffic without prechain in g per kg fuel consumption (petrol or diesel); broken down by car engine displacement, type of drive (P=Petrol, D=Diesel) and reduction standard. Source: ifeu. TREMOD 1999

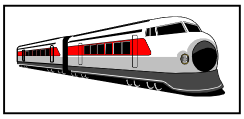
	P: CCC up to EURO 2 D: conv.	EURO2	EURO3	EURO4
	NO_x in g/kg fuel consumption			
P < 1.4 l	9.3		2.5	1.7
P 1.4 – 2.0 l	8.0		2.3	1.6
P > 2.0 l	5.5		1.5	1.1
D 1.4 – 2.0 l	11.4	9.4	7.2	5.2
D > 2.0 l	11.7	9.5	7.3	5.3
	NMVOC in g/kg fuel consumption			
P < 1.4 l	6.2		2.4	1.8
P 1.4 – 2.0 l	4.1		1.4	1.0
P > 2.0 l	3.8		1.1	0.8
D 1.4 – 2.0 l	1.5	1.0	0.8	0.8
D > 2.0 l	1.5	0.9	0.8	0.8
	Particulates in g/kg fuel consumption			
D 1.4 - 2.0 l	1.8	1.2	0.9	0.5
D > 2.0 l	1.8	1.3	0.9	0.5
	CO in g/kg fuel consumption			
P < 1.4 l	87		55	43
P 1.4 – 2.0 l	62		31	24
P > 2.0 l	44		17	11
D 1.4 – 2.0 l	9.1	5.9	5.1	4.9
D > 2.0 l	7.8	5.1	4.3	4.2
	Fuel consumption in g / car-km			
P < 1.4 l	54.5		53.2	52.2
P 1.4 – 2.0 l	62.0		59.6	58.6
P > 2.0 l	78.1		76.0	75.1
D 1.4 – 2.0 l	55.2	53.9	53.5	49.0
D > 2.0 l	68.8	66.6	65.8	60.3

Rail (passenger)

The values for Deutsche Bahn AG are taken as a basis for rail transport. However, at the time of going to print no recent and consistent data are available which distinguish between train types (ICE, IC, IR..). These figures will only be accessible in the course of the year 2000.

Tab. 31: Emission factors in g per pers.-km for Deutsche Bahn including the provision of energy (= prechain). Source: TREMOD 1999

Pollutant	Long-distance transport	Short-distance transport
CO_2	45	118
NO_x	0.13	0.66
NMVOC	0.01	0.05
Particulates	0.03	0.04
CO	0.04	0.16



The emission factors for long-distance traffic listed in Tab. 31 are compatible with data for individual train types. Thus the CO_2-emission value for ICE/IC trains is approx. 45 g/pkm, taking real load factors into account.

☞ **TIP**

Normally the Accounts Department of your company will only record the costs of business travel. You can of course evaluate the tickets singly. For a simple assessment calculate the kilometres from the travel costs using the factors:

2nd Class	0.272 DM/km
1st Class	0.408 DM/km (tariff status 1.4.1999)

Clarify whether staff generally use a "Railcard" when travelling. In this case the prices are halved. If an ICE train is used, use 0.33 DM/km (2nd Class) or 0.50 DM/km (1st Class) for your calculations. However, these are only estimated values since the ICE prices depend on the relevant line runs.

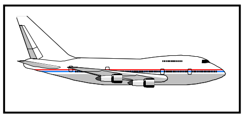
If your company has a big-ticket account, remember to consider the discount. Don't forget the runabout/ commuter tickets either. Here you will have to estimate how much these tickets are used.

Aircraft (passenger transport)

For air traffic a distinction is made between short/medium-distance flights and long-distance flights. As already mentioned for freight transport, the technology of the aircraft used has a critical influence on the energy consumption and emission of pollutants. That is why the values can differ substantially depending on the composition of the aircraft fleet or by airline.

Tab. 32 shows emission factors which already contain the prechain for provision of kerosene. The values are based on an average kerosene consumption of approx. 40 g/person km for long-distance flights and about 63 g/person km for short-distance flights.

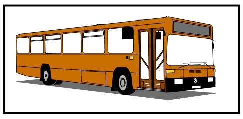
By comparison, Lufthansa quotes a kerosene consumption of 42 g/person km as an overall mean value (short and long-distance routes). In the long-distance sector the figure may even drop below 32 g/person km, and in the short-distance sector it lies between 40 and 70 g/person km.



If precise values are to be calculated, it is advisable to contact the relevant airline and request current emission factors. The emission factors should relate to the actual traffic performance in person km - i.e. they should consider the real loading.

Tab. 32: Emission factors for air passenger transport in g per pers.-km including the provision of fuel (=prechain). Source: ifeu 1999

Pollutant	Short/medium-distance flight	Long-distance-flight
CO_2	207	132
NO_x	0.83	0.52
NMVOC	0.06	0.04
Particulates	0.003	0.001
CO	1.3	0.12

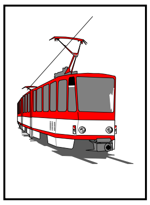


Fixed-route bus

You will generally need information about local public transport in order to appraise the environmental influence of commuter traffic. Normally only very generalised values or assumptions will be available here, so that the data in Tab. 7 are sufficient. If necessary you can distinguish between bus sizes (see Tab. 33). However, the influence of the load factor in local public transport will be considerably higher.

Tab. 33: Emission factors zum Bezugsjahr 2000 für Linienbusse in g per Pers.-km einschließlich der Bereitstellung des Kraftstoffes (=Prechain). Source: ifeu. TREMOD 1999

Pollutant	Buses with GVWR < 20 t	Buses with GVWR > 20 t
CO_2	82	76
NO_x	0,92	0,97
NMVOC	0,12	0,08
Particulates	0,03	0,03
CO	0,35	0,20



Public track-bound transport

Public track-bound transport comprises trams, light-rail rapid transits and underground railway systems. The values can differ substantially depending on the vehicle technology used, the average speed and the distance between stops. In addition, the influence of the load must be considered. In local public transport it is on average 25 %, and in public track-bound transport it can reach 50 % in conurbations.

Tab. 34: Emission factors for trams, light-rail rapid transits and underground railway systems in g per pers.-km including the provision of energy (=prechain). Source: ifeu. TREMOD 1999

Pollutant	Public track-bound transport
CO_2	72.5
NO_x	0.05
NMVOC	< 0.01
Particulates	-
CO	0.02

FOR EXAMPLE: Passenger transport of an administration

The Ministry for Environment, Energy and Transport (MUEV) of the German State Saarland introduced an environmental management system by analogy with EMAS in 1997. The MUEV is currently distributed between 7 sites in Saarbrücken. Altogether 350 staff are employed there. The largest contributions to transport are expected from commuter traffic and official journeys. The vehicle fleet consists of only 12 vehicles.

By agreement with the staff council a survey was conducted among staff to help determine driving habits and distances to the place of work. The return rate was very good at just under 70 %. The results showed that approx. 50 % commute from within a radius of 20 km, and a further 20 % from a radius between 20-30 km. At distances >10 km cars are used by 80 % and more. CO_2 emissions of over 270 t per year were estimated from this. More than half of these emissions originate from staff who commute from 30 km and more to Saarbrücken.

The questionnaire was not only used to calculate the transport and emission balance, but also to ask about the reasons for transport behaviour. Although most of the interviewees stated that public transport was basically available, the time involved and the poor connections were criticised. A further argument was the cost. Consequently interest in a job ticket was correspondingly high. Nearly two thirds of the staff coming from a distance between 10-20 km were interested in a job ticket. This measure is still being reviewed by the state government of Saarland. The greater the distance to the workplace, the more the staff are willing to form car pools. This is supported by a restricted distribution of scarce parking places. Most of the parking places made available are awarded to staff who demonstrably use car pools. Since the "long-distance" commuters make a large contribution to the CO_2 emissions, this measure certainly has an influence on the emission balance of the Ministry.

5. Annex

Literature

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Glossary

Evaluation

Component of an ecobalance (LCA) in which the results of the inventory analysis and/or the impact assessment are brought together for the conclusions and recommendations.

Decibel dB(A)

Unit of measurement for noise, or more precisely for the sound pressure level over the entire acoustic frequency range. The scale is logarithmic. A noise with a certain dB-value is felt to be just as disturbing as one which acts for only half the time, but is 3 dB louder.

EMAS

Abbreviation for Eco-Management and Audit Scheme, the title of the EC-Regulation on the Environmental Management and Eco-Audit.

Emission

The discharging or outflow of solid, liquid or gaseous substances from plants, technical procedures or vehicles which pollute the air, water or other environmental areas. Noise, vibrations, light, heat and radioactive radiation are also frequently termed emissions. Emissions lead to air-borne pollution in the environment.

Emission factor

A characteristic quantity stating what quantity of pollutants is released by a certain performance of a process or an activity. In the transport sector EF are often related to the vehicle km travelled (g/car-km), the traffic performance (g/tkm) or the quantity of fuel consumed (g/kg). It is important to know the basic technology or the marginal conditions under which the technology is used, e.g. vehicle, loading, driving condition etc.

EURO-Standards

Abbreviation for the exhaust gas boundary values for vehicles in the EU. The regulations of the EC Environment Council usually relate to special exhaust test procedures (EU/ECE test cycle); the boundary values are therefore not suitable for direct calculation of actual emissions. For instance on 1 October 1991 the EC Environment Council specified the stages EURO I (for series production as of 1992/93) and EURO II (as of 1995/96) for lorries and buses. The third stage EURO III applies as of 1999. Further stages are being planned for 2005/8.

Vehicle km travelled

Measurement quantity for the volume of traffic, related to the vehicles used. The vehicle km travelled are measured in vehicle-kilometres (e.g. lorry-km or car-km).

Air-borne pollution

The influence of atmospheric pollution, noises, vibrations, light, heat, radiation etc. on people, animals, plants, soil, water, the atmosphere or objects (e.g. cultural monuments).

Input

Material (or energy) supplied to a process, a plant or a system. It can consist of raw materials, auxiliary materials or expendable supplies (process materials), materials for production, semi-finished products etc.

ISO 14.001

International standard "Environmental Management Systems" of the International Organization for Standardization from the Standard Series 14.000 on environmental management. Alternative to EMAS Regulation for certification of environmental management systems for companies.

ISO 14.040

International Ecobalance standard "Principles and General Requirements" of the International Organization for Standardization from the Standard Series 14.000 on environmental management.

Ratio

Assessment quantity in which the results of the inventory analysis are aggregated, weighted or set in relation to the performance of the system.

Core balance

In a site-related or company-related ecobalance describes the environmental impacts occurring directly in the company, e.g. gate-to-gate. Cf. complementary balance.

Carbon dioxide (CO_2)

A gas resulting as the product of combustion of fuels containing carbon, e.g. fossil sources of energy. CO_2 from fossil sources contributes substantially to the greenhouse effect and thus to harming the earth's atmosphere.

Carbon monoxide (CO)

A gas that develops as a result of incomplete combustion of fuels containing carbon. CO is a breathing poison that leads to impairment of oxygen intake in the blood in humans. This can lead to many function impairments in the sector of the cardiovascular system or the brain.

Complementary balance

Expands a core balance to include the environmental impacts occurring outside the company. These can also occur in another company.

LCA

Abbreviation for Life Cycle Assessment. See Ecobalance.

Life cycle

Consecutive and connected stages of a product system from the extraction of raw material to final elimination (cradle to grave).

Non-Methane Volatile Organic Compounds (NMVOC)

Summarising term for volatile organic compounds ("hydrocarbons") *without* methane. These compounds can comprise many individual substances with differing human-toxic or eco-toxic impact potential, for example benzene or even in dioxins and furans.

Output

Material (or energy) given off by a process or a system. A material can be a raw material or a product, intermediate product, pollutant or waste.

Eco-Audit

A management instrument for systematic, documented and regular valuation of the performance, management and procedures of a company for protection of the environment. In the EC Regulation it is termed an environmental audit. In everyday use it is often an overall term for the theme of environmental management systems for companies.

Ecobalance

Another term for Life Cycle Assessment (LCA). Compilation and assessment of the input and output flows and the potential environmental impacts of a product system in the course of its life cycle. Steps in an ecobalance: stipulation of the objective and the examination framework, inventory analysis, impact assessment and evaluation. Ecobalances for companies used to mean company-related or site-related environmental balances.

Inventory analysis

Component of an ecobalance comprising the compilation and quantification of the inputs and outputs of a system.

Sulphur dioxide (SO_2)

The gas normally occurs as a product of combustion if the fuel contains sulphur. SO_2 is an irritant gas that can impair the respiratory tract in humans. It can also lead to damage to vegetation. It is a key substance in what is known as acid rain.

Site

The EC-Eco-Audit relates explicitly to sites, i.e. to the terrain on which a company's commercial activities are carried out. This also includes the equipment and infrastructure used within the scope of this activity, whether fixed or not.

Nitrogen oxides (NO_x)

Frequently also called nitrous oxides. The gases consist of nitrogen monoxide (NO) and nitrogen dioxide (NO_2). They are normally formed in combustion processes at high temperatures from atmospheric nitrogen in the presence of air. NO_2 is an irritant gas that can harm human respiratory organs. It also leads to damage to vegetation and contributes to acidifying precipitation. Finally, nitrogen oxides are precursor materials for forming photochemical oxidants, e.g. ozone, that lead to summer smog.

Material flow analysis

Detailed investigation of the material and energy flows in a production system. Material flow analyses can be related to company sites, company networks, as well as individual products (see Ecobalance). Their chief purpose is to provide information for the planning and optimising of systems.

System boundary

Interface between a production system and its environment or other production systems. Clear system boundaries are necessary to keep environmental balances and ecobalances plausible and the outlay reasonable.

Environmental audit

Component of the EMAS and an instrument of the environmental management of a company comprising a systematic, documented, regular and plausible recording and valuation of the (environmental) activities of the company and the actual environmental management system.

Environmental balance

Input and output balance of the material and energy flows of a company or company site. Formerly frequently known as Ecobalance of a company.

Environmental statement

A public statement prepared by the company, required in the Eco-Audit Regulation, which includes a numerical summary of the emissions, the waste generated, the consumption of raw materials and other environmentally relevant aspects of the company.

Transport generated

Another term for traffic generated, used mainly for freight transport. It is stated in tonnes (t).

Transport performance

Another term for traffic performance. It is mainly used for freight transport. It is stated in (tkm).

Environmental management system

That part of a management system that describes the organisational structure, responsibilities practices, behaviours, formal procedures and resources for determining and implementing the company environmental policy.

Impact assessment

Component of an ecobalance serving to identify and appraise potential environmental impacts of a system. By contrast with the valuation the impact assessment is still a scientific analysis. For example, determining the Global Warming Potential (GWP) belongs to the impact assessment, while the CO_2-emissions are part of an inventory analysis.

Traffic generated

Measuring quantity for the number of traffic operations in passenger traffic, the number of runs or passenger trips, in freight transport the weight (e.g. in tonnes) or the number of goods transported.

Traffic performance

The traffic performance results from the traffic generated multiplied by the distance travelled (each time). The traffic performance is stated in person-kilometres (pkm) for passenger transport and in tonne-kilometres (tkm) for freight transport.

Further Guides:

Bayrisches Staatsministerium [Bavarian Ministry of State] (Ed.) (1996): Der umweltbewußte Kfz-Betrieb. Bearbeitet von TÜV Bayern Sachsen. Verkehr und Fahrzeug GmbH. Munich.

Bayrisches Staatsministerium [Bavarian Ministry of State] (Ed.) (1996): Der umweltbewußte Fuhrparkbetrieb. Bearbeitet von TÜV Bayern Sachsen. Verkehr und Fahrzeug GmbH. Munich

Both guides provide information about technical procedures in companies and their environmental burdens, point up reduction measures and explain the legal provisions for companies. Checklists with questions on environmental protection are included with the guides.

Available from: Bayrisches Staatsministerium für Landesentwicklung und Umweltfragen [Bavarian Ministry of State for State Development and Environmental Issues], Rosenkavaliersplatz 2. 81925 Munich. *Gratis*

Bundesumweltministerium [Federal Ministry of the Environment] / Umweltbundesamt (1995) (Ed.): Handbuch Umweltcontrolling. Verlag Vahlen

The manual is a practically oriented and comprehensive guide for building up an environmental controlling system and is now one of the classics in environmental management literature. A new edition is planned in the year 2000.

Available from: bookshops

Bundesumweltministerium [Federal Ministry of the Environment] / Umweltbundesamt (1997) (Ed.): Leitfaden Betriebliche Umweltkennzahlen. Erstellt von Institut für Umweltmanagement IMU Augsburg.

What are indicatorss? What information do they provide? How are they formed? The guide provides an easy-to-understand overview with many examples

Available from: Umweltbundesamt Berlin. Postfach 33 00 22. 14191 Berlin

Landesanstalt für Umweltschutz [State Institute for Environmental Protection] Baden-Württemberg (1996) (Ed.): Umweltmanagement für Ver-kehrsbetriebe. Leitfaden zur Anwen-dung der EG-Öko-Audit-Verordnung. Erstellt vom ifeu-Institut und von U-BICOM. Karlsruhe

This guide provides assistance in introducing environmental management systems in transport companies in accordance with the EC-Eco-Audit-Regulation. It discusses organisational aspects and shows how to prepare and evaluate a company balance, how to prepare an environmental programme, what measures this can contain and what requirements are to be made of an environmental statement.

Available from: Verlagsauslieferung der LfU bei der JVA Mannheim. Druckerei, Herzogenriedstr. 111, 68169 Mannheim. Fax.: 0621/398370. DM 20.- each.

Landesanstalt für Umweltschutz [State Institute for Environmental Protection] Baden-Württemberg (1996) (Ed.): Umweltmanagement für kommunale Verwaltungen. Leitfaden zur Anwendung der EG-Öko-Audit-Verordnung. Erstellt vom ifeu-Institut. Karlsruhe

This guide backs up administrations in the introduction of environmental management systems in accordance with the EC-Eco-Audit-Regulation. It includes a diskette with comprehensive work materials and checklists for checking the management system, as well as forms for recording and editing data. It also contains forms for recording the environmental influences of staff commuter traffic and official travel.

Available from: Verlagsauslieferung der LfU bei der JVA Mannheim. Druckerei, Herzogen-riedstr. 111, 68169 Mannheim. Fax.: 0621/398370. DM 20.-

Umweltbundesamt (Ed.) (1999): Leitfaden betriebliche Umweltauswirkungen. - Ihre Erfassung und Bewertung als Baustein eines Umweltmanagementsystems - Erstellt von UPW - Büro für umweltorientiertes Planen und Wirtschaften. Bonn

Environmental impacts are defined here as the reaction of the environment to polluting materials and other influences. The guide provides assistance in recording the environmental impacts of the company and *contains a number of work sheets, assessment standards and environmental data.*

Available from: Umweltbundesamt Berlin. Postfach 33 00 22. 14191 Berlin