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IVL Swedish Environmental Research Institute

Life Cycle Assessment of Road

A Pilot Study for Inventory Analysis

Second Revised Edition

Håkan Stripple

B 1210 E
March 2001
Gothenburg, Sweden

For the Swedish National Road Administration

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PREFACE

The impact of traffic on society and environment has been the object of extensive investigation activity during a relatively long period of time. One condition for the development of traffic and transportation systems has been a wide extension of the infrastructure that is being used by vehicles. This infrastructure is very comprehensive and relatively complex. The road system includes a nation-wide system with different geo-technical and meteorological conditions. A road network contains many different components from direct materials in the road itself to peripheral equipment such as lighting, traffic lights, game fences, road signs, bridges, tunnels, etc. The production of materials for the road system represents an entire industrial sector in the Swedish economy.

The construction, operation and maintenance of the road network have in many cases, from an environmental point of view, been regarded as less significant compared to the impact of vehicles using the road during its lifetime. Any unambiguous evidence of this or any quantification of the conditions have not been presented, especially not seen from a life cycle assessment perspective which includes a system of direct road work, materials, transportation and peripheral equipment, etc.

The extended sectoral responsibility of the National Road Administration for the environmental impact of the vehicle transportation system has increased the need for extended knowledge about the environmental effects of road maintenance. This study is a first attempt at, with the help of life cycle assessment technique, increasing knowledge about the importance of road maintenance, seen from a life cycle perspective.

It is against this background that the Swedish Environmental Research Institute has carried out the study “Life Cycle Assessment of road - a Pilot Study for Inventory Analysis”. The study has been carried out on the instruction of and in collaboration with the National Road Administration as an industry specific project at IVL.

Svante Nordlander has been responsible for the project on behalf of the Swedish National Road Administration.

A great number of people have contributed to the realisation of this project. I would like to thank everyone at the Swedish National Road Administration and in the participating companies for contributing to the project with ideas and information.

Gothenburg, November 1995

Håkan Stripple

PREFACE TO SECOND REVISED EDITION

This second edition of Life Cycle Assessment of Road is an English translation of the Swedish report 'Livscykelanalys av väg', Swedish Environmental Research Institute (IVL) report B 1210 from 1995. The translation has been performed on behalf of Surrey County Council in England by Anna Eriksson and Lucia Elghali in co-operation with Håkan Stripple at IVL.

Based on experiences and comments from the original report some minor changes of the content have also been made. Comments to three subjects have been made:

- Inherent energy content in road surface materials.
- Road lighting and the influence of different road surface materials.
- CO_2 uptake in concrete.

Table 4.2.12.2 (application of tack coat) and table 4.2.38.2 (inventory data for hot mixed asphalt) in the original report has been replaced due to typing error. The typing errors affect only these tables and not the model or other results.

Gothenburg, March 2001

Håkan Stripple

SUMMARY

In co-operation with the Swedish National Road Administration, the Swedish Environmental Research Institute (IVL) has performed a basic life cycle assessment covering the inventory part for road construction, road maintenance and road operation. The infrastructure that forms the basis for our vehicle transportation system, the roads, stands for a significant part of a modern society and the construction, the maintenance and the operation of roads are technically relatively complex. The road system includes a nation-wide system with different geo-technical and meteorological conditions. The road system consists not only of asphalt layers, concrete and stone materials but it has become a sophisticated technical product including traffic control systems, road lights, road signs, geo-technical stabilisation materials, bridges, tunnels, etc. The production of materials for the road system represents an entire industrial sector.

This work is a preliminary study where the road system has been studied in terms of life cycle assessment methodology. The complete life cycle of a road has been studied including the extraction of raw materials, the production of construction products, the construction process, the maintenance and operation of the road and finally the disposal/reuse of the road at the end of the life cycle (end of the analysed time period). The contribution from traffic during the same time period is not included in the study. However, as a brief comparison, the contribution from the traffic has been roughly calculated and compared with the road system. A schematic picture of the life cycle of a road is presented in figure I.

Main structure of a life cycle for a road

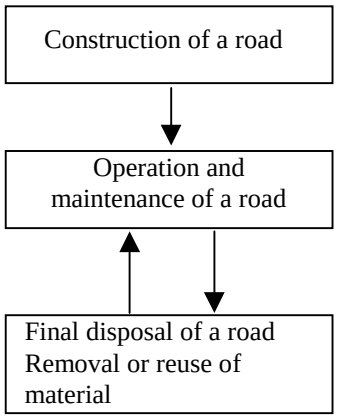


Figure I An overview of a life cycle for a road. The final disposal of a road is normally included in the maintenance of the road and some of the materials are reused. Most roads have no final end. Instead they are reconstructed or replaced by a new road while the old road remains in operation.

Specific circumstances for roads that make them different from other products are for example that each studied object is unique and the variations are significant due to geo-technical conditions, geographic location of the road, meteorological conditions, traffic intensity etc. Due to the varying conditions, the possibility of using a static life

cycle model is limited. The work has instead focused on a method in which the construction, maintenance and operation of the road have been broken down to small process units. The process units have then been used to build up a dynamic model in which it is possible to vary different process conditions and to simulate the different road system activities during a specific time period. Life cycle inventory (LCI) data for different process units has been calculated based on measured data from the processes. The data includes energy consumption, emissions and consumption of raw materials. The methodology used in this study for the life cycle assessment has, as far as possible, followed the recommendations from SETAC (Society of Environmental Toxicology and Chemistry).

The work has resulted in a computer model that has been used to analyse three different road surface materials: concrete and two types of asphalt depending on its construction process. The asphalt processes analysed are a conventional hot method where the asphalt is heated and mixed with stone material and a cold asphalt process where the asphalt is mixed with water to an emulsion and then mixed with stone materials. In addition, two different engine alternatives for vehicles and machines used in the processes, conventional diesel engines and modern low emission diesel engines, have been studied.

An overview of the total energy consumption divided into construction, maintenance and operation in a life cycle perspective is shown in figure II. In addition, the inherent energy bonded in the asphalt layer is also shown in the same figure. The inherent energy is however not a direct energy use due to the fact that the bitumen material is not combusted and the energy is thus not released. The inherent energy use can be treated as a resource use of bitumen. The figure shows the situation without asphalt recycling. An asphalt recycling process can reduce the resource use of bitumen.

The total energy consumption in construction, maintenance and operation of a 1 km long road during 40 years has been calculated to 23 TJ for an asphalt surface and 27 TJ for a concrete surface where the energy differences are small for the hot and cold asphalt methods. Of the total energy consumption, the 40 years of operation accounts for a large part of the consumption. This energy consumption originates from consumption of electrical energy from road lighting and traffic control (approximately 12 TJ) i.e. nearly all of the energy consumption for the operation of the road. An equal intensity of lighting has been assumed for asphalt roads and concrete roads. A brighter road surface can however require less illumination intensity and thus a reduced use of electric power. The difference in energy consumption for a conventional diesel engine and a low emission diesel engine is small and thus shows no significant difference in the total energy consumption.

In connection with the analysis of the results it should be pointed out that the conditions are very complex and that this study only reflects specified cases, namely those which are described by the input data that has been used in the model. The analysis is also a first application of a complex model which should be regarded as a first research model of the conditions which are present in a road system seen from a life cycle assessment perspective.

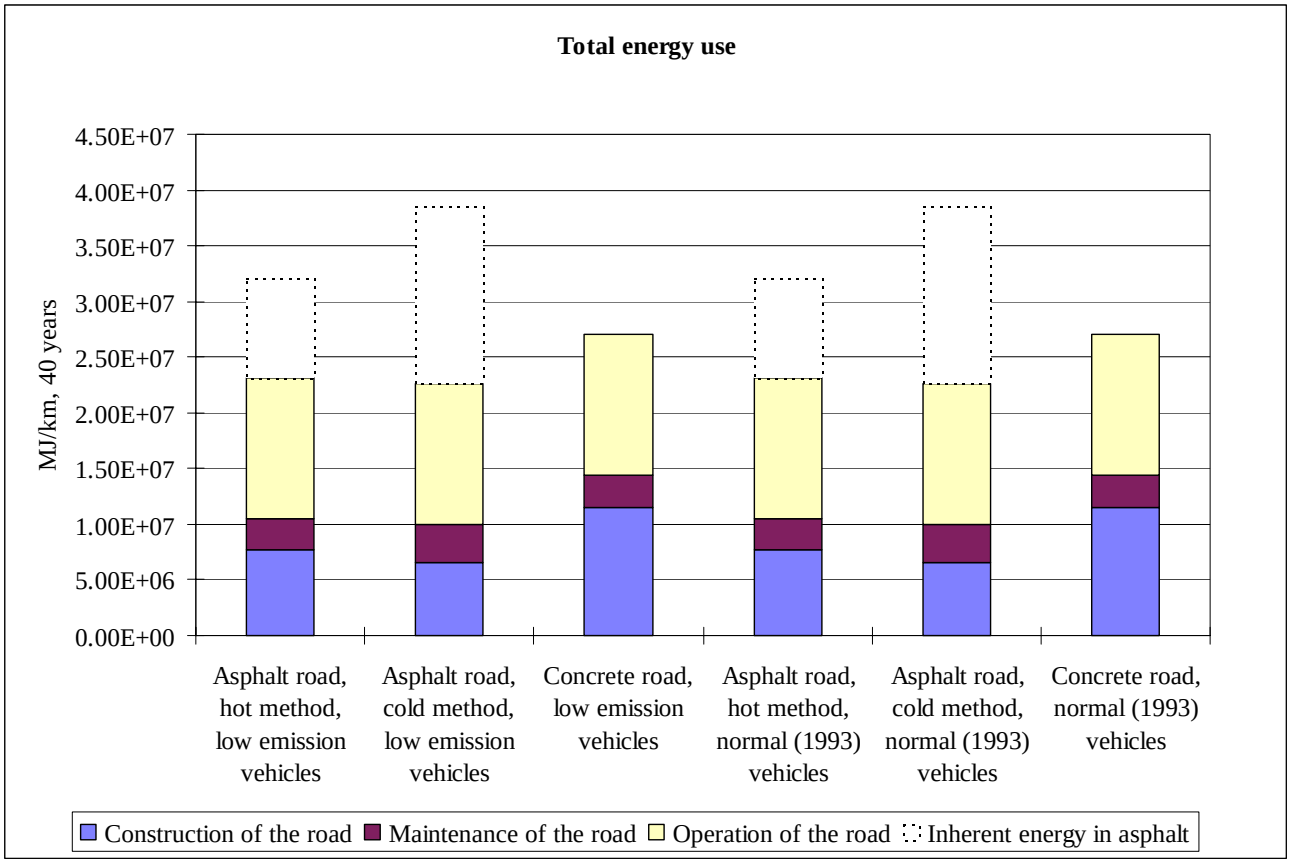


Figure II Total energy consumed for three different road surface materials and two different engine alternatives for construction vehicles divided into road construction, road maintenance and road operation for a 1 km long road during 40 years of operation. Dotted lines show inherent energy bonded in the road materials but not released as energy. Of the energy used for operation, approximately 12 TJ is consumed by road lights and traffic control.

An approximation of the energy consumption of the traffic during the 40 years of operation gives a total energy consumption of 229.2 TJ based on a traffic intensity of 5000 cars/day and with a fuel consumption of 0.1 litre fuel/km and car including pre combustion (production) of the fuel. Calculations of the energy use of the road compared to the energy use of the traffic are presented in table I for a traffic intensity of 5000 cars/day with and without electric energy consumption for road lights and traffic control.

Table I The energy use of the road as a percentage of the energy used from traffic with a traffic intensity of 5000 vehicles/day with and without road lights and traffic control.

Road type	**The energy use of the road compared to the energy use of the traffic with a traffic intensity of 5000 vehicles/day and <u>with</u> road lights and traffic control. (%)**	**The energy use of the road compared to the energy use of the traffic with a traffic intensity of 5000 vehicles/day and <u>without</u> road lights and traffic control. (%)**
Asphalt road, hot method	10.1	4.9
Asphalt road, cold method	9.9	4.7
Concrete road	11.8	6.6

The emissions of NO_x, SO_2 and CO_2 for the road system divided into construction, maintenance and operation of the road are shown in the figures III - V. The calculations of the emissions for the different engine alternatives are based on the assumption that the emission of NO_x is decreased with a factor of 2 when using a low emission diesel engine compared to a conventional diesel engine. The same assumption has been made for the emission of SO_2 but his is rather due to a corresponding decrease of the sulphur content in the fuel. The emission of CO_2 has been assumed to be equal for the two engine alternatives due to equivalent energy consumption. Figure V shows the situation without the slow long-term processes such as uptake of CO_2 in concrete (carbonation) and in-air oxidation of bitumen. These processes are very slow and can occur during several hundreds or thousands of years usually as waste processes and have not been covered in the study. If these processes are included the CO_2 emission from concrete roads can be reduced and the CO_2 emission from asphalt roads can be increased.

The dominating activity for the emission of NO_x SO_2 and CO_2 is the construction of the road. This is most significant for the emission of CO_2. The maintenance of the road is the second largest source of the emissions and for NO_x emission this activity gives a significant contribution. The operation of the road accounts only for a small part of the total emissions. However, it should be borne in mind that the emission calculations from the electrical energy production are based on Swedish average production that mainly consists of hydropower and nuclear power generated electricity with low emissions of NO_x, SO_2 and CO_2.

The situation for a complete road system is very complex and the analysis in this study covers only one simplified case, namely the situation described by the input variables in this model. The analysis in the study has been carried out using a preliminary research model and thus the results have to be considered with this in mind. Further work should be able to verify and improve the results from this model.

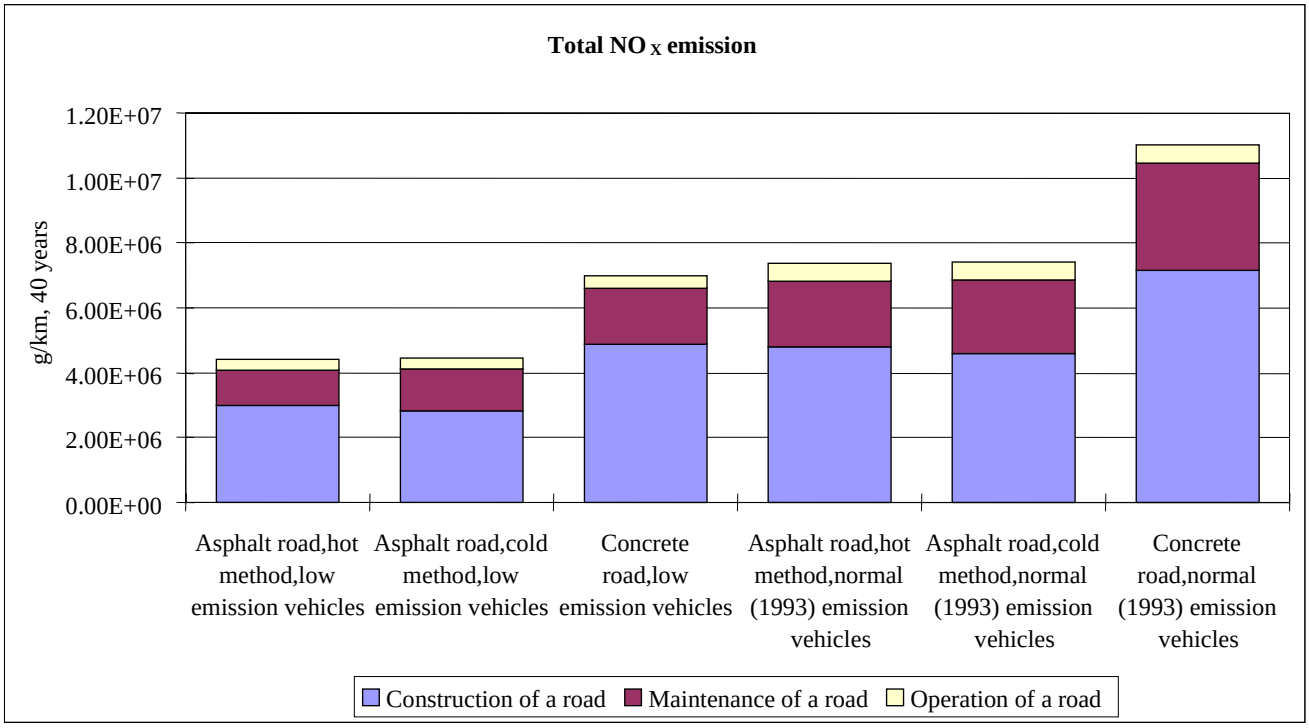


Figure III Total NO_X emission for three different road surface materials and two different engine alternatives for construction vehicles divided into road construction, road maintenance and road operation for a 1 km long road during 40 years of operation.

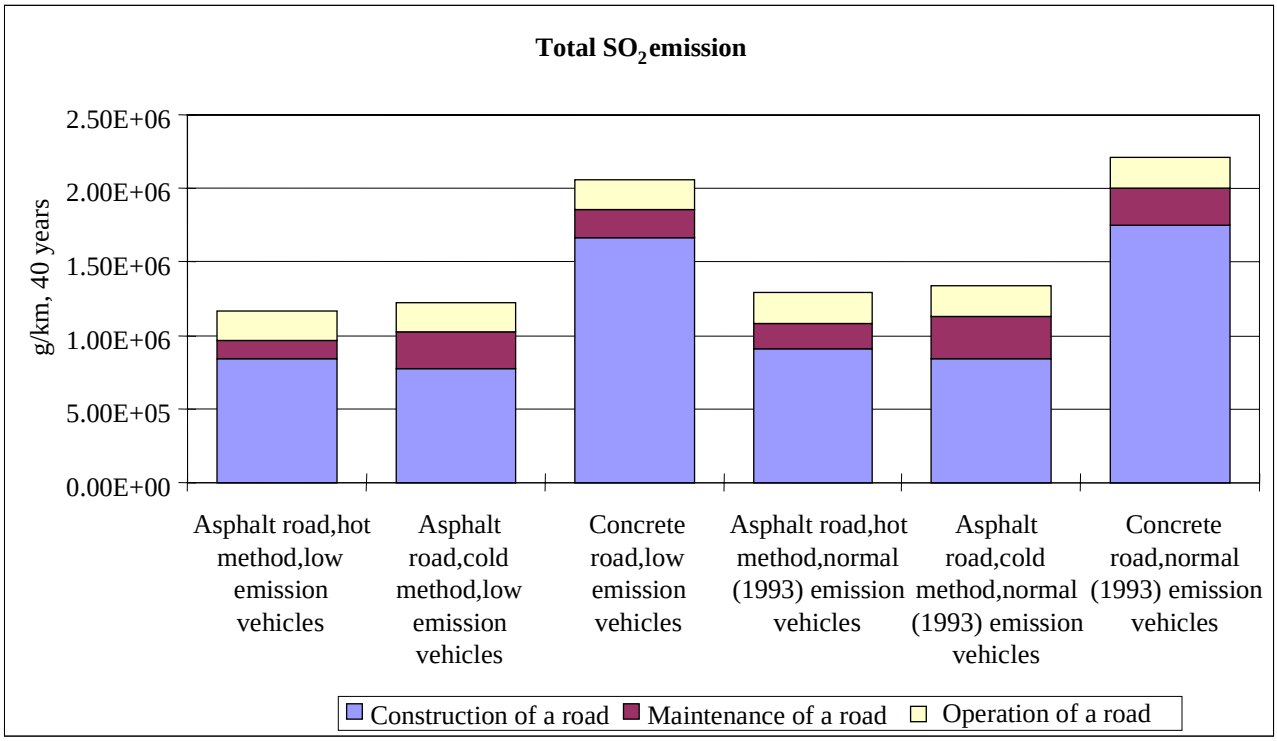


Figure IV Total SO_2emission for three different road surface materials and two different engine alternatives for construction vehicles divided into road construction, road maintenance and road operation for a 1 km long road during 40 years of operation.

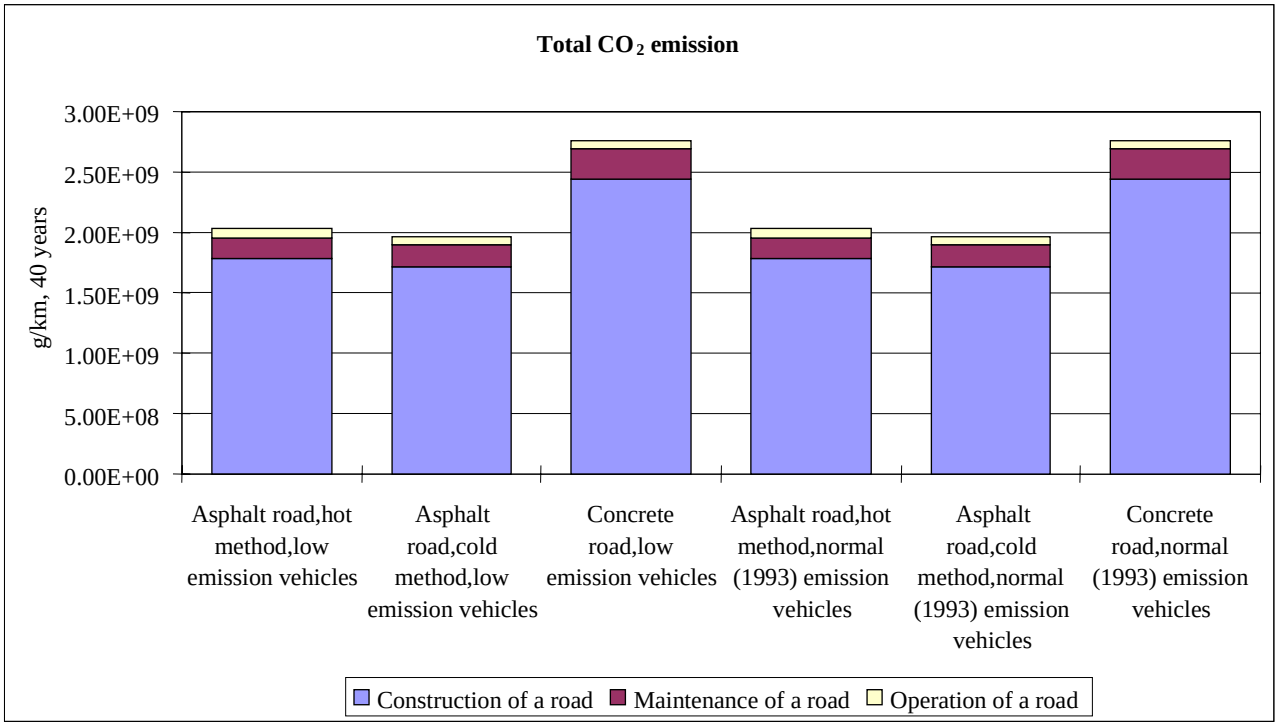


Figure V Total CO_2 emissions for three different road surface materials and two different engine alternatives for construction vehicles divided into road construction, road maintenance and road operation for a 1 km long road during 40 years of operation. The figure shows the situation without the slow long term processes such as uptake of CO_2 in concrete and in-air oxidation of bitumen.

CONTENTS

1 Introduction

The impact of traffic on society and environment has been the object of extensive investigation activity during a relatively long period of time. One condition for the development of traffic and transport systems has been a wide extension of the infrastructure that is being used by vehicles. This infrastructure is very comprehensive and relatively complex. The road system includes a nation-wide system with different geo-technical and meteorological conditions. A road network contains many different components from direct materials in the road itself to peripheral equipment such as lighting, traffic lights, game fences, road signs, bridges, tunnels etc. The production of materials for the road system represents an entire industrial sector in the Swedish economy.

The construction, operation and maintenance of the road network have in many cases, from an environmental point of view, been regarded as less significant compared to the impact of vehicles using the road during its lifetime. Any unambiguous evidence of this or any quantification of the conditions have not been presented, especially not seen from a life cycle assessment perspective which includes a system of direct road work, materials, transportation and peripheral equipment etc.

This work is a preliminary study, where the road system has been studied in terms of a life cycle assessment methodology. The complete life cycle of a road has been studied here, including the extraction of raw materials, the production of construction products and the construction process, the maintenance and operation of the road and finally the disposal/reuse of the road at the end of the life cycle. The contribution from traffic during the same time period is not included in the study. However, as a brief comparison, the contribution from the traffic has been roughly calculated and compared with the road system. A schematic picture of the life cycle of a road is presented in figure 1.1.

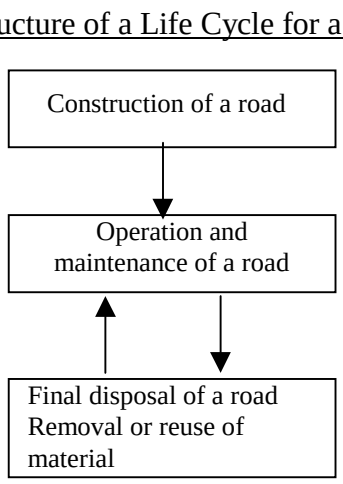


Figure 1.1 An overview of a life cycle for a road. The final disposal of a road is normally included in the maintenance of the road and some of the materials are reused. Most roads have no final end. Instead they are reconstructed or replaced by a new road while the old road remains in operation.

The first phase of the life cycle of a road is the projection and construction phase. In this phase, the road and any related peripheral equipment is constructed. It includes several heavy work elements such as excavation in order to obtain the desired routing of the road, foundation reinforcement work and other efforts. These elements do not normally reoccur at a later stage in the lifetime of a road. After the construction phase the road moves on to a usage phase, which contains the operation and maintenance phases. The operation includes elements such as winter road maintenance, clearing/mowing of verges, maintenance of peripheral equipment, etc. The maintenance of the road is related to the wear of the carriageway and the road structure, and includes replacement of the wearing course on the carriageway and replacement of the road structure, etc. Both the operation and the maintenance are events that reoccur during the lifetime of the road. The operation and maintenance periods are determined by the desired road standard, the desired density of traffic and so on. Normally a road does not have a final end. The road is built and thereafter used year after year. Through continuous maintenance of the road, the materials used in the road are successively replaced. Old roads that are given a new routing are often left without being demolished.

A road is different from many other products in that the production methods, materials consumption, etc vary significantly both between and within different construction projects. For example, geo-technical conditions may vary and the geographic location of the road may be different. Due to the varying conditions, it has not been possible to use a static life cycle assessment model. Instead, the study has focussed on a method in which the roadwork has been broken down into known process units. The process units have then been used to build up a dynamic computer model in which it is possible to vary different process conditions and to simulate the different road system activities during a specific time period. An important part of the work has been to

create a model that accepts data of a relatively high level of detail, in order for the results from the model simulations to be applicable in further development of the sub-processes. The study has concentrated on development of the methodology for LCI/LCA of roads, identification of emissions for each sub-process respectively and creation of a functioning computer model where the new theories can be tested and developed.

The study has resulted in a preliminary working computer model that has been used to analyse three different types of road surface materials: concrete and two types of asphalt depending on its construction process. The asphalt processes analysed are a conventional hot method where the asphalt is heated and mixed with stone material and a cold asphalt process where the asphalt is mixed with water to an emulsion and then mixed with stone materials. In this context, however, it should be pointed out that the computer model in its current form should be regarded as a tool to be used for research and that any long standing, detailed conclusions should not be drawn as a result of the model at this stage.

The development of the methodology for life cycle assessment used in this study has, as far as possible, followed the most widely spread standard in connection with LCA, namely the standard which has developed out of recommendations produced by SETAC (Society of Environmental Toxicology and Chemistry). An overview of the life cycle assessment methodology is presented in section 2 below. The study includes only the goal definition and the inventory analysis parts of the LCA, and therefore this is not a complete LCA according to the definitions presented by SETAC.

2 Life Cycle Assessment – methodology, an overview

2.1 Introduction

For the purpose of this study a methodology for Life Cycle Assessment (LCA) has been used. This methodology will be briefly described in this section, with emphasis on the parts that are of relevance in the context of roads.

Life Cycle Assessment is a tool which makes it possible to assess the environmental impact of a product, a process or an activity, through identifying and quantifying the flows of energy and material; evaluating the consumption of energy and materials as well as emissions generated; and identifying and evaluating possible measures for improving the environment. The analysis comprises the complete life cycle of a product, process or activity, including the production of raw materials, manufacturing, transport and distribution, usage, re-usage, maintenance, recycling of materials and final disposal or destruction. By using the life cycle assessment technique, it is possible to study whole complex systems where interactions between the sub-systems exist. This forms an increasingly important part of the analysis of activities where an environmental decision often has a complex effect on a whole system.

The primary purposes of an LCA can be summarised in a few points:

- To give a complete picture, as far as possible, of the interactions between an activity and the surrounding environment.
- To contribute to the understanding of the environmental consequences of human activity.
- To provide decision-makers with information about the environmental prerequisites for an activity.
- To identify the possible measures for improving environment.

The areas in which the Life Cycle Assessment could be of use are many. Some of these are presented below, divided into internal and external use:

Internal use of Life Cycle Assessment:

- Strategic planning of an activity.
- Building of knowledge.
- Development of environmental strategies for an activity.
- Construction, development and maximisation of products and processes.
- Identification of measures for improvement.
- Identification of critical steps in the process.
- Usage in prognoses.
- Preparation of specifications, regulations and purchasing procedures in the organisation.
- Environmental inspection of a business.
- Minimisation of waste.

External use of Life Cycle Assessment:

- Marketing.
- Environmental branding.
- Information purposes.
- Policy information.

A life cycle assessment analyses the environmental impact from a system, taking into account ecological effects, effects on health and the consumption of resources. An LCA does not, however, take into account economic or social effects. Like other scientific models, an LCA contains simplifications of the real system, which is why an LCA cannot claim to contain an absolute and complete representation of each environmental interaction.

Even though LCA is not a new concept, interest has increased dramatically since the late 1980's. This period has been described as an awakening phase (Finnveden, 1993). During this phase the need for international harmonisation and standardisation of methodology for LCA was recognised.

A common structure and terminology is also beginning to emerge as a result of numerous conferences and workshops (for example: Smet, 1990, Fava et al, 1991, SETAC-Europe, 1992, Fava et al, 1993, Consoli et al, 1993, CML, 1993). Of particular interest is the "Code of Practice" proposed by SETAC (Society of Environmental Toxicology and Chemistry) (Consoli et al, 1993), as a result of a workshop held during spring 1993. This document forms the basis of the structure and methodology that is described and used in this study. During later years, "guidelines" for LCA have also been published in Holland (Heijungs et al, 1992) and in the US (Vigon et al, 1993). Similar projects are also being undertaken in Canada (Husseini, 1993) and the Nordic countries. All this work is based on a similar structure. There are a few differences in terms of terminology and methods and principles recommended, but on the whole, the framework is the same. The work produced up to now by the International Standards Organisation (ISO) has resulted in a recommendation to use SETAC's "Code of Practice" as a basis for future work (Perriman, 1993). The European standards organisation CEN, has in turn proposed to follow ISO's recommendations (Perriman, 1993).

The framework proposed in "Code of Practice" (Consoli et al, 1993) is not a standard. There is still scope for different choices of methodology and system boundaries. However, there is a terminology, a framework and comments regarding which choices should be presented.

2.2 The Framework

An environmental Life Cycle Assessment is an analysis and evaluation of the environmental impact of a product which performs a specific function "from cradle to grave", i.e. from the extraction of raw materials, via production and consumption, to waste disposal. This is a relatively wide definition that requires further commentary:

- "Life Cycle Assessment" and "LCA" are used synonymously in this report with "environmental Life Cycle Assessment". The latter expression indicates that it is possible to study other aspects than the environmental aspects using a life cycle perspective.

- Not only an analysis is included in a complete LCA, but also an assessment of the environmental impact. This is often a necessary step if one wishes to draw conclusions regarding for example, which products should be preferred to others, from an environmental point of view. It is often desirable to be able to distinguish between the parts of an LCA that consists of a more traditional natural science type analysis and those parts where values of a political or moral nature are included.

- When talking about an LCA for a "product" it is easy to imagine a material product, for example a milk carton. In comparative studies however, it is necessary to specify the function performed by the product, for example to package a certain amount of milk. Assuming this, we realise that the product does not have to be a material product. For example, it could instead be a service function. In the case of a road, it would be possible to see the construction of a specific road section as the desired function, but one can also go a step further and study the services which that section of the road performs (for example transportation of a certain quantity of goods or people).

- It is important that the product is studied "from cradle to grave". In comparative analysis however, one can disregard common parts between the alternatives being compared. For example, if we are comparing two alternative handling methods for waste and the transportation method of the waste is identical in both cases, the transportation component can be excluded.

- According to the definition above, both quantitative and qualitative methods can be used in an environmental LCA. The emphasis in this study has been on quantitative methods, even though qualitative aspects will occasionally be mentioned.

A complete LCA consists of four components, of which the third is divided into three sub-components, as shown in table 2.2.1. (Consoli et al, 1993):

Table 2.2.1 Components of a complete LCA

1.	Goal definition and scoping
2.	Inventory analysis
3.	Impact assessment
	3.1 Classification
	3.2 Characterisation
	3.3 Valuation
4.	Improvement assessment

These components and sub-components will be discussed further in the following sections. The current section comprises only the first two steps in the Life Cycle Assessment process; goal definition and inventory analysis.

2.3 Goal definition and scoping

The objective of the study should be described in the goal definition and scoping components. This is an important step, as this should to a great extent drive the choices of system limitations and methodology.

Furthermore, the scope and limitations of the study should be described here. This should be done in accordance with the goal definition. The following issues are included in this and should be considered:

- Is this a complete LCA or will certain components or sub-components be excluded?
- Will all sub-steps of the lifecycle (raw materials extraction, production, consumption and waste disposal) be included or will some be excluded?
- Which types of environmental impact will be assessed and how will it be done?
- A description of the systems, including which function they perform. Based on this, the "functional unit" can be described. This is the unit that the results from an LCA are related to. An example of a "functional unit" is the construction, operation and maintenance of 1 km of road during 40 years. In comparative studies, it is important that the same functional unit is used for all systems. The systems being studied, or parts of them, will often perform many different functions. To make the systems comparable, the systems will have to be widened or the environmental burdens be allocated between the different products in some way. The methods for this will be discussed in the following section.
- A description of important presumptions.
- A description of the limitations of the system in time and space.

In conclusion, the different choices of methods and limitations that will be made in the following components should be described and justified already in this section.

2.4 Inventory Analysis

The inventory analysis describes the material and energy flows to and from the system. The system consists of different sub-steps such as raw materials extraction, transportation, production, consumption and waste disposal. All of these sub-steps require different types of inflows and generate different types of outflows. In an LCA it should be possible, in principle, to trace all inflows back to the "cradle" i.e. the raw materials as extracted, and to trace all outflows to the "grave", i.e. as emissions to the environment. The result of the inventory analysis is a summary of all inflows and outflows related to the "functional unit".

The system is limited by its system boundaries. In principle, there are three types of boundaries that must be fixed (Heijungs et al, 1992):

1. Boundaries between the technical system and the environment.
2. Boundaries between relevant and irrelevant processes within the technical system.
3. Boundaries between the technical system and other technical systems.

To fix the boundary between relevant and irrelevant processes is normally necessary in order for the study to be feasible. An example of this type of limitation is that one often ignores the production of capital goods (factories, lorries, etc).

The third type of limitation is often necessary to set because products move between different technical systems. In these situations, it is necessary to allocate the environmental burdens between the different products. There are, in principle, three different types of systems which lead to allocation problems (Huppes, 1992):

1. *"Multi-output"*: This situation arises when several different products are produced simultaneously and the environmental burdens in the form of consumption of raw materials and emissions are to be allocated between the different products. This is a problem for example in the production of bitumen out of crude oil for asphalt pavement.

2. *"Multi-input"*: An example of this situation is incineration of waste, where several different products make up the inflow to the plant and the outflow consists of smoke gases and ashes. Thus, this outflow must be allocated to the incoming products in some way.

3. *"Open-loop recycling"*: If a product or a material is being recycled and used to manufacture another product, this is called "open-loop recycling". Even in this case, the environmental burdens must be allocated between the original product and the secondary product.

The question of which principle should be used for allocation in these different cases has been widely discussed. One can distinguish between three different principles of allocation:

1. Physical/chemical causal allocation: According to this principle, one should as far as possible try to identify the physical/chemical causes of the emissions and the raw materials consumption, and then allocate the environmental burdens according to the cause-effect principle.

2. Social/economic causal allocation: According to this principle the environmental burdens should be allocated on the products which are the social cause of the driving of a process. This is often reflected by the economic picture (one drives a process to earn money, and the environmental burdens should be allocated to the different products in proportion to an economic parameter of some kind).

3. Allocation according to a physical parameter: Examples of commonly used parameters are:
   a) Weight.
   b) Volume.
   c) Energy content.
   d) Area.
   e) Number of mol.

How system boundaries should be fixed, what allocation principles should be used and similar decisions, should in principle be made already in the goal definition. This is partly because the choice of methodology should largely depend on the objective of the study, and partly to indicate that these choices are subjective to a great extent. Generally however, the inventory analysis is considered to be based on the traditional methods of natural science.

2.5 Impact Assessment

2.5.1 Classification

In the classification, the types of environmental impacts different inflows and outflows in the inventory analysis can result in should be described. For example, all types of emissions that could contribute towards global warming are grouped under the heading “Global warming”. The description of the impacts should be based on a scientific analysis of relevant environmental processes.

Therefore, it is important to decide which types of environmental impacts should be considered in an LCA. This is something which has been widely discussed (see for example: Fava et al, 1993, Finnveden and Lindfors, 1992a, Finnveden et al, 1992, Finnveden, 1993b, Heijungs et al, 1992, Lindfors, 1992, Consoli et al, 1993, SETAC-Europe, 1992). Based partly on suggestions that have been made in different contexts and partly on what is possible to handle in latter parts of an LCA, the following list of impact categories which ought to be used in a complete LCA, has been suggested. (Finnveden, 1993b).

Table 2.5.1 Impact categories, which ought to be included in a complete LCA.

1.	Resource consumption	1.1	Energy and material
		1.2	Land
		1.3	Water
2.	Health effects	2.1	Toxic effects
(including working environment)		2.2	Physical effects
		2.3	Psychological effects
		2.4	Illnesses caused by biological organisms
3.	Ecological effects	3.1	Global warming
		3.2	Ozone depletion
		3.3	Acidification
		3.4	Eutrophication of aquatic systems
		3.5	Eutrophication of terrestrial systems
		3.6	Formation of photochemical oxidants
		3.7	Ecological toxicity
		3.8	Effects on the biodiversity

4. Inflows which have not been traced all the way from the "cradle"

5. Outflows which have not been traced all the way to the "grave"

Categories 4 and 5 are not really effect categories but are included to make sure they will not disappear in the latter analysis. In "Code of Practice", there is a list of examples of impact categories. It is not identical to table 2.5.1, but it is similar.

Decisions about which impact categories should be included in a specific study are dependent on the objective of the study, among other things. The choice of categories should therefore be made already in the goal definition, if possible.

2.5.2 Characterisation

The classification section should describe which flows contribute to each impact category. In the characterisation step, the contributions of the different flows to each impact category are aggregated. This aggregation should be based on a traditional scientific analysis of the relevant environmental processes. For example, in the classification, we describe which flows could contribute towards global warming. In the characterisation, the contributions of the different flows to global warming are aggregated. One way of doing this is using so called CO_2 equivalents.

At the moment, intensive development efforts are being made in order to find aggregation methods for the characterisation (for example Fava et al, 1993, Finnveden, 1993b, Finnveden and Lindfors, 1992a, Finnveden et al, 1992, Heijungs et al, 1992, SETAC-Europe, 1992). Only for a few of the categories (global warming and ozone depletion) is there a consensus within the LCA community regarding which methods can be used. For some of the categories, no applicable quantitative methods exist at all that fulfil the requirements of the characterisation method.

2.5.3 Valuation

In the valuation step, different impact categories are compared with each other. This can be done either qualitatively or quantitatively. If it is done quantitatively it will result in the only figure that will describe the environmental impact of the product. In the valuation, different types of environmental impacts will be compared with each other, for example a potential impact on people's health would be weighed against the impact on biological variety, or consumption of finite resources. This can not be done simply based on traditional scientific methods. In addition, valuations of a political and/or moral nature must be introduced.

Intensive development work is being carried out at present, in order to find valuation methods (For example CML, 1993, Fava et al, 1993, Finnveden, 1993b, Heijungs et al, 1992, SETAC-Europe, 1992, Steen and Ryding, 1992). There is currently no international consensus regarding which methods can be used and when. Different methods have been known to give different results (For example Baumann and Rydberg, 1992 and 1993, Hofstetter, 1993). This is only to be expected as different methods are based on different principles regarding which aspects of the environment are worth protecting and how then these should be valued, plus the fact that the valuations themselves often differ.

2.6 Improvement Assessment

In the final component of the framework, the possibilities of improvement will be assessed. This is perhaps the least developed component in connection with LCA, and the issue will not be discussed further in this study.

2.7 Commentary to the Framework

The background to the framework described above is the desire to separate parts that rely on traditional scientific methods from those parts which contain values of a political or moral nature. The inventory analysis, the classification and the characterisation should be based on an analysis of the relevant technical and scientific processes. The choices that must be made with reference to system boundaries and methodology for these components are, to some extent, subjective and should therefore be made in the goal definition, which is subjective in its nature. For the valuation we require values, which is why these methods have been laid down as a special sub-component.

In Life Cycle Assessments, the emphasis has previously been on the inventory analysis. Often there has not been any assessment of the environmental impact, or only an elementary assessment. The purpose of the environmental impact assessment is in principle twofold:

1. To convert the information regarding in and outflows (obtained from the inventory analysis) into information about the potential environmental impact. The information about inflows and outflows does not itself contain any information about the environmental impact, to obtain knowledge of the environmental impact that different products generate, the information must be interpreted.

2. To aggregate the information in order to obtain a manageable foundation for decision making. An LCA is often used as a basis on which to make decisions. The inventory analysis can generate a large amount of information, so in order for the basis of decisions to be manageable, the information must be aggregated. How far this needs to be taken depends on how unambiguous the result is (if all information points in the same direction, aggregation is not really needed) and the needs of the decision maker. In the framework described here, the aggregation is done in two steps. In the first step, the characterisation, the information is aggregated within different effect categories. In the second step, the valuation, information is aggregated between different effect categories. From the characterisation, only unambiguous conclusions can really be drawn if all parameters are pointing in the same direction. If this is not the case, a valuation where the different effect categories are weighed against each other is required.

The description of the framework can give the impression that the LCA is a linear process where one goes from component to component. It can, however, be of more benefit to view LCA as an iterative process. A procedure has been suggested (Ekvall et al, 1992, Finnveden et al, 1991, Lindfors, 1992) in which a first initial LCA is followed by some form of sensitivity analysis in order to identify the most important parts of the life cycle. These parts can then be studied closer in a more detailed analysis.

3 Goal definition and Scope

3.1 Introduction and background

As could be seen from the general description of LCA in chapter 2, LCA is a flexible tool that can be used for many purposes. The objective of this study has been to produce a working methodology for LCA inventory analysis of the road construction process, to carry out a preliminary trial inventory analysis and to summarise data to get a complete overview of the road construction process.

The road construction process differs noticeably from other manufacturing processes through its great variation with regard to manufacturing conditions. Large and important variations exist between different sites, but even within the same strip of road the conditions can vary substantially. The terrain can be more or less hilly which in turn brings about differences in excavation work needed. The projected routing of the road play a crucial role in this. The road can also follow the outline of the terrain to a greater or lesser extent. For traffic related reasons there is a tendency towards making the road lie as flat as possible in the ground. In this case, one tries as far as possible to design the routing of the road, which leads to a minimum of external,

transported materials. However, a flatter road in hilly terrain leads to an increased amount of internal transports in the longitudinal direction of the road. Figure 3.1.1 shows the conditions between the internal transports in longitudinal direction of the road and the balanced route.

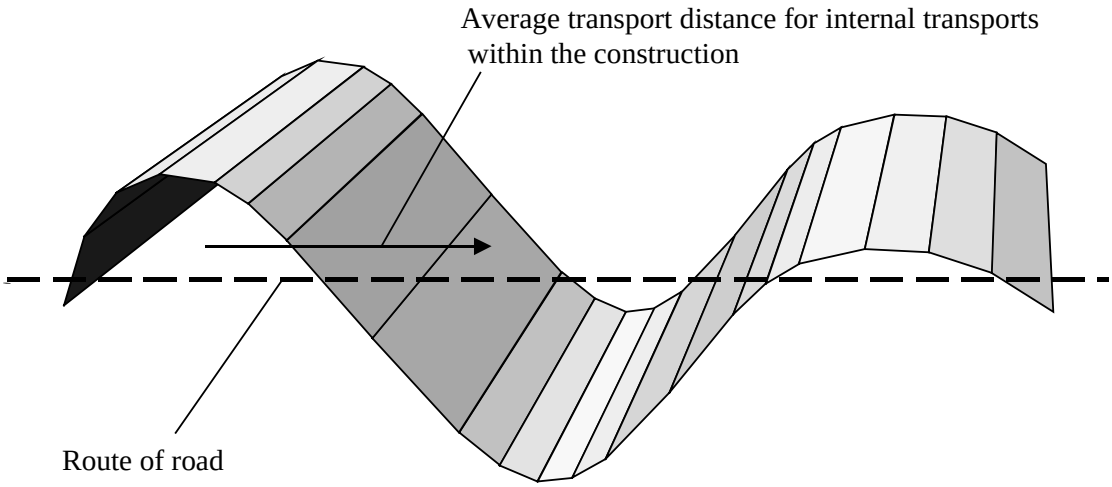


Figure 3.1.1 Schematic picture showing the relationship between the terrain and the balanced route of the road, and the transportation of excavated material in the direction of the road.

When the route of the road passes through an open excavation in the landscape we say that the road is in a cutting, figure 3.1.2. This type of landscape-modifying process often involves great working efforts and is therefore an important component to study.

Questions regarding the possible benefits to the traffic of designing a flatter road should be considered in relation to the size of efforts in the road construction process.

The technical composition of a road varies substantially depending on the land characteristics along the route, estimated traffic flow etc but also depending on active choices between certain comparable techniques, such as between different types of paving, even if these to some extent are also driven by other technical parameters. To make the model calculations possible, certain simplified fundamental prerequisites regarding the composition of the road have been assumed. A schematic picture of the composition of the modelled road is shown in figure 3.1.2.

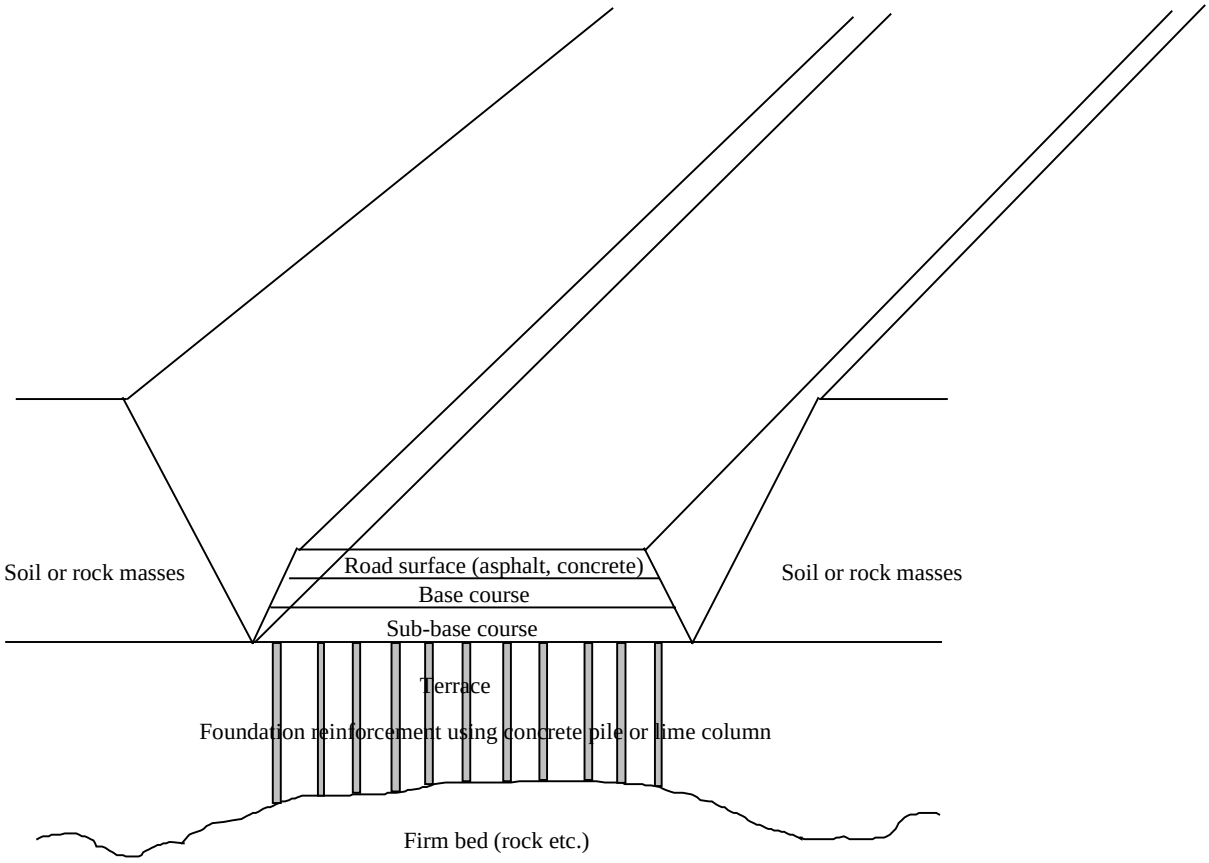


Figure 3.1.2 A schematic picture of the composition of the modelled road used in the study.

3.2 Goal Definition

The main purpose of the study has been to carry out, according to definitions by SETAC and using the life cycle assessment technique, goal definition and inventory analysis studies to analyse the road construction process.

The objectives and the technical applications of the research project have been numerous. The primary purpose has been to produce an increased knowledge base concerning the technical mechanisms, and the dynamics driving the consumption of energy and raw materials, and which result in undesired emissions and environmental impact in road construction processes from a life cycle perspective.

The subsequent areas of application can be several, for example, identification of critical process steps, development and maximisation of products and production methods, development of environmental strategies and strategic planning of the operation, etc.

Important sub-goals for the study have been:

- to come up with a methodology for life cycle assessments of road construction processes.
- to identify and quantify the sub-components which describe a road construction process.
- to design a model structure for the road construction process based on the identified sub-components.
- to produce a computer program covering the model structure where it is possible to simulate a road construction process.
- to try the computer model on a few of the imagined applications.

In the light of the complex production process for roads, and especially the greatly varying production conditions in combination with the requirement of high level of detail to achieve maximum technical application, a technique has been chosen in which the production process has been broken down into independent sub-components. With the help of these sub-components a conceptual road can be built based on a theoretical model structure for the activities included in the construction process. Each sub-component or sub-process have been formed in the inventory analysis and are presented in its performance units in chapter 4 and in appendix (Resource and emission data for processes).

Each sub-component will be analysed respectively using the life cycle assessment methodology and represent generally applicable readings. The life cycle assessment of the sub-components has to the greatest possible extent been done in collaboration with manufacturers or those who practice respective activities.

For each sub-component there are generally applicable emission and energy values. These can either be used for calculations in a real project case, for example integrated with a GIS (Geographic Information System), where values for soil volumes, areas etc are available or, like in this study, be used in the production of an imagined model case where it is possible to simulate different construction solutions in order to deepen the knowledge about energy aspects and environmental aspects in road construction.

In the choice of final functional unit for the analysis of the roadwork, it has emerged that a section of road itself is the simplest and the most representative functional unit. In the model all results are refereed to a so-called Road Object. The road object is the object that is analysed in the model and described by all the input data in the model such as road length (1 km), road width (13 m), surface thickness, etc. The road object represents the functional unit of the entire system.

This study is a first research project which on a detailed level, using LCA technique, investigates the road construction process. Further work remains in order to apply and verify the research results before long-standing and general conclusions can be drawn from the study.

3.3 Scope and limitations

A life cycle assessment is integrated both backwards in the production chain towards raw materials extraction, and forwards towards destruction or recycling of the consumed product. This very comprehensive way of tackling the issue makes it necessary to create some limitations in order to be able to handle the system. The lack of relevant LCA data from certain primary and complex areas also makes it necessary to introduce certain limitations. It could, however, be of great use to try to roughly estimate the size of the errors that have occurred.

As previously mentioned we often neglect fixed capital investments and only deal with the operation of these in the analysis. This is also the case for several parts in this study. As far as vehicles and maintenance machines are concerned, the production of the vehicles or machines themselves has consequently not been taken into account, but only the operation of the vehicle and principally the consumption of fuel, which is the dominating component of the operation part. The production of the fuel (diesel in most cases) from crude oil extraction via refining to distribution has, however, been taken into account in this study. Certain calculations have been carried out for the vehicle production in relation to the amount of fuel the vehicle consumes in its lifetime. These preliminary calculations, which have been communicated in this project, show that for larger lorries, the manufacturing part including the extraction of raw materials constitutes of 3-4 %. For manufacturing of maintenance vehicles such as wheeled loaders, excavators, dumpers etc, it should be possible to obtain similar values.

Furthermore, the manufacturing of production plants such as refineries, cement plants, asphalt plants, etc, have not been included in the analysis but the operation has.

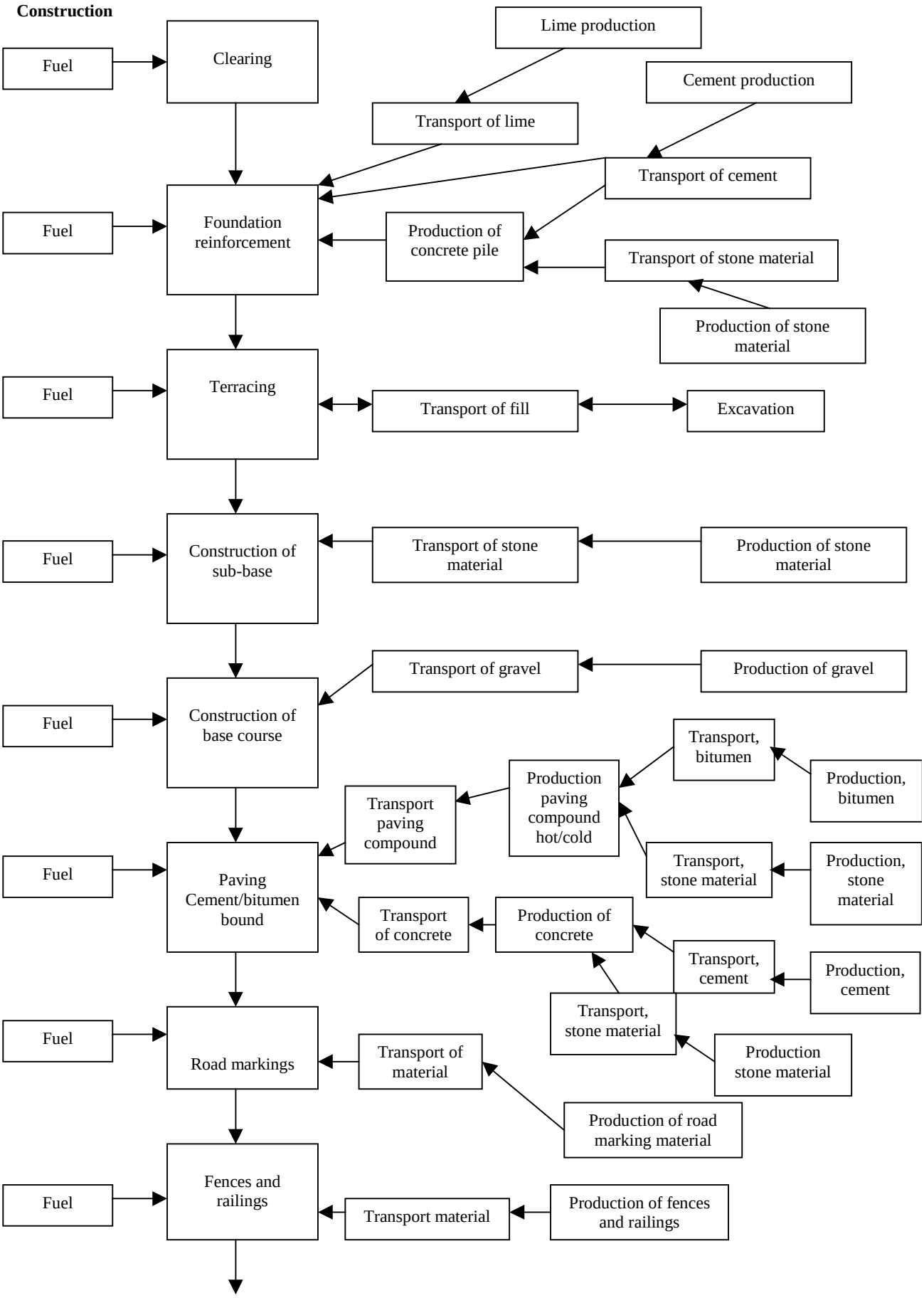
Regarding the production of electrical energy, data for so called Swedish average electricity has been used, which to a large part is based on hydropower and nuclear power with an element of fossil fuel and biomass fuels.

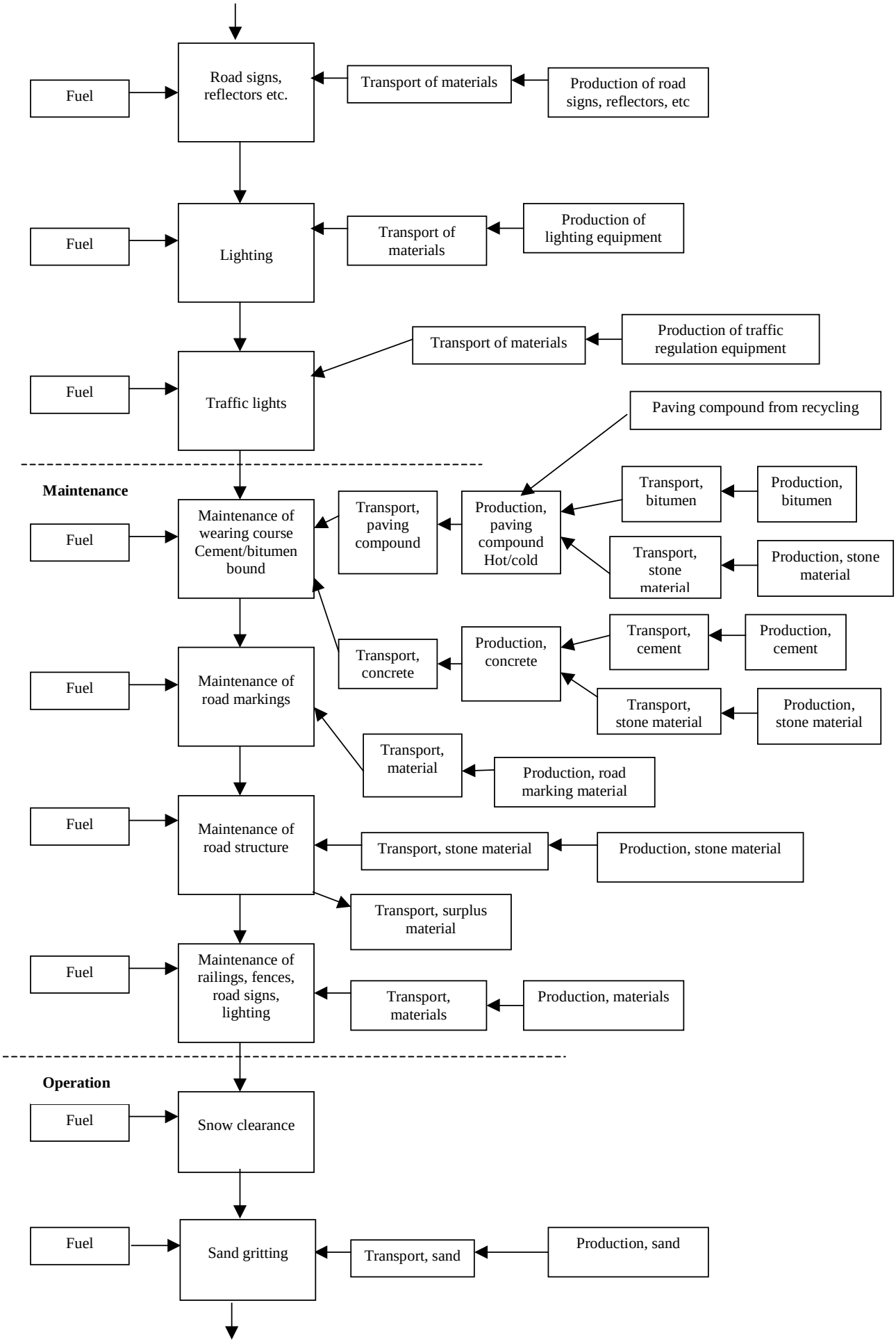
The limitations of a life cycle assessment in time are also of importance in this case. A road is different from a normal product in that it does not have a definitive end in time. A road can be seen as a constantly on-going process where, through active decisions, one can determine the objective for a certain accessibility between two points. As long as the decision regarding the determined accessibility remains, the road also remains, although it is exposed to a constant process of change. After a certain period of time, only certain parts are remaining of the original road, in physical terms. Depending on which materials have been chosen, the maintenance intervals become different and the chosen time aspect in the analyses of vital importance. In the computer model that has been developed within the frame of the project, it is possible to vary the studied time period. For those simulations that can be found in this study, 40 years has been chosen as the time period used. 40 years also constitute the economic calculation period commonly used in internal analyses by the Swedish National Road Administration.

3.4 The model structure

The composition of the model structure for construction, operation and maintenance of a road is based on the sub components that will fill the model. The model structure is shown in figure 3.4.1 and represents a schematic picture of the events and activities that form the basis for the inventory analysis and the model work in the life cycle assessment. The model structure, which constitutes a stylised and mathematical picture of reality, differs from the same in certain respects. Primarily, the model sets its sights on the specific process operations that exist. In reality there may be several others, let us call them unspecified activities. A further application of the model will show the correspondence between the model and reality.

Model of a life cycle for a road




Fuel
Road signs, reflectors etc.
Transport of materials
Production of road signs, reflectors, etc
Fuel
Lighting
Transport of materials
Production of lighting equipment
Fuel
Traffic lights
Transport of materials
Production of traffic regulation equipment
Paving compound from recycling
Maintenance
Fuel
Maintenance of wearing course Cement/bitumen bound
Transport, paving compound
Production, paving compound Hot/cold
Transport, bitumen
Production, bitumen
Transport, stone material
Production, stone material
Fuel
Maintenance of road markings
Transport, concrete
Production, concrete
Transport, cement
Production, cement
Transport, stone material
Production, stone material
Transport, material
Production, road marking material
Fuel
Maintenance of road structure
Transport, stone material
Production, stone material
Transport, surplus material
Fuel
Maintenance of railings, fences, road signs, lighting
Transport, materials
Production, materials
Operation
Fuel
Snow clearance
Fuel
Sand gritting
Transport, sand
Production, sand

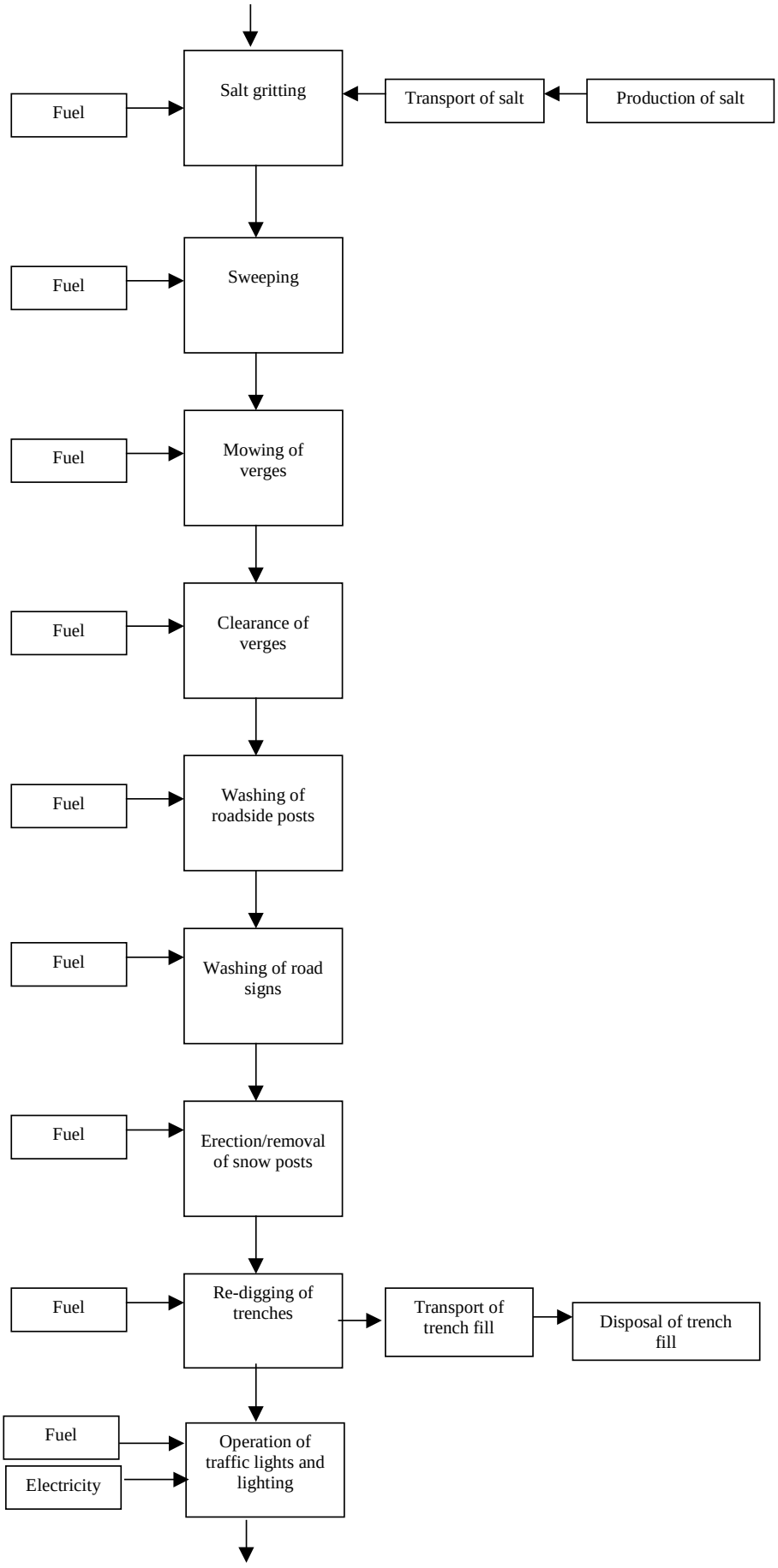


Figure 3.4.1 Model structure for construction, operation and maintenance of a road

4 Inventory Analysis

4.1 Introduction

The inventory analysis is in this case based on the sub-components that have emerged and which at a later stage in the process together with input variables makes up the core in the calculation model. The sub-components are made up of factors which show emissions, energy consumption and resource consumption for different basic activities, for example expressed per number of vehicle km (vkm), amount of m^3 excavated material, tonne[1] asphalt produced, etc. These so-called performance units have as far as possible been chosen based on practical applicability. Of significant importance in the calculation work when calculating factors, are the functions that connect machine data (for example g NO_x/MJ added fuel), which are often known, with capacity data for the machine (for example amount of excavated material per added fuel unit). This varies significantly depending on the operation characteristics. The energy content in the fuel for combustion is based on the lower heating value.

The inventory analysis includes the basic emission, resource and energy parameters. Certain other effects such as noise and severance effects are not included in the current design of the model. The model can however, be easily complemented with additional parameters as required.

Input data for the parameters is naturally of vital importance for the final results of the model. The choice of input data has as far as possible been made based on real data from plants in operation. For maintenance vehicles and loading vehicles, it has been assumed that the operation has taken place using a modern, low emission diesel engine, of environmental diesel operation class 2. This can give low emissions and low energy consumption in comparison to an older machine under today's conditions. It is however impossible to change these parameters in the model. Input data can also have different quality depending on the data that is available. The central parts in the model have a relatively good data quality while a more peripheral activity can have a more uncertain quality. I would like to mention here that the data for the production of salt is sourced in Germany.

In section 4.2, the emission, energy and resource factors that have been calculated in the study have been presented and background information for the factors that have emerged are also presented. The factors can also be found in the model sheets from the model simulations in appendix 1.

[1] In the entire report tonnes refer to metric tonnes, 1 metric tonne=1000 kg.

4.2 Emission, energy and resource factors

4.2.1 Electricity production

In Sweden electricity is primarily produced using hydropower and nuclear power, although other sources such as fossil fuel or biomass fuel are sometimes used. Some exchange of electricity with neighbouring countries also exists. In this study, data for Swedish average electricity production has been used. Where significant changes in electricity production occur, it could be appropriate to use information about marginal production rather than average production. This is because it is the marginal production that increases or decreases if you increase or reduce the usage of electricity somewhat. In this type of case, it may be difficult to determine how the marginal production takes place, as the marginal production varies depending on weather and seasonal variations, for example. During the colder months of the year, the marginal production of electricity in Sweden is mostly accomplished by using oil and coal condense power production.

Values for raw materials consumption and emission factors are presented in table 4.2.1.1 for Swedish average electricity. Data for electricity production using coal condense power production has also been included in the table, as a comparison. The information about electricity production only shows the flows surrounding the production itself. No data about the environmental impact in connection with extraction of raw materials and transportation for example, are included in these figures (for average electricity, coal, some transports are included).

In the production of electricity, district heating is sometimes also produced. In the information used in this report, this fact does not seem to have been taken into account. There has been no allocation between heating and power and therefore all the environmental burdens are assumed to be due to the production of power.

Table 4.2.1.1 Raw materials consumption and emission factors for electricity production.

In or outflow	Unit per MJ electricity	"Average electricity"[1)]	Coal condensate[2)]
Biomass fuel[3)]	MJ	0.045	0
Oil[3)]	MJ	0.064	0
Peat[3)]	MJ	0.0045	0
Coal[3)]	MJ	0.040	3.0
Natural gas[3)]	MJ	0.0093	0
Uranium[4)]	MJ	1.6	0
Hydropower[5)]	MJ	0.47	0
CO_2	g	3.8	240
SO_2	g	0.0067	1.4
NO_x	g	0.0092	1.2
Dust	g	7.0E-5	0.01
CO	g	0.0021	
Radioactive discharge	manSv	1.0E-10	
Ashes	g	0.07	8[6]
Radioactive waste:			
Highly active	cm^3	0.0014	
Medium and low active	cm^3	0.015	
Demolition waste	cm^3	0.015	
N_2O	g	4.2E-4	0.0015
VOC	g	0.0011	
CH_4	g	1.4E-4	

1) If no other information is given according to Lundgren (1993), his material is mainly based on Swedish material

2) If no other information is given according to Baumann et al (1993a), their material is mainly based on a few different Danish surveys.

3) For "average electricity" calculated using information in Lundgren (1993) and an efficiency of 33 % (Bousted, 1992), the same efficiency has been used for "coal condense power production"

4) Calculated using information in Lundgren (1993) and a efficiency of 35 % (Bousted, 1992)

5) Calculated using information in Lundgren (1993)

6) Estimated through the following assumptions: ash content around 10 %, energy content around 30MJ/kg

4.2.2 Emissions and energy consumption during transport by truck

Life cycle data for truck transports has been calculated for two different types of lorries in two different driving conditions. The lorries can be assumed to represent the different types of transports that take place during road construction and road maintenance. The vehicles represent transport by distribution truck outside of urban areas and remote transport by long distance truck. The loading capacity is 14 tonnes for the distribution truck and 32 tonnes for the remote transport vehicle. The weight is assumed to be the limiting factor for the loading capacity when transporting bulk material which has a high density such as soil, gravel, stone, sand, concrete, asphalt, etc.

In the life cycle inventory of truck transports, only fuel consumption during operation and the production of the corresponding amount of fuel has been taken into account.

The fuel is assumed to be of environmental class 2 with a sulphur content of 0.05 % and an effective heating value of 35.1 MJ/litre (l). The production of the truck is not included in the analysis.

Basic data for the two alternatives is shown in table 4.2.2.1. Emission and energy factors for diesel consumption in connection with the truck transports together with pre-combustion emissions are presented in table 4.2.2.2. The latter two describe emissions in extraction, transportation and refining of oil. The total flows are obtained by adding flows during operation to the pre-combustion additions. In the calculation of the latter a weight allocation has been used (Tillman et al, 1991). The information should be considered as fairly unreliable. It has been shown previously (Ekvall, 1992, Finnveden and Antonsson, 1992) that the pre-combustion additions vary significantly between different studies. The total emission and energy factors, including pre-combustion factors, are also presented calculated per vehicle kilometre (vkm) for the two cases respectively.

Table 4.2.2.1 Fuel/energy consumption for two types of lorries. The fuel consumption has been given at full load, with no load, and with transport with full load and empty car in return.

Type of truck	**Area of operation**	**Fuel consumption at maximum load (litre/vkm)**	**Fuel consumption without load (litre/vkm)**	**Fuel consumption at maximum load, and empty on return (litre/vkm)**	**Energy consumption at maximum load, and empty on return (MJ/vkm)**
Distribution truck, max load 14 tonnes	Outside urban area	0.39	0.29	0.34	11.9
Long-distance truck, max load 32 tonnes	Rural roads	0.47	0.29	0.38	13.3

Table 4.2.2.2 Emissions and energy consumption for distribution truck outside of urban areas and remote transport based on the case of maximum load and empty on return.

In or outflow	Unit	Flow per MJ used diesel, distribution truck, [1)]	Flow per MJ used diesel, long-distance transport, [1)]	"Pre-combustion" - addition per MJ used diesel, [2)]	Total flow, distribution truck per vkm, full load, empty on return	Total flow, long-distance transport per vkm, full load, empty on return
Oil	MJ	1	1	0.1	1.31E+01	1.47E+01
CO_2	g	75	75	4	9.43E+02	1.05E+03
SO_2	g	0.024 [3)]	0.024 [3)]	0.014	4.53E-01	5.07E-01
NO_x	g	0.5	0.6	0.0041	6.02E+00	8.06E+00
Dust	g	0.008	0.01	4.80E-04	1.01E-01	1.40E-01
CO	g	0.08	0.1	1.30E-04	9.56E-01	1.34E+00
N_2O	g	0.0016 [4)]	0.0016 [4)]		1.91E-02	2.13E-02
HC	g	0.03	0.03	0.0084	4.58E-01	5.12E-01
CH_4	g	5.00E-05	5.00E-05		5.97E-04	6.67E-04
Oil (aq)	g			4.00E-04	4.77E-03	5.34E-03
Phenol(aq)	g			5.07E-04	6.80E-03	7.60E-03
COD	g			0.0012	1.43E-02	1.60E-02
Tot-N (aq)	g			1.90E-04	2.27E-03	2.53E-03

1) Division into vehicle categories after discussion with truck manufacturer and data based on different surveys referred to by Jönsson (1993).
2) Tillman et al (1991).
3) Correspond to a sulphur content of around 0.05% (Jönsson, 1993).
4 Almén (1992) according to Jönsson (1993).

4.2.3 Sea freight (shipments)

Certain transports of material are done by sea freight, such as the transportation of salt from Germany for use in road maintenance during the winter. Energy consumption and emissions for sea charter have been calculated based on emission and fuel data from Lloyd's register of shipping. In this case, life cycle data for sea transport lacks data for the construction of the boat. Pre-combustion factors for the fuel consumption have been assumed to be the same as for diesel production. Energy consumption has been assumed to be 0.13 MJ/tonne, km and the sulphur content in the fuel to be 1 %. Data is shown in table 4.2.3.1.

Table 4.2.3.1 Data for cargo ships (Lloyds register of shipping, 1990)

In or outflow	Unit	Flow per tonne, km	"Pre-combustion"-addition per tonne, km	Total, cargo ship, per tonne, km
Diesel oil/Heating oil	MJ	0.13	0.013	1.43E-01
Diesel oil/Heating oil	g	3	0.3	3.30E+00
CO_2	g	9.5	0.52	1.00E+01
SO_2	g	0.063	0.00182	6.48E-02
NO_x	g	0.252	0.000533	2.53E-01
Dust	g		6.24E-05	6.24E-05
CO	g	0.027	1.69E-05	2.70E-02
HC	g	0.0075	0.001092	8.59E-03
Oil (aq)	g		0.000052	5.20E-05
Phenol(aq)	g		7.41E-05	7.41E-05
COD	g		0.000156	1.56E-04
Tot-N (aq)	g		2.47E-05	2.47E-05

4.2.4 Diesel driven maintenance vehicles

Maintenance vehicles for the purpose of road construction are often equipped with a diesel engine as their source of power. The type and size of the engine, however, vary. Because of the age spread of machinery in Sweden, there are engines with very different emission factors and fuel consumption in existence. How ageing and wear affect emissions and fuel consumption is difficult to estimate with certainty. The development work in later years within engine development has resulted in the so-called low-emission engines, which have reduced emissions considerably. The introduction of the so-called green diesel with a lower sulphur content has also contributed to the lowering of emissions. Development work by manufacturers is also in different time-phases regarding the development and introduction of new engine models with lower emissions. For many machine types, it is currently possible to choose between a conventional engine and a low-emission engine. Legal requirements together with customers' active choices will most certainly lead to a big increase in the use of modern low-emission engines.

In order to analyse the current and future direction of machinery, the study has only touched upon low-emission engines. The uncertainty is even greater if we have to take into account different engine types and age distribution. In order to avoid effects from different development phases of the machines without reflecting the effects from the different production methods, the same engine data has been used for several comparable machines. In addition, engine data varies depending on the type of operation cycle it has, the strains on the engine etc. Engine data for this study represents generic values for a low emission diesel engine of the type Volvo BM. The fuel has been assumed to be of environmental class 2 with a sulphur content of 0.05 % and a lower heating value of 35.1 MJ/litre. The life cycle inventory has in this case included the fuel consumption in operation and the production of a corresponding amount of fuel, called pre-combustion factors in this study. Data for the engine analysis is presented in table 4.2.4.1. Diesel engines of a non-low emission type release a greater amount of emissions. A very rough estimate of the emissions from

non-low emission diesel engines can make the direct emissions of NO_x, CO, HC and PM in operation double.

Table 4.2.4.1 Emissions and energy consumption in diesel engine operation for a low-emission engine and diesel of environmental class 2 for maintenance vehicles, including operation and production of diesel oil.

In or outflow	**Unit per MJ used diesel oil**	**Flow in operation**	**"Precombustion" -addition [2)]**	**Total, per MJ used diesel oil**	**Total per litre used diesel oil**
Diesel-/Heating oil	MJ	1	0.1	1.1	38.6
CO_2	g	75	4	79	2773
SO_2 [3)]	g	0.024	0.014	0.038	1.33
NO_x [1)]	g	0.71	0.0041	0.71	25.1
Dust [1)]	g	0.028	0.00048	0.028	1.00
CO [1)]	g	0.085	0.00013	0.085	2.99
N_2O	g	0.0016 [4)]		0.0016	0.056
HC [1)]	g	0.043	0.0084	0.051	1.80
CH_4	g	0.00005 [4)]		0.00005	0.0018
Oil (aq)	g		0.0004	0.0004	0.014
Phenol(aq)	g		0.00057	0.00057	0.020
COD	g		0.0012	0.0012	0.042
Tot-N (aq)	g		0.00019	0.00019	0.0067

1) Data from Volvo BM
2) Tillman et al (1991)
3) Corresponds to a sulphur content of 0.05 %
4) Almén (1992) according to Jönsson (1993)

4.2.5 Excavation classes and weight/volume conditions for fill

The energy usage and thereby also the emissions in the preparation of different types of fill depend among other things on the type of fill used. A hard material with a low workability requires more energy in the preparation than a material that is easy to work. To be able to take these variations into account in the energy consumption, for example for digging using an excavator or loading of soil using a wheeled loader, the materials can be grouped into five different excavation classes. These are subsequently used in the production calculations for each machine respectively. During winter conditions with heavy ground frost, snow and ice, the conditions can be very variable and therefore also difficult to calculate. The energy consumption can increase by 50 % or more. The working methods can also change, for example in the case of heavy ground frost, the ground may need to be pre-prepared through blasting. The excavation classes and examples of material compositions are described in table 4.2.5.1.

Table 4.2.5.1 Excavation classes for different materials

Excavation class	Workability	Examples of material
1	Easy	Mud, loose soil, sandy gravel
2	Medium	Compact soil, hard clay, gravel Less than 25 % stone
3	Medium to hard	Very compact soil, stony gravel Up to 50 % stone
4	Hard	Block rich ridge gravel, gravely moraine, very compact soil Up to 75 % stone
5	Very hard	Block rich solid moraine, fragmented rock or other crushable rock, limestone, slate

In roadwork several different types of material with different characteristics are handled. Relatively large volumes are handled and transported. In production calculations for excavation and transportation, volume is often used as to measure the amount of material. In addition, the weight could be of interest as this is often the limiting factor for a loading vehicle, for example. We also differentiate between fixed volume and loose volume, where fixed volume represents the compacted material as it lies in the terrain while loose volume represents the volume taken up by the material after it has been excavated. It is normally appropriate to base transport calculations on the loose volume. Indicative values for material densities in fixed and loose volume for different materials are shown in table 4.2.5.2.

Table 4.2.5.2 Indicative values for material densities of common materials used in roadwork.

Material	Fixed volume kg/m^3 (vf)	Loose volume kg/m^3 (vl)	Swelling factor
Clay			
dry	1640	1170	1.40
damp	2100	1500	1.40
dry with gravel	1660	1424	1.17
wet with gravel	1840	1540	1.19
compact	2017	1660	1.21
Soil			
dry	1100	960	1.15-1.35
damp	2100	1680	1.25
sand/gravel mixed	1660	1420	1.17
stone mixed (25 % stone)	1960	1570	1.25
Sand			
dry	1600	1420	1.13
damp	2070	1840	1.12
dry with gravel	1930	1720	1.12
wet with gravel	2230	2020	1.10
Gravel			
dry	1470	1330	1.10-1.15
wet	2340	2130	1.10-1.15
Rock			
granite	2970	1980	1.5
limestone	2640	1590	1.66
sandstone	2400	1440	1.65
stone, crushed	2670	1620	1.65
plaster, solid	2580	1980	1.30

4.2.6 Wheel loaders

In the life cycle inventory data calculations for wheel loaders, only the operation of the wheel loader has been taken into account, specifically the consumption and production of diesel. LCI data for the production of wheel loaders has not been available from manufacturers. Data for wheel loaders is expressed per produced volume (m^3) soil or gravel, for example. Table 4.2.6.2 shows fuel and production data for a standard machine used in roadwork, Volvo BM L180, and table 4.2.6.3 shows corresponding energy and emission data.

In this case, engine/machine data and the production capacity of the machine are important aspects to consider in the life cycle inventory. In order to carry out a production calculation, knowledge about the loader, the material that is being handled and the conditions at the site is required.

Loader

- How much material fits into the bucket? – This depends on the nominal volume of the bucket and the degree to which it is filled.
- How long is the cycle time for each bucket? To load, transport, empty and return to the starting position - depending on type of material loaded, the distance of transportation and the competence of the driver.
- What is the effective working/loading time per hour? – This depends on maintenance of machines, work planning, length of breaks etc.

Material

- What is the density (tonne/m^3) of the material when it is in a loose, worked state? - affects the decision about size of bucket.
- What type of workability is the material of? - affects the cycle time, the choice of bucket type and degree to which the bucket is filled.
- The bearing capacity and the coefficient of friction of the material – This affects the cycle time of the machine.

Site

- Land conditions at the site; the characteristics of the transport route, the slope, the surface quality etc – This affects the cycle time.
- Planning of the work and the driver's ability and experience – This affects the effective working time and the exploitation degree.

In order to do a production analysis for normal working conditions or produce estimates, it is appropriate to use the diagrams produced by the manufacturer for each machine, over the production volume as a function of excavation class and transport distances. This method has been the basis of the calculations in the life cycle inventory.

For wheel loaders, two activities can be distinguished depending on usage, namely vehicle loading, where the transport distance is assumed to be less than 10 m, and loading/carrying efforts where the wheel loader also carries out the transportation of the material. Loading/carrying work normally exists to a very limited extent in roadwork and is not further analysed in this study.

The production and the excavation classes for vehicle loading can be seen in table 4.2.6.1. The table is valid in normal working conditions where the transport distance is less than 10 m and the effective working time is 50 min/hour.

Table 4.2.6.1 Production and excavation classes for a few different wheel loaders from VME (Volvo BM) for loading of vehicles. (Volvo BM, loading handbook)

Wheel loader model	Bucket capacity m³ (yd³)	Excavation class	Production m³ (yd³) / 50 min 100 (130) 200 (260) 300 (390) 400 (520) 500 (650)
L50B	1,2-1,5 (1,57-1,96)	1	
	1,2 (1,57)	2	
	1,2 (1,57)	3	
L70B	1,6-1,9 (2,09-2,48)	1	
	1,6-1,8 (2,09-2,35)	2	
	1,6 (2,09)	3	
L90B	2,1-2,5 (2,7-3,3)	1	
	2,1-2,3 (2,7-3,0)	2	
	2,1-2,3 (2,7-3,0)	3	
	2,1 (2,7)	4	
L120B	2,8-3,3 (3,7-4,3)	1	
	2,8-3,1 (3,7-4,0)	2	
	2,8-3,1 (3,7-4,0)	3	
	2,8 (3,7)	4	
L150	3,5-4,0 (4,6-5,1)	1	
	3,5-4,0 (4,6-5,1)	2	
	3,5-4,0 (4,6-5,1)	3	
	3,5 (4,6)	4	
L180	4,2-4,8 (5,5-6,25)	1	
	4,2-4,6 (5,0-6,0)	2	
	4,2-4,4 (5,5-5,75)	3	
	4,2 (5,5)	4	

The markings in the table show differences in production volume depending on the experience of the driver and the type of bucket used

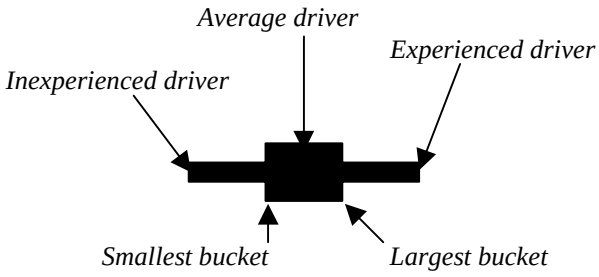


Table 4.2.6.2 Production data and energy consumption for a wheeled loader of type Volvo BM L180, for different excavation classes in loading of vehicles. Data from VME.

Excavation class	Average production (m^3/h)	Fuel consumption (litre/h)	Fuel consumption by volume produced (litre/m^3)	Added energy by volume produced (MJ/m^3)
1	520	23	4.42E-02	1.55
2	470	23	4.89E-02	1.72
3	410	35	8.54E-02	3.00
4	370	35	9.46E-02	3.32

Table 4.2.6.3 Inventory analysis data for wheeled loader, type Volvo BM L180, for different excavation classes in loading of vehicles.

In or outflow	Unit	Total per MJ used diesel	Total per production volume (m^3), Excavation class 1	Total per production volume (m^3), Excavation class 2	Total per production volume (m^3), Excavation class 3	Total per production volume (m^3), Excavation class 4
Diesel oil	MJ	1.1	1.71E+00	1.89E+00	3.30E+00	3.65E+00
CO_2	g	79	1.23E+02	1.36E+02	2.37E+02	2.62E+02
SO_2	g	0.038	5.90E-02	6.53E-02	1.14E-01	1.26E-01
NO_x	g	0.71	1.11E+00	1.23E+00	2.14E+00	2.37E+00
Dust	g	0.028	4.42E-02	4.89E-02	8.53E-02	9.46E-02
CO	g	0.085	1.32E-01	1.46E-01	2.55E-01	2.83E-01
N_2O	g	0.0016	2.48E-03	2.75E-03	4.79E-03	5.31E-03
HC	g	0.051	7.98E-02	8.83E-02	1.54E-01	1.71E-01
CH_4	g	0.00005	7.76E-05	8.59E-05	1.50E-04	1.66E-04
Oil (aq)	g	0.0004	6.21E-04	6.87E-04	1.20E-03	1.33E-03
Phenol (aq)	g	0.00057	8.85E-04	9.79E-04	1.71E-03	1.89E-03
COD	g	0.0012	1.86E-03	2.06E-03	3.60E-03	3.98E-03
Tot-N (aq)	g	0.00019	2.95E-04	3.26E-04	5.69E-04	6.31E-04

4.2.7 Excavators

The life cycle inventory has in this case taken into account the operation of the excavator, as well as the production of the consumed amount of diesel. Data for the production of the excavator has not been analysed due to the lack of data from the manufacturer. The analysis has been based on a machine of the Åkerman EC 620 model. Engine data has been taken from the model data, presented in the chapter about diesel engine operated maintenance vehicles. In rough estimates, data expressed per production volume can be assumed to be relatively generic for similar machine types. The fuel consumption is assumed for medium intensive usage. In the case of heavy ground frost or other extreme operation conditions, the average production and the fuel consumption can change dramatically, which is why data can not be directly applied for these cases. Production data for the machine is shown in table 4.2.7.1. In table 4.2.7.2 further corresponding emission and energy data is shown. The production volumes can in this case be estimated using fixed volumes.

Table 4.2.7.1 Production data for an excavator of the type Åkerman EC620 in loading of a dumper, when the excavator and a dumper are at the same level and the turn angle is 90–180 degrees, divided into excavation classes. Data from Åkermans.

Excavation class	Average production (m^3/h)	Fuel consumption (litre/h)	Fuel consumption per production volume (litre/m^3)	Added energy per production volume (MJ/m^3)
1	450	34	0.076	2.65
2	430	34	0.079	2.78
3	360	34	0.094	3.32
4	300	34	0.113	3.98

Table 4.2.7.2 Emission and energy data for each excavation class per production volume. The volume can be estimated using the fixed volume.

In or outflow	Unit	Total per MJ used diesel	Total per production volume (m^3), Excavation class 1	Total per production volume (m^3), Excavation class 2	Total per production volume (m^3), Excavation class 3	Total per production volume (m^3), Excavation class 4
Diesel oil	MJ	1.1	2.92E+00	3.05E+00	3.65E+00	4.38E+00
CO_2	g	79	2.10E+02	2.19E+02	2.62E+02	3.14E+02
SO_2	g	0.038	1.01E-01	1.05E-01	1.26E-01	1.51E-01
NO_x	g	0.71	1.89E+00	1.98E+00	2.37E+00	2.84E+00
Dust	g	0.028	7.55E-02	7.90E-02	9.44E-02	1.13E-01
CO	g	0.085	2.26E-01	2.36E-01	2.82E-01	3.39E-01
N_2O	g	0.0016	4.24E-03	4.44E-03	5.30E-03	6.36E-03
HC	g	0.051	1.36E-01	1.43E-01	1.70E-01	2.04E-01
CH_4	g	0.00005	1.33E-04	1.39E-04	1.66E-04	1.99E-04
Oil (aq)	g	0.0004	1.06E-03	1.11E-03	1.33E-03	1.59E-03
Phenol (aq)	g	0.00057	1.51E-03	1.58E-03	1.89E-03	2.27E-03
COD	g	0.0012	3.18E-03	3.33E-03	3.98E-03	4.77E-03
Tot-N (aq)	g	0.00019	5.04E-04	5.27E-04	6.30E-04	7.56E-04

4.2.8 Dumper

In the life cycle inventory calculations of dumper trucks, only the direct fuel consumption and the production of the corresponding amount of fuel have been taken into account. The production of the dumper itself has not been considered. Engine data has been taken from the model data presented in the chapter about diesel engine driven maintenance vehicles. Calculations have been based on Volvo BMs dumper model A35. In rough estimates data related to the production volume and distance of transport should be suitable for use for similar machine types and sizes.

When calculating loading volumes, one has to distinguish between the fixed volume in the ground and the loose volume that the material fills when it has been dug up and loaded onto the dumper. The relationship between the loose volume and the fixed

volume is called “the swelling factor”. The swelling factor varies depending on the type of material, how heavily compacted the material is in the ground etc. In this study, the swelling factor is assumed to be 1.2.

The fuel consumption in production using dumpers is heavily dependent on the driving conditions that exist at the work site. Variations can be seen, partly due to the slope of the ground, partly due to the characteristics of the ground. If the dumpsite is situated higher than the point of loading, the fuel consumption is increased. The nature of the ground can also vary between pure asphalt road and very uneven and slippery conditions. To be able to take these different driving conditions into account, these conditions have been divided into three classes, easy driving conditions, average driving conditions and difficult driving conditions. A rough description of the three is shown in table 4.2.8.1.

Table 4.2.8.1 Description of classes of driving conditions for dumpers.

Driving conditions	**Description**
Easy driving conditions	Level, easily accessible road
Average driving conditions	Broken ground, uneven ground conditions
Difficult driving conditions	Hilly conditions, bad ground conditions, possibly with low bearing capacity.

These three classes of driving conditions correspond to three different fuel consumption amounts, as follows; maximum consumption (35 litre/h), average consumption (27.5 litre/h) and a minimum fuel consumption (20 litre/h). Further, an average transport speed of 15 km/h has been assumed, as well as the fact that the machine is empty on return. In the tables 4.2.8.2 and 4.2.8.3 data for fuel and energy consumption is shown as well as emission data in relation to the loose transport volume (Lm^3) and the distance of transport (km) from the point of loading to the dumpsite.

Table 4.2.8.2 Fuel and energy consumption for three different operational cases using a dumper in relation to distance of transport and loose volume.

Driving conditions	**Fuel consumption per volume and transport distance (litre/Lm^3km)**	**Energy consumption per volume and transport distance (MJ/Lm^3km)**
Easy driving conditions	0.14	4.914
Average driving conditions	0.193	6.7743
Difficult driving conditions	0.249	8.7399

Table 4.2.8.3 Emissions and energy consumption for dumper, Volvo BM A35, in different driving conditions in relation to loose volume and distance of transport.

In or outflow	Unit	Total per MJ used diesel	Easy driving conditions $(Lm^3\ km)^{-1}$	Average driving conditions $(Lm^3\ km)^{-1}$	Difficult driving conditions $(Lm^3\ km)^{-1}$
Diesel oil	MJ	1.1	5.41E+00	7.45E+00	9.61E+00
CO_2	g	79	3.88E+02	5.35E+02	6.90E+02
SO_2	g	0.038	1.87E-01	2.57E-01	3.32E-01
NO_x	g	0.71	3.51E+00	4.84E+00	6.24E+00
Dust	g	0.028	1.40E-01	1.93E-01	2.49E-01
CO	g	0.085	4.18E-01	5.77E-01	7.44E-01
N_2O	g	0.0016	7.86E-03	1.08E-02	1.40E-02
HC	g	0.051	2.53E-01	3.48E-01	4.49E-01
CH_4	g	0.00005	2.46E-04	3.39E-04	4.37E-04
Oil (aq)	g	0.0004	1.97E-03	2.71E-03	3.50E-03
Phenol (aq)	g	0.00057	2.80E-03	3.86E-03	4.98E-03
COD	g	0.0012	5.90E-03	8.13E-03	1.05E-02
Tot-N (aq)	g	0.00019	9.34E-04	1.29E-03	1.66E-03

4.2.9 Road rollers

In the inventory calculations of rollers, only the direct fuel consumption and the production of the corresponding amount of fuel have been taken into account. The production of the roller itself has not been considered. Engine data has been taken from the model data presented in the chapter about diesel engine driven maintenance vehicles. Calculations have been based on rollers from Dynapac's product program where calculations have been made for a few different sizes of rollers as well as for rollers partly designed for compaction of soil, and partly for compaction of asphalt. These rollers are normally not equipped with Volvo engines, but have diesel engines from Deutz. The different sizes of rollers have different areas of usage, and the result of the packing will also be different for the different rollers. To some extent, the values for the rollers studied can be generally applied to other types of rollers in corresponding sizes.

The calculations are however, based on the assumption that similar driving conditions exist for the different rollers. Therefore, the rolling speed has been set to 4 km/h and the number of passes needed to achieve good soil compaction results, has been set to 6 passes. This will however, give different compaction results for the different rollers. In the laying of asphalt the number of passes per layer is set to 8. Further, the effective covering width of the roller has been set to 85 % of the total width of the roller vehicle. The effective working time for the machine has been assumed to be 50 min/h.

The results of the calculations related to area units, express amount of material per layer. For good compaction results for soil materials one can assume a maximum thickness of 0.5 m per layer. When laying asphalt, 1-3 coats are normally laid. As an indication, 1 coat of asphalt is sufficient for maintenance and 2-3 coats are required for a new road. Table 4.2.9.1 shows basic data for a few different machines out of Dynapac's product program for rollers. In table 4.2.9.2 the results of the life cycle inventory of rolling of one layer is presented.

Table 4.2.9.1 Basic data for soil and asphalt compaction machines from Dynapac's product program. Data from Dynapac.

Roller model	**Working weight (tonnes)**	**Fuel consumption (litre/h)**	**Roller width (m)**	**Covering roller width 85% (m)**	**Rolling speed (km/h)**	**Number of passes**	**Theoretical rolling capacity (m^2/h)**	**Effective rolling capacity, 50 min/h (m^2/h)**	**Fuel consumption (litre/m^2)**	**Energy consumption (MJ/m^2)**
Dynapac CA 151D, soil compaction	6.2	12	1.676	1.42	4	6	950	791	0.0152	0.5322
Dynapac CA 251D, soil compaction	9.8	17	2.130	1.81	4	6	1207	1006	0.0169	0.5932
Dynapac CA 301D, soil compaction	12	18	2.130	1.81	4	6	1207	1006	0.0179	0.6281
Dynapac CC 122, asphalt compaction	2.5	4.7	1.200	1.02	4	8	510	425	0.0111	0.3882
Dynapac CC 142, asphalt compaction	3.6	6.7	1.3	1.11	4	8	553	460	0.0146	0.5108
Dynapac CC 211, asphalt compaction	7.2	12	1.45	1.23	4	6	822	685	0.0175	0.6151
Dynapac CC 421, asphalt compaction	10.1	18	1.675	1.42	4	6	949	791	0.0228	0.7988

Table 4.2.9.2 Results of the life cycle analysis of rolling of one coat of asphalt or soil/gravel.

In or outflow	**Unit**	**Total per MJ used diesel**	**Total per m^2, CA 151D**	**Total per m^2, CA 251D**	**Total per m^2, CA 301D**	**Total per m^2, CC 122**	**Total per m^2, CC 142**	**Total per m^2, CC 211**	**Total per m^2, CC421**
Diesel oil	MJ	1.1	5.85E-01	6.53E-01	6.91E-01	4.27E-01	5.62E-01	6.77E-01	8.79E-01
CO_2	g	79	4.20E+01	4.69E+01	4.96E+01	3.07E+01	4.04E+01	4.86E+01	6.31E+01
SO_2	g	0.038	2.02E-02	2.25E-02	2.39E-02	1.48E-02	1.94E-02	2.34E-02	3.04E-02
NO_x	g	0.71	3.80E-01	4.24E-01	4.49E-01	2.77E-01	3.65E-01	4.39E-01	5.70E-01
Dust	g	0.028	1.52E-02	1.69E-02	1.79E-02	1.11E-02	1.45E-02	1.75E-02	2.27E-02
CO	g	0.085	4.53E-02	5.05E-02	5.35E-02	3.30E-02	4.35E-02	5.24E-02	6.80E-02
N_2O	g	0.0016	8.52E-04	9.49E-04	1.01E-03	6.21E-04	8.17E-04	9.84E-04	1.28E-03
HC	g	0.051	2.74E-02	3.05E-02	3.23E-02	2.00E-02	2.63E-02	3.16E-02	4.11E-02
CH_4	g	0.00005	2.66E-05	2.97E-05	3.14E-05	1.94E-05	2.55E-05	3.08E-05	3.99E-05
Oil (aq)	g	0.0004	2.13E-04	2.37E-04	2.51E-04	1.55E-04	2.04E-04	2.46E-04	3.20E-04
Phenol (aq)	g	0.00057	3.03E-04	3.38E-04	3.58E-04	2.21E-04	2.91E-04	3.51E-04	4.55E-04
COD	g	0.0012	6.39E-04	7.12E-04	7.54E-04	4.66E-04	6.13E-04	7.38E-04	9.59E-04
Tot-N (aq)	g	0.00019	1.01E-04	1.13E-04	1.19E-04	7.38E-05	9.70E-05	1.17E-04	1.52E-04

4.2.10 Asphalt pavers

In the life cycle inventory calculations of asphalt pavers only the direct fuel consumption and the production of the corresponding amount of fuel have been taken into account. The production of the asphalt paver itself has not been considered. Engine data has been taken from the model data presented in the chapter about diesel engine driven maintenance vehicles. Calculations have been based on asphalt pavers from Dynapac's product program where calculations have been made for two sizes of asphalt pavers, commonly used in Sweden. These asphalt pavers are normally not equipped with Volvo engines, but have diesel engines from Deutz.

In the calculations, the laying speed has been assumed constant at 4 m/min (240 m/h). Further, it has been assumed that the fuel consumption is only negligible, depending on the thickness of the asphalt coat being laid. The width of the screed can be changed for most machines, which means that the theoretical laying capacity can vary. For both studied machines, a standard width of the screed has been assumed. The effective working time for the machine has been assumed to be 50 min/h.

Basic data used in the inventory calculations for two different asphalt pavers from Dynapac's product program are shown in table 4.2.10.1. The results of the inventory are presented in table 4.2.10.2. The calculations are for laying of one asphalt coat.

Table 4.2.10.1 Basic data for two different asphalt pavers. Data from Dynapac.

Asphalt paver	**Fuel consumption (l/h)**	**Paving width (m)**	**Paving speed (m/h)**	**Theoretical paving capacity (m^2/h)**	**Effective paving capacity, 50 min/h (m^2/h)**	**Fuel consumption (l/m^2)**	**Energy use (MJ/m^2)**
Dynapac F12	20	5.0	240	1200	1000	0.0200	0.7020
Dynapac F16	22	6.5	240	1560	1300	0.0169	0.5940

Table 4.2.10.2 Results from the life cycle inventory of two different asphalt pavers. The results are for one coat of asphalt.

In or outflow	Unit	Total per MJ used diesel	Total per m^2, Dynapac F12	Total per m^2, Dynapac F16
Diesel oil	MJ	1.1	7.72E-01	6.53E-01
CO_2	g	79	5.55E+01	4.69E+01
SO_2	g	0.038	2.67E-02	2.26E-02
NO_x	g	0.71	5.01E-01	4.24E-01
Dust	g	0.028	2.00E-02	1.69E-02
CO	g	0.085	5.98E-02	5.06E-02
N_2O	g	0.0016	1.12E-03	9.50E-04
HC	g	0.051	3.61E-02	3.05E-02
CH_4	g	0.00005	3.51E-05	2.97E-05
Oil (aq)	g	0.0004	2.81E-04	2.38E-04
Phenol(aq)	g	0.00057	4.00E-04	3.39E-04
COD	g	0.0012	8.42E-04	7.13E-04
Tot-N(aq)	g	0.00019	1.33E-04	1.13E-04

4.2.11 Production of bitumen

Asphalt for Swedish road surfacing work is commonly produced from crude oil with high bitumen content. The crude oil is extracted in Venezuela and transported by tanker to Nynäshamn for refining. In the refinery the bitumen part, which is used in the production of asphalt, is extracted. The remaining part, i.e. the lighter fraction is used for the production of fuel.

A schematic picture illustrates the production chain for bitumen in figure 4.2.11.1. Crude oil with a high content of bitumen (60-65 %) is extracted in Venezuela. Data from the extraction process itself is estimated based on the steam production during the extraction of crude oil. Crude oil is transported by tanker boat from Venezuela to Nynäshamn for refining. In the refinery, the bitumen part is extracted out of the crude oil. The lighter products from the crude oil go on to be refined further in internal processes or external plants outside of the refinery. The allocation of the energy consumption and emissions from the refinery on to the different products, taking into account the internal processes in the refinery, has been done based on weight and with an allocation distribution of 40 %/60 % for bitumen and the lighter products respectively. From the refinery the finished product is transported out to regional depots. The transport to the depots is done by tanker boat. There are 12 depots in the country, of which two are situated next to a refinery (Gothenburg and Nynäshamn). At these depots, no transport by tanker boat is needed. From the depots bitumen is transported out to the users by tanker boat.

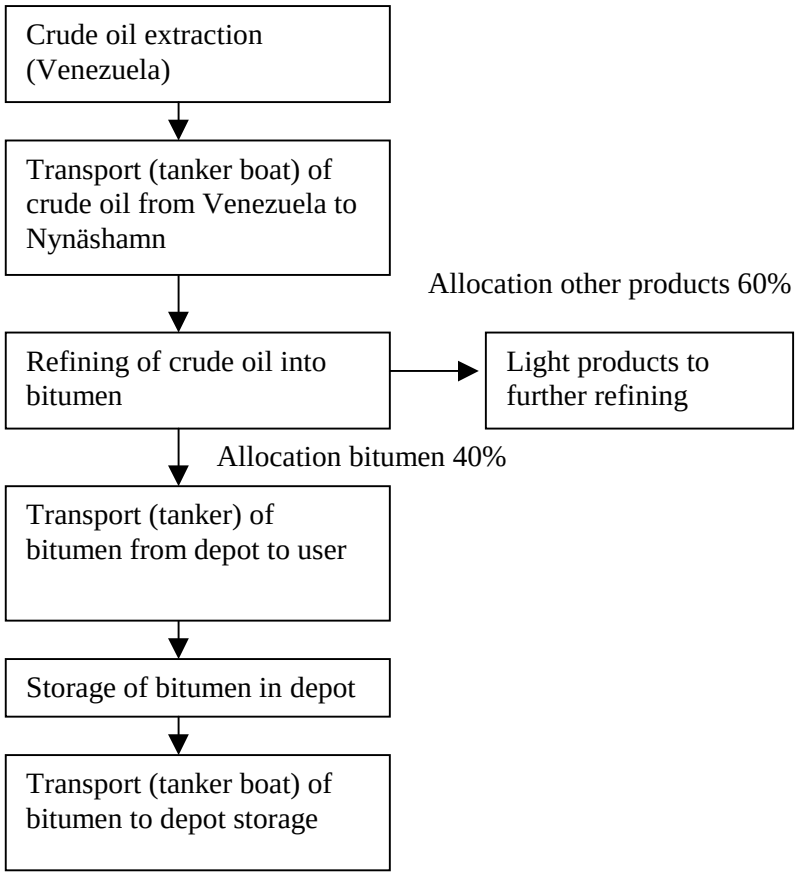


Figure 4.2.11.1 Overview of a model structure for production of bitumen, from crude oil to finished product, delivered to one of the regional depots in Nynäs.

Sea freight

For transport by sea using a coastal freight tanker to a local depot, a loading amount of 4,400 tonnes has been assumed per boat transport occasion. The tanker boat returns empty to the refinery. Furthermore, a fuel consumption of 15 tonnes of oil per transport occasion is assumed, which gives a fuel consumption of 3.4 kg fuel per delivered tonne of bitumen to the depot. The sulphur content in the fuel is 0.9 %. Average freight distance to local depot is 2*225 nautical mile, return trip, which corresponds to 833 km. Emission values for an average coastal tanker is described in table 4.2.11.1. Further necessary additions are hydrocarbon emissions during loading of the tanker and during filling of the cistern of 0.3 g THC/tonne produced bitumen = > THC: 0.6 g/tonne produced bitumen each.

The tanker boat transportation of crude oil from Venezuela to a Swedish refinery has been calculated based on an estimated fuel consumption for the tanker boat of 0.7 % of the weight of the load. Emission data is evident from table 4.2.11.2. The results of the LCI analysis of the sea freight expressed per tonne produced bitumen, can be found in the summary table 4.2.11.6.

Table 4.2.11.1 Emission factors for coast tanker with diesel engine

Compound	**Emission factor [2] (g/kg added fuel)**
SO_2 [1]	17.6
NO_x	59
CO	8
CO_2	3250
HC	2.7

[1] At a sulphur content of 0.9 %
[2] Data from Lloyd's Register of Shipping, 1990.

Table 4.2.11.2 Emission factors for sea going tankers with diesel engines

Compound	**Emission factor [2] (g/kg added fuel)**
SO_2 [1]	63
NO_x	84
CO	9
CO_2	3165
HC	2.5

[1] At a sulphur content of 3%
[2] Data from Lloyd's Register of Shipping, 1990.

Crude oil extraction in Venezuela
Outline energy data from the extraction of a heavy Venezuelan crude oil, Laguna, has been produced in this project. The oil field is in what is commonly described as the "second recovery period" which is calculated to extend over 30 years. During the oil fields' primary period, 30 years, negligible steam quantities have been used. The production during both periods is assumed to be the same.

The average steam consumption has been calculated as 0.28 tonnes of steam of 1000 psi (69 bar) per tonne crude oil. The steam is assumed to be produced as saturated steam and the initial temperature is assumed to be 30 degrees Celsius. This gives an enthalpic difference of 2648 kJ/kg of steam. The above assumed steam consumption, an efficiency of 70 % in steam generation, and a bitumen content of 60 % in the crude oil gives this an energy consumption of 1779 MJ fuel per tonne produced bitumen.

In the steam production, natural gas from associated oil fields of light crude oils is used as a source of energy. The natural gas that has not been used for steam generation

has usually, previously, been burnt off. The emissions of the combustion have been estimated, due to lack of measuring data, from known emission factors for corresponding plants. The emission factors are detailed in table 4.2.11.3 and the emissions calculated on the produced amount of bitumen are shown in table 4.2.11.4.

Table 4.2.11.3 Emission factors for steam production. Combustion of natural gas.

Compound	**Emission factor [1] (g/MJ added fuel)**
NO_x	0.08
SO_2	0.001
CO	0.01
CO_2	56

[1] Estimated data from IVL.

Table 4.2.11.4 Emission in steam production calculated per tonne produced amount of bitumen. Combustion of natural gas.

Compound	**Emission, [1] g/tonne produced bitumen**
NO_x	142
SO_2	1.8
CO	18
CO_2	99624

[1] Estimated data from IVL.

The above calculations are in many ways built on estimated values and the results therefore will have to be considered as relatively unreliable. In addition to the above emissions, a relatively large emission of oil, VOC, HC etc are expected because of the production methods used. An estimate of this emission has not been possible to bring about within the framework of this project.

Refining of crude oil in bitumen production

The analysis for refining of crude oil in the production of bitumen is based on data from Nynäs refinery in Nynäshamn. Data for the energy consumption and emissions has been taken from operation data from the refinery. In the allocation of emissions and energy consumption in the refining the crude oil, the bitumen part has been given a part of 40 % of the total energy consumption and emissions from the refinery. The remaining parts have been allocated to the light fuel fraction. The energy consumption of electricity has been included as Swedish average electricity consumption. The result of the life cycle inventory is shown in summary table 4.2.11.6.

Storage of bitumen at local depot

Bitumen is stored in local depots in heat maintained cisterns. Average size of cisterns is assumed to be 5000 m^3. The average turnover for a cistern of 5000 m^3 is 20000 tonnes of bitumen each year. Energy consumption for the heat maintenance of a corresponding cistern is about 1000 MWh/year. This gives an energy consumption of 50 kWh per tonne bitumen delivered from the depot. The heating is partly done using electricity (90 %) and partly using heating oil 1 (10 %). The calculations for the production of the electricity are based on Swedish average electricity. Emission factors in the combustion of light heating oil have been estimated through comparisons with corresponding oil heated plants, table 4.2.11.5. For production of light heating oil, the same pre-combustion additions have been assumed as for the production of diesel oil. In addition to the hydrocarbon emissions from the combustion of the heating oil, hydrocarbon are also emitted from the bitumen cisterns themselves (HC: 1.6 g/tonne bitumen) and from the loading of the tankers at delivery (HC: 0.3g/tonne bitumen). The result from the life cycle inventory is shown in summary table 4.2.11.6.

Table 4.2.11.5 Emission factors for combustion of light heating oil in the operation of bitumen cisterns.

Compound	**Emission factor [2] (g/MJ added fuel)**
SO_2 [1]	0.05
NO_x	0.1
CO	0.1
CO_2	76
HC	0.01

[1] At a sulphur content of 0.1 %

[2] Estimated data from IVL.

Summary of results - bitumen

The results of the different steps in the production of bitumen, from crude oil extraction to storing in local depot including filling of the tanker lorry in the delivery to customer are presented in table 4.2.11.6 together with the summarised result for the whole production chain. The results have in all cases been calculated per tonne produced bitumen.

Table 4.2.11.6 Summary table for the inventory of bitumen production from crude oil extraction to delivery from local depot.

In or outflow	Unit	Crude oil extraction in Venezuela per tonne bitumen	Transport of crude oil to refinery per tonne bitumen	Refining from local store per tonne produced bitumen excluding electricity production	Contribution from electricity production in refining per tonne bitumen	Transport (tanker) of bitumen from refinery to depot storage per tonne bitumen excluding pre-combustion	Pre-combustion for tanker transport from refinery to depot storage per tonne bitumen	Storage of bitumen in depot per tonne bitumen, including pre-combustion addition, excluding electricity production	Contribution from electricity production at storage per tonne bitumen	Total per tonne produced bitumen
Bitumen	g			1.00E+06						1.00E+06
Heating oil, diesel[2)]	g		7.00E+03	1.38E+04	1.35E+02	3.40E+03	3.40E+02	4.64E+02	2.43E+02	2.54E+04
Heating oil, diesel	MJ		2.87E+02	5.73E+02	5.76E+00	1.45E+02	1.45E+01	1.98E+01	1.04E+01	1.06E+03
Electricity[1)]	MJ			9.00E+01				1.62E+02		2.52E+02
Biomass fuel	MJ				4.05E+00				7.29E+00	1.13E+01
Peat	MJ				4.05E-01				7.29E-01	1.13E+00
Coal	MJ				3.60E+00				6.48E+00	1.01E+01
Natural gas	MJ	1.78E+03			8.37E-01				1.51E+00	1.78E+03
Uranium	MJ				1.44E+02				2.59E+02	4.03E+02
Hydro power	MJ				4.23E+01				7.61E+01	1.18E+02
SO_2	g	1.80E+00	4.41E+02	1.05E+02	6.03E-01	5.98E+01	2.03E+00	1.10E+00	1.09E+00	6.12E+02
NO_x	g	1.42E+02	5.88E+02	8.00E+01	8.28E-01	2.01E+02	5.95E-01	1.87E+00	1.49E+00	1.02E+03
CO_2	g	9.96E+04	2.22E+04	3.70E+04	3.42E+02	1.11E+04	5.81E+02	1.44E+03	6.16E+02	1.73E+05
Dust	g			8.00E+00	6.30E-03		6.97E-02	8.64E-03	1.13E-02	8.10E+00
N_2O	g				3.78E-02				6.80E-02	1.06E-01
CH_4	g				1.26E-02				2.27E-02	3.53E-02
CO	g	1.80E+01	6.30E+01		1.89E-01	2.72E+01	1.89E-02	1.80E+00	3.40E-01	1.11E+02
HC	g		1.75E+01			9.80E+00	1.22E+00	2.23E+00		3.08E+01
VOC	g			2.00E+02	9.90E-02				1.78E-01	2.00E+02
HC (aq)	g			2.00E+00						2.00E+00
BOD (aq)	g			1.90E+01						1.90E+01
COD (aq)	g			3.44E+02			1.74E-01	2.16E-02		3.44E+02
P (aq)	g			2.00E+00						2.00E+00
N (aq)	g			5.00E+00			2.76E-03	3.42E-03		5.03E+00
Hazardous chemical waste	g			2.63E+02						2.63E+02
Radioactive exposure	manSv				9.00E-09				1.62E-08	2.52E-08
Ashes	g				6.30E+00				1.13E+01	1.76E+01
Radioactive waste:										
Highly active	cm^3				1.26E-01				2.27E-01	3.53E-01
Medium and low active	cm^3				1.35E+00				2.43E+00	3.78E+00
Demolition waste	cm^3				1.35E+00				2.43E+00	3.78E+00
Oil (aq)	g						5.81E-02	7.20E-03		6.53E-02
Phenol (aq)	g						8.28E-02	1.03E-03		8.37E-02

1) The separately presented consumption of electricity is only included for information. The consumption of electricity has been broken down into parts for Swedish average electricity and been included in the analysis as the original raw material

2) The consumption of heating oil in grams has only been included for information as it is an important component. Otherwise the electricity consumption has been given in MJ.

4.2.12 Tack coating using bitumen emulsion

To increase the adhesion in road surfacing work using asphalt, the base is tack coated before the asphalt coat is laid on. The tack coating has in this study been assumed to be done using an emulsion consisting of 50 % bitumen and 50 % water, which is spread out onto the base using a Savalco asphalt spreader of type HM 10HD. This machine is a diesel driven asphalt spreader with an Isuzu diesel engine of 28 kW (38 hp). Basic data for a low emission engine has been used in the analysis. The machine weight is 1200 kg. In tack coating, different thicknesses of the asphalt coat are sometimes present. The most common layer thicknesses are 0.1, 0.15 and 0.2 kg bitumen emulsion/m^2. The asphalt spreader is equipped with two different spreading widths, 2.5 m and 4 m. The fuel consumption at the two different widths has been assumed constant for the machine. Calculations have been done for the three different thicknesses at the two different spreading widths. In the study, the diesel consumption of the machine and the usage of bitumen have been taken into account. The production of the machine itself has not been included in the analysis. Basic data for the asphalt spreading is shown in table 4.2.12.1. In table 4.2.12.2 the result of the calculations of the asphalt spreading are shown.

Table 4.2.12.1 Basic data for spreading of 50 % bitumen emulsion solution using asphalt spreader, type Savalco HM 10HD.

Machine type	**Layer thickness (kg/m^2)**	**Bitumen consump -tion (kg/m^2)**	**Laying speed (km/h)**	**Ramp width (m)**	**Laying capacity (m^2/h)**	**Fuel consump -tion, diesel (litre/h)**	**Fuel consumption per area unit (litre/m^2)**	**Energy use, diesel, per area unit (MJ/m^2)**
Tack coating machine, 2.5m ramp, 0.1kg/m^2	0.1	0.05	11.4	2.5	28500	3	1.05E-04	3.69E-03
Tack coating machine, 2.5m ramp, 0.15 kg/m^2	0.15	0.075	7.65	2.5	19125	3	1.57E-04	5.51E-03
Tack coating machine, 2.5m ramp, 0.2 kg/m^2	0.2	0.1	5.7	2.5	14250	3	2.11E-04	7.39E-03
Tack coating machine, 4m ramp, 0.1kg/m^2	0.1	0.05	11.4	4	45600	3	6.58E-05	2.31E-03
Tack coating machine, 4m ramp, 0.15 kg/m^2	0.15	0.075	7.65	4	30600	3	9.80E-05	3.44E-03
Tack coating machine, 4m ramp, 0.2 kg/m^2	0.2	0.1	5.7	4	22800	3	1.32E-04	4.62E-03

Table 4.2.12.2 Inventory results for application of bitumen based adhesion layers (tack coat) using a 50 % bitumen emulsion for different operational cases using Savalco HM 10 HD tack coat spreader.

In or outflow	Unit	Tack coating machine, 2.5m ramp, 0.1 kg/m^2	Tack coating machine, 2.5 m ramp, 0.15 kg/m^2	Tack coating machine, 2.5 m ramp, 0.2 kg/m^2	Tack coating machine, 4 m ramp, 0.1 kg/m^2	Tack coating machine, 4 m ramp, 0.15 kg/m^2	Tack coating machine, 4 m ramp, 0.2 kg/m^2
Bitumen	g	5.00E+01	7.50E+01	1.00E+02	5.00E+01	7.50E+01	1.00E+02
Heating oil, diesel	g	1.36E+00	2.05E+00	2.73E+00	1.33E+00	1.99E+00	2.66E+00
Heating oil, diesel	MJ	5.71E-02	8.56E-02	1.14E-01	5.55E-02	8.33E-02	1.11E-01
Electricity	MJ	1.26E-02	1.89E-02	2.52E-02	1.26E-02	1.89E-02	2.52E-02
Biomass fuel	MJ	5.65E-04	8.48E-04	1.13E-03	5.65E-04	8.48E-04	1.13E-03
Peat	MJ	5.65E-05	8.48E-05	1.13E-04	5.65E-05	8.48E-05	1.13E-04
Coal	MJ	5.05E-04	7.58E-04	1.01E-03	5.05E-04	7.58E-04	1.01E-03
Natural gas	MJ	8.90E-02	1.34E-01	1.78E-01	8.90E-02	1.34E-01	1.78E-01
Uranium	MJ	2.02E-02	3.02E-02	4.03E-02	2.02E-02	3.02E-02	4.03E-02
Hydropower	MJ	5.90E-03	8.85E-03	1.18E-02	5.90E-03	8.85E-03	1.18E-02
SO_2	g	3.07E-02	4.61E-02	6.15E-02	3.07E-02	4.60E-02	6.14E-02
NO_x	g	5.36E-02	8.04E-02	1.07E-01	5.26E-02	7.89E-02	1.05E-01
CO_2	g	8.94E+00	1.34E+01	1.79E+01	8.83E+00	1.32E+01	1.77E+01
VOC	g	1.00E-02	1.50E-02	2.00E-02	1.00E-02	1.50E-02	2.00E-02
Dust	g	5.08E-04	7.62E-04	1.02E-03	4.70E-04	7.04E-04	9.39E-04
N_2O	g	1.12E-05	1.68E-05	2.24E-05	8.99E-06	1.35E-05	1.80E-05
CH_4	g	1.95E-06	2.92E-06	3.90E-06	1.88E-06	2.82E-06	3.76E-06
CO	g	5.86E-03	8.79E-03	1.17E-02	5.75E-03	8.62E-03	1.15E-02
HC	g	1.73E-03	2.59E-03	3.46E-03	1.66E-03	2.49E-03	3.32E-03
HC (aq)	g	1.00E-04	1.50E-04	2.00E-04	1.00E-04	1.50E-04	2.00E-04
BOD (aq)	g	9.50E-04	1.43E-03	1.90E-03	9.50E-04	1.43E-03	1.90E-03
COD (aq)	g	1.72E-02	2.58E-02	3.44E-02	1.72E-02	2.58E-02	3.44E-02
P (aq)	g	1.00E-04	1.50E-04	2.00E-04	1.00E-04	1.50E-04	2.00E-04
N (aq)	g	2.52E-04	3.78E-04	5.04E-04	2.52E-04	3.78E-04	5.04E-04
Hazardous chemical waste	g	1.32E-02	1.97E-02	2.63E-02	1.32E-02	1.97E-02	2.63E-02
Radioactive exposures	manSv	1.26E-12	1.89E-12	2.52E-12	1.26E-12	1.89E-12	2.52E-12
Ashes	g	8.80E-04	1.32E-03	1.76E-03	8.80E-04	1.32E-03	1.76E-03
Radioactive waste:							
Highly active	cm^3	1.77E-05	2.65E-05	3.53E-05	1.77E-05	2.65E-05	3.53E-05
Medium and low active	cm^3	1.89E-04	2.84E-04	3.78E-04	1.89E-04	2.84E-04	3.78E-04
Demolition waste	cm^3	1.89E-04	2.84E-04	3.78E-04	1.89E-04	2.84E-04	3.78E-04
Oil (aq)	g	4.74E-06	7.10E-06	9.49E-06	4.19E-06	6.27E-06	8.38E-06
Phenol (aq)	g	6.76E-06	1.01E-05	1.35E-05	5.97E-06	8.94E-06	1.19E-05

4.2.13 Production of crushed aggregates

The life cycle inventory of crushed aggregates is based on a production of crushed aggregates from rock mass. The rock is blasted and the blasted rock is transported by diesel driven maintenance vehicle to a stone breaker. The blasted rock is then crushed and sieved to become the final product. The material in the analysis is based on real total values for energy consumption for a whole factory including all energy consumption for the site. In analyses of the diesel driven maintenance vehicles, values

for a standard engine for maintenance vehicles has been used. The electricity consumption is based on Swedish average electricity consumption. Production of fixed assets and maintenance vehicles have been omitted in this analysis. Equally, the consumption of blasting agent as well as the production of blasting agent, have not been included in this study. Any diversification between different qualities (such as particle size) of crushed aggregates has unfortunately not been possible to do within the framework of the project. Energy consumption for the site is shown in table 4.2.13.1 and the result of the life cycle inventory is presented in table 4.2.13.2.

Table 4.2.13.1 Energy consumption in the production of crushed aggregates. Basic data from Sabema.

Consumption	**Unit**	**Amount per tonne crushed aggregates produced**
Diesel	litre	0.484
Diesel	MJ	16.99
Electricity	MJ	21.19

Table 4.2.13.2 Results from life cycle inventory for production of crushed aggregates.

In or outflow	Unit	Electricity per tonne crushed aggregates produced	Maintenance vehicle per tonne crushed aggregates produced	Total per tonne crushed aggregates produced
Rock	g			1.00E+06
Biomass fuel	MJ	9.45E-01		9.45E-01
Oil	MJ	1.36E+00	1.87E+01	2.00E+01
Peat	MJ	9.45E-02		9.45E-02
Coal	MJ	8.48E-01		8.48E-01
Natural gas	MJ	1.97E-01		1.97E-01
Uranium	MJ	3.39E+01		3.39E+01
hydropower	MJ	9.96E+00		9.96E+00
CO_2	g	8.05E+01	1.34E-03	1.42E+03
SO_2	g	1.42E-01	6.46E-01	7.88E-01
NO_x	g	1.95E-01	1.21E+01	1.23E-01
Dust	g	1.48E-03	4.76E-01	4.77E-01
CO	g	4.45E-02	1.44E+00	1.49E+00
Radioactive discharge	manSv	2.12E-09		2.12E-09
Ashes	g	1.48E+00		1.48E+00
Radioactive waste:				
Highly active	cm^3	2.97E-02		2.97E-02
Medium and low active	cm^3	3.18E-01		3.18E-01
Demolition waste	cm^3	3.18E-01		3.18E-01
N_2O	g	8.90E-03	2.72E-02	3.61E-02
VOC	g	2.33E-02	8.66E-01	8.90E-01
CH_4	g	2.97E-03	8.50E-04	3.82E-03
Oil (aq)	g		6.80E-03	6.80E-03
Phenol (aq)	g		9.68E-03	9.68E-03
COD	g		2.04E-02	2.04E-02
Tot-N (aq)	g		3.23E-03	3.23E-03

4.2.14 Extraction of pit-run gravel and sand

The extraction of natural gravel and sand has in the analysis been assumed to take place from a pit where the gravel/sand is dug out of the pit using a wheel loader, and is thereafter loaded onto lorry loaders for further transportation. For the operation of the wheel loader, excavation class 2 has been assumed for the gravel/sand pit. Some electricity consumption also takes place at the site. Data for electricity consumption has been collected from a real site (2.398 MJ electricity/tonne gravel/sand). In table 4.2.14.1 the results of the life cycle inventory for natural gravel or sand is shown.

Table 4.2.14.1 Life cycle inventory for extraction of pit-run gravel/sand from pit.

In or outflow	**Unit**	**Electricity production per tonne gravel/sand produced**	**Wheel loader operation, excavation class 2, per tonne gravel/sand produced**	**Total extraction, per tonne gravel/sand produced**
Pit-run gravel/sand	g			1.00E+06
Biomass fuel	MJ	1.08E-01		1.08E-01
Oil	MJ	1.53E-01	8.86E-01	1.04E+00
Peat	MJ	1.08E-02		1.08E-02
Coal	MJ	9.59E-02		9.59E-02
Natural gas	MJ	2.23E-02		2.23E-02
Uranium	MJ	3.84E+00		3.84E+00
Hydropower	MJ	1.13E+00		1.13E+00
CO_2	g	9.11E+00	6.36E+01	7.28E+01
SO_2	g	1.61E-02	3.06E-02	4.67E-02
NO_x	g	2.21E-02	5.75E-01	5.97E-01
Dust	g	1.68E-04	2.29E-02	2.31E-02
CO	g	5.04E-03	6.86E-02	7.36E-02
Radioactive discharge	manSv	2.40E-10		2.40E-10
Ashes	g	1.68E-01		1.68E-01
Radioactive waste:				
Highly active	cm^3	3.36E-03		3.36E-03
Medium and low active	cm^3	3.60E-02		3.60E-02
Demolition waste	cm^3	3.60E-02		3.60E-02
N_2O	g	1.01E-03	1.29E-03	2.30E-03
VOC	g	2.64E-03	4.14E-02	4.40E-02
CH_4	g	3.36E-04	4.03E-05	3.76E-04
Oil (aq)	g		3.22E-04	3.22E-04
Phenol (aq)	g		4.59E-04	4.59E-04
COD	g		9.67E-04	9.67E-04
Tot-N (aq)	g		1.53E-04	1.53E-04

4.2.15 Production of quicklime

Data for quicklime (CaO) production has been taken from Nordkalk Oy, Finland. In the production of quicklime, limestone is worked in a quarry, the limestone is then transported to a plant for re-combustion of limestone ($CaCO_3$) to CaO ($CaCO_3(s) \rightarrow CaO(s)+CO_2(g)$), after which the final product is transported to the end user.

In many applications the quicklime is mixed with water to form calciumhydroxide according to $CaO(s)+H_2O(l) \rightarrow Ca(OH)_2(s)$. During such use of quicklime the product can take up CO_2 according to the reaction $Ca(OH)_2+CO_2 \rightarrow CaCO_3(s)+H_2O$. The theoretical uptake of CO_2 has been estimated to 786 g/kg CaO (for pure limestone, $CaCO_3$). The uptake rate of CO_2 is difficult to estimate and depends on the type of use, shape of the product, moisture content, access to CO_2 (air) etc. The only use of quicklime in this study is in the production of foundation reinforcement using cement/lime columns (chapter 4.2.34). The uptake of CO_2 is normally very slow or negligible in this case due to lack of CO_2 (H_2CO_3) in the ground. The uptake of CO_2 during the specified time period of 40 years has thus been estimated to be very small and has not been considered in the study. However, the concentration of carbonate ions in the ground can be significant especially in the topsoil of the ground (< 1 m) and in materials exposed to air. In an infinite time perspective a theory is that all the released amount of CO_2 from the limestone in the production can be considered to be taken up (786 g/kg CaO). However, this theory has not been fully confirmed. See also chapter 4.2.16 and 4.2.17.

Lime production takes place at several sites in Sweden, and where the limestone is collected from depends on where the roadwork site is located. The data below includes an example of a transport distance (360 km by sea freight and 150 km by truck). Basic data from the inventory analysis of the quicklime production is shown in table 4.2.15.1.

Table 4.2.15.1 Production of quicklime (CaO).

In or outflow	Unit	Quicklime production per kg CaO
(Electricity)	MJ	0.144
Limestone	g	2000
Biomass fuel	MJ	0.006
Oil	g	21.6
Oil	MJ	0.89
Peat	MJ	0.0006
Coal	g	281
Coal	MJ	7.9
Natural gas	MJ	0.0013
Uranium	MJ	0.23
Hydropower	MJ	0.068
CO_2 [1)]	g	2035
SO_2	g	0.94
NO_x	g	3.25
Dust	g	0.0095
CO	g	0.37
Radioactive discharge	manSv	1.44E-11
Ashes	g	
Radioactive waste:		
Highly active	cm^3	0.0002
Medium and low active	cm^3	0.0022
Demolition waste	cm^3	0.0022
VOC	g	0.021
CH_4	g	0.0000144

[1)] Theoretically 786 g CO_2/kg CaO is released from the limestone during the production.

4.2.16 Production of cement

Inventory analysis data for cement in this case includes data from the working to the final product at the factory gates. Data from Swedish average production has been used as well as data from Swedish average electricity production. Data from the inventory analysis is shown in table 4.2.16.1.

Table 4.2.16.1 Production of cement from working to final product in factory.

In or outflow	Unit	Cement production from working to product per kg produced cement[1)]	Contribution from electricity production per kg produced cement	Total cement production per kg cement
Electricity	MJ	3.90E-01		
Limestone	g	1.56E+03		1.56E+03
Biomass fuel	MJ		1.76E-02	1.76E-02
Oil	MJ	4.06E-02	2.50E-02	6.56E-02
Peat	MJ		1.76E-03	1.76E-03
Coal	MJ	3.86E+00	1.56E-02	3.88E+00
Natural gas	MJ		3.63E-06	3.63E-03
Uranium	MJ		6.24E-01	6.24E-01
Hydropower	MJ		1.83E-01	1.83E-01
CO_2[2)]	g	8.05E+02	1.48E+00	8.06E+02
SO_2	g	1.00E+00	2.61E-03	1.00E+00
NO_x	g	2.00E+00	3.59E-03	2.00E+00
Dust	g	1.00E+00	2.73E-05	1.00E+00
CO	g		8.19E-04	8.19E-04
Radioactive discharge	manSv		3.90E-11	3.90E-11
Ashes	g		2.73E-02	2.73E-02
Radioactive waste:				
Highly active	cm^3		5.46E-04	5.46E-04
Medium and low active	cm^3		5.85E-03	5.85E-03
Demolition waste	cm^3		5.85E-03	5.85E-03
N_2O	g		1.64E-04	1.64E-04
VOC	g		4.29E-04	4.29E-04
CH_4	g		5.46E-05	5.46E-05

1) Data from Swedish average production, Cementa AB.

2) Approximately 686 g of the CO_2 emission originates from the release of CO_2 from the limestone ($CaCO_3 \rightarrow CaO+CO_2$). An amount of CO_2 is taken up by the concrete in the carbonation process during the lifetime of the concrete. See chapter 4.2.17.

4.2.17 Production of cement based road concrete

The final mix of the different components of the road concrete takes place at a mixing plant. There, mainly cement, pit-run gravel/sand, crushed aggregates and water is mixed in predetermined proportions. In the present analysis the production of concrete has been assumed to take place according to a fixed general recipe for road concrete. Material usage and energy consumption is shown in table 4.2.17.1. In addition to the materials given in the table, there are additional admixtures, such as water reducing admixture (3-6 kg/m^3) and air entraining admixture (0.1-0.4 kg/m^3) and water. These have not been treated in the analysis.

The analysis for concrete production is based on the fact that LCI data for cement, crushed aggregates and gravel/sand production has been weighed together with the energy consumption for the mixing plant, which can be divided into consumption of

electricity and consumption of diesel oil. The consumption of diesel oil has been assumed to take place through combustion in a low emission engine for a maintenance vehicle. The calculations have been based on emissions and energy consumption per produced volume unit of concrete. For the further analysis, we can assume that the final volume for the cured concrete takes the same volume as the produced volume of concrete from the mixing plant.

In principal, cement consists of Calcium oxide (CaO), Silicone oxide (SiO_2), Aluminium oxide (Al_2O_3) and Iron oxide (Fe_2O_3). In the production of cement, several different chemical compounds are formed such as $3CaO{\cdot}SiO_2$, $2CaO{\cdot}SiO_2$, $3CaO{\cdot}Al_2O_3$ and $3CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$. When cement/concrete cure a number of different chemical reactions occur such as the hydratisation reactions. Important reactions are the formation of tobermorit that can be described as:

$$2(3CaO{\cdot}SiO_2) + 6H_2O \rightarrow 3CaO{\cdot}2SiO_2{\cdot}3H_2O + 3Ca(OH)_2$$
or
$$2(2CaO{\cdot}SiO_2) + 4H_2O \rightarrow 3CaO{\cdot}2SiO_2{\cdot}3H_2O + 3Ca(OH)_2$$

In the production of cement, carbondioxide (CO_2) is released both from the production process (heating) and from the material itself when limestone is converted to calciumoxide ($CaCO_3 \rightarrow CaO + CO_2$). However, concrete can also take up CO_2 during its lifetime in the carbonation process. In this chemical process CO_2 from the air is absorbed in the moisture phase in the concrete to form carbonic acid according to,

$$CO_2 + H_2O \rightarrow H_2CO_3$$

The carbonic acid can then react with the calciumhydroxide in the concrete according to,

$$Ca(OH)_2 + H_2CO_3 \rightarrow CaCO_3 + 2H_2O$$

The carbonation process is slow. The reaction speed is fastest when the relative humidity (RH) is between 50 and 70 %. For RH-values below 25 %, too little water exists in the concrete and the reaction almost stops. In water saturated concrete the CO_2 transport in the concrete is reduced and the carbonation reaction is significantly slower. It is thus difficult to estimate how much CO_2 concrete actually take up during a specified time period. In principle, all the released CO_2 from the limestone in the cement production is taken up by the concrete during an infinite time period. However, the uptake mechanism from other parts than the $Ca(OH)_2$ has not been fully confirmed. The theoretical uptake of CO_2 in the concrete has been estimated to 686 g/kg cement or 274 kg/m^3 road concrete. For road concrete the uptake time period can be several hundred or thousands of years. Only a small part of the CO_2 is taken up during the considered 40 years in this project. The effect of carbonation on CO_2 has thus been excluded in this study but it is important to notice that a significant amount of CO_2 will be taken up in the concrete during a very long or infinite time period.

Data from the calculations are shown in table 4.2.17.2. Each sub-component is presented separately here, as well as the total value per produced volume of concrete. Data for the present analysis does not, however, include the transport of crushed aggregates and gravel/sand to the mixing plant or the transportation of cement from the cement plant to the mixing plant. These components are variable and vary depending on where the roadwork site is located.

Table 4.2.17.1 Basic material and energy usage in production of cement based road concrete.

Consumption	**Unit**	**Amount per m^3 produced concrete**
Cement	kg	400
Crushed aggregates	kg	1200
Pit-run gravel/sand	kg	700
Diesel	MJ	48.68
Diesel	litre	1.39
Electricity	MJ	16.72

Table 4.2.17.2 Results divided by sub-components and total result for an LCI of the concrete production, excluding transportation of cement from cement plant and transportation of pit-run gravel/sand and crushed aggregates.

In or outflow	**Unit**	**Electricity per m^3 produced concrete**	**Diesel maintenance vehicle per m^3 produced concrete**	**Crushed aggregates per m^3 produced concrete**	**Gravel/sand extraction per m^3 produced concrete**	**Cement production per m^3 produced concrete**	**Concrete production, excluding transports, total per produced m^3 concrete**
Limestone	g					6.24E+05	6.24E+05
Biomass fuel	MJ	7.52E-01		1.14E+00	7.55E-02	7.02E+00	8.99E+00
Oil	MJ	1.07E+00	5.53E+01	2.41E+01	7.28E-01	2.62E+01	1.06E+02
Peat	MJ	7.52E-02		1.14E-01	7.55E-03	7.02E-01	8.99E-01
Coal	MJ	6.69E-01		1.02E+00	6.70E-02	1.55E+03	1.55E+03
Natural gas	MJ	1.55E-01		2.36E-01	1.56E-02	1.45E+00	1.86E+00
Uranium	MJ	2.68E+01		4.07E+01	2.69E+00	2.50E+02	3.20E+02
Hydropower	MJ	7.86E+00		1.20E+01	7.89E-01	7.33E+01	9.39E+01
CO_2 [1)]	g	6.35E+01	3.85E+03	1.71E+03	5.09E+01	3.23E+05	3.28E+05
SO_2	g	1.12E-01	1.85E+00	9.45E-01	3.27E-02	4.01E+02	4.04E+02
NO_x	g	1.54E-01	3.46E+01	1.47E+01	4.18E-01	8.01E+02	8.51E+02
Dust	g	1.17E-03	1.36E+00	5.73E-01	1.62E-02	4.00E+02	4.02E+02
CO	g	3.51E-02	4.14E+00	1.79E+00	5.15E-02	3.28E-01	6.34E+00
Radioactive discharge	man Sv	1.67E-09		2.54E-09	1.68E-10	1.56E-08	2.00E-08
Ashes	g	1.17E+00		1.78E+00	1.18E-01	1.09E+01	1.40E+01
Radioactive waste:							
Highly active	cm^3	2.34E-02		3.56E-02	2.35E-03	2.18E-01	2.80E-01
Medium and low active	cm^3	2.51E-01		3.81E-01	2.52E-02	2.34E+00	3.00E+00
Demolition waste	cm^3	2.51E-01		3.81E-01	2.52E-02	2.34E+00	3.00E+00
N_2O	g	7.02E-03	7.79E-02	4.33E-02	1.61E-03	6.55E-02	1.95E-01
VOC	g	1.84E-02	2.48E+00	1.07E+00	3.08E-02	1.72E-01	3.77E+00
CH_4	g	2.34E-03	2.43E-03	4.58E-03	2.63E-04	2.18E-02	3.15E-02
Oil (aq)	g		1.95E-02	8.16E-03	2.26E-04		2.79E-02
Phenol (aq)	g		2.77E-02	1.16E-02	3.21E-04		3.79E-02
COD	g		5.84E-02	2.45E-02	6.77E-04		8.69E-02
Tot-N (aq)	g		9.25E-03	3.87E-03	1.97E-04		1.32E-02

1) A certain amount of CO_2 is taken up by the concrete in the carbonation process during the lifetime of the concrete.

4.2.18 Production of polyethylene plastic

Data for energy consumption, material usage and emissions represent an average from all European cracker works and 36 polymerisation plants for ethylene, table 4.2.18.1. Data gives the total values for production of 1 kg polyethylene plastic, from raw materials extraction to final product. Energy consumption shows total usage, i.e. consumption of energy in the production processes as well as consumption of raw materials to the plastic material itself, which is included in the product and counted as

raw material. Consumption of polyethylene plastic for road construction is in this project occurring in the laying of concrete road to cover the newly paved road in a plastic film, in connection with the addition of a so-called retarder to the road surface.

Table 4.2.18.1 Data from raw material to final product for the production of 1kg of polyethylene plastic. Energy values include both energy for manufacturing and the raw material used in the plastic, "feedstock".

In or outflow	**Unit**	**Polyethylene, per kg produced polyethylene** [1)]
(Electrical energy)	MJ	7.89
(Oil, total)	MJ	35.34
(Other fuels)	MJ	42.6
(Total energy consumption)	MJ	85.73
Fuels:		
Coal	MJ	2.75
Oil	MJ	3.07
Gas	MJ	11.53
Water power	MJ	0.46
Nuclear power	MJ	1.53
Other	MJ	0.14
Raw materials:		
Coal	MJ	0.01
Oil	MJ	32.76
Gas	MJ	33.59
Emissions:		
Particles	g	2
CO	g	0.8
CO_2	g	1100
SO_x	g	7
NO_x	g	00
HC	g	21
COD	g	1
BOD	g	0.15
Oil (aq)	g	0.1
Phenols (aq)	g	0.001
Phosphates (aq)	g	0.005
Total N (aq)	g	0.02
Industrial waste	g	3.1
Mineral waste	g	22
Slag and ashes	g	7

[1)] Data from Boustead I., 1993.

4.2.19 Sand gritting of road in winter road maintenance

Spreading of sand during winter maintenance is mostly done using a truck. The activity can be divided into two components, namely driving of the truck and production of sand. Sand can either be from a natural origin or from crushed material. In the model, several data types for gritting can be assumed to be variable. Input data for the model for gritting using sand are as follows:

- Share of aggregate and crushed sand respectively (in Sweden currently 30 % aggregate and 70 % crushed sand is used, with a tendency towards an increase in the share of crushed sand).

- Amount of sand per area unit (normally around 120 g/m^2).

- Length of gritted road strip, km.

- Number of grittings per annum.

The model is built up of three components, truck operation using distribution truck outside of urban areas, extraction of aggregate and production of sand from crushed materials. The spreading of sand has been assumed to take place with a width of 2.5 m. In the gritting of road, the road is normally covered by the gritting lorry once in each direction. Apart from this transport, another transport to and from the road takes place, to pick up sand.

4.2.20 Extraction of salt for winter road maintenance

Extraction of salt for winter road maintenance is mainly done through the working of salt in mines. Most of the salt is collected from Germany. The energy for the extraction can be based on coal or natural gas. Data for the extraction in the study has been taken from workings in Holland and in Great Britain but can probably be applied also to German conditions. Data for both natural gas based and coal based salt extraction is presented in table 4.2.20.1. In the model study the coal based extraction has been assumed. The emissions from salt production are roughly estimated values and therefore considered relatively unreliable.

Table 4.2.20.1 Energy and emission data for salt extraction in winter road maintenance

In or outflow	Unit	Extraction based on natural gas, per tonne salt	Extraction based on coal, per tonne salt
Natural gas	MJ	2220	
Coal	MJ		1480
CO_2 [1)]	g	124000	136000
SO_2 [1)]	g	0.004	740
NO_x [1)]	g	444	444
CO [1)]	g	44	30

[1)] Estimated values from IVL.

4.2.21 Salt gritting of road in winter road maintenance

Gritting of road in winter road maintenance has in this study been assumed to occur through solid sodium chloride being spread over the road. Spreading of the salt is mostly done using a truck. The activity can be divided into two components; driving of the truck and production and transportation of the salt. Salt for Swedish road maintenance is extracted from mines, mainly in Germany, and transported to Sweden by sea freight and by truck. In the model, certain data types for the gritting can be assumed to be variable. Input for the model for gritting using salt are as follows:

- Amount of salt per area unit (normally 15-20 g/m^2, imminent regulation of salt spreading will aim at around 10 g/m).
- Length of gritted road strip, km.
- Number of grittings per annum.
- Distance of transport between salt depot - salt mine.

The model is made up of two components, truck operation using distribution truck outside of urban areas, and extraction and transportation of salt. The spreading of salt has been assumed to take place with a width of around 4m. In the gritting of road the road is normally covered by the gritting truck once in each direction. Apart from this transport, another transport to and from the road takes place, to pick up salt from the storage depot.

4.2.22 Snow clearance

Snow clearance can be done using many different vehicles such as tractors, wheel loaders etc. The most common vehicle for snow clearance of the public road network is probably truck with an attached snow clearance unit. In this study, only snow clearance using truck has been included. Snow clearance has been assumed to give 30 % higher emission and energy consumption levels compared to normal operation of a truck. The vehicle has been assumed to be of the type distribution truck in operation outside of urban areas.

Snow clearance is normally done by covering each traffic lane once, which is why it is suitable to calculate per km cleared strip of road and not per area unit (m^2) cleared road. The number of clearings per annum is variable in the model.

4.2.23 Mowing of verges

The mowing of the verges are done by machine, and often using wheel loaders, or other comparable vehicle, with an attached mowing unit. A representative machine size for mowing is a wheel loader of type Volvo BM L 70B. This machine has been used as an example in the study. In the life cycle inventory, only the fuel consumption and the production of the fuel have been taken into account.

The fuel consumption calculated per km is relatively high in mowing, when the machine is operated using a high rotational frequency in a low gear. Fuel consumption has been calculated to be 13.2 litre/h and the mowing speed to be 10 km/h. This gives a fuel consumption of 1.3 litre/km or 46.3 MJ/km. The cutting width covered by the machine on the verge results in a mowing width of 1.5 m. The total mowing width for a verge can vary but is normally between 1-7 m. The total energy consumption and the total emissions are the products of the number of passes done by the machine and the analysis results for one pass calculated per km, table 4.2.23.1.

Table 4.2.23.1 Mowing of verge using wheel loader, type Volvo BM L 70. The results show emissions and energy consumption at one pass by the machine, which results in a mowing width of 1.5 m.

In or outflow	**Unit**	**Total per MJ used diesel**	**Mowing, edge trimming of 1.5 m width per km verge**
Diesel oil	MJ	1.1	5.09E+01
CO_2	g	79	3.66E+03
SO_2	g	0.038	1.76E+00
NO_x	g	0.71	3.31E+01
Dust	g	0.028	1.32E+00
CO	g	0.085	3.94E+00
N_2O	g	0.0016	7.14E-02
HC	g	0.051	2.38E+00
CH_4	g	0.00005	2.32E-03
Oil (aq)	g	0.0004	1.85E-02
Phenol (aq)	g	0.00057	2.64E-02
COD	g	0.0012	5.56E-02
Tot-N (aq)	g	0.00019	8.80E-03

4.2.24 Clearing of verges

Light clearing of bushes etc from the verges is done mechanically and often using a wheeled loader, or other comparable vehicle, with an attached clearing unit. A representative machine size for clearing is a wheeled loader of type Volvo BM L 70B. This machine has been used as an example in the study. In the life cycle inventory, only the fuel consumption and the production of the fuel have been taken into account.

The fuel consumption calculated per km is relatively high in clearing, as the machine is operated using a high rotational frequency in a low gear. Fuel consumption has been calculated to be 13.2 litre/h and the clearing speed to be 5 km/h. This gives a fuel consumption of 2.6 litre/km or 92.2 MJ/km. The cutting width covered by the machine on the verge results in a clearing width of 1.2 m. The total energy consumption and emissions are the products of the number of passes done by the machine and the analysis results for one pass calculated per km, table 4.2.24.1.

Table 4.2.24.1 Light clearing (bushes, shrubs) of verges using a wheel loader, type Volvo BM L 70. The results show emissions and energy consumption for one pass by the machine, which results in a cleared width of 1.2 m.

In or outflow	**Unit**	**Total per MJ used diesel**	**Clearing of a 1.2 m width per km verge**
Diesel oil	MJ	1.1	1.02E+02
CO_2	g	79	7.32E+03
SO_2	g	0.038	3.52E+00
NO_x	g	0.71	6.61E+01
Dust	g	0.028	2.64E+00
CO	g	0.085	7.88E+00
N_2O	g	0.0016	1.48E-01
HC	g	0.051	4.76E+00
CH_4	g	0.00005	4.63E-03
Oil (aq)	g	0.0004	3.70E-02
Phenol (aq)	g	0.00057	5.28E-02
COD	g	0.0012	1.11E-01
Tot-N (aq)	g	0.00019	1.76E-02

4.2.25 Trench digging in maintenance of road

Trenches alongside the roads need re-digging with regular intervals. The interval periods can vary between different types of roads but are normally relatively long, up to 20 years.

Re-digging of the trenches is often done using an excavator and two lorries/maintenance vehicles that transports the excavated material. A normal transport distance for the surplus material is around 10 km. In the inventory analysis, only the fuel consumption of the machines has been taken into account. The fuel consumption (diesel) for the lorries/maintenance vehicles has been estimated at 20

litre/h. Emission estimates for the operation has been assumed to be the same as for other maintenance vehicles. Trench digging capacity has been estimated at 700 m trench per 8-hour shift, i.e. a digging speed of 87.5 m/h. The corresponding fuel and energy consumption is shown in table 4.2.25.1. Table 4.2.25.2 shows the results of the inventory analysis of the trench digging.

Table 4.2.25.1 Fuel (diesel)/energy consumption in trench digging in connection with maintenance of road.

Machine type	**Fuel consumption (litre/m of trench)**	**Energy use (MJ/m of trench)**
Lorries, 2	0.27	9.62
Excavator, 1	0.23	8.04
Total, trench digging	**0.50**	**17.66**

Table 4.2.25.2 Inventory analysis results of trench digging in connection with maintenance of road.

In or outflow	**Unit**	**Total per MJ used diesel**	**Trench digging per m of trench, from truck operation**	**Trench digging per m of trench, from excavator**	**Trench digging per m of trench, Total**
Diesel oil	MJ	1.1	1.06E+01	8.84E+01	1.94E+01
CO_2	g	79	7.6E+02	6.35E+02	1.39E+03
SO_2	g	0.038	3.65E-01	3.05E-01	6.71E-01
NO_x	g	0.71	6.87E+00	5.74E+00	1.26E+01
Dust	g	0.028	2.74E-01	2.29E-01	5.03E-01
CO	g	0.085	8.19E-01	6.84E-01	1.50E+00
N_2O	g	0.0016	1.54E-02	1.29E-02	2.82E-02
HC	g	0.051	4.94E-01	4.13E-01	9.07E-01
CH_4	g	0.00005	4.81E-04	4.02E-04	8.83E-04
Oil (aq)	g	0.0004	3.85E-03	3.22E-03	7.06E-03
Phenol (aq)	g	0.00057	5.48E-03	4.58E-03	1.01E-02
COD	g	0.0012	1.15E-02	9.65E-03	2.12E-02
Tot-N(aq)	g	0.00019	1.83E-03	1.53E-03	3.35E-03

4.2.26 Erection and removal of snow posts

Erection and removal of snow posts is done using a carrier car with a diesel engine. Normally the snow posts are erected in the autumn and removed in the spring, so that the total activity erection/removal occurs once a year. The emissions from the operation have been assumed to be the same as for other maintenance vehicles with corresponding diesel engines. The erection/removal capacity has been estimated at 2.5 km/h and 3.5 km/h respectively. For the erection, this represents a distance of 20 km in an 8-hour shift. The fuel consumption for the vehicle is 8 litre/h. Table 4.2.26.1 shows the fuel/energy consumption and table 4.2.26.2 shows the corresponding inventory analysis results.

Table 4.2.26.1 Fuel/energy consumption in erection and removal of snow posts.

Activity	**Fuel consumption (litre/km road side)**	**Energy consumption (MJ/km road side)**
Erection of snow posts	3.2	112.3
Removal down of snow posts	2.3	80.7
Total, erection and removal	**5.5**	**193.1**

Table 4.2.26.2 Inventory analysis results of erection and removal of snow posts.

In or outflow	**Unit**	**Total per MJ used diesel**	**Erection of snow posts per km road side**	**Removal of snow posts per km road side**	**Total erection/removal of snow posts per km road side**
Diesel oil	MJ	1.1	1.24E+02	8.88E+01	2.12E+02
CO_2	g	79	8.87E+03	6.83E+03	1.53E+04
SO_2	g	0.038	4.27E+00	3.07E+00	7.34E+00
NO_x	g	0.71	8.02E+01	5.76E+01	1.38E+02
Dust	g	0.028	3.20E+00	2.30E+00	5.50E+00
CO	g	0.085	9.56E+00	6.87E+00	1.64E+01
N_2O	g	0.0016	1.80E-01	1.29E-01	3.09E-01
HC	g	0.0051	5.77E+00	4.15E+00	9.92E+00
CH_4	g	0.00005	5.61E-03	4.04E-03	9.65E-03
Oil (aq)	g	0.0004	4.49E-02	3.23E-02	7.72E-02
Phenol (aq)	g	0.00057	6.40E-02	4.60E-02	1.10E-01
COD	g	0.0012	0.35E-01	9.69E-02	2.32E-01
Tot-N (aq)	g	0.00019	2.13E-02	1.53E-02	3.67E-02

4.2.27 Washing of road signs

Washing of road signs is most commonly done using a carrier vehicle with an attached washing unit and takes place on average twice a year. The vehicle is diesel engine driven and the emissions have been assumed to be the same as for other maintenance vehicles. The fuel consumption has been assumed to be 8 litre/h. The washing speed naturally varies depending on the number of signs per road strip but for the purpose of the study, it has been set to 5 km roadside/h, which corresponds to 6 road signs per km roadside. This gives an average fuel and energy consumption of 1.6 litre diesel/km roadside and 56.2 MJ/km roadside respectively. Table 4.2.27.1 shows the inventory analysis results for washing of road markings/road signs.

Table 4.2.27.1 Inventory analysis results for washing of road signs using carrier vehicle with attached washing unit.

In or outflow	Unit	Total per MJ used diesel	Washing of road signs per km road side
Diesel oil	MJ	1.1	6.18E+01
CO_2	g	79	4.44E+03
SO_2	g	0.038	2.13E+00
NO_x	g	0.71	4.01E+01
Dust	g	0.028	1.60E+00
CO	g	0.085	4.78E+00
N_2O	g	0.0016	8.99E-02
HC	g	0.051	2.89E+00
CH_4	g	0.00005	2.81E-03
Oil (aq)	g	0.0004	2.25E-02
Phenol (aq)	g	0.00057	3.20E-02
COD	g	0.0012	6.74E-02
Tot-N(aq)	g	0.00019	1.07E-02

4.2.28 Washing of roadside posts

Washing of roadside posts is done using a carrier vehicle with an attached washing unit. Only the fuel consumption of the vehicle has been taken into account in this analysis. The fuel consumption has been estimated at 8 litre/h. The washing speed is 8 km roadside/h. This gives an average fuel consumption of 1.0 litre diesel/km roadside or 35.1 MJ/km roadside. Washing of roadside posts takes place 10 times per year. Table 4.2.28.1 shows the inventory analysis results for washing of roadside posts.

Table 4.2.28.1 Inventory analysis results for washing of roadside posts using carrier vehicle with attached washing unit.

In or outflow	Unit	Total per MJ used diesel	Washing of roadside posts per km road side
Diesel oil	MJ	1.1	3.86E+01
CO_2	g	79	2.77E+03
SO_2	g	0.038	1.33E+00
NO_x	g	0.71	2.51E+01
Dust	g	0.028	1.00E+00
CO	g	0.085	2.99E+00
N_2O	g	0.0016	5.62E-02
HC	g	0.051	1.80E+00
CH_4	g	0.00005	1.76E-03
Oil (aq)	g	0.0004	1.40E-02
Phenol (aq)	g	0.00057	2.00E-02
COD	g	0.0012	4.12E-02
Tot-N (aq)	g	0.00019	6.67E-03

4.2.29 Felling

Before the direct ground work can be started at a roadwork site, the potential clump of forest must be felled. This is often done using a forest-processing machine, which fells, trims and saws the log into appropriate sizes. The timber is then transported from the forest to a local depot by forest tractor, from where the timber is then collected by long distance lorries for further transport.

The production capacity of a forest processor has in the study been estimated to be 25 m^3 wood/h with a corresponding fuel consumption of 12 litre diesel oil/h. Corresponding average figures for a forest tractor has been estimated at 15 m^3 wood/h and 10 litre diesel oil/h. The resulting fuel and energy consumption is shown in table 4.2.29.1. The inventory analysis results from the total felling to the local depot in the forest are shown in table 4.2.29.2.

The amount of environmental burdens from the felling work itself that should be allocated on to the road depends on the conditions for the road construction. If the forest consists of trees that can be felled, which would be felled under all circumstances and that leads to emissions from another felling site if not felled, then no burdens from this part should be allocated onto the road. However, if the vegetation consists of smaller trees, which cannot be used, the felling part should be allocated to the road. This relationship has led to the allocation part to the road being included as a variable in the model and can therefore be changed according to the conditions that prevail at the construction site. In the calculation examples, 10 % of the energy consumption and emissions of the felling have been allocated to the road.

When the forest along the routing of a road is felled, a once-for-all emission of CO_2 occurs, because of the decreasing biomass that the road uses. This emission should be completely allocated to the road, otherwise there is a risk that the biomass will grow back. The emission of CO_2 from forest has been calculated to be 771 kg CO_2/m^3 forest

(Eriksson H, Ambio, 1991). When forest m^3 (fm^3) is used in the model for input data, the emission of CO_2 has been multiplied by a factor of 2 in order to include the whole biomass, including lops and branches, and to some extent also take into account the increased CO_2 formation, which is the consequence of taking away a certain amount of humus in the ground. This can then be oxidised and form CO_2. The estimates of this component are for obvious reasons rough. Emissions of other greenhouse gases such as CH_4 and N_2O also exist in connection with the felling. Rough estimates of these emissions show that they are negligible in relation to the emission of CO_2.

In the road example in this study a forest clump consisting of 200 fm^3/ha has been assumed. For 13 m road it has also been assumed that 10 m verge on each side of the road must be cleared from trees. This gives a total felling of 660 fm^3 for the 1 km long road section.

Table 4.2.29.1 Fuel/energy consumption for forest machine in the felling of forest.

Machine type	**Fuel consumption (litre/m^3 felled forest)**	**Energy consumption (MJ/m^3 felled forest)**
Forest processing machine	0.48	16.85
Forest tractor for transport out of the forest	0.67	23.52
Total, from felling to storage at local depot.	1.15	40.37

Table 4.2.29.2 Inventory analysis results from felling to storage at local depot in the forest, divided into forest processing machine and transport out of the forest to local depot.

In or outflow	**Unit**	**Total per MJ used diesel**	**Forest processing machine per m^3 felled forest**	**Forest tractor per m^3 felled forest**	**Total, felling to local depot per m^3 felled forest**
Diesel oil	MJ	1.1	1.85E+01	2.59E+01	4.44E+01
CO_2	g	79	1.33E+03	1.86E+03	3.19E+03
SO_2	g	0.038	6.46E-01	8.94E-01	1.53E+00
NO_x	g	0.71	1.20E+01	1.68E+01	2.88E+01
Dust	g	0.028	4.80E-01	6.70E-01	1.15E+00
CO	g	0.085	1.43E+00	2.00E+00	3.44E+00
N_2O	g	0.0016	2.70E-02	3.76E-02	6.46E-02
HC	g	0.051	8.66E-01	1.21E+00	2.07E+00
CH_4	g	0.00005	8.42E+04	1.18E-03	2.02E-03
Oil (aq)	g	0.0004	6.74E-03	9.41E-03	1.61E-02
Phenol (aq)	g	0.00057	9.60E-03	1.34E-02	2.30E-02
COD	g	0.0012	2.02E-02	2.82E-02	4.84E-02
Tot-N (aq)	g	0.00019	3.20E-03	4.47E-03	7.67E-03

4.2.30 Synthetic rubber - EPDM

The largest consumption of synthetic rubber in road construction comes from sealing of joints in production of concrete roads. In the inventory analysis for the sealing process of concrete roads, data has been produced for the production of EPDM-rubber, table 4.2.30.1.

Table 4.2.30.1 Production of EPDM Rubber.

In or outflow	**Unit**	**Production of EPDM-rubber, per kg rubber produced [1)]**
Heating oil, Diesel	g	510
Heating oil, Diesel	MJ	21
Coal	g	200
Coal	MJ	5.6
(Electricity)	MJ	5
SO_2	g	5.7
NO_x	g	4
CO_2	g	2328
NMVOC	g	19
PAH	g	3.00E-05
Particles	g	2.1
N_2O	g	0.05
CH_4	g	3.5
CO	g	0.8
COD (aq)	g	20
Tot-N (aq)	g	0.04

1) Environmental Life-Cycle Inventories of Energy Systems, Bundesamt für Energiewirtschaft, Sauter P Swiss Federal Institute of Technology, Zurich, Switzerland, 1994.

4.2.31 Aluminium

In this context, aluminium is mainly being used for the peripheral equipment of the road, such as road signs, traffic lights, lighting etc. Data for production of aluminium can be found in table 4.2.31.1. Data represents produced aluminium with a recycling rate of 75 %.

Table 4.2.31.1 Production of Aluminium with 75 % recycling rate.

In or outflow	Unit	Aluminium production per kg Al with 75% recycling rate	Contribution from electricity production per kg Al with 75% recycling rate	Aluminium production in total per kg Al
Aluminium	g	2.50E+02		2.50E+02
Bauxite	g			
Stone salt	g	7.80E+01		7.80E+01
Limestone	g	2.18E+01		2.18E+01
(Electricity)	MJ	2.53E+01		2.53E+01
Biomass fuel	MJ		1.14E+00	1.14E+00
Oil	MJ	9.60E+00	1.62E+00	1.12E+01
Peat	MJ		1.14E-01	1.14E-01
Coal	MJ		1.01E+00	1.01E+00
Natural gas	MJ	1.80E+00	2.35E-01	2.04E+00
Uranium	MJ		4.05E+01	4.05E+01
Hydropower	MJ		1.19E+01	1.19E+01
CO_2	g	1.23E+03	9.61E+01	1.33E+03
SO_2	g	6.90E+00	1.70E-01	7.07E+00
NO_x	g	4.80E+00	2.33E-01	5.03E+00
Dust	g	5.53E+01	1.77E-03	5.03E+00
CO	g	7.00E-01	5.31E-02	7.53E-01
Ashes	g	5.00E-02	1.77E+00	1.82E+00
N_2O	g		1.06E-02	1.06E-02
VOC	g		2.78E-02	2.78E-02
CH_4	g		3.54E-03	3.54E-03
HC	g	1.40E+00		1.40E+00
HCl	g	2.00E-01		2.00E-01
COD	g	9.00E+00		9.00E+00
Radioactive discharge	manSv		2.53E-09	2.53E-09
Radioactive waste:				
Highly active	cm^3		3.54E-02	3.54E-02
Medium and low active	cm^3		3.80E-01	3.80E-01
Demolition waste	cm^3		3.80E-01	3.80E-01

1) Data from the packaging investigation, Tillman et al

4.2.32 Steel Production

One direct utilisation of steel in road construction is its use in reinforcement bars for concrete roads, known as dowels, and for peripheral equipment such as road signs, fences and railings, etc. For the peripheral equipment, hot dip galvanised steel is used to a great extent. Data for steel and hot dip galvanised steel is presented in table 4.2.32.1. The consumption of zinc in the galvanising process has been calculated to be 0.5 % of the weight of the steel used. The amount of zinc used can naturally vary somewhat depending on the thickness of the zinc layer, and the geometrical design of the product.

Table 4.2.32.1 Production of steel and hot dip galvanised steel for reinforcement bars, road signs, railings, fences etc. Data represents new, not recycled, material.

In or outflow	**Unit**	**Production of steel, per kg steel produced** [1)]	**Production of zinc, per kg hot dip galvanised steel produced (0.5 % Zn)**	**Production of galvanised steel per kg steel**
Iron from deposit	g	1000		1.00E+03
Zinc from deposit	g		5	5.00E+00
Heating oil, diesel	MJ	3.6	0.032	3.36E+00
Coal	MJ	15.3	0.0048	1.53E+01
Natural gas	MJ	1.78	0.0307	1.81E+00
(Electricity)	MJ	4.64	0.0805	4.72E+00
SO_2	g	7.34	0.1405	7.48E+00
NO_x	g	4.86	0.077	4.94E+00
CO_2	g	2200	23.25	2.22E+03
CO	g	1	0.0195	1.02E+00
NMVOC	g	1.2	0.014	1.12E+00
PAH	g	3.34E-05	0.0000000	3.39E-05
H_2S	g	0.0194	0.0000225	1.94E-02
Particles	g	39.2	0.0455	3.92E+01
N_2O	g	0.03	0.0006	3.06E-02
CH_4	g	9.1	0.0695	9.17E+00
COD (aq)	g	9.30E-03	0.000115	9.42E-03
Tot-N	g	7.47E-03	0.000085	7.56E-03

1) Environmental Life-Cycle Inventories of Energy Systems, Bundesamt für Energiewirtschaft, Sauter P Swiss Federal Institute of Technology, Zurich, Switzerland, 1994.

4.2.33 Zinc production

Data shows the production of zinc to galvanising of steel, table 4.2.33.1.

Table 4.2.33.1 Production of zinc.

In or outflow	Unit	Production of zinc, per kg zinc produced [1)]
Zinc from deposit	g	1000
Heating oil, diesel	g	156
Heating oil, diesel	MJ	6.4
Coal	g	3404
Coal	MJ	0.96
Natural gas	MJ	6.14
(Electricity)	MJ	16.1
SO_2	g	28.1
NO_x	g	15.4
CO_2	g	4650
CO	g	3.9
NMVOC	g	2.8
PAH	g	1.00E-04
H_2S	g	0.0045
Particles	g	9.1
N_2O	g	0.12
CH_4	g	13.9
COD (aq)	g	0.023
Tot-N	g	0.017

1) Environmental Life-Cycle Inventories of Energy Systems, Bundesamt für Energiewirtschaft, Sauter P Swiss Federal Institute of Technology, Zurich, Switzerland, 1994.

4.2.34 Foundation reinforcement using cement/lime columns

Foundation reinforcement work using cement/lime columns is carried out through driving a drilling tool of a certain diameter into the ground while cement and lime are being added. The most common diameter for this type of drill is 600 mm, which is also the one that has been used in this study. The machine that operates the drilling tool is diesel driven at around 200 hp. The machine has a high effect exploitation during the whole working process. The normal consumption of materials and fuel is shown in table 4.2.34.1. The results of the inventory analysis are presented in table 4.2.34.2. Data has been calculated per meter of cement/lime column produced. For the model road in the study (1 km), it has been assumed that 100 m of this is stabilised with cement/lime columns. The distance between the centres of the columns has been assumed to be 1.5 m in both the longitudinal and transverse directions of the road. The stabilised road width has been put down as 17 m. With an average column length of 10 m, this gives a total column length of 8840 m.

Table 4.2.34.1 Normal consumption of materials and fuel in foundation reinforcement work using cement/lime columns (∅=600mm). Data from building contractors for foundation reinforcement work.

Material	Consumption	Unit
Cement	11.5	kg/m column
Quicklime	11.5	kg/m column
Diesel	0.5	litre/m column
Diesel	17.55	MJ/m column

Table 4.2.34.2 Production of cement/lime columns (∅=600mm) in ground reinforcement work.

In or outflow	Unit	Quicklime production per meter cement/lime column	Cement production per meter cement/lime column	Diesel consumption per meter cement/lime column	Cement/lime column total per m cement/lime column
Limestone	g	2.30E+04	1.79E+04		4.09E+04
Biomass fuel	MJ	6.90E-02	2.02E-01		2.71E-01
Oil	g	2.48E+02	1.83E+01	5.44E-01	2.67E+02
Oil	MJ	1.02E+01	7.54E-01	1.93E+01	3.03E+01
Peat	MJ	6.90E-03	2.02E-02		2.71E-02
Coal	g	3.32E+03	1.58E+03		4.81E+03
Coal	MJ	9.09E+01	4.46E+01		1.35E+02
Natural gas	MJ	1.50E-02	4.17E-02		5.67E-02
Uranium	MJ	2.65E+00	7.18E+00		9.82E+00
Hydropower	MJ	7.82E-01	2.11E+00		2.89E+00
CO_2	g	2.34E+04	9.27E+03	1.39E+03	3.41E+04
SO_2	g	1.08E+01	1.15E+01	6.67E-01	2.3E+01
NO_x	g	3.74E+01	2.30E+01	1.25E+01	7.29E+01
Dust	g	1.09E-01	1.15E+01	5.00E-01	1.21E+01
CO	g	4.26E+00	9.42E-03	1.49E+00	5.76E+00
Radioactive discharge	manSv	1.66E-10	4.49E-10		6.14E-10
Ashes	g	1.15E-02	3.14E-01		3.25E-01
Radioactive waste:					
Highly active	cm^3	2.30E-03	6.28E-03		8.58E-03
Medium and low active	cm^3	2.53E-02	6.73E-02		9.26E-02
Demolition waste	cm^3	2.53E-02	6.73E-02		9.26E-02
N_2O	g		1.88E-03	2.81E-02	3.00E-02
VOC	g	2.42E-01	4.93E-03	9.02E-01	1.15E+00
CH_4	g	1.66E-04	6.28E-04	8.87E-04	1.67E-03
Oil (aq)	g			7.02E-03	7.02E-03
Phenol (aq)	g			1.00E-02	1.00E-02
COD	g			2.11E-02	2.11E-02
Tot-N (aq)	g			3.33E-03	3.33E-03

4.2.35 Foundation reinforcement using concrete piles

In foundation reinforcement work using pre-fabricated concrete piles, quadratic, reinforced concrete piles are driven into the ground using a diesel driven piling machine. A normal cross section of a concrete pile is 275 X 275 mm. The data presented below is based on these dimension and includes the material consumption in the manufacturing of the piles, as well as the diesel consumption in the piling work. Potential pile footings have not been included in the analysis. (If pile footings exist, they often have the dimensions 2m X 2m X 0.45m, which leads to a concrete consumption of 1.8 m^3 per pile footing). The usage of material for the piling process is shown in table 4.2.35.1. Inventory analysis data is shown for the different materials as well as for piling work, table 4.2.35.2. Data is presented per meter of pile used. For the model road of the study (1 km) it has been assumed that 100 m of the road is stabilised with concrete piles. The distance between the centres of the piles has been assumed to be 3m in both the longitudinal and transverse directions of the road. The stabilised road width has been assumed to be 17 m. Assuming an average pile length of 10 m, this gives a total pile length of 2450 m.

Table 4.2.35.1 Material consumption in piling work. Cross section of pile measures 275 X 275mm. Data from pile manufacturers and building contractors.

Material	**Consumption**	**Unit**
Cement	35	kg/m concrete pile
Steel	9.5	kg/m concrete pile
Crushed aggregates	60.5	kg/m concrete pile
Pit-run gravel	60.5	kg/m concrete pile
Diesel	0.29	litre/m concrete pile
Diesel	10.18	MJ/m concrete pile

Table 4.2.35.2 Production of concrete piles and piling work, excluding transportation of raw materials to the pile production site, divided into components and total.

In or outflow	Unit	Pit-run gravel per m concrete pile	Crushed aggregates per m concrete pile	Production of steel per m concrete pile	Cement production per m concrete pile	Diesel consumption per m concrete pile	Concrete pile total per m concrete pile
Iron from deposit	g			9.50E+03			9.50E+03
Limestone	g				5.46E+04		5.46E+04
Pit-run gravel	g	6.05E+04					6.05E+04
Rock	g		6.05E+04				6.05E+04
Biomass fuel	MJ	6.53E-03	5.77E-02		6.14E-01		6.78E-01
Oil	MJ	6.29E-02	1.12E+00	3.42E+01	2.29E+00	1.12E+01	4.90E+01
Peat	MJ	6.53E-04	5.77E-03		6.14E-02		6.78E-02
Coal	MJ	5.80E-03	5.13E-02	1.45E+02	1.36E+02		2.81E+02
Natural gas	MJ	1.35E-03	1.19E-02	1.69E+01	1.27E-01		1.71E+01
Uranium	MJ	2.32E-01	2.05E+00		2.18E+01		2.41E+01
Hydropower	MJ	6.82E-02	6.03E-01		6.42E+00		7.09E+00
CO_2	g	4.40E+00	8.61E+01	2.09E+04	2.82E+04	8.04E+02	5.00E+04
SO_2	g	2.82E-03	4.76E-02	6.97E+01	3.51E+01	3.87E-01	1.05E+02
NO_x	g	3.60E-02	7.42E-01	4.62E+01	7.01E+00	7.27E+00	1.24E+02
Dust	g	1.40E-03	2.89E-02	3.72E+02	3.50E+01	2.90E-01	4.08E+02
CO	g	4.45E-03	9.01E-02	9.50E+00	2.87E-02	8.76E-01	1.05E-01
Radioactive discharge	manSv	1.45E-11	1.28E-10		1.37E-09		1.51E-09
Ashes	g	1.02E-02	8.97E-02		9.56E-01		1.06E+00
Radioactive waste:							
Highly active	cm^3	2.03E-04	1.79E-03		1.91E-02		2.11E-02
Medium and low active	cm^3	2.18E-03	1.92E-02		2.05E-01		2.26E-01
Demolition waste	cm^3	2.18E-03	1.92E-02		2.05E-01		2.26E-01
N_2O	g	1.39E-04	2.18E-03	2.85E-01	5.73E-03	1.63E-02	3.09E-01
VOC	g	2.66E-03	5.38E-02	1.14E+01	1.50E-02	5.23E-01	1.20E+01
CH_4	g	2.29E-05	2.31E-04	8.65+01	1.91E-03	5.09E-04	8.65E+01
Oil (aq)	g	1.95E-05	4.11E-04			4.07E-03	4.50E-03
Phenol (aq)	g	2.78E-05	5.86E-04			5.80E-03	6.24E-03
COD	g	5.85E-05	1.23E-03	8.84E-02		1.22E-02	1.02E-01
Tot-N (aq)	g	9.26E-06	1.95E-04	7.10E-02		1.93E-03	7.13E-02
PAH	g			3.17E-04			3.17E-04
H_2S	g			1.84E-01			1.84E-01

4.2.36 Wildlife fences

Wildlife fences are produced using hot dip galvanised steel. The consumption of materials for a normal wildlife fence has been calculated to be 3.76 kg hot dip galvanised steel/m wildlife fence. The erection of the wildlife fence is carried out in several stages. The total fuel consumption for the erection of the fence has been estimated at 0.08 litre diesel/m wildlife fence. Inventory analysis data for the wildlife fence can be found in table 4.2.36.1.

Table 4.2.36.1 Data for wildlife fences. Calculated based on the erection of the fence and materials consumption.

In or outflow	Unit	Production of hot dip galvanised steel per m wildlife fence	Diesel consumption per m wildlife fence	Wildlife fence total per m erected wildlife fence
Iron from deposit	g	3.76E+03		3.76E+03
Zinc from deposit	g	1.88E+01		1.88E+01
Heating oil, diesel	g	3.35E+02		3.35E+02
Heating oil, diesel	MJ	1.37E+01	3.09E+00	1.67E+01
Coal	g	2.05E+03		2.05E+03
Coal	MJ	5.75E+01		5.75E+01
Natural gas	MJ	6.81E+00		6.81E+00
(Electricity)	MJ	1.77E+01		1.77E+01
SO_2	g	2.81E+01	1.07E-01	2.82E+01
NO_x	g	1.86E+01	2.01E+00	2.06E+01
CO_2	g	8.36E+03	2.22E+02	8.58E+03
CO	g	3.83E+00	2.39E-01	4.07E+00
NMVOC	g	4.56E+00	1.44E-01	4.71E+00
PAH	g	1.27E-04		1.27E-04
H_2S	g	7.30E-02		7.30E-02
Particles	g	1.48E+02	8.00E-02	1.48E+02
N_2O	g	1.15E-01	4.49E-03	1.20E-01
CH_4	g	3.45E+01	1.40E-04	3.45E+01
COD (aq)	g	3.54E-02	3.37E-03	3.88E-02
Tot-N	g	2.84E-02	5.34E-04	2.89E-02
Oil (aq)	g		1.12E-03	1.12E-03
Phenol (aq)	g		1.60E-03	1.60E-03

4.2.37 Road markings, signs, lighting, traffic lights and other railings and fences

The additional peripheral equipment that surrounds a road varies significantly depending on the type of road, traffic density etc. In this project, it has not been possible to do a detailed study of these components, but in general we can assume that the materials used mainly consist of hot dip galvanised steel and aluminium. Some electric and electronic components are also present. In addition, electrical energy is used for the operation of the peripheral equipment. In this study, the resource consumption has been calculated based on the consumption of hot dip galvanised steel, aluminium, diesel for erection and maintenance as well as electrical energy for the operation.

4.2.38 Production of hot mixed asphalt

In the hot mixed asphalt plant, bitumen and stone materials are mixed according to the hot method. Warm bitumen is mixed with the heated stone material, where the stone material has been heated using an oil burner. The heating oil used is medium heavy (of class EO3) with a sulphur content of around 0.1 %. The bitumen content in the paving compound is around 6 %. Material and energy consumption as well as inventory analysis data for the asphalt plant are shown in tables 4.2.38.1 and 4.2.38.2.

Table 4.2.38.1 Material and energy consumption for asphalt from hot mixed asphalt plant. Operation data for a plant.

Material	**Consumption**	**Unit**
Bitumen	0.06	tonne/tonne asphalt
Crushed aggregates	0.94	tonne/tonne asphalt
Electrical energy	36	MJ/tonne asphalt
Heating oil	285	MJ/tonne asphalt

Table 4.2.38.2 Inventory analysis data for asphalt from hot mixed asphalt plant, divided into components and total. Transportation of material is not included except for those transports included in bitumen and crushed aggregates production.

In or outflow	Unit	Bitumen per tonne asphalt	Crushed aggregates per tonne asphalt	Electrical energy per tonne asphalt	Heating energy per tonne asphalt	Asphalt, hot mixed, total per tonne produced asphalt
Bitumen	g	6.00E+04				6.00E+04
Rock	g		9.40E+05			9.40E+05
Heating oil, diesel	MJ	6.36E+01	1.88E+01	2.30E+00	2.85E+02	3.70E+02
Electricity [1)]	MJ	1.51E+01	19.9	36		7.10E+01
Biomass fuel	MJ	6.78E-01	8.96E-01	1.62E+00		3.19E+00
Peat	MJ	6.78E-02	8.96E-02	1.62E-01		3.19E-01
Coal	MJ	6.06E-01	7.97E-01	1.44E+00		2.84E+00
Natural gas	MJ	1.07E+02	1.85E-01	3.35E-01		1.07E+02
Uranium	MJ	2.42E+01	3.19E+01	5.76E+01		1.14E+02
Hydropower	MJ	7.08E+00	9.36E+00	1.69E+01	2.88E+01	6.21E+01
SO_2	g	3.67E+01	7.40E-01	2.41E-01	1.43E+01	5.20E+01
NO_x	g	6.12E+01	1.15E+01	3.31E-01	4.56E+01	1.19E+02
CO_2	g	1.04E+04	1.34E+03	1.37E+02	2.25E+04	3.44E+04
VOC	g	1.20E+01	8.36E-01	3.96E-02		1.29E+01
Dust	g	4.86E-01	4.49E-01	2.52E-03	2.85E+00	3.79E+00
N_2O	g	6.36E-03	3.39E-02	1.15E-02		5.18E-02
CH_4	g	2.12E-03	3.59E-03	5.04E-03		1.07E-02
CO	g	6.66E+00	1.40E+00	7.56E-02	3.71E+00	1.18E+01
HC	g	1.85E+00				1.85E+00
HC (aq)	g	1.20E-01				1.20E-01
BOD (aq)	g	1.14E+00				1.14E+00
COD (aq)	g	2.06E+01	1.92E-02			2.07E+01
P (aq)	g	1.20E-01				1.20E-01
N (aq)	g	3.02E-01	3.03E-03			3.05E-01
Environmentally hazardous waste	g	1.58E+01				1.58E+01
Radioactive discharge	manSv	1.51E-09	1.99E-09	3.60E-09		7.10E-09
Ashes	g	1.06E+00	1.39E+00	2.52E+00		4.97E+00
Radioactive waste:						
Highly active	cm^3	2.12E-02	2.79E-02	5.04E-02		9.95E-02
Medium and low active	cm^3	2.27E-01	2.99E-01	5.40E-01		1.07E+00
Demolition waste	cm^3	2.27E-01	2.99E-01	5.40E-01		1.07E+00
Oil (aq)	g	3.92E-03				3.92E-03
Phenol (aq)	g	5.58E-03				5.58E-03

1) Only given as additional information. Data for electric power production are included in the resource and emission figures.

4.2.39 Production of cold mixed asphalt

In the production of cold mixed asphalt, bitumen is emulsified in an emulsifier to become an emulsion consisting of 65 % bitumen and 35 % water. The asphalt is thereafter manufactured in an asphalt plant for cold mixing which is usually located in different geographical location from the emulsifier. An asphalt plant for cold mixing is normally mobile and can be placed near the road construction site. In the asphalt plant, an asphalt which consists of 6 % bitumen emulsion and 94 % crushed aggregates, is produced. In table 4.2.39.1 the material and energy consumption for the finished product is shown. This is after it has been laid on the road and after the water in the emulsion has evaporated. Table 4.2.39.2 shows corresponding inventory analysis data both for the sub-components in the production and for totals.

Table 4.2.39.1 Material and energy consumption for paving compound from cold rolled asphalt plant. Data from the Swedish National Road Administration.

Material	Consumption	Unit
Bitumen	0.04	ton/ton asphalt
Crushed aggregates	0.96	ton/ton asphalt
Electrical energy for the mill	1.27	MJ/ton asphalt
Heating oil for heating at the mill	5.81	MJ/ton asphalt
Diesel for the cold rolled asphalt plant, mobile with diesel generated electricity	21.1	MJ/ton asphalt

Table 4.2.39.2 Inventory analysis data for asphalt from cold mixed asphalt plants, divided into components and total. Transportation of material is not included except for those transports included in bitumen and crushed aggregates production.

In or outflow	Unit	Bitumen per tonne asphalt	Crushed aggregates per tonne asphalt	Electrical energy, the mill, per tonne asphalt	Heating energy, the mill, per tonne asphalt	Electricity generation (diesel) to mobile cold mixed asphalt plant per tonne asphalt	Asphalt, cold mixed, total per tonne produced asphalt
Bitumen	g	4.00E+04					4.00E+04
Rock	g		9.60E+05				9.60E+05
Heating oil, diesel	MJ	4.24E+01	1.92E+01	8.13E-02	5.81E+00	2.32E+01	9.07E+01
Electricity	MJ	1.01E+01	2.03E+01	1.27E+00			3.17E+01
Biomass fuel	MJ	4.52E-01	9.15E-01	5.72E-02			1.42E+00
Peat	MJ	4.52E-02	9.15E-02	5.72E-03			1.42E-01
Coal	MJ	4.04E-01	8.14E-01	5.08E-02			1.27E+00
Natural gas	MJ	7.12E+01	1.89E-01	1.18E-02			7.14E+01
Uranium	MJ	1.61E+01	3.25E+01	2.03E+00			5.07E+01
Hydropower	MJ	4.72E+00	9.56E+00	5.97E-01			1.49E+01
SO_2	g	2.45E+01	7.56E-01	8.51E-03	2.91E-01	8.02E-01	2.63E+01
NO_x	g	4.08E+01	1.18E+01	1.17E-02	9.30E-01	1.51E+01	6.86E+01
CO_2	g	6.92E+03	1.37E+03	4.83E+00	4.59E+02	1.67E+03	1.04E+04
VOC	g	8.01E+00	8.54E-01	1.40E-03			8.87E+00
Dust	g	3.24E-01	4.58E-01	8.89E-05	5.81E-02	6.01E-01	1.44E+00
N_2O	g	4.24E-03	3.48E-02	5.33E-04		3.38E-02	7.33E-02
CH_4	g	1.41E-03	3.66E-03	1.78E-04		1.06E-03	6.31E-03
CO	g	4.44E+00	1.43E+00	2.67E-03	7.55E-02	1.80E+00	7.75E+00
HC	g	1.23E+00				1.08E+00	2.31E+00
HC (aq)	g	8.00E-02					8.00E-02
BOD (aq)	g	7.60E-01					7.60E-01
COD (aq)	g	1.38E+01	1.96E-02			2.53E-02	1.38E+01
P (aq)	g	8.00E-02					8.00E-02
N (aq)	g	2.01E-01	3.10E-03			4.01E-03	2.08E-01
Environmentally hazardous waste	g	1.05E+01					1.05E+01
Radioactive discharge	manSv	1.01E-09	2.03E-09	1.27E-10			3.17E-09
Ashes	g	7.04E-01	1.42E+00	8.89E-02			2.21E+00
Radioactive waste:							0.00E+00
Highly active	cm^3	1.41E-02	2.85E-02	1.78E-03			4.44E-02
Medium and low active	cm^3	1.51E-01	3.05E-01	1.91E-02			4.75E-01
Demolition waste	cm^3	1.51E-01	3.05E-01	1.91E-02			4.75E-01
Oil (aq)	g	2.61E-03	6.52E-03			8.44E-03	1.76E-02
Phenol (aq)	g	3.72E-03	9.30E-03			1.20E-02	2.50E-02

4.2.40 Cement stabilisation of base course in concrete road construction

In the cement stabilisation of a base course a layer of concrete is laid as base course. The layer can be 150 mm thick. The amount of cement used is around 125 kg/m^3 stabilisation layer. The stabilisation layer is applied using a diesel driven slip form

layer of a smaller model. The diesel consumption of this element has been estimated at 0.034 litre/m^2 laid concrete road. Table 4.2.40.1 shows the results of the inventory analysis for the operation of the slip form layer including the production of diesel fuel. The manufacturing of the machine itself has not been included in the analysis. The consumption of materials that are part of the stabilisation layer is not included in the data below, but has been treated separately.

Table 4.2.40.1 Cement stabilisation of base course in concrete road construction excluding the consumption of cement, Data from laying machine [1)].

In or outflow	**Unit**	**Cement stabilisation of base course per m^2 road**
Diesel oil	MJ	1.32E+00
CO_2	g	9.48E+01
SO_2	g	4.56E-02
NO_x	g	8.57E-01
Dust	g	3.42E-02
CO	g	1.02E-01
N_2O	g	1.92E-03
HC	g	6.17E-02
CH_4	g	6.00E-05
Oil (aq)	g	4.80E-04
Phenol (aq)	g	6.84E-04
COD (aq)	g	1.44E-03
Tot-N (aq)	g	2.28E-04

1) Data from Skanska.

4.2.41 Laying of concrete wearing course in concrete road construction

In placing of concrete for concrete roads, a slip form paver that covers the whole width of the road in one go is used. Normally two carriageways are covered at the same time, a standard total width of these is 9m. Reinforcement bars (or dowels) for the joints are also placed in concrete. This is usually carried out by placing a longitudinal joint in the centre of the road and transverse joints along the road, 5 meters apart. In the centre joint, dowel bars are placed at a distance of around 1000 mm from each other. For the transverse joints, the dowel bars are placed at a distance of 250 mm in the slow moving lane and 500 mm for the fast moving lane. Data in this study is based on these road measurements. In the inventory analysis of the concreting process, data has been included for the energy consumption of the slip form paver and the consumption of steel for the reinforcement of joints. The consumption of diesel oil for the slip form paver has been calculated to be 0.1117 litre/m^2 laid concrete road. Corresponding consumption of reinforcement bars has been calculated to be 1.288 kg/m^2 laid concrete road. The result from the inventory analysis is shown in table 4.2.41.1.

Table 4.2.41.1 Laying of concrete wearing course in concrete road construction, including operation of the slip form paver and the consumption of steel for the reinforcement bars. The concrete consumption is treated separately and is not included in the data below [1)].

In or outflow	Unit	Operation of the slip form paver per m^2 concrete road [2)]	Steel production for reinforcement bars per m^2 concrete road	Concrete road laying (wearing course) total per m^2 concrete road
Iron from deposit	g		1.29E+03	1.29E+03
Heating oil, diesel	MJ	4.53E+00	4.64E+00	9.17E+00
Coal	MJ		1.97E+01	1.97E+01
Natural gas	MJ		2.29E+00	2.29E+00
(Electricity)	MJ		5.98E+00	5.98E+00
SO_2	g	1.57E-01	9.45E+00	9.61E+00
NO_x	g	2.94E+00	6.26E+00	9.20E+00
CO_2	g	3.26E+02	2.93E+03	3.16E+03
CO	g	3.51E-01	1.29E+00	1.64E+00
NMVOC	g	2.12E-01	1.55E+00	1.76E+00
PAH	g		4.30E-05	4.30E-05
H_2S	g		2.50E-02	2.50E-02
Particles	g	1.17E-01	5.05E+01	5.06E+01
N_2O	g	6.59E-03	3.86E-02	4.52E-02
CH_4	g	2.06E-04	1.17E+01	1.17E+01
COD (aq)	g	4.95E-03	1.20E-02	1.69E-02
Tot-N	g	7.83E-04	9.26E-03	1.04E-02
Oil (aq)	g	1.65E-03		1.65E-03
Phenol (aq)	g	2.35E-03		2.35E-03

1) Data from Hochtief Betongstrassenbau and Skanska.
2) Data include diesel consumption in operation and production of the corresponding diesel oil.

4.2.42 Exposure of aggregate on concrete carriageway

In order to improve the structure of the surface of the carriageway, the aggregate in the concrete is exposed after the concreting has taken place. This is done through a process where an admixture known as a retarder, consisting of water and sugar/cellulose compounds, is placed on the newly concreted surface. This solution stops the cement from burning into the surface layer. To prevent evaporation on the concrete surface, the surface is covered in polyethylene film. After the concrete has cured, the road surface is swept to the desired surface structure. In the inventory analysis of this process, the consumption of fuel for machine equipment (diesel driven) and the consumption of polyethylene film for covering the surface, have been taken into account. The consumption of retarder is around 400 g/m^2. The contribution from this part of the process has not been possible to analyse. However, the contribution can be assumed to be relatively small. Material, energy and inventory analysis data are presented in table 4.2.42.1 and 4.2.42.2.

Table 4.2.42.1 Material and energy consumption in exposure of aggregate on concrete carriageway [1)].

Material	Consumption	Unit
Diesel	0.0159	litre/m^2 concrete road
Energy (diesel)	0.559	MJ/m^2 concrete road
Polyethylene film	0.476	kg/m^2 concrete road

1) Data from Skanska and Robuco, Belgium.

Table 4.2.42.2 Inventory analysis data for the exposure of aggregate on concrete carriageway. Data includes the consumption of polyethylene film, as well as energy consumption for the machine equipment.

In or outflow	Unit	Polyethylene plastic consumption per m^2 concrete road	Operation of machine equipment for exposure per m^2 concrete road [1)]	Exposure of concrete carriageway, total, per m^2 concrete road
(Electrical energy)	MJ	3.76E-01		3.76E-01
(Oil, total)	MJ	1.68E+00	6.15E-01	2.30E+00
(Other fuels)	MJ	2.03E+00		2.03E+00
(Total energy consumption)	MJ	4.09E+00		4.09E+00
Fuels:				
Coal	MJ	1.31E-01		1.31E-01
Oil	MJ	1.46E-01	6.15E-01	7.16E-01
Natural gas	MJ	5.49E-01		5.49E-01
Hydropower	MJ	2.19E-02		2.19E-02
Nuclear power	MJ	7.28E-02		7.28E-02
Other	MJ	6.66E-03		6.66E-03
Raw materials:				
Coal	MJ	4.76E-04		4.76E-04
Oil	MJ	1.56E+00		1.56E+00
Natural gas	MJ	1.60E+00		1.60E+00
Wood	MJ	4.76E-04		4.76E-04
Iron ore	g	9.52E-03		9.52E-03
Limestone	g	7.14E-03		7.14E-03
Bauxite	g	1.43E-02		1.43E-02
Sodium chloride	g	3.33E-01		3.33E-01
Emissions:				
Clay	g	9.52E-04		9.52E-04
Particles	g	9.52E-02	1.59E-02	1.11E-01
CO	g	3.81E-02	4.76E-02	8.57E-02
CO_2	g	5.247E+01	4.42E+01	9.65E+01
SO_x	g	3.33E-01	2.12E-02	3.54E-01
NO_x	g	5.24E-01	3.99E-01	9.23E-01
N_2O	g		8.94E-04	8.94E-04
HC	g	1.00E+00	2.87E-02	1.03E+00
CH_4	g		2.80E-05	2.80E-05
COD	g	4.76E-02	6.71E-04	4.83E-02
BOD	g	7.14E-03		7.14E-03
Chloride ions (aq)	g	5.71E-03		5.71E-03
Oil (aq)	g	4.76E-03	2.24E-04	4.98E-03
Phenol (aq)	g	4.76E-05	3.19E-04	3.66E-04
Phosphates (aq)	g	2.38E-04		
Tot-N (aq)	g	9.52E-04	1.06E-04	1.06E-03
Industrial waste	g	1.48E-01		1.48E-01
Mineral waste	g	1.05E+00		1.05E+00
Slag and ashes	g	3.33E-01		3.33E-01

1) Data include diesel consumption in operation and production of the corresponding diesel oil.

4.2.43 Sawing and sealing of joints in concrete road construction

To control the formation of cracks, a crevice is sawn in the carriageway, where the reinforcement bars were placed. The crack initiator forms a crack and thereby also a natural expansion joint, which prevents crack formation in other parts of the carriageway. The sawed joint is sealed with a rubber strip or with sealant. Diesel driven equipment are used for both sawing and sealing work. Normally, two lanes are concreted at the same time to a total width of 9 m. Sealing is usually carried out by placing a longitudinal joint in the centre of the road and transverse joints along the road, 5 meters apart. Data in this study is based on these road measurements. In the inventory analysis, data has been included for the energy consumption of the machine equipment and the consumption of sealing material for the joints. Material, energy and inventory analysis data are shown in table 4.2.43.1 and 4.2.43.2.

Table 4.2.43.1 Material and energy consumption for sealing work in concrete road construction. Data from Skanska.

Material	Consumption	Unit
Diesel	0.141	litre/m^2 concrete road
Energy (diesel)	0.494	MJ/m^2 concrete road
EPDM-rubber	0.0747	kg/m^2 concrete road

Table 4.2.43.2 Inventory analysis data for sealing work on concrete carriageway. Data includes consumption of EPDM rubber for the sealing of joints and energy consumption for the machine equipment.

In or outflow	Unit	Sealing material (EPDM) per m^2 concrete road	Operation of machines in sealing per m^2 concrete road [1)]	Sealing work total, per m^2 concrete road
Heating oil, diesel	MJ	1.57E+00	5.43E-01	2.11E+00
Coal	MJ	4.18E-01		4.18E-01
(Electricity)	MJ	3.74E-01		3.74E-01
SO_2	g	4.26E-01	1.88E-02	4.45E-01
NO_x	g	2.99E-1	3.53E-01	6.52E-01
CO_2	g	1.74E+02	3.90E+01	2.13E+02
NMVOC	g	1.42E+00	2.54E-02	1.44E+00
PAH	g	2.24E-06		2.24E-06
Particles	g	1.57E-01	1.41E-02	1.71E-01
N_2O	g	3.74E-03	7.90E-04	4.53E-03
CH_4	g	2.61E-01	2.47E-05	2.61E-01
CO	g	5.98E-02	4.21E-02	1.02E-01
COD (aq)	g	1.49E+00	5.93E-04	1.49E+00
Tot-N	g	2.99E-03	9.39E-05	3.08E-03
Oil (aq)	g		1.98E-04	1.98E-04
Phenol (aq)	g		2.82E-04	2.82E-04

1) Data include diesel consumption in operation and production of the corresponding diesel oil.

4.2.44 Laying of road markings

Road markings – white lines on the carriageway – comprise of either a thermoplastic material or solution-based material. Currently, thermoplastic materials are predominantly used, which is why only this option has been analysed. The thermoplastic material is produced from a large number of different substances. Because of its complex composition, it has not been possible to analyse the production of the thermoplastic material. The analysis in this study is totally based on the emissions and the energy consumption that are connected to the laying of the compound and the corresponding consumption for the production of diesel. These are divided into two components; operation of diesel driven vehicles (maintenance vehicles) and heating of the thermoplastic material using a diesel burner. The analysis below, tables 4.2.44.1 and 4.2.44.2, shows both these components separately and together.

Table 4.2.44.1 Fuel consumption for operation of diesel driven vehicles and operation of the diesel burner for heating of the thermoplastic material. Roughly estimated average values including transportation to the construction site, which is normally a relatively large part of the total fuel consumption.

Material	**Consumption**	**Unit**
Diesel consumption, diesel heater	8	litre/km marked road
Diesel consumption, diesel engine	17	litre/km marked road
Energy consumption, diesel heater	280.8	MJ/km marked road
Energy consumption, diesel engine	596.7	MJ/km marked road

Table 4.2.44.2 Inventory analysis data for road markings using thermoplastic material. Only the operation of equipment is included in the analysis, the production of the thermoplastic material has not been included.

In or outflow	Unit	Operation of diesel engine per km marked road	Operation of diesel burner per km marked road [1)]	Road markings, total, per km marked road
Diesel oil	MJ	6.56E+02	3.09E+02	9.65E+02
CO_2	g	4.71E+04	2.22E+04	6.93E+04
SO_2	g	2.27E+01	1.07E+01	3.33E+01
NO_x	g	4.26E+02	5.73E+01	4.83E+02
Dust	g	1.70E+01	5.75E+00	2.27E+01
CO	g	5.08E+01	1.41E+01	6.49E+01
N_2O	g	9.55E-01		9.55E-01
HC	g	3.07E+01	5.17E+00	3.58E+01
CH_4	g	2.98E-02		2.98E-02
Oil (aq)	g	2.39E-01	1.12E-01	3.15E-01
Phenol (aq)	g	3.40E-01	1.60E-01	5.00E-01
COD	g	7.06E-01	3.37E-01	1.05E+00
Tot-N (aq)	g	1.13E-01	5.34E-02	1.67E-01

4.2.45 Surface milling of concrete and asphalt paving

Surface milling (or planing) of road paving takes place in order to even out irregularities in the road surface due to uneven wear, and in order to reduce the thickness of the surface paving. Surface milling can also be done in connection with recycling methods of asphalt paving. Two different base milling methods exist for concrete surfaces. In the construction of a road, the thickness of the wearing course is increased, so that a total milling/flattening of the surface can be done without jeopardising the strength of the road. Another method involves milling of the areas where tracks by the wheels of vehicles has caused the most wear. The tracks from the milling are then re-filled with concrete. The energy consumption of the milling has been estimated based on machine data. For concrete milling with tracks of 12 mm depth, an energy consumption of 2.06 litre diesel/m^2 milled area or 72.1 MJ/m^2 milled area, can be assumed. Milling of asphalt paving has been estimated at 0.0044 litre diesel/m^2 milled area or 1.56 MJ/m^2 milled area. The differences in energy consumption between the two types of paving are surprisingly large. Inventory analysis data for both processes is presented in table 4.2.45.1.

Table 4.2.45.1 Inventory analysis data for surface milling of concrete and asphalt paving in re-surfacing of road. Capacity and energy consumption data from the National Road Administration and manufacturers.

In or outflow	Unit	Surface milling of concrete road, 12 mm milling depth, per m^2 milled area [1)]	Surface milling of asphalt road, per m^2 milled area [1)]
Diesel oil	MJ	7.95E+01	1.70E+00
CO_2	g	5.71E-03	1.22E-02
SO_2	g	2.75E+00	5.87E-02
NO_x	g	5.16E+01	1.10E+00
Dust	g	2.06E+00	4.40E-02
CO	g	6.16E+00	1.31E-01
N_2O	g	1.16E-01	2.47E-03
HC	g	3.72E+00	7.94E-02
CH_4	g	3.62E-03	7.72E-05
Oil (aq)	g	2.89E-02	6.18E-04
Phenol (aq)	g	4.12E-02	8.80E-04
COD	g	8.68E-02	1.85E-03
Tot-N (aq)	g	1.37E-02	2.93E-04

1) Data include diesel consumption in operation and production of the corresponding diesel oil.

4.2.46 Operation of the road – complementary activities

The operation of the road during its lifetime has in this study been calculated based on known activities such as sanding, salting, clearing etc. These activities, however, do not cover the whole spectrum of jobs that are performed during the lifetime of a road. Other activities that are sometimes needed are for example smaller repairs, various different maintenance activities, etc. Therefore it has been necessary to complete the model with another, additional, activity which represents and summarises these so-called complementary activities in the operation. There is no doubt that these activities exist, but it is very difficult to quantify them in terms of energy consumption and emissions. These complementary activities can, however, be assumed to be dominated by operation of vehicles and therefore some consumption of diesel. The difficulties in quantifying these activities have led to the size of the activities being input as a variable in the model and represent a percentage of the total vehicle operation of the operation. For example, if other relevant activities are assumed to be 10 % of the total vehicle operation, the corresponding energy consumption and emissions are added to the total load of the operation.

4.3 Model calculations

The calculated factors for each sub-component respectively are put together with quantitative input data for the system analysed, according to the model structure that has been produced. The model calculations have been done using Microsoft Excel in order to obtain maximum openness and transparency in the development work. Input data variables for the road object to be analysed and input data for production factors can easily be varied. Certain direct factors can also be easily altered. From the model calculations, results are shown from each activity respectively, but also summarised

into the categories of construction, operation and maintenance as well as being presented as a grand total for all activities. The results from a model simulation are presented in appendix 1.

5 Results and conclusions

5.1 Model objects and input data

The study is based on a developed Road Model. The computer model calculates the energy use, resource use and the emissions from the life cycle of a road. The model is written in Excel from Microsoft. The model is build up of different worksheets for different input and output of data. The data in the different worksheets are linked together in the calculation formulas for each cell. The main data flow in the model is shown in figure 5.1.1. Thus, if input values are changed, the entire model is recalculated and the new results are shown. There are three different types of data in the calculation worksheets (Road Model and Processes). These are:

- direct input values written in italic
- calculated data for the different processes written in normal style
- sum values written in bold

The sum values are shown above the corresponding process. In the Road Model worksheet there are also values showing the sum of initial construction of the road, the sum of maintenance during the studied time period, the sum of operation activities during the studied time period and the total sum of the entire system, all marked in bold blue.

Only direct input values, written in italic, and parameters in the pavement and process parameters worksheets can be changed. Other cells contain formulas and can not be changed without redesign of the model. However, the model can easily be redesigned with the Excel formulas to meet other production procedures or the use of other materials.

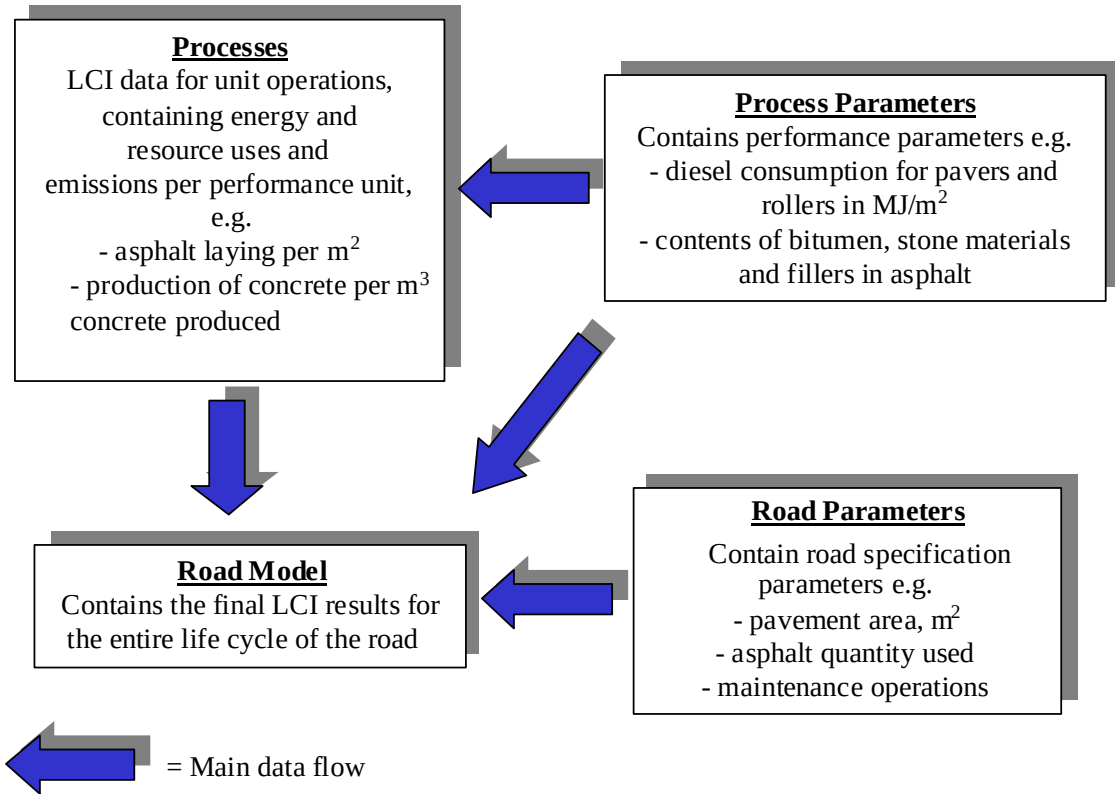


Figure 5.1.1. Main data flow in the LCI Road computer model.

The computer model gives the possibility to analyse and vary a number of different activities within a road system. The model simulation that has taken place within the framework of this study can be seen as an example of the existing possibilities of analysis. A central technical question is the decision regarding which type of paving to use on the road. The question is complex both from a technical and economic point of view and has been the subject of previous investigations. The direct environmental and energy aspects have, however, not been analysed from a life cycle assessment perspective. For the present model simulation, therefore, we have chosen to analyse three different surface materials; asphalt road using hot mixed method, asphalt road using cold mixed method and a concrete road.

A significant part of the activities that are present during road services is made up of processes using different types of diesel driven vehicles. The choice of engine type, emission factors, etc. can affect the final result to a great extent. Two different types of engines have therefore been investigated. These represent the so-called low emission diesel engine out of the 1994 model programme, and a standard engine representing today's (year 1994) machinery and maintenance vehicles. Emission factors for today's standard vehicles/maintenance machines have been assumed to give a double emission of NO_x, SO_2, CO, dust and hydrocarbons. For the SO_2 emission, the sulphur content in the fuel is the deciding parameter, which is why an increased part low sulphur containing fuel has been assumed in the operation of the low emission engines, representing a halving of the sulphur emission.

The choice of input data to the model is an important component in the model work. When analysing the results it is important to notice that all road sites are unique even if the processes are similar. Thus, the model results are only valid for this particular road defined in the model. However, for road sites with similar conditions more general conclusion can be drawn from the information but the conclusions should be handled with great care. A few general assumptions regarding length of life times for different process alternatives must be made. The choice of length of the studied period can also be vital and in this case a time period of 40 years has been chosen for the study. The section of road concerned is 1 km long. The total width of the road is 13 m. One part of the road has been assumed to be in a cutting, which means it has an excavation volume of 100000 m^3. A sub-base of a thickness of 1 m and a base course of the thickness 0.5 m has also been assumed. The road has been assumed to be lit and to have certain traffic regulations. In the choice of input data there has been a desire to keep the parameters as similar as possible between the different alternatives. All input data parameters are shown in the printed results in appendix.

In the choice of final functional unit for the analysis of the roadwork, it has emerged that a section of the road itself (Road object) is the simplest and the most representative functional unit. A further analysis can show the more complex application of the transportation work as functional unit. The choice of amount of transportation work is very sensitive and will make a big impact on the total analysis. The total life cycle relationships between the transportation work and maintenance intervals, construction techniques, etc. have not been fully investigated.

5.2 Results and conclusions

The total results of the model simulations for the three studied alternative paving materials are shown in full in the printed results in appendix 1. The results here are based on vehicles and maintenance vehicles with low emission engines. Furthermore, model simulations have been run on two different engine alternatives for vehicles and maintenance vehicles: low emission engines and today's standard vehicles with a conventional diesel engine. The results of these model simulations can be found in the summary table in appendix 1.

An overview of the total energy consumption divided between construction, operation and maintenance from a life cycle assessment perspective, is shown in figure 5.2.1. In addition, the inherent energy bonded in the asphalt layer is also shown in the same figure. The inherent energy is however not a direct energy use due to the fact that the bitumen material is not combusted and the energy is thus not released. The inherent energy use can be treated as a resource use of bitumen. The figure shows the situation without asphalt recycling. An asphalt recycling process can reduce the resource use of bitumen.

The total energy consumption in construction, operation and maintenance for a 1 km long road during a period of 40 years of operation has been calculated as around 23 TJ for asphalt surface, and around 27 TJ for a concrete surface. The energy differences are very small between the cold and the hot methods for asphalt. The operation of the road makes up a large part of the total energy consumption. The energy consumption

of the operation in the model mainly comes from the consumption of electrical energy for street lighting and traffic lights. An equal intensity of illumination has been assumed for asphalt roads and concrete roads. A brighter road surface can however require less illumination intensity and thus a reduced use of electric power. This electrical energy makes up around 12 TJ in this case, i.e. almost the whole energy consumption of the operation component. The differences in energy consumption for the different engine alternatives are small and have not been taken into account in the model, which is why no energy differences exist between the different engine alternatives in the model calculations.

The distribution between different sources of energy for the system in operation using low emission engines is shown in figure 5.2.2. The most prominent energy sources are oil, coal, uranium and hydropower. The consumption of uranium and hydropower can be linked to the production of electrical energy for primarily lighting and traffic regulation. The consumption of biomass fuel and peat can also be related to the Swedish average electricity production. The consumption of oil is relatively similar for the different paving alternatives. The consumption of coal, however, is significantly higher for the concrete road than for the asphalt alternatives. This is connected with the fact that the production of asphalt is oil based, whereas the production of cement is coal based, as the cement kilns are driven by coal powder. Almost the whole difference in total energy consumption (4 TJ) between asphalt paving and concrete paving can be related to road concrete (cement) for around 3 TJ of coal. The main part of the coal consumption can be related to the operation of the cement kilns in the production of cement.

A rough estimate of the energy consumption for traffic on the section of road during a corresponding 40-year period, shows a total consumption of 229.2 TJ with the assumption of 5000 cars/24hours and with a total energy consumption including pre-combustion addition of 0.1 litre petrol/km and vehicle. In table 5.2.1 the calculations of the contribution of the road to energy consumption, in relation to the energy consumption of the traffic, is presented. A vehicle intensity of 5000 cars/24 hours has been assumed and calculations have been done both with and without the electricity consumption for lighting and traffic regulation as these elements make up a significant part of the total energy consumption. Most Swedish rural roads are not lit and lack this energy consumption.

Table 5.2.1 The energy use of the road as a percentage of the energy used from traffic with a traffic intensity of 5000 vehicles/day with and without road lights and traffic control.

Road type	**The energy use of the road compared to the energy use of the traffic with a traffic intensity of 5000 vehicles/day and <u>with</u> road lights and traffic control. (%)**	**The energy use of the road compared to the energy use of the traffic with a traffic intensity of 5000 vehicles/day and <u>without</u> road lights and traffic control. (%)**
Asphalt road, hot method	10.1	4.9
Asphalt road, cold method	9.9	4.7
Concrete road	11.8	6.6

The emissions of NO_x, SO_2 and CO_2 for the system divided between construction, operation and maintenance are shown in figures 5.2.3 - 5.2.5. The calculations of the emissions for the different engine alternatives; low emission engine and today's conventional engine respectively is based on the assumption that the NO_x emission increases by a factor of 2 for today's standard engine compared to a low emission engine. The SO_2 emission has also been assumed to increase by a factor of 2 even if this increase is more related to a decrease in the sulphur content in the types of fuel used, than changes in the construction of the engine. The CO_2 emission has been assumed to be constant for both engine alternatives because of the unchanged energy consumption. Figure 5.2.5. shows the situation without the slow long-term processes such as uptake of CO_2 in concrete (carbonation, see chapter 4.2.15 to 4.2.17) and in-air oxidation of bitumen. These processes are very slow and can occur during several hundreds or thousands of years usually as waste processes and have not been covered in the study. If these processes are included the CO_2 emission from concrete roads can be reduced and the CO_2 emission from asphalt roads can be increased.

Regarding the emissions of NO_x, SO_2 and CO_2, these are dominated by the emissions from the construction of the road. This is perhaps most relevant for the emission of CO_2. The maintenance of the road constitutes one of the largest sources of emissions and for the NO_x emission, it constitutes a significant part. The operation of the road stands for only a small part of the emissions. This is because electricity production in Sweden mainly us hydro and nuclear energy, which have low emission levels of the traditional substances.

In connection with the analysis of the results it should be pointed out that the conditions are very complex and that this study only reflects one type of case, namely those which are described by the input data that has been used. The analysis is also a first application of a complex model which should be regarded as a first research model of the conditions which are present in a road system seen from a life cycle assessment perspective.

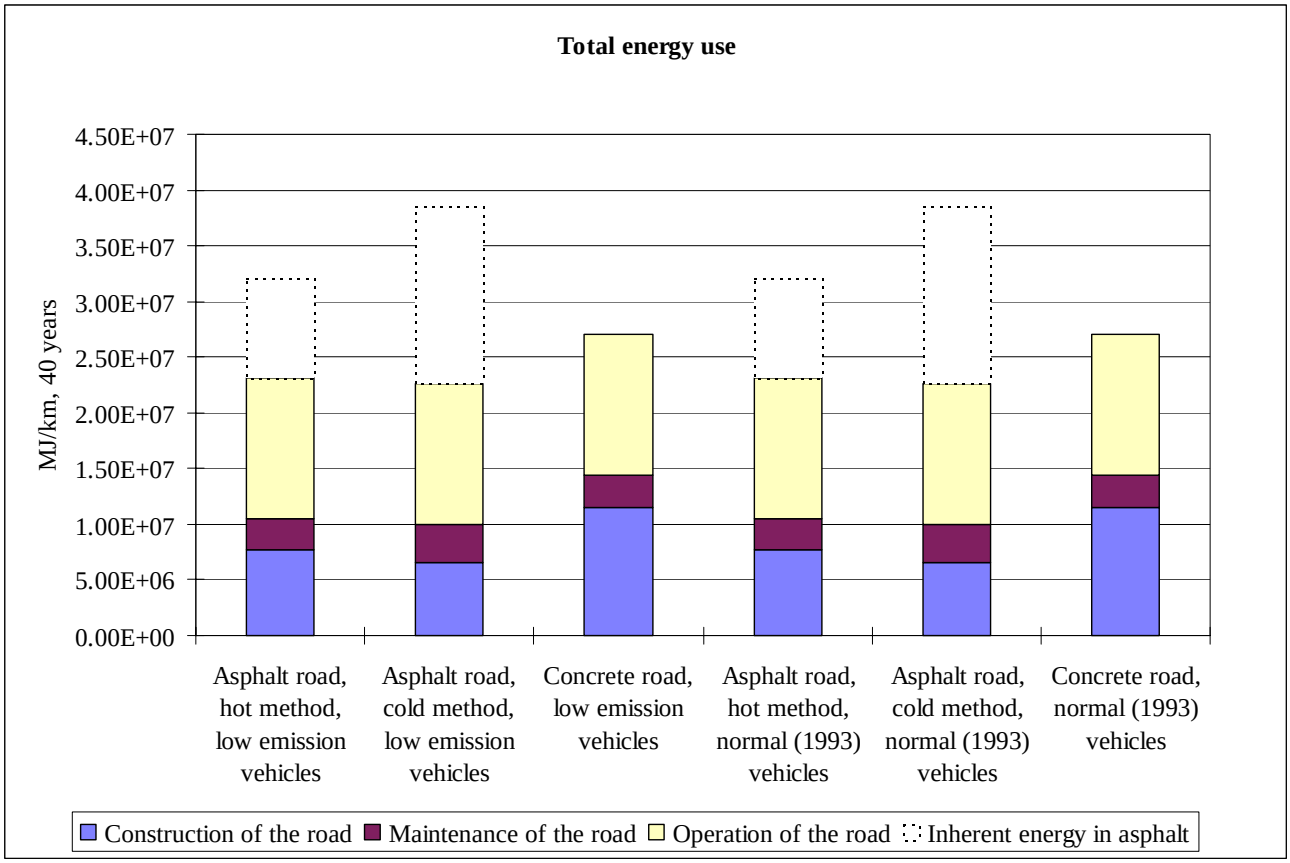


Figure 5.2.1 Total energy consumed for three different road surface materials and two different engine alternatives for construction vehicles divided into road construction, road maintenance and road operation for a 1 km long road during 40 years of operation. Dotted lines show inherent energy bonded in the road materials but not released as energy. Of the energy used for operation, approximately 12 TJ is consumed by road lights and traffic control.

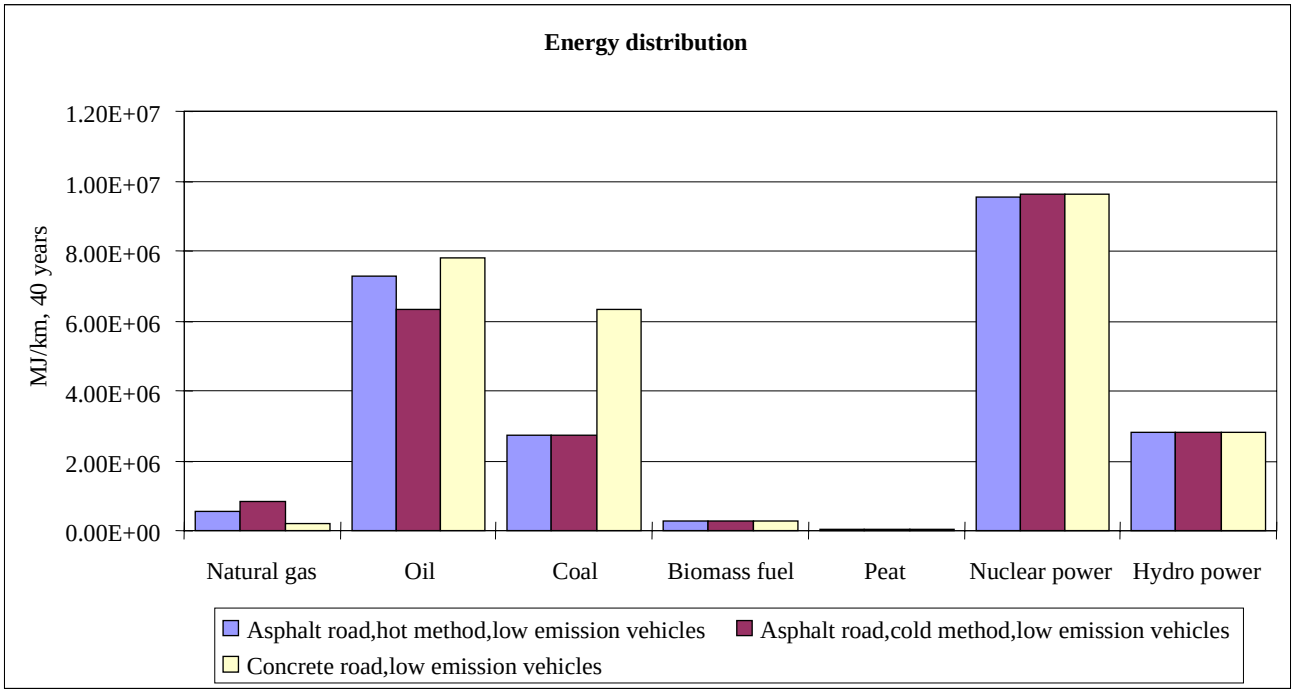


Figure 5.2.2 Total energy distribution for three different paving alternatives using vehicles/maintenance machines with low emission engines for 1 km road during 40 years of operation. Inherent energy is not shown.

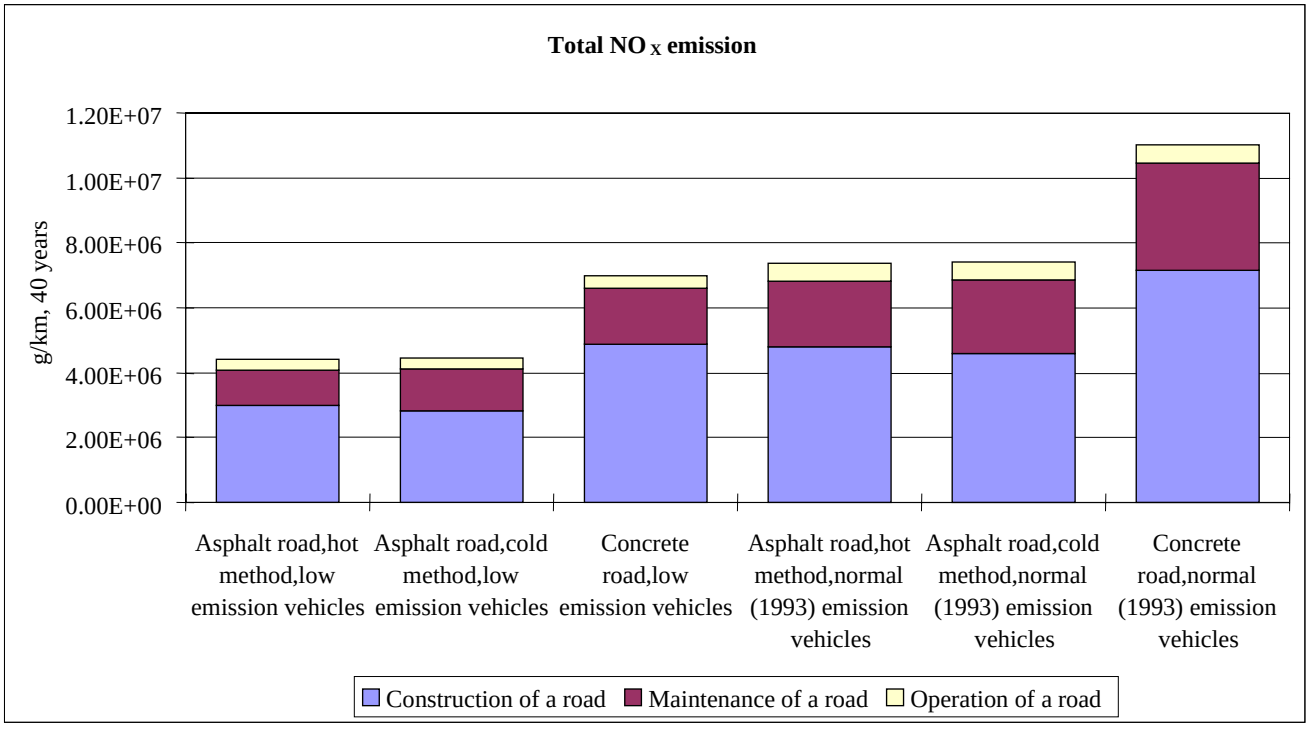


Figure 5.2.3 Total NO_X emission for three different road surface materials and two different engine alternatives for construction vehicles divided into road construction, road maintenance and road operation for a 1 km long road during 40 years of operation.

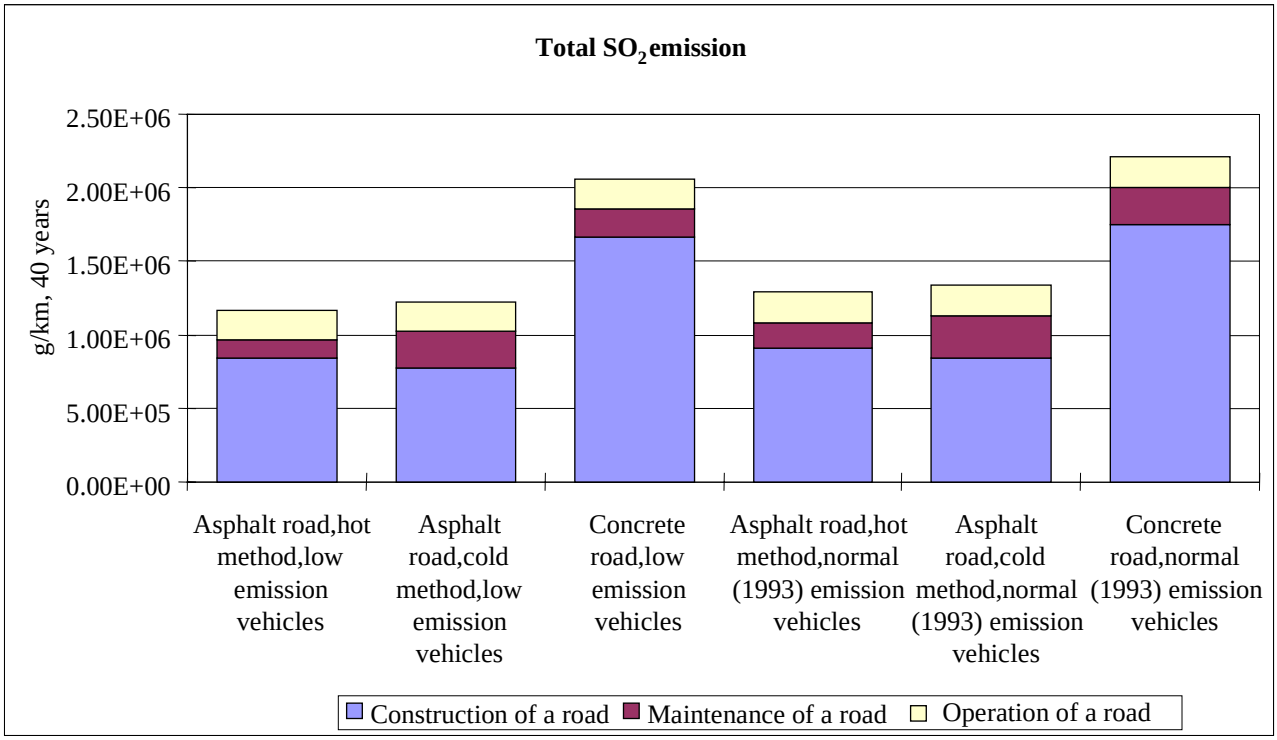


Figure 5.2.4 Total SO_2 emission for three different road surface materials and two different engine alternatives for construction vehicles divided into road construction, road maintenance and road operation for a 1 km long road during 40 years of operation.

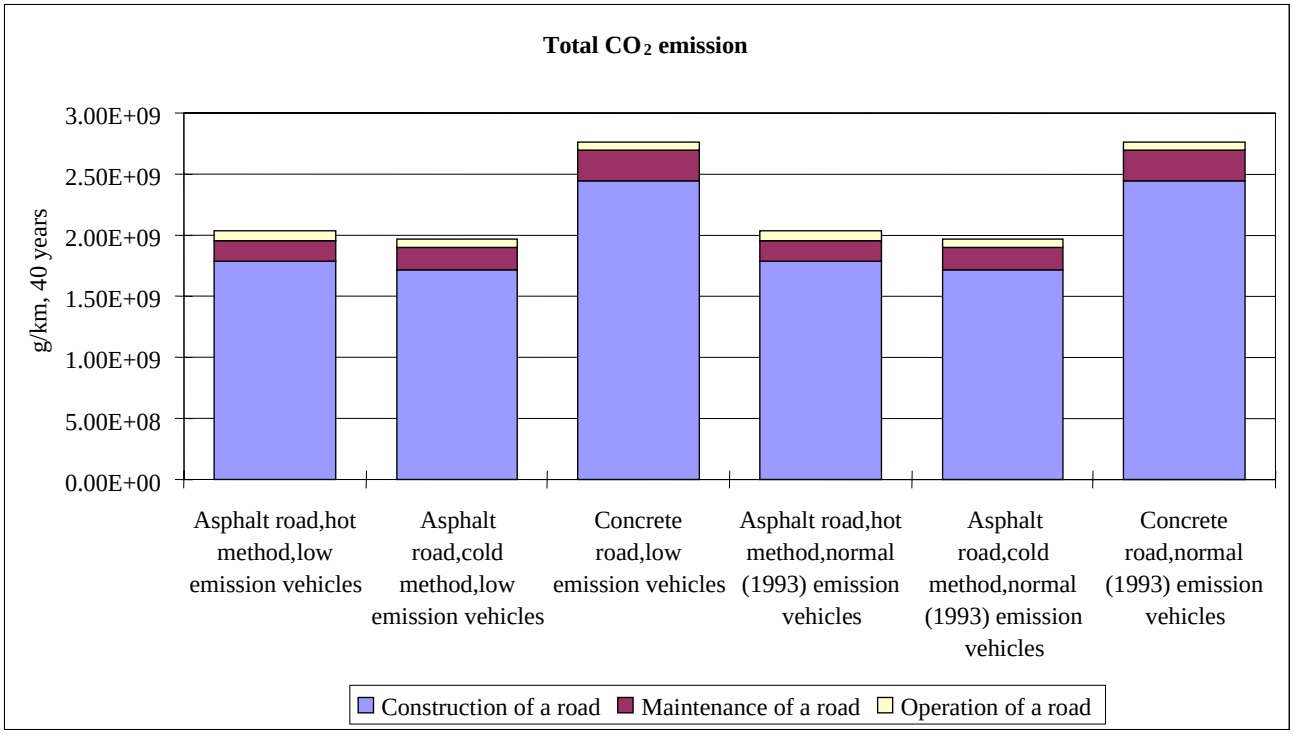


Figure 5.2.5 Total CO_2 emission for three different road surface materials and two different engine alternatives for construction vehicles divided into road construction, road maintenance and road operation for a 1 km long road during 40 years of operation. The figure shows the situation without the slow long term processes such as uptake of CO_2 in concrete and in-air oxidation of bitumen.

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VME, Volvo BM, Lastarhandbok, Volvo BM Hjullastare

Appendix

Scenario Specifications and Results from Model Simulations

	A	B	C	D	E	F	G	H	I	J	K
1			**Material/Energy resources**								
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**	**Hydro power**	**Bitumen**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**g**
4											
5	***Production of electric power, Swedish average***	***MJ electricity***	***1.00E+00***	***9.30E-03***	***6.40E-02***	***4.00E-02***	***4.50E-02***	***4.50E-03***	***1.60E+00***	***4.70E-01***	
6											
7	***Production of (Precombustion) diesel and fuel oil***	***MJ crude oil to production***			***1.00E-01***						
8											
9	***Distribution truck (14 tonne load)***	***MJ used diesel***			***1.00E+00***						
10											
11	***Long distance truck (32 tonne load)***	***MJ used diesel***			***1.00E+00***						
12											
13	***Production of quicklime (CaO)***	***kg CaO***	***1.44E-01***	***1.30E-03***	***8.90E-01***	***7.90E+00***	***6.00E-03***	***6.00E-04***	***2.30E-01***	***6.80E-02***	
14											
15	***Production of polyeten plastic***	***kg polyethen plastic***	***7.89E+00***	***4.51E+01***	***3.58E+01***	***2.76E+00***					
16											
17	***Production of rock salt (coal based)***	***tonne salt***				***1.48E+03***					
18											
19	***Production of EPDM-rubber***	***kg EPDM***	***5.00E+00***		***2.10E+01***	***5.60E+00***					
20											
21	***Aluminium production***	***kg Aluminium***	***2.53E+01***	***1.80E+00***	***9.60E+00***						
22											
23	***Production of steel***	***kg steel***	***4.64E+00***	***1.78E+00***	***3.60E+00***	***1.53E+01***					
24											
25	***Production of zink for galvanization***	***kg zinc***	***1.61E+01***	***6.14E+00***	***6.40E+00***	***9.60E-01***					
26											
27	***Combustion of fuel oil with fuel oil burner***	***MJ used fuel oil***			***1.00E+00***						
28											
29											
30	**Truck transport, distribution truck outside urban area (14 tonne load), full load, empty on return**	**vkm**			**1.31E+01**						
31	Distribution truck (14 tonne load)	vkm			1.19E+01						
32	Production of diesel	vkm			1.19E+00						
33											
34	**Truck transport, long distance truck, rural roads (32 tonne load), full load, empty on return**	**vkm**			**1.47E+01**						
35	Long distance truck (32 tonne load)	vkm			1.33E+01						
36	Production of diesel	vkm			1.33E+00						
37											
38	**Ship transport, coast freight**	**tonne,km**			**1.43E-01**						
39	*Ship transport, operation of the ship(engine data)*	*tonne,km*			*1.30E-01*						
40	Production of diesel	tonne,km			1.30E-02						
41											
42	**General road construction equipment (excavators, wheel loader etc.), diesel driven**	**MJ used diesel**			**1.10E+00**						
43	*Equipment in operation, diesel driven (engine data)*	MJ used diesel			*1.00E+00*						
44	Production of diesel	MJ used diesel			1.00E-01						
45											
46	**Wheel loader in truck loading operation, depends on excavation class**	**fixed m3 loaded material**			**3.30E+00**						
47											
48	**Excavator in truck loading operation, depends on excavation class**	**fixed m3 loaded material**			**3.65E+00**						
49											
50	**Dumper truck transport, depends on driving conditions at driving site**	**loose m3, km**			**7.45E+00**						
51											
52	**Compacting (ground, base course etc.) with roller, for one layer**	**m2 compacted surface**			**6.91E-01**						
53											
54	**Asphalt rolling, for one layer**	**m2 asphalt surface**			**8.79E-01**						
55											
56	**Asphalt paving, for one layer of asphalt**	**m2 asphalt surface**			**6.53E-01**						

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I	J	K
1			**Material/Energy resources**								
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**	**Hydro power**	**Bitumen**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**g**
57											
58	**Production of bitumen**	**tonne bitumen**	**4.14E+02**	**1.78E+03**	**1.06E+03**	**1.01E+01**	**1.13E+01**	**1.13E+00**	**4.03E+02**	**1.18E+02**	**1.00E+06**
59	*Crude oil extraction in Venezuela, Laguna*	*tonne bitumen*		*1.78E+03*							
60	*Bitumen production, refining from local store excluding electric power generation*	*tonne bitumen*			*5.73E+02*						*1.00E+06*
61	*Transport of crude oil to refinery*	*tonne bitumen*			*2.87E+02*						
62	Production of electric power to refinery	tonne bitumen	9.00E+01	8.37E-01	5.76E+00	3.60E+00	4.05E+00	4.05E-01	1.44E+02	4.23E+01	
63	*Transport (ship) of bitumen from raffinery to local store excluding precombustion*	*tonne bitumen*			*1.45E+02*						
64	Precombustion for diesel to ship transport from refinary to local store	tonne bitumen			1.45E+01						
65	*Store of bitumen at local store including precombustion but excluding electric power production*	*tonne bitumen*	*1.62E+02*		*1.98E+01*						
66	Production of electric power for local bitumen store	tonne bitumen	1.62E+02	1.51E+00	1.04E+01	6.48E+00	7.29E+00	7.29E-01	2.59E+02	7.61E+01	
67											
68	**Application of adhesion layer (emulsion)**	**m2 applied surface**	**2.07E-02**	**8.91E-02**	**5.68E-02**	**5.04E-04**	**5.67E-04**	**5.67E-05**	**2.02E-02**	**5.92E-03**	**5.00E+01**
69	Bitumen use	m2 applied surface	2.07E-02	8.91E-02	5.28E-02	5.04E-04	5.67E-04	5.67E-05	2.02E-02	5.92E-03	5.00E+01
70	Operation of application equipment (diesel driven)	m2 applied surface			4.06E-03						
71											
72	**Production of crushed aggregates**	**tonne prod. crushed aggregates**	**2.12E+01**	**1.97E-01**	**2.00E+01**	**8.48E-01**	**9.54E-01**	**9.54E-02**	**3.39E+01**	**9.96E+00**	
73	Operation of machines and transport vehicles, diesel, and resource materials in production of crushed aggregates	tonne prod. crushed aggregates			1.87E+01						
74	Electric power production for production of crushed aggregates	tonne prod. crushed aggregates	2.12E+01	1.97E-01	1.36E+00	8.48E-01	9.54E-01	9.54E-02	3.39E+01	9.96E+00	
75											
76	**Extraction of pit-run graval and sand**	**tonne prod. gravel/sand**	**2.40E+00**	**2.23E-02**	**1.04E+00**	**9.59E-02**	**1.08E-01**	**1.08E-02**	**3.84E+00**	**1.13E+00**	
77	Operation of wheel loader (diesel), excavation class 2 and resource materials	tonne prod. gravel/sand			8.88E-01						
78	Electric power production for production of pit-run gravel and sand	tonne prod. gravel/sand	2.40E+00	2.23E-02	1.53E-01	9.59E-02	1.08E-01	1.08E-02	3.84E+00	1.13E+00	
79											
80	**Production of cement**	**kg cement**	**3.90E-01**	**3.63E-03**	**6.56E-02**	**3.88E+00**	**1.76E-02**	**1.76E-03**	**6.24E-01**	**1.83E-01**	
81	Production of cement	kg cement	3.90E-01		4.06E-02	3.86E+00					
82	Electric power production for production of cement	kg cement		3.63E-03	2.50E-02	1.56E-02	1.76E-02	1.76E-03	6.24E-01	1.83E-01	
83											
84	**Concrete production**	**m3 produced concrete**	**2.00E+02**	**1.86E+00**	**1.06E+02**	**1.55E+03**	**8.99E+00**	**8.99E-01**	**3.20E+02**	**9.39E+01**	
85	Cement use	m3 produced concrete	1.56E+02	1.45E+00	2.62E+01	1.55E+03	7.02E+00	7.02E-01	2.50E+02	7.33E+01	
86	Use of crushed aggregates	m3 produced concrete	2.54E+01	2.36E-01	2.41E+01	1.02E+00	1.14E+00	1.14E-01	4.07E+01	1.20E+01	
87	Use of pit-run gravel and sand	m3 produced concrete	1.68E+00	1.56E-02	7.29E-01	6.71E-02	7.55E-02	7.55E-03	2.69E+00	7.89E-01	
88	Diesel use for vehicles and machines	m3 produced concrete			5.35E+01						
89	Electric power for concrete production	m3 produced concrete	1.67E+01	1.55E-01	1.07E+00	6.69E-01	7.52E-01	7.52E-02	2.68E+01	7.86E+00	
90											
91	**Sand gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**	**1.84E+01**	**1.71E-01**	**5.58E+01**	**7.36E-01**	**8.28E-01**	**8.28E-02**	**2.94E+01**	**8.65E+00**	
92	Operation of vehicle, distribution truck	for this road objekt per gritting operation			3.94E+01						
93	Sand use, cruched material	for this road objekt per gritting operation	1.65E+01	1.54E-01	1.56E+01	6.61E-01	7.44E-01	7.44E-02	2.64E+01	7.77E+00	
94	Sand use, natural occuring material	for this road objekt per gritting operation	1.87E+00	1.74E-02	8.12E-01	7.48E-02	8.42E-02	8.42E-03	2.99E+00	8.79E-01	
95											
96	**Salt gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**			3.94E+01	1.92E+02					
97	Operation of vehicle, distribution truck	for this road objekt per gritting operation			3.94E+01						
98	Salt use, coal based rock salt	for this road objekt per gritting operation				1.92E+02					
99											
100	**Snow clearance, snow clearance truck per drived distance**	**km**			**1.71E+01**						
101											
102	**Mowing of verges per km mowed verge. Mowing width is 1.5 m**	**km mowed verge**			**5.09E+01**						
103											
104	**Clearing of verges per km cleared verge. Clearing width is 1.2 m**	**km cleared verge**			**1.02E+02**						
105											
106	**Road trench digging**	**m digged trench**			**1.94E+01**						
107	Transport of excavated materials	m digged trench			1.06E+01						
108	Operation of excavator	m digged trench			8.84E+00						
109											

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I	J	K
1			**Material/Energy resources**								
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**	**Hydro power**	**Bitumen**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**g**
110	**Erection and removal of snow posts**	**km roadside**			**2.12E+02**						
111	Erection of snow posts	km roadside			1.24E+02						
112	Removal of snow posts	km roadside			8.88E+01						
113											
114	**Washing of road signs per km roadside**	**km roadside**			**6.18E+01**						
115											
116	**Washing of roadside posts per km roadside**	**km roadside**			3.86E+01						
117											
118	**Forest felling/clearing, total including forest transport to lokal forest store**	**m3 felled forest**			**4.44E+01**						
119	Operation of felling machine	m3 felled forest			1.85E+01						
120	Operation of timber transporter	m3 felled forest			2.59E+01						
121											
122	***CO2 emission due to permanent reduction (forest felling) of biomass***	***m3 felled forest***									
123											
124	**Production of galvanized steel**	**kg galvanized steel**	**4.70E+00**	**1.80E+00**	**3.61E+00**	**1.52E+01**					
125	Steel production	kg galvanized steel	4.62E+00	1.77E+00	3.58E+00	1.52E+01					
126	Zinc production	kg galvanized steel	8.05E-02	3.07E-02	3.20E-02	4.80E-03					
127											
128	**Production of Aluminium**	**kg aluminium**	**5.06E+01**	**2.04E+00**	**1.12E+01**	**1.01E+00**	**1.14E+00**	**1.14E-01**	**4.05E+01**	**1.19E+01**	
129	Aluminium production	kg aluminium	2.53E+01	1.80E+00	9.60E+00						
130	Electric power production for aluminium production	kg aluminium	2.53E+01	2.35E-01	1.62E+00	1.01E+00	1.14E+00	1.14E-01	4.05E+01	1.19E+01	
131											
132	**Road foundation reinforcement using cement/lime columns**	**m cement/lime column**	**6.14E+00**	**5.67E-02**	**3.03E+01**	**1.35E+02**	**2.71E-01**	**2.71E-02**	**9.82E+00**	**2.89E+00**	
133	Cement production	m cement/lime column	4.49E+00	4.17E-02	7.54E-01	4.46E+01	2.02E-01	2.02E-02	7.18E+00	2.11E+00	
134	Quicklime production	m cement/lime column	1.66E+00	1.50E-02	1.02E+01	9.09E+01	6.90E-02	6.90E-03	2.65E+00	7.82E-01	
135	Operation of machine, diesel engine	m cement/lime column			1.93E+01						
136											
137	**Road foundation reinforcement using concrete piles**	**m concrete pile**	**5.92E+01**	**1.71E+01**	**4.90E+01**	**2.81E+02**	**6.78E-01**	**6.78E-02**	**2.41E+01**	**7.09E+00**	
138	Cement production	m concrete pile	1.37E+01	1.27E-01	2.29E+00	1.36E+02	6.14E-01	6.14E-02	2.18E+01	6.42E+00	
139	Steel production	m concrete pile	4.41E+01	1.69E+01	3.42E+01	1.45E+02					
140	Crushed aggregates production	m concrete pile	1.28E+00	1.19E-02	1.21E+00	5.13E-02	5.77E-02	5.77E-03	2.05E+00	6.03E-01	
141	Extraction of pit-run gravel and sand	m concrete pile	1.45E-01	1.35E-03	6.30E-02	5.80E-03	6.53E-03	6.53E-04	2.32E-01	6.82E-02	
142	Piling, operation of machine, diesel engine	m concrete pile			1.12E+01						
143											
144	**Production and assembly of wildlife fences**	**m wildlife fence**	**1.77E+01**	**6.77E+00**	**1.67E+01**	**5.73E+01**					
145	Production of galvanized steel	m wildlife fence	1.77E+01	6.77E+00	1.36E+01	5.73E+01					
146	Diesel use for assembly (putting up the fence)	m wildlife fence			3.09E+00						
147											
148	**Production of hot asphalt in asphalt plant**	**tonne asphalt**	**8.08E+01**	**1.07E+02**	**3.69E+02**	**2.84E+00**	**3.20E+00**	**3.20E-01**	**1.14E+02**	**3.34E+01**	**6.00E+04**
149	Production of bitumen	tonne asphalt	2.48E+01	1.07E+02	6.33E+01	6.05E-01	6.80E-01	6.80E-02	2.42E+01	7.11E+00	6.00E+04
150	Production of crushed aggregates	tonne asphalt	1.99E+01	1.85E-01	1.88E+01	7.97E-01	8.96E-01	8.96E-02	3.19E+01	9.36E+00	
151	Electric power for asphalt plant	tonne asphalt	3.60E+01	3.35E-01	2.30E+00	1.44E+00	1.62E+00	1.62E-01	5.76E+01	1.69E+01	
152	Energy use at asphalt plant, fuel oil	tonne asphalt			2.85E+02						
153											
154	**Production of cold asphalt in asphalt plant including emulsifier**	**tonne asphalt**	**3.82E+01**	**7.15E+01**	**9.05E+01**	**1.27E+00**	**1.43E+00**	**1.43E-01**	**5.07E+01**	**1.49E+01**	**4.00E+04**
155	Production of bitumen	tonne asphalt	1.66E+01	7.13E+01	4.22E+01	4.03E-01	4.54E-01	4.54E-02	1.61E+01	4.74E+00	4.00E+04
156	Production of crushed aggregates	tonne asphalt	2.03E+01	1.89E-01	1.92E+01	8.14E-01	9.15E-01	9.15E-02	3.25E+01	9.56E+00	
157	Electric power for emulsifier	tonne asphalt	1.27E+00	1.18E-02	8.13E-02	5.08E-02	5.72E-02	5.72E-03	2.03E+00	5.97E-01	
158	Energy use, fuel oil for heating of emulsifier	tonne asphalt			5.81E+00						
159	Energy use, diesel oil for mobile electric power generation for asphalt plant	tonne asphalt			2.32E+01						
160											
161	**Cement stabilisation of base course, slipform paver**	**m2 stabilised surface**			**1.31E+00**						
162											
163	**Concrete road paving, wearing course including slipform paver and dowels**	**m2 concrete road**	**5.98E+00**	**2.29E+00**	**9.17E+00**	**1.97E+01**					
164	Operation of slipform paver	m2 concrete road			4.53E+00						

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I	J	K
1			**Material/Energy resources**								
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**	**Hydro power**	**Bitumen**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**g**
165	Steel use for dowels	m2 concrete road	5.98E+00	2.29E+00	4.64E+00	1.97E+01					
166											
167	**Exposure of aggregate on concrete carriageway, machine operation-polyeten film**	**m2 concrete road**	**3.76E-01**	**2.15E+00**	**2.32E+00**	**1.31E-01**					
168	Machine operation, diesel engine	m2 concrete road			6.15E-01						
169	Polyeten film	m2 concrete road	3.76E-01	2.15E+00	1.71E+00	1.31E-01					
170											
171	**Sawing and sealing of joints in concrete road construction**	**m2 concrete road**	**3.74E-01**		**2.11E+00**	**4.18E-01**					
172	Machine operation, diesel engine	m2 concrete road			5.43E-01						
173	EPDM-rubber	m2 concrete road	3.74E-01		1.57E+00	4.18E-01					
174											
175	**Construction of sub-base at road site**	**tonne sub-base**			**7.72E+00**						
176											
177	**Construction of base course**	**tonne base course**			**7.72E+00**						
178											
179	**Sub-base, loading of blasted rock with excavator**	**tonne blasted rock**			**2.26E+00**						
180											
181	**Diesel heating (combustion) in road marking operation**	**MJ used diesel**			**1.10E+00**						
182	*Diesel combustion for use in diesel burner in road marking*	*MJ used diesel*			*1.00E+00*						
183	Production of diesel	MJ used diesel			1.00E-01						
184											
185	**Road marking with thermoplastic materials exclusive production of road marking materials**	**km marked väg**			**9.65E+02**						
186	Operation of diesel vehicle	km marked väg			6.56E+02						
187	Operation of diesel burner	km marked väg			3.09E+02						
188											
189	**Excavation of sub-base and base course with excavator, excavation class 4**	**fixed m3**			**4.38E+00**						
190											
191	**Surface milling (12 mm) of concrete road in road maintenance**	**m2 milled road area**			**7.95E+01**						
192											
193	**Maintenance of concrete road, concrete paving in milled tracks, machine operation**	**m filled track**			**7.72E-02**						
194											
195	**Operation of road, sweeping per km drived distance with sweeping vehicle**	**km**			**3.86E+01**						
196											
197	**Surface milling of asphalt layer per area unit**	**m2 milled road area**			**1.72E+00**						

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	L	M	N	O	P	Q	R	S	T	U
1										**Emissions to Air**		
2			**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**	**SO2**	**NOx**	**CO**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4												
5	***Production of electric power, Swedish average***	***MJ electricity***								***6.70E-03***	***9.20E-03***	***2.10E-03***
6												
7	***Production of (Precombustion) diesel and fuel oil***	***MJ crude oil to production***								***1.40E-02***	***4.10E-03***	***1.30E-04***
8												
9	***Distribution truck (14 tonne load)***	***MJ used diesel***								***2.40E-02***	***5.00E-01***	***8.00E-02***
10												
11	***Long distance truck (32 tonne load)***	***MJ used diesel***								***2.40E-02***	***6.00E-01***	***1.00E-01***
12												
13	***Production of quicklime (CaO)***	***kg CaO***			***2.00E+03***					***9.40E-01***	***3.25E+00***	***3.70E-01***
14												
15	***Production of polyeten plastic***	***kg polyethen plastic***								***7.00E+00***	***1.10E+01***	***8.00E-01***
16												
17	***Production of rock salt (coal based)***	***tonne salt***				***1.00E+06***				***7.40E+02***	***4.44E+02***	***3.00E+01***
18												
19	***Production of EPDM-rubber***	***kg EPDM***								***5.70E+00***	***4.00E+00***	***8.00E-01***
20												
21	***Aluminium production***	***kg Aluminium***			***2.18E+01***	***7.80E+01***	***2.50E+02***			***6.90E+00***	***4.80E+00***	***7.00E-01***
22												
23	***Production of steel***	***kg steel***						***1.00E+03***		***7.34E+00***	***4.86E+00***	***1.00E+00***
24												
25	***Production of zink for galvanization***	***kg zinc***							***1.00E+03***	***2.81E+01***	***1.54E+01***	***3.90E+00***
26												
27	***Combustion of fuel oil with fuel oil burner***	***MJ used fuel oil***								***5.00E-02***	***1.60E-01***	***1.30E-02***
28												
29												
30	**Truck transport, distribution truck outside urban area (14 tonne load), full load, empty on return**	**vkm**								**4.53E-01**	**6.02E+00**	**9.56E-01**
31	Distribution truck (14 tonne load)	vkm								2.86E-01	5.97E+00	9.55E-01
32	Production of diesel	vkm								1.67E-01	4.89E-02	1.55E-03
33												
34	**Truck transport, long distance truck, rural roads (32 tonne load), full load, empty on return**	**vkm**								**5.07E-01**	**8.06E+00**	**1.34E+00**
35	Long distance truck (32 tonne load)	vkm								3.20E-01	8.00E+00	1.33E+00
36	Production of diesel	vkm								1.87E-01	5.47E-02	1.73E-03
37												
38	**Ship transport, coast freight**	**tonne,km**								**6.48E-02**	**2.53E-01**	**2.70E-02**
39	*Ship transport, operation of the ship(engine data)*	*tonne,km*								*6.30E-02*	*2.52E-01*	*2.70E-02*
40	Production of diesel	tonne,km								1.82E-03	5.33E-04	1.69E-05
41												
42	**General road construction equipment (excavators, wheel loader etc.), diesel driven**	**MJ used diesel**								**3.80E-02**	**7.14E-01**	**8.51E-02**
43	*Equipment in operation, diesel driven (engine data)*	MJ used diesel								*2.40E-02*	*7.10E-01*	*8.50E-02*
44	Production of diesel	MJ used diesel								1.40E-02	4.10E-03	1.30E-04
45												
46	**Wheel loader in truck loading operation, depends on excavation class**	**fixed m3 loaded material**								**1.14E-01**	**2.14E+00**	**2.55E-01**
47												
48	**Excavator in truck loading operation, depends on excavation class**	**fixed m3 loaded material**								**1.26E-01**	**2.37E+00**	**2.83E-01**
49												
50	**Dumper truck transport, depends on driving conditions at driving site**	**loose m3, km**								**2.57E-01**	**4.83E+00**	**5.76E-01**
51												
52	**Compacting (ground, base course etc.) with roller, for one layer**	**m2 compacted surface**								**2.39E-02**	**4.49E-01**	**5.35E-02**
53												
54	**Asphalt rolling, for one layer**	**m2 asphalt surface**								**3.04E-02**	**5.70E-01**	**6.80E-02**
55												
56	**Asphalt paving, for one layer of asphalt**	**m2 asphalt surface**								**2.26E-02**	**4.24E-01**	**5.06E-02**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	L	M	N	O	P	Q	R	S	T	U
1										**Emissions to Air**		
2			**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**	**SO2**	**NOx**	**CO**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
57												
58	**Production of bitumen**	**tonne bitumen**								**6.12E+02**	**1.02E+03**	**1.11E+02**
59	*Crude oil extraction in Venezuela, Laguna*	*tonne bitumen*								*1.80E+00*	*1.42E+02*	*1.80E+01*
60	*Bitumen production, refining from local store excluding electric power generation*	*tonne bitumen*								*1.05E+02*	*8.00E+01*	
61	*Transport of crude oil to refinery*	*tonne bitumen*								*4.41E+02*	*5.88E+02*	*6.30E+01*
62	Production of electric power to refinery	tonne bitumen								6.03E-01	8.28E-01	1.89E-01
63	*Transport (ship) of bitumen from raffinery to local store excluding precombustion*	*tonne bitumen*								*5.98E+01*	*2.01E+02*	*2.72E+01*
64	Precombustion for diesel to ship transport from refinary to local store	tonne bitumen								2.03E+00	5.95E-01	1.89E-02
65	*Store of bitumen at local store including precombustion but excluding electric power production*	*tonne bitumen*								*1.10E+00*	*1.87E+00*	*1.80E+00*
66	Production of electric power for local bitumen store	tonne bitumen								1.09E+00	1.49E+00	3.40E-01
67												
68	**Application of adhesion layer (emulsion)**	**m2 applied surface**								**3.08E-02**	**5.34E-02**	**5.84E-03**
69	Bitumen use	m2 applied surface								3.06E-02	5.08E-02	5.53E-03
70	Operation of application equipment (diesel driven)	m2 applied surface								1.40E-04	2.64E-03	3.14E-04
71												
72	**Production of crushed aggregates**	**tonne prod. crushed aggregates**		**1.00E+06**						**7.88E-01**	**1.23E+01**	**1.49E+00**
73	Operation of machines and transport vehicles, diesel, and resource materials in production of crushed aggregates	tonne prod. crushed aggregates		1.00E+06						6.46E-01	1.21E+01	1.45E+00
74	Electric power production for production of crushed aggregates	tonne prod. crushed aggregates								1.42E-01	1.95E-01	4.45E-02
75												
76	**Extraction of pit-run graval and sand**	**tonne prod. gravel/sand**	**1.00E+06**							**4.67E-02**	**5.98E-01**	**7.37E-02**
77	Operation of wheel loader (diesel), excavation class 2 and resource materials	tonne prod. gravel/sand	1.00E+06							3.07E-02	5.76E-01	6.87E-02
78	Electric power production for production of pit-run gravel and sand	tonne prod. gravel/sand								1.61E-02	2.21E-02	5.04E-03
79												
80	**Production of cement**	**kg cement**			**1.56E+03**	**1.56E+03**	**1.56E+03**	**1.56E+03**	**1.56E+03**	**1.00E+00**	**2.00E+00**	**8.19E-04**
81	Production of cement	kg cement			1.56E+03	1.56E+03	1.56E+03	1.56E+03	1.56E+03	1.00E+00	2.00E+00	
82	Electric power production for production of cement	kg cement								2.61E-03	3.59E-03	8.19E-04
83												
84	**Concrete production**	**m3 produced concrete**	**7.00E+05**	**1.20E+06**	**6.24E+05**	**6.24E+05**	**6.24E+05**	**6.24E+05**	**6.24E+05**	**4.04E+02**	**8.52E+02**	**6.35E+00**
85	Cement use	m3 produced concrete			6.24E+05	6.24E+05	6.24E+05	6.24E+05	6.24E+05	4.01E+02	8.01E+02	3.28E-01
86	Use of crushed aggregates	m3 produced concrete		1.20E+06						9.45E-01	1.48E+01	1.79E+00
87	Use of pit-run gravel and sand	m3 produced concrete	7.00E+05							3.27E-02	4.19E-01	5.16E-02
88	Diesel use for vehicles and machines	m3 produced concrete								1.85E+00	3.48E+01	4.14E+00
89	Electric power for concrete production	m3 produced concrete								1.12E-01	1.54E-01	3.51E-02
90												
91	**Sand gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**	**7.80E+05**	**7.80E+05**						**2.01E+00**	**2.81E+01**	**4.09E+00**
92	Operation of vehicle, distribution truck	for this road objekt per gritting operation								1.36E+00	1.80E+01	2.87E+00
93	Sand use, cruched material	for this road objekt per gritting operation		7.80E+05						6.14E-01	9.62E+00	1.16E+00
94	Sand use, natural occuring material	for this road objekt per gritting operation	7.80E+05							3.65E-02	4.67E-01	5.75E-02
95												
96	**Salt gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**				1.30E+05				9.76E+01	7.58E+01	6.77E+00
97	Operation of vehicle, distribution truck	for this road objekt per gritting operation								1.36E+00	1.80E+01	2.87E+00
98	Salt use, coal based rock salt	for this road objekt per gritting operation				1.30E+05				9.62E+01	5.77E+01	3.90E+00
99												
100	**Snow clearance, snow clearance truck per drived distance**	**km**								**5.90E-01**	**7.82E+00**	**1.24E+00**
101												
102	**Mowing of verges per km mowed verge. Mowing width is 1.5 m**	**km mowed verge**								**1.76E+00**	**3.31E+01**	**3.94E+00**
103												
104	**Clearing of verges per km cleared verge. Clearing width is 1.2 m**	**km cleared verge**								**3.52E+00**	**6.61E+01**	**7.88E+00**
105												
106	**Road trench digging**	**m digged trench**								**6.71E-01**	**1.26E+01**	**1.50E+00**
107	Transport of excavated materials	m digged trench								3.66E-01	6.87E+00	8.19E-01
108	Operation of excavator	m digged trench								3.06E-01	5.74E+00	6.84E-01
109												

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	L	M	N	O	P	Q	R	S	T	U
1										**Emissions to Air**		
2			**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**	**SO2**	**NOx**	**CO**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
110	**Erection and removal of snow posts**	**km roadside**								**7.33E+00**	**1.38E+02**	**1.64E+01**
111	Erection of snow posts	km roadside								4.27E+00	8.02E+01	9.56E+00
112	Removal of snow posts	km roadside								3.07E+00	5.76E+01	6.87E+00
113												
114	**Washing of road signs per km roadside**	**km roadside**								**2.14E+00**	**4.01E+01**	**4.78E+00**
115												
116	**Washing of roadside posts per km roadside**	**km roadside**								1.33E+00	2.51E+01	2.99E+00
117												
118	**Forest felling/clearing, total including forest transport to lokal forest store**	**m3 felled forest**								**1.53E+00**	**2.88E+01**	**3.44E+00**
119	Operation of felling machine	m3 felled forest								6.40E-01	1.20E+01	1.43E+00
120	Operation of timber transporter	m3 felled forest								8.94E-01	1.68E+01	2.00E+00
121												
122	***CO2 emission due to permanent reduction (forest felling) of biomass***	***m3 felled forest***										
123												
124	**Production of galvanized steel**	**kg galvanized steel**						**9.95E+02**	**5.00E+00**	**7.44E+00**	**4.91E+00**	**1.01E+00**
125	Steel production	kg galvanized steel						9.95E+02		7.30E+00	4.84E+00	9.95E-01
126	Zinc production	kg galvanized steel							5.00E+00	1.41E-01	7.70E-02	1.95E-02
127												
128	**Production of Aluminium**	**kg aluminium**			**2.18E+01**	**7.80E+01**	**2.50E+02**			**7.07E+00**	**5.03E+00**	**7.53E-01**
129	Aluminium production	kg aluminium			2.18E+01	7.80E+01	2.50E+02			6.90E+00	4.80E+00	7.00E-01
130	Electric power production for aluminium production	kg aluminium								1.70E-01	2.33E-01	5.31E-02
131												
132	**Road foundation reinforcement using cement/lime columns**	**m cement/lime column**			**4.09E+04**	**1.79E+04**	**1.79E+04**	**1.79E+04**	**1.79E+04**	**2.30E+01**	**7.29E+01**	**5.76E+00**
133	Cement production	m cement/lime column			1.79E+04	1.79E+04	1.79E+04	1.79E+04	1.79E+04	1.15E+01	2.30E+01	9.42E-03
134	Quicklime production	m cement/lime column			2.30E+04					1.08E+01	3.74E+01	4.26E+00
135	Operation of machine, diesel engine	m cement/lime column								6.67E-01	1.25E+01	1.49E+00
136												
137	**Road foundation reinforcement using concrete piles**	**m concrete pile**	**6.05E+04**	**6.05E+04**	**5.46E+04**	**5.46E+04**	**5.46E+04**	**6.41E+04**	**5.46E+04**	**1.05E+02**	**1.24E+02**	**1.05E+01**
138	Cement production	m concrete pile			5.46E+04	5.46E+04	5.46E+04	5.46E+04	5.46E+04	3.51E+01	7.01E+01	2.87E-02
139	Steel production	m concrete pile						9.50E+03		6.97E+01	4.62E+01	9.50E+00
140	Crushed aggregates production	m concrete pile		6.05E+04						4.76E-02	7.46E-01	9.02E-02
141	Extraction of pit-run gravel and sand	m concrete pile	6.05E+04							2.83E-03	3.62E-02	4.46E-03
142	Piling, operation of machine, diesel engine	m concrete pile								3.87E-01	7.27E+00	8.67E-01
143												
144	**Production and assembly of wildlife fences**	**m wildlife fence**						**3.74E+03**	**1.88E+01**	**2.81E+01**	**2.05E+01**	**4.05E+00**
145	Production of galvanized steel	m wildlife fence						3.74E+03	1.88E+01	2.80E+01	1.85E+01	3.81E+00
146	Diesel use for assembly (putting up the fence)	m wildlife fence								1.07E-01	2.01E+00	2.39E-01
147												
148	**Production of hot asphalt in asphalt plant**	**tonne asphalt**		**9.40E+05**						**5.20E+01**	**1.18E+02**	**1.18E+01**
149	Production of bitumen	tonne asphalt								3.67E+01	6.09E+01	6.63E+00
150	Production of crushed aggregates	tonne asphalt		9.40E+05						7.40E-01	1.16E+01	1.40E+00
151	Electric power for asphalt plant	tonne asphalt								2.41E-01	3.31E-01	7.56E-02
152	Energy use at asphalt plant, fuel oil	tonne asphalt								1.43E+01	4.56E+01	3.71E+00
153												
154	**Production of cold asphalt in asphalt plant including emulsifier**	**tonne asphalt**		**9.60E+05**						**2.64E+01**	**6.85E+01**	**7.73E+00**
155	Production of bitumen	tonne asphalt								2.45E+01	4.06E+01	4.42E+00
156	Production of crushed aggregates	tonne asphalt		9.60E+05						7.56E-01	1.18E+01	1.43E+00
157	Electric power for emulsifier	tonne asphalt								8.51E-03	1.17E-02	2.67E-03
158	Energy use, fuel oil for heating of emulsifier	tonne asphalt								2.91E-01	9.30E-01	7.55E-02
159	Energy use, diesel oil for mobile electric power generation for asphalt plant	tonne asphalt								8.02E-01	1.51E+01	1.80E+00
160												
161	**Cement stabilisation of base course, slipform paver**	**m2 stabilised surface**								**4.52E-02**	**8.50E-01**	**1.01E-01**
162												
163	**Concrete road paving, wearing course including slipform paver and dowels**	**m2 concrete road**						**1.29E+03**		**9.61E+00**	**9.20E+00**	**1.64E+00**
164	Operation of slipform paver	m2 concrete road								1.57E-01	2.94E+00	3.51E-01

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	L	M	N	O	P	Q	R	S	T	U
1										**Emissions to Air**		
2			**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**	**SO2**	**NOx**	**CO**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
165	Steel use for dowels	m2 concrete road						1.29E+03		9.45E+00	6.26E+00	1.29E+00
166												
167	**Exposure of aggregate on concrete carriageway, machine operation-polyeten film**	**m2 concrete road**								**3.54E-01**	**9.23E-01**	**8.57E-02**
168	Machine operation, diesel engine	m2 concrete road								2.12E-02	3.99E-01	4.76E-02
169	Polyeten film	m2 concrete road								3.33E-01	5.24E-01	3.81E-02
170												
171	**Sawing and sealing of joints in concrete road construction**	**m2 concrete road**								**4.45E-01**	**6.52E-01**	**1.02E-01**
172	Machine operation, diesel engine	m2 concrete road								1.88E-02	3.53E-01	4.21E-02
173	EPDM-rubber	m2 concrete road								4.26E-01	2.99E-01	5.98E-02
174												
175	**Construction of sub-base at road site**	**tonne sub-base**								**2.67E-01**	**5.01E+00**	**5.98E-01**
176												
177	**Construction of base course**	**tonne base course**								**2.67E-01**	**5.01E+00**	**5.98E-01**
178												
179	**Sub-base, loading of blasted rock with excavator**	**tonne blasted rock**								**7.79E-02**	**1.46E+00**	**1.75E-01**
180												
181	**Diesel heating (combustion) in road marking operation**	**MJ used diesel**								**3.80E-02**	**2.04E-01**	**5.01E-02**
182	*Diesel combustion for use in diesel burner in road marking*	*MJ used diesel*								*2.40E-02*	*2.00E-01*	*5.00E-02*
183	Production of diesel	MJ used diesel								1.40E-02	4.10E-03	1.30E-04
184												
185	**Road marking with thermoplastic materials exclusive production of road marking materials**	**km marked väg**								**3.33E+01**	**4.83E+02**	**6.49E+01**
186	Operation of diesel vehicle	km marked väg								2.27E+01	4.26E+02	5.08E+01
187	Operation of diesel burner	km marked väg								1.07E+01	5.73E+01	1.41E+01
188												
189	**Excavation of sub-base and base course with excavator, excavation class 4**	**fixed m3**								**1.51E-01**	**2.84E+00**	**3.39E-01**
190												
191	**Surface milling (12 mm) of concrete road in road maintenance**	**m2 milled road area**								**2.75E+00**	**5.16E+01**	**6.16E+00**
192												
193	**Maintenance of concrete road, concrete paving in milled tracks, machine operation**	**m filled track**								**2.67E-03**	**5.01E-02**	**5.98E-03**
194												
195	**Operation of road, sweeping per km drived distance with sweeping vehicle**	**km**								**1.33E+00**	**2.51E+01**	**2.99E+00**
196												
197	**Surface milling of asphalt layer per area unit**	**m2 milled road area**								**5.93E-02**	**1.11E+00**	**1.33E-01**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	V	W	X	Y	Z	AA	AB	AC	AD	AE
1										**Emissions to Water**		
2			**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**	**BOD**	**COD**	**Phosphorus-total**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4												
5	***Production of electric power, Swedish average***	***MJ electricity***	***3.80E+00***		***1.40E-04***	***1.10E-03***		***4.20E-04***	***7.00E-05***			
6												
7	***Production of (Precombustion) diesel and fuel oil***	***MJ crude oil to production***	***4.00E+00***	***8.40E-03***					***4.80E-04***		***1.20E-03***	
8												
9	***Distribution truck (14 tonne load)***	***MJ used diesel***	***7.50E+01***	***3.00E-02***	***5.00E-05***			***1.60E-03***	***8.00E-03***			
10												
11	***Long distance truck (32 tonne load)***	***MJ used diesel***	***7.50E+01***	***3.00E-02***	***5.00E-05***			***1.60E-03***	***1.00E-02***			
12												
13	***Production of quicklime (CaO)***	***kg CaO***	***2.04E+03***		***1.44E-05***	***2.10E-02***			***9.50E-03***			
14												
15	***Production of polyeten plastic***	***kg polyethen plastic***	***1.10E+03***	***2.10E+01***					***2.00E+00***	***1.50E-01***	***1.00E+00***	***5.00E-03***
16												
17	***Production of rock salt (coal based)***	***tonne salt***	***1.36E+05***									
18												
19	***Production of EPDM-rubber***	***kg EPDM***	***2.33E+03***		***3.50E+00***		***1.90E+01***	***5.00E-03***	***2.10E+00***		***2.00E+01***	
20												
21	***Aluminium production***	***kg Aluminium***	***1.23E+03***	***1.40E+00***					***5.53E+01***		***9.00E+00***	
22												
23	***Production of steel***	***kg steel***	***2.20E+03***		***9.10E+00***		***1.20E+00***	***3.00E-02***	***3.92E+01***		***9.30E-03***	
24												
25	***Production of zink for galvanization***	***kg zinc***	***4.65E+03***		***1.39E+01***		***2.80E+00***	***1.20E-01***	***9.10E+00***		***2.30E-02***	
26												
27	***Combustion of fuel oil with fuel oil burner***	***MJ used fuel oil***	***7.90E+01***						***1.00E-02***			
28												
29												
30	**Truck transport, distribution truck outside urban area (14 tonne load), full load, empty on return**	**vkm**	**9.43E+02**	**4.58E-01**	**5.97E-04**			**1.91E-02**	**1.01E-01**		**1.43E-02**	
31	Distribution truck (14 tonne load)	vkm	8.95E+02	3.58E-01	5.97E-04			1.91E-02	9.55E-02			
32	Production of diesel	vkm	4.77E+01	1.00E-01					5.73E-03		1.43E-02	
33												
34	**Truck transport, long distance truck, rural roads (32 tonne load), full load, empty on return**	**vkm**	**1.05E+03**	**5.12E-01**	**6.67E-04**			**2.13E-02**	**1.40E-01**		**1.60E-02**	
35	Long distance truck (32 tonne load)	vkm	1.00E+03	4.00E-01	6.67E-04			2.13E-02	1.33E-01			
36	Production of diesel	vkm	5.34E+01	1.12E-01					6.40E-03		1.60E-02	
37												
38	**Ship transport, coast freight**	**tonne,km**	**1.00E+01**	**8.59E-03**					**6.24E-05**		**1.56E-04**	
39	*Ship transport, operation of the ship(engine data)*	*tonne,km*	*9.50E+00*	*7.50E-03*								
40	Production of diesel	tonne,km	5.20E-01	1.09E-03					6.24E-05		1.56E-04	
41												
42	**General road construction equipment (excavators, wheel loader etc.), diesel driven**	**MJ used diesel**	**7.90E+01**	**5.14E-02**	**5.00E-05**			**1.60E-03**	**2.85E-02**		**1.20E-03**	
43	*Equipment in operation, diesel driven (engine data)*	MJ used diesel	*7.50E+01*	*4.30E-02*	*5.00E-05*			*1.60E-03*	*2.80E-02*			
44	Production of diesel	MJ used diesel	4.00E+00	8.40E-03					4.80E-04		1.20E-03	
45												
46	**Wheel loader in truck loading operation, depends on excavation class**	**fixed m3 loaded material**	**2.37E+02**	**1.54E-01**	**1.50E-04**			**4.80E-03**	**8.54E-02**		**3.60E-03**	
47												
48	**Excavator in truck loading operation, depends on excavation class**	**fixed m3 loaded material**	**2.62E+02**	**1.71E-01**	**1.66E-04**			**5.31E-03**	**9.46E-02**		**3.98E-03**	
49												
50	**Dumper truck transport, depends on driving conditions at driving site**	**loose m3, km**	**5.35E+02**	**3.48E-01**	**3.39E-04**			**1.08E-02**	**1.93E-01**		**8.12E-03**	
51												
52	**Compacting (ground, base course etc.) with roller, for one layer**	**m2 compacted surface**	**4.96E+01**	**3.23E-02**	**3.14E-05**			**1.00E-03**	**1.79E-02**		**7.54E-04**	
53												
54	**Asphalt rolling, for one layer**	**m2 asphalt surface**	**6.31E+01**	**4.11E-02**	**3.99E-05**			**1.28E-03**	**2.27E-02**		**9.59E-04**	
55												
56	**Asphalt paving, for one layer of asphalt**	**m2 asphalt surface**	**4.69E+01**	**3.05E-02**	**2.97E-05**			**9.50E-04**	**1.69E-02**		**7.13E-04**	

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	V	W	X	Y	Z	AA	AB	AC	AD	AE
1										**Emissions to Water**		
2			**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**	**BOD**	**COD**	**Phosphorus-total**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
57												
58	**Production of bitumen**	**tonne bitumen**	**1.73E+05**	**3.07E+01**	**3.53E-02**	**2.00E+02**		**1.06E-01**	**8.10E+00**	**1.90E+01**	**3.44E+02**	**2.00E+00**
59	*Crude oil extraction in Venezuela, Laguna*	*tonne bitumen*	*9.96E+04*									
60	*Bitumen production, refining from local store excluding electric power generation*	*tonne bitumen*	*3.70E+04*			*2.00E+02*			*8.00E+00*	*1.90E+01*	*3.44E+02*	*2.00E+00*
61	*Transport of crude oil to refinery*	*tonne bitumen*	*2.22E+04*	*1.75E+01*								
62	Production of electric power to refinery	tonne bitumen	3.42E+02		1.26E-02	9.90E-02		3.78E-02	6.30E-03			
63	*Transport (ship) of bitumen from raffinery to local store excluding precombustion*	*tonne bitumen*	*1.11E+04*	*9.80E+00*								
64	Precombustion for diesel to ship transport from refinary to local store	tonne bitumen	5.80E+02	1.22E+00					6.96E-02		1.74E-01	
65	*Store of bitumen at local store including precombustion but excluding electric power production*	*tonne bitumen*	*1.44E+03*	*2.23E+00*					*8.64E-03*		*2.16E-02*	
66	Production of electric power for local bitumen store	tonne bitumen	6.16E+02		2.27E-02	1.78E-01		6.80E-02	1.13E-02			
67												
68	**Application of adhesion layer (emulsion)**	**m2 applied surface**	**8.93E+00**	**1.73E-03**	**1.95E-06**	**1.00E-02**		**1.12E-05**	**5.10E-04**	**9.50E-04**	**1.72E-02**	**1.00E-04**
69	Bitumen use	m2 applied surface	8.64E+00	1.54E-03	1.76E-06	1.00E-02		5.29E-06	4.05E-04	9.50E-04	1.72E-02	1.00E-04
70	Operation of application equipment (diesel driven)	m2 applied surface	2.92E-01	1.90E-04	1.85E-07			5.90E-06	1.05E-04		4.43E-06	
71												
72	**Production of crushed aggregates**	**tonne prod. crushed aggregates**	**1.42E+03**	**8.73E-01**	**3.82E-03**	**2.33E-02**		**3.61E-02**	**4.85E-01**		**2.04E-02**	
73	Operation of machines and transport vehicles, diesel, and resource materials in production of crushed aggregates	tonne prod. crushed aggregates	1.34E+03	8.73E-01	8.50E-04			2.72E-02	4.84E-01		2.04E-02	
74	Electric power production for production of crushed aggregates	tonne prod. crushed aggregates	8.05E+01		2.97E-03	2.33E-02		8.90E-03	1.48E-03			
75												
76	**Extraction of pit-run graval and sand**	**tonne prod. gravel/sand**	**7.29E+01**	**4.15E-02**	**3.76E-04**	**2.64E-03**		**2.30E-03**	**2.32E-02**		**9.68E-04**	
77	Operation of wheel loader (diesel), excavation class 2 and resource materials	tonne prod. gravel/sand	6.38E+01	4.15E-02	4.04E-05			1.29E-03	2.30E-02		9.68E-04	
78	Electric power production for production of pit-run gravel and sand	tonne prod. gravel/sand	9.11E+00		3.36E-04	2.64E-03		1.01E-03	1.68E-04			
79												
80	**Production of cement**	**kg cement**	**8.06E+02**		**5.46E-05**	**4.29E-04**		**1.64E-04**	**1.00E+00**			
81	Production of cement	kg cement	8.05E+02						1.00E+00			
82	Electric power production for production of cement	kg cement	1.48E+00		5.46E-05	4.29E-04		1.64E-04	2.73E-05			
83												
84	**Concrete production**	**m3 produced concrete**	**3.28E+05**	**3.58E+00**	**3.15E-02**	**2.20E-01**		**1.95E-01**	**4.02E+02**		**8.36E-02**	
85	Cement use	m3 produced concrete	3.23E+05		2.18E-02	1.72E-01		6.55E-02	4.00E+02			
86	Use of crushed aggregates	m3 produced concrete	1.71E+03	1.05E+00	4.58E-03	2.80E-02		4.33E-02	5.82E-01		2.45E-02	
87	Use of pit-run gravel and sand	m3 produced concrete	5.10E+01	2.90E-02	2.63E-04	1.85E-03		1.61E-03	1.62E-02		6.78E-04	
88	Diesel use for vehicles and machines	m3 produced concrete	3.85E+03	2.50E+00	2.43E-03			7.79E-02	1.39E+00		5.84E-02	
89	Electric power for concrete production	m3 produced concrete	6.35E+01		2.34E-03	1.84E-02		7.02E-03	1.17E-03			
90												
91	**Sand gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**	**3.99E+03**	**2.09E+00**	**5.06E-03**	**2.02E-02**		**8.72E-02**	**7.00E-01**		**5.96E-02**	
92	Operation of vehicle, distribution truck	for this road objekt per gritting operation	2.83E+03	1.37E+00	1.79E-03			5.73E-02	3.04E-01		4.30E-02	
93	Sand use, cruched material	for this road objekt per gritting operation	1.11E+03	6.81E-01	2.98E-03	1.82E-02		2.81E-02	3.79E-01		1.59E-02	
94	Sand use, natural occuring material	for this road objekt per gritting operation	5.68E+01	3.24E-02	2.93E-04	2.06E-03		1.79E-03	1.81E-02		7.55E-04	
95												
96	**Salt gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**	2.05E+04	1.37E+00	1.79E-03			5.73E-02	3.04E-01		4.30E-02	
97	Operation of vehicle, distribution truck	for this road objekt per gritting operation	2.83E+03	1.37E+00	1.79E-03			5.73E-02	3.04E-01		4.30E-02	
98	Salt use, coal based rock salt	for this road objekt per gritting operation	1.77E+04									
99												
100	**Snow clearance, snow clearance truck per drived distance**	**km**	**1.23E+03**	**5.96E-01**	**7.76E-04**			**2.48E-02**	**1.32E-01**		**1.86E-02**	
101												
102	**Mowing of verges per km mowed verge. Mowing width is 1.5 m**	**km mowed verge**	**3.66E+03**	**2.38E+00**	**2.32E-03**			**7.41E-02**	**1.32E+00**		**5.56E-02**	
103												
104	**Clearing of verges per km cleared verge. Clearing width is 1.2 m**	**km cleared verge**	**7.32E+03**	**4.76E+00**	**4.63E-03**			**1.48E-01**	**2.64E+00**		**1.11E-01**	
105												
106	**Road trench digging**	**m digged trench**	**1.40E+03**	**9.08E-01**	**8.83E-04**			**2.83E-02**	**5.03E-01**		**2.12E-02**	
107	Transport of excavated materials	m digged trench	7.60E+02	4.94E-01	4.81E-04			1.54E-02	2.74E-01		1.15E-02	
108	Operation of excavator	m digged trench	6.35E+02	4.13E-01	4.02E-04			1.29E-02	2.29E-01		9.65E-03	
109												

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	V	W	X	Y	Z	AA	AB	AC	AD	AE
1										**Emissions to Water**		
2			**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**	**BOD**	**COD**	**Phosphorus-total**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
110	**Erection and removal of snow posts**	**km roadside**	**1.52E+04**	**9.92E+00**	**9.65E-03**			**3.09E-01**	**5.50E+00**		**2.32E-01**	
111	Erection of snow posts	km roadside	8.87E+03	5.77E+00	5.62E-03			1.80E-01	3.20E+00		1.35E-01	
112	Removal of snow posts	km roadside	6.38E+03	4.15E+00	4.04E-03			1.29E-01	2.30E+00		9.68E-02	
113												
114	**Washing of road signs per km roadside**	**km roadside**	**4.44E+03**	**2.89E+00**	**2.81E-03**			**8.99E-02**	**1.60E+00**		**6.74E-02**	
115												
116	**Washing of roadside posts per km roadside**	**km roadside**	2.77E+03	1.80E+00	1.76E-03			5.62E-02	1.00E+00		4.21E-02	
117												
118	**Forest felling/clearing, total including forest transport to lokal forest store**	**m3 felled forest**	**3.19E+03**	**2.08E+00**	**2.02E-03**			**6.46E-02**	**1.15E+00**		**4.84E-02**	
119	Operation of felling machine	m3 felled forest	1.33E+03	8.66E-01	8.43E-04			2.70E-02	4.80E-01		2.02E-02	
120	Operation of timber transporter	m3 felled forest	1.86E+03	1.21E+00	1.18E-03			3.76E-02	6.70E-01		2.82E-02	
121												
122	***CO2 emission due to permanent reduction (forest felling) of biomass***	***m3 felled forest***	***1.54E+06***									
123												
124	**Production of galvanized steel**	**kg galvanized steel**	**2.21E+03**		**9.12E+00**		**1.21E+00**	**3.05E-02**	**3.90E+01**		**9.37E-03**	
125	Steel production	kg galvanized steel	2.19E+03		9.05E+00		1.19E+00	2.99E-02	3.90E+01		9.25E-03	
126	Zinc production	kg galvanized steel	2.33E+01		6.95E-02		1.40E-02	6.00E-04	4.55E-02		1.15E-04	
127												
128	**Production of Aluminium**	**kg aluminium**	**1.33E+03**	**1.40E+00**	**3.54E-03**	**2.78E-02**		**1.06E-02**	**5.53E+01**		**9.00E+00**	
129	Aluminium production	kg aluminium	1.23E+03	1.40E+00					5.53E+01		9.00E+00	
130	Electric power production for aluminium production	kg aluminium	9.61E+01		3.54E-03	2.78E-02		1.06E-02	1.77E-03			
131												
132	**Road foundation reinforcement using cement/lime columns**	**m cement/lime column**	**3.41E+04**	**9.02E-01**	**1.67E-03**	**2.46E-01**		**3.00E-02**	**1.21E+01**		**2.11E-02**	
133	Cement production	m cement/lime column	9.27E+03		6.28E-04	4.93E-03		1.88E-03	1.15E+01			
134	Quicklime production	m cement/lime column	2.34E+04		1.66E-04	2.42E-01			1.09E-01			
135	Operation of machine, diesel engine	m cement/lime column	1.39E+03	9.02E-01	8.78E-04			2.81E-02	5.00E-01		2.11E-02	
136												
137	**Road foundation reinforcement using concrete piles**	**m concrete pile**	**5.00E+04**	**5.79E-01**	**8.65E+01**	**1.66E-02**	**1.14E+01**	**3.09E-01**	**4.08E+02**		**1.02E-01**	
138	Cement production	m concrete pile	2.82E+04		1.91E-03	1.50E-02		5.73E-03	3.50E+01			
139	Steel production	m concrete pile	2.09E+04		8.65E+01		1.14E+01	2.85E-01	3.72E+02		8.84E-02	
140	Crushed aggregates production	m concrete pile	8.61E+01	5.28E-02	2.31E-04	1.41E-03		2.18E-03	2.94E-02		1.23E-03	
141	Extraction of pit-run gravel and sand	m concrete pile	4.41E+00	2.51E-03	2.28E-05	1.60E-04		1.39E-04	1.40E-03		5.86E-05	
142	Piling, operation of machine, diesel engine	m concrete pile	8.04E+02	5.23E-01	5.09E-04			1.63E-02	2.90E-01		1.22E-02	
143												
144	**Production and assembly of wildlife fences**	**m wildlife fence**	**8.54E+03**	**1.44E-01**	**3.43E+01**		**4.54E+00**	**1.19E-01**	**1.47E+02**		**3.86E-02**	
145	Production of galvanized steel	m wildlife fence	8.32E+03		3.43E+01		4.54E+00	1.14E-01	1.47E+02		3.52E-02	
146	Diesel use for assembly (putting up the fence)	m wildlife fence	2.22E+02	1.44E-01	1.41E-04			4.50E-03	8.00E-02		3.37E-03	
147												
148	**Production of hot asphalt in asphalt plant**	**tonne asphalt**	**3.44E+04**	**2.67E+00**	**1.07E-02**	**1.21E+01**		**5.54E-02**	**3.79E+00**	**1.14E+00**	**2.07E+01**	**1.20E-01**
149	Production of bitumen	tonne asphalt	1.04E+04	1.84E+00	2.12E-03	1.20E+01		6.35E-03	4.86E-01	1.14E+00	2.07E+01	1.20E-01
150	Production of crushed aggregates	tonne asphalt	1.34E+03	8.21E-01	3.59E-03	2.19E-02		3.39E-02	4.56E-01		1.92E-02	
151	Electric power for asphalt plant	tonne asphalt	1.37E+02		5.04E-03	3.96E-02		1.51E-02	2.52E-03			
152	Energy use at asphalt plant, fuel oil	tonne asphalt	2.25E+04						2.85E+00			
153												
154	**Production of cold asphalt in asphalt plant including emulsifier**	**tonne asphalt**	**1.04E+04**	**3.15E+00**	**6.31E-03**	**8.03E+00**		**7.32E-02**	**1.45E+00**	**7.60E-01**	**1.38E+01**	**8.00E-02**
155	Production of bitumen	tonne asphalt	6.91E+03	1.23E+00	1.41E-03	8.01E+00		4.23E-03	3.24E-01	7.60E-01	1.38E+01	8.00E-02
156	Production of crushed aggregates	tonne asphalt	1.37E+03	8.38E-01	3.66E-03	2.24E-02		3.46E-02	4.66E-01		1.96E-02	
157	Electric power for emulsifier	tonne asphalt	4.83E+00		1.78E-04	1.40E-03		5.33E-04	8.89E-05			
158	Energy use, fuel oil for heating of emulsifier	tonne asphalt	4.59E+02						5.81E-02			
159	Energy use, diesel oil for mobile electric power generation for asphalt plant	tonne asphalt	1.67E+03	1.08E+00	1.06E-03			3.38E-02	6.01E-01		2.53E-02	
160												
161	**Cement stabilisation of base course, slipform paver**	**m2 stabilised surface**	**9.40E+01**	**6.12E-02**	**5.95E-05**			**1.90E-03**	**3.39E-02**		**1.43E-03**	
162												
163	**Concrete road paving, wearing course including slipform paver and dowels**	**m2 concrete road**	**3.16E+03**	**2.12E-01**	**1.17E+01**		**1.55E+00**	**4.52E-02**	**5.06E+01**		**1.69E-02**	
164	Operation of slipform paver	m2 concrete road	3.25E+02	2.12E-01	2.06E-04			6.59E-03	1.17E-01		4.94E-03	

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	V	W	X	Y	Z	AA	AB	AC	AD	AE
1										**Emissions to Water**		
2			**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**	**BOD**	**COD**	**Phosphorus-total**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
165	Steel use for dowels	m2 concrete road	2.83E+03		1.17E+01		1.55E+00	3.86E-02	5.05E+01		1.20E-02	
166												
167	**Exposure of aggregate on concrete carriageway, machine operation-polyeten film**	**m2 concrete road**	**9.65E+01**	**1.03E+00**	**2.80E-05**			**8.94E-04**	**1.11E-01**	**7.14E-03**	**4.83E-02**	**2.38E-04**
168	Machine operation, diesel engine	m2 concrete road	4.42E+01	2.87E-02	2.80E-05			8.94E-04	1.59E-02		6.71E-04	
169	Polyeten film	m2 concrete road	5.24E+01	1.00E+00					9.52E-02	7.14E-03	4.76E-02	2.38E-04
170												
171	**Sawing and sealing of joints in concrete road construction**	**m2 concrete road**	**2.13E+02**	**2.54E-02**	**2.61E-01**		**1.42E+00**	**1.16E-03**	**1.71E-01**		**1.49E+00**	
172	Machine operation, diesel engine	m2 concrete road	3.90E+01	2.54E-02	2.47E-05			7.90E-04	1.41E-02		5.93E-04	
173	EPDM-rubber	m2 concrete road	1.74E+02		2.61E-01		1.42E+00	3.74E-04	1.57E-01		1.49E+00	
174												
175	**Construction of sub-base at road site**	**tonne sub-base**	**5.55E+02**	**3.61E-01**	**3.51E-04**			**1.12E-02**	**2.00E-01**		**8.42E-03**	
176												
177	**Construction of base course**	**tonne base course**	**5.55E+02**	**3.61E-01**	**3.51E-04**			**1.12E-02**	**2.00E-01**		**8.42E-03**	
178												
179	**Sub-base, loading of blasted rock with excavator**	**tonne blasted rock**	**1.62E+02**	**1.05E-01**	**1.03E-04**			**3.28E-03**	**5.84E-02**		**2.46E-03**	
180												
181	**Diesel heating (combustion) in road marking operation**	**MJ used diesel**	**7.90E+01**	**1.84E-02**					**2.05E-02**		**1.20E-03**	
182	*Diesel combustion for use in diesel burner in road marking*	*MJ used diesel*	*7.50E+01*	*1.00E-02*					*2.00E-02*			
183	Production of diesel	MJ used diesel	4.00E+00	8.40E-03					4.80E-04		1.20E-03	
184												
185	**Road marking with thermoplastic materials exclusive production of road marking materials**	**km marked väg**	**6.93E+04**	**3.58E+01**	**2.98E-02**			**9.55E-01**	**2.27E+01**		**1.05E+00**	
186	Operation of diesel vehicle	km marked väg	4.71E+04	3.07E+01	2.98E-02			9.55E-01	1.70E+01		7.16E-01	
187	Operation of diesel burner	km marked väg	2.22E+04	5.17E+00					5.75E+00		3.37E-01	
188												
189	**Excavation of sub-base and base course with excavator, excavation class 4**	**fixed m3**	**3.14E+02**	**2.05E-01**	**1.99E-04**			**6.37E-03**	**1.13E-01**		**4.78E-03**	
190												
191	**Surface milling (12 mm) of concrete road in road maintenance**	**m2 milled road area**	**5.71E+03**	**3.72E+00**	**3.62E-03**			**1.16E-01**	**2.06E+00**		**8.68E-02**	
192												
193	**Maintenance of concrete road, concrete paving in milled tracks, machine operation**	**m filled track**	**5.55E+00**	**3.61E-03**	**3.51E-06**			**1.12E-04**	**2.00E-03**		**8.42E-05**	
194												
195	**Operation of road, sweeping per km drived distance with sweeping vehicle**	**km**	**2.77E+03**	**1.80E+00**	**1.76E-03**			**5.62E-02**	**1.00E+00**		**4.21E-02**	
196												
197	**Surface milling of asphalt layer per area unit**	**m2 milled road area**	**1.23E+02**	**8.02E-02**	**7.80E-05**			**2.50E-03**	**4.44E-02**		**1.87E-03**	

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	AF	AG	AH	AI	AJ	AK	AL	AM
1							Waste			Radioactive waste
2			Nitrogen-total	HC	Oil	Phenol	Total	Landfillled	Hazardous chemical waste	Highly active
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**cm3**
4										
5	***Production of electric power, Swedish average***	***MJ electricity***					***7.00E-02***	***7.00E-02***		***1.40E-03***
6										
7	***Production of (Precombustion) diesel and fuel oil***	***MJ crude oil to production***	***1.90E-04***		***4.00E-04***	***5.70E-04***				
8										
9	***Distribution truck (14 tonne load)***	***MJ used diesel***								
10										
11	***Long distance truck (32 tonne load)***	***MJ used diesel***								
12										
13	***Production of quicklime (CaO)***	***kg CaO***					***1.00E-03***	***1.00E-03***		***2.00E-04***
14										
15	***Production of polyeten plastic***	***kg polyethen plastic***	***2.00E-02***		***1.00E-01***	***1.00E-03***	***3.21E+01***	***3.21E+01***		
16										
17	***Production of rock salt (coal based)***	***tonne salt***								
18										
19	***Production of EPDM-rubber***	***kg EPDM***	***4.00E-02***							
20										
21	***Aluminium production***	***kg Aluminium***					***5.00E-02***	***5.00E-02***		
22										
23	***Production of steel***	***kg steel***	***7.47E-03***							
24										
25	***Production of zink for galvanization***	***kg zinc***	***1.70E-02***							
26										
27	***Combustion of fuel oil with fuel oil burner***	***MJ used fuel oil***								
28										
29										
30	**Truck transport, distribution truck outside urban area (14 tonne load), full load, empty on return**	**vkm**	**2.27E-03**		**4.77E-03**	**6.80E-03**				
31	Distribution truck (14 tonne load)	vkm								
32	Production of diesel	vkm	2.27E-03		4.77E-03	6.80E-03				
33										
34	**Truck transport, long distance truck, rural roads (32 tonne load), full load, empty on return**	**vkm**	**2.53E-03**		**5.34E-03**	**7.60E-03**				
35	Long distance truck (32 tonne load)	vkm								
36	Production of diesel	vkm	2.53E-03		5.34E-03	7.60E-03				
37										
38	**Ship transport, coast freight**	**tonne,km**	**2.47E-05**		**5.20E-05**	**7.41E-05**				
39	*Ship transport, operation of the ship(engine data)*	*tonne,km*								
40	Production of diesel	tonne,km	2.47E-05		5.20E-05	7.41E-05				
41										
42	**General road construction equipment (excavators, wheel loader etc.), diesel driven**	**MJ used diesel**	**1.90E-04**		**4.00E-04**	**5.70E-04**				
43	*Equipment in operation, diesel driven (engine data)*	MJ used diesel								
44	Production of diesel	MJ used diesel	1.90E-04		4.00E-04	5.70E-04				
45										
46	**Wheel loader in truck loading operation, depends on excavation class**	**fixed m3 loaded material**	**5.70E-04**		**1.20E-03**	**1.71E-03**				
47										
48	**Excavator in truck loading operation, depends on excavation class**	**fixed m3 loaded material**	**6.31E-04**		**1.33E-03**	**1.89E-03**				
49										
50	**Dumper truck transport, depends on driving conditions at driving site**	**loose m3, km**	**1.29E-03**		**2.71E-03**	**3.86E-03**				
51										
52	**Compacting (ground, base course etc.) with roller, for one layer**	**m2 compacted surface**	**1.19E-04**		**2.51E-04**	**3.58E-04**				
53										
54	**Asphalt rolling, for one layer**	**m2 asphalt surface**	**1.52E-04**		**3.20E-04**	**4.55E-04**				
55										
56	**Asphalt paving, for one layer of asphalt**	**m2 asphalt surface**	**1.13E-04**		**2.38E-04**	**3.39E-04**				

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	AF	AG	AH	AI	AJ	AK	AL	AM
1							**Waste**			**Radioactive waste**
2			**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**	**Hazardous chemical waste**	**Highly active**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**cm3**
57										
58	**Production of bitumen**	**tonne bitumen**	**5.03E+00**	**2.00E+00**	**6.52E-02**	**8.37E-02**	**2.81E+02**	**1.76E+01**	**2.63E+02**	**3.53E-01**
59	*Crude oil extraction in Venezuela, Laguna*	*tonne bitumen*								
60	*Bitumen production, refining from local store excluding electric power generation*	*tonne bitumen*	*5.00E+00*	*2.00E+00*			*2.63E+02*		*2.63E+02*	
61	*Transport of crude oil to refinery*	*tonne bitumen*								
62	Production of electric power to refinery	tonne bitumen					6.30E+00	6.30E+00		1.26E-01
63	*Transport (ship) of bitumen from raffinery to local store excluding precombustion*	*tonne bitumen*								
64	Precombustion for diesel to ship transport from refinary to local store	tonne bitumen	2.76E-02		5.80E-02	8.27E-02				
65	*Store of bitumen at local store including precombustion but excluding electric power production*	*tonne bitumen*	*3.42E-03*		*7.20E-03*	*1.03E-03*				
66	Production of electric power for local bitumen store	tonne bitumen					1.13E+01	1.13E+01		2.27E-01
67										
68	**Application of adhesion layer (emulsion)**	**m2 applied surface**	**2.52E-04**	**1.00E-04**	**4.74E-06**	**6.29E-06**	**1.40E-02**	**8.82E-04**	**1.32E-02**	**1.76E-05**
69	Bitumen use	m2 applied surface	2.52E-04	1.00E-04	3.26E-06	4.18E-06	1.40E-02	8.82E-04	1.32E-02	1.76E-05
70	Operation of application equipment (diesel driven)	m2 applied surface	7.01E-07		1.48E-06	2.10E-06				
71										
72	**Production of crushed aggregates**	**tonne prod. crushed aggregates**	**3.23E-03**		**6.80E-03**	**9.68E-03**	**1.48E+00**	**1.48E+00**		**2.97E-02**
73	Operation of machines and transport vehicles, diesel, and resource materials in production of crushed aggregates	tonne prod. crushed aggregates	3.23E-03		6.80E-03	9.68E-03				
74	Electric power production for production of crushed aggregates	tonne prod. crushed aggregates					1.48E+00	1.48E+00		2.97E-02
75										
76	**Extraction of pit-run graval and sand**	**tonne prod. gravel/sand**	**1.53E-04**		**3.23E-04**	**4.60E-04**	**1.68E-01**	**1.68E-01**		**3.36E-03**
77	Operation of wheel loader (diesel), excavation class 2 and resource materials	tonne prod. gravel/sand	1.53E-04		3.23E-04	4.60E-04				
78	Electric power production for production of pit-run gravel and sand	tonne prod. gravel/sand					1.68E-01	1.68E-01		3.36E-03
79										
80	**Production of cement**	**kg cement**					**2.73E-02**	**2.73E-02**		**5.46E-04**
81	Production of cement	kg cement								
82	Electric power production for production of cement	kg cement					2.73E-02	2.73E-02		5.46E-04
83										
84	**Concrete production**	**m3 produced concrete**	**1.32E-02**		**2.79E-02**	**3.97E-02**	**1.40E+01**	**1.40E+01**		**2.80E-01**
85	Cement use	m3 produced concrete					1.09E+01	1.09E+01		2.18E-01
86	Use of crushed aggregates	m3 produced concrete	3.87E-03		8.16E-03	1.16E-02	1.78E+00	1.78E+00		3.56E-02
87	Use of pit-run gravel and sand	m3 produced concrete	1.07E-04		2.26E-04	3.22E-04	1.18E-01	1.18E-01		2.35E-03
88	Diesel use for vehicles and machines	m3 produced concrete	9.25E-03		1.95E-02	2.77E-02				
89	Electric power for concrete production	m3 produced concrete					1.17E+00	1.17E+00		2.34E-02
90										
91	**Sand gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**	**9.44E-03**		**1.99E-02**	**2.83E-02**	**1.29E+00**	**1.29E+00**		**2.58E-02**
92	Operation of vehicle, distribution truck	for this road objekt per gritting operation	6.80E-03		1.43E-02	2.04E-02				
93	Sand use, cruched material	for this road objekt per gritting operation	2.52E-03		5.30E-03	7.55E-03	1.16E+00	1.16E+00		2.31E-02
94	Sand use, natural occuring material	for this road objekt per gritting operation	1.20E-04		2.52E-04	3.59E-04	1.31E-01	1.31E-01		2.62E-03
95										
96	**Salt gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**	6.80E-03		1.43E-02	2.04E-02				
97	Operation of vehicle, distribution truck	for this road objekt per gritting operation	6.80E-03		1.43E-02	2.04E-02				
98	Salt use, coal based rock salt	for this road objekt per gritting operation								
99										
100	**Snow clearance, snow clearance truck per drived distance**	**km**	**2.95E-03**		**6.21E-03**	**8.84E-03**				
101										
102	**Mowing of verges per km mowed verge. Mowing width is 1.5 m**	**km mowed verge**	**8.80E-03**		**1.85E-02**	**2.64E-02**				
103										
104	**Clearing of verges per km cleared verge. Clearing width is 1.2 m**	**km cleared verge**	**1.76E-02**		**3.70E-02**	**5.28E-02**				
105										
106	**Road trench digging**	**m digged trench**	**3.36E-03**		**7.06E-03**	**1.01E-02**				
107	Transport of excavated materials	m digged trench	1.83E-03		3.85E-03	5.48E-03				
108	Operation of excavator	m digged trench	1.53E-03		3.22E-03	4.58E-03				
109										

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	A	B	AF	AG	AH	AI	AJ	AK	AL	AM
1							**Waste**			**Radioactive waste**
2			**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**	**Hazardous chemical waste**	**Highly active**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**cm3**
110	**Erection and removal of snow posts**	**km roadside**	**3.67E-02**		**7.72E-02**	**1.10E-01**				
111	Erection of snow posts	km roadside	2.13E-02		4.49E-02	6.40E-02				
112	Removal of snow posts	km roadside	1.53E-02		3.23E-02	4.60E-02				
113										
114	**Washing of road signs per km roadside**	**km roadside**	**1.07E-02**		**2.25E-02**	**3.20E-02**				
115										
116	**Washing of roadside posts per km roadside**	**km roadside**	6.67E-03		1.40E-02	2.00E-02				
117										
118	**Forest felling/clearing, total including forest transport to lokal forest store**	**m3 felled forest**	**7.67E-03**		**1.61E-02**	**2.30E-02**				
119	Operation of felling machine	m3 felled forest	3.20E-03		6.74E-03	9.60E-03				
120	Operation of timber transporter	m3 felled forest	4.47E-03		9.41E-03	1.34E-02				
121										
122	***CO2 emission due to permanent reduction (forest felling) of biomass***	***m3 felled forest***								
123										
124	**Production of galvanized steel**	**kg galvanized steel**	**7.52E-03**							
125	Steel production	kg galvanized steel	7.43E-03							
126	Zinc production	kg galvanized steel	8.50E-05							
127										
128	**Production of Aluminium**	**kg aluminium**					**1.82E+00**	**1.82E+00**		**3.54E-02**
129	Aluminium production	kg aluminium					5.00E-02	5.00E-02		
130	Electric power production for aluminium production	kg aluminium					1.77E+00	1.77E+00		3.54E-02
131										
132	**Road foundation reinforcement using cement/lime columns**	**m cement/lime column**	**3.33E-03**		**7.02E-03**	**1.00E-02**	**3.25E-01**	**3.25E-01**		**8.58E-03**
133	Cement production	m cement/lime column					3.14E-01	3.14E-01		6.28E-03
134	Quicklime production	m cement/lime column					1.15E-02	1.15E-02		2.30E-03
135	Operation of machine, diesel engine	m cement/lime column	3.33E-03		7.02E-03	1.00E-02				
136										
137	**Road foundation reinforcement using concrete piles**	**m concrete pile**	**7.31E-02**		**4.50E-03**	**6.42E-03**	**1.06E+00**	**1.06E+00**		**2.11E-02**
138	Cement production	m concrete pile					9.56E-01	9.56E-01		1.91E-02
139	Steel production	m concrete pile	7.10E-02							
140	Crushed aggregates production	m concrete pile	1.95E-04		4.11E-04	5.86E-04	8.97E-02	8.97E-02		1.79E-03
141	Extraction of pit-run gravel and sand	m concrete pile	9.28E-06		1.95E-05	2.78E-05	1.02E-02	1.02E-02		2.03E-04
142	Piling, operation of machine, diesel engine	m concrete pile	1.93E-03		4.07E-03	5.80E-03				
143										
144	**Production and assembly of wildlife fences**	**m wildlife fence**	**2.88E-02**		**1.12E-03**	**1.60E-03**				
145	Production of galvanized steel	m wildlife fence	2.83E-02							
146	Diesel use for assembly (putting up the fence)	m wildlife fence	5.34E-04		1.12E-03	1.60E-03				
147										
148	**Production of hot asphalt in asphalt plant**	**tonne asphalt**	**3.05E-01**	**1.20E-01**	**1.03E-02**	**1.41E-02**	**2.08E+01**	**4.97E+00**	**1.58E+01**	**9.95E-02**
149	Production of bitumen	tonne asphalt	3.02E-01	1.20E-01	3.91E-03	5.02E-03	1.68E+01	1.06E+00	1.58E+01	2.12E-02
150	Production of crushed aggregates	tonne asphalt	3.03E-03		6.39E-03	9.10E-03	1.39E+00	1.39E+00		2.79E-02
151	Electric power for asphalt plant	tonne asphalt					2.52E+00	2.52E+00		5.04E-02
152	Energy use at asphalt plant, fuel oil	tonne asphalt								
153										
154	**Production of cold asphalt in asphalt plant including emulsifier**	**tonne asphalt**	**2.08E-01**	**8.00E-02**	**1.76E-02**	**2.47E-02**	**1.27E+01**	**2.22E+00**	**1.05E+01**	**4.44E-02**
155	Production of bitumen	tonne asphalt	2.01E-01	8.00E-02	2.61E-03	3.35E-03	1.12E+01	7.06E-01	1.05E+01	1.41E-02
156	Production of crushed aggregates	tonne asphalt	3.10E-03		6.52E-03	9.30E-03	1.42E+00	1.42E+00		2.85E-02
157	Electric power for emulsifier	tonne asphalt					8.89E-02	8.89E-02		1.78E-03
158	Energy use, fuel oil for heating of emulsifier	tonne asphalt								
159	Energy use, diesel oil for mobile electric power generation for asphalt plant	tonne asphalt	4.01E-03		8.44E-03	1.20E-02				
160										
161	**Cement stabilisation of base course, slipform paver**	**m2 stabilised surface**	**2.26E-04**		**4.76E-04**	**6.78E-04**				
162										
163	**Concrete road paving, wearing course including slipform paver and dowels**	**m2 concrete road**	**1.04E-02**		**1.65E-03**	**2.35E-03**				
164	Operation of slipform paver	m2 concrete road	7.83E-04		1.65E-03	2.35E-03				

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	A	B	AF	AG	AH	AI	AJ	AK	AL	AM
1							**Waste**			**Radioactive waste**
2			**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**	**Hazardous chemical waste**	**Highly active**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**cm3**
165	Steel use for dowels	m2 concrete road	9.62E-03							
166										
167	**Exposure of aggregate on concrete carriageway, machine operation-polyeten film**	**m2 concrete road**	**1.06E-03**		**4.98E-03**	**3.66E-04**	**1.53E+00**	**1.53E+00**		
168	Machine operation, diesel engine	m2 concrete road	1.06E-04		2.24E-04	3.19E-04				
169	Polyeten film	m2 concrete road	9.52E-04		4.76E-03	4.76E-05	1.53E+00	1.53E+00		
170										
171	**Sawing and sealing of joints in concrete road construction**	**m2 concrete road**	**3.08E-03**		**1.98E-04**	**2.82E-04**				
172	Machine operation, diesel engine	m2 concrete road	9.39E-05		1.98E-04	2.82E-04				
173	EPDM-rubber	m2 concrete road	2.99E-03							
174										
175	**Construction of sub-base at road site**	**tonne sub-base**	**1.33E-03**		**2.81E-03**	**4.00E-03**				
176										
177	**Construction of base course**	**tonne base course**	**1.33E-03**		**2.81E-03**	**4.00E-03**				
178										
179	**Sub-base, loading of blasted rock with excavator**	**tonne blasted rock**	**3.90E-04**		**8.20E-04**	**1.17E-03**				
180										
181	**Diesel heating (combustion) in road marking operation**	**MJ used diesel**	**1.90E-04**		**4.00E-04**	**5.70E-04**				
182	*Diesel combustion for use in diesel burner in road marking*	*MJ used diesel*								
183	Production of diesel	MJ used diesel	1.90E-04		4.00E-04	5.70E-04				
184										
185	**Road marking with thermoplastic materials exclusive production of road marking materials**	**km marked väg**	**1.67E-01**		**3.51E-01**	**5.00E-01**				
186	Operation of diesel vehicle	km marked väg	1.13E-01		2.39E-01	3.40E-01				
187	Operation of diesel burner	km marked väg	5.34E-02		1.12E-01	1.60E-01				
188										
189	**Excavation of sub-base and base course with excavator, excavation class 4**	**fixed m3**	**7.56E-04**		**1.59E-03**	**2.27E-03**				
190										
191	**Surface milling (12 mm) of concrete road in road maintenance**	**m2 milled road area**	**1.37E-02**		**2.89E-02**	**4.12E-02**				
192										
193	**Maintenance of concrete road, concrete paving in milled tracks, machine operation**	**m filled track**	**1.33E-05**		**2.81E-05**	**4.00E-05**				
194										
195	**Operation of road, sweeping per km drived distance with sweeping vehicle**	**km**	**6.67E-03**		**1.40E-02**	**2.00E-02**				
196										
197	**Surface milling of asphalt layer per area unit**	**m2 milled road area**	**2.96E-04**		**6.24E-04**	**8.89E-04**				

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	AN	AO	AP
1					
2			**Medium and low active**	**Demolition waste**	**Radioactive exposure**
3	**Activity**	**Per unit**	**cm3**	**cm3**	**manSv**
4					
5	***Production of electric power, Swedish average***	***MJ electricity***	***1.50E-02***	***1.50E-02***	***1.00E-10***
6					
7	***Production of (Precombustion) diesel and fuel oil***	***MJ crude oil to production***			
8					
9	***Distribution truck (14 tonne load)***	***MJ used diesel***			
10					
11	***Long distance truck (32 tonne load)***	***MJ used diesel***			
12					
13	***Production of quicklime (CaO)***	***kg CaO***	***2.20E-03***	***2.20E-03***	***1.44E-11***
14					
15	***Production of polyeten plastic***	***kg polyethen plastic***			
16					
17	***Production of rock salt (coal based)***	***tonne salt***			
18					
19	***Production of EPDM-rubber***	***kg EPDM***			
20					
21	***Aluminium production***	***kg Aluminium***			
22					
23	***Production of steel***	***kg steel***			
24					
25	***Production of zink for galvanization***	***kg zinc***			
26					
27	***Combustion of fuel oil with fuel oil burner***	***MJ used fuel oil***			
28					
29					
30	**Truck transport, distribution truck outside urban area (14 tonne load), full load, empty on return**	**vkm**			
31	Distribution truck (14 tonne load)	vkm			
32	Production of diesel	vkm			
33					
34	**Truck transport, long distance truck, rural roads (32 tonne load), full load, empty on return**	**vkm**			
35	Long distance truck (32 tonne load)	vkm			
36	Production of diesel	vkm			
37					
38	**Ship transport, coast freight**	**tonne,km**			
39	*Ship transport, operation of the ship(engine data)*	*tonne,km*			
40	Production of diesel	tonne,km			
41					
42	**General road construction equipment (excavators, wheel loader etc.), diesel driven**	**MJ used diesel**			
43	*Equipment in operation, diesel driven (engine data)*	MJ used diesel			
44	Production of diesel	MJ used diesel			
45					
46	**Wheel loader in truck loading operation, depends on excavation class**	**fixed m3 loaded material**			
47					
48	**Excavator in truck loading operation, depends on excavation class**	**fixed m3 loaded material**			
49					
50	**Dumper truck transport, depends on driving conditions at driving site**	**loose m3, km**			
51					
52	**Compacting (ground, base course etc.) with roller, for one layer**	**m2 compacted surface**			
53					
54	**Asphalt rolling, for one layer**	**m2 asphalt surface**			
55					
56	**Asphalt paving, for one layer of asphalt**	**m2 asphalt surface**			

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	AN	AO	AP
1					
2			**Medium and low active**	**Demolition waste**	**Radioactive exposure**
3	**Activity**	**Per unit**	**cm3**	**cm3**	**manSv**
57					
58	**Production of bitumen**	**tonne bitumen**	**3.78E+00**	**3.78E+00**	**2.52E-08**
59	*Crude oil extraction in Venezuela, Laguna*	*tonne bitumen*			
60	*Bitumen production, refining from local store excluding electric power generation*	*tonne bitumen*			
61	*Transport of crude oil to refinery*	*tonne bitumen*			
62	Production of electric power to refinery	tonne bitumen	1.35E+00	1.35E+00	9.00E-09
63	*Transport (ship) of bitumen from raffinery to local store excluding precombustion*	*tonne bitumen*			
64	Precombustion for diesel to ship transport from refinary to local store	tonne bitumen			
65	*Store of bitumen at local store including precombustion but excluding electric power production*	*tonne bitumen*			
66	Production of electric power for local bitumen store	tonne bitumen	2.43E+00	2.43E+00	1.62E-08
67					
68	**Application of adhesion layer (emulsion)**	**m2 applied surface**	**1.89E-04**	**1.89E-04**	**1.26E-12**
69	Bitumen use	m2 applied surface	1.89E-04	1.89E-04	1.26E-12
70	Operation of application equipment (diesel driven)	m2 applied surface			
71					
72	**Production of crushed aggregates**	**tonne prod. crushed aggregates**	**3.18E-01**	**3.18E-01**	**2.12E-09**
73	Operation of machines and transport vehicles, diesel, and resource materials in production of crushed aggregates	tonne prod. crushed aggregates			
74	Electric power production for production of crushed aggregates	tonne prod. crushed aggregates	3.18E-01	3.18E-01	2.12E-09
75					
76	**Extraction of pit-run graval and sand**	**tonne prod. gravel/sand**	**3.60E-02**	**3.60E-02**	**2.40E-10**
77	Operation of wheel loader (diesel), excavation class 2 and resource materials	tonne prod. gravel/sand			
78	Electric power production for production of pit-run gravel and sand	tonne prod. gravel/sand	3.60E-02	3.60E-02	2.40E-10
79					
80	**Production of cement**	**kg cement**	**5.85E-03**	**5.85E-03**	**3.90E-11**
81	Production of cement	kg cement			
82	Electric power production for production of cement	kg cement	5.85E-03	5.85E-03	3.90E-11
83					
84	**Concrete production**	**m3 produced concrete**	**3.00E+00**	**3.00E+00**	**2.00E-08**
85	Cement use	m3 produced concrete	2.34E+00	2.34E+00	1.56E-08
86	Use of crushed aggregates	m3 produced concrete	3.81E-01	3.81E-01	2.54E-09
87	Use of pit-run gravel and sand	m3 produced concrete	2.52E-02	2.52E-02	1.68E-10
88	Diesel use for vehicles and machines	m3 produced concrete			
89	Electric power for concrete production	m3 produced concrete	2.51E-01	2.51E-01	1.67E-09
90					
91	**Sand gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**	**2.76E-01**	**2.76E-01**	**1.84E-09**
92	Operation of vehicle, distribution truck	for this road objekt per gritting operation			
93	Sand use, cruched material	for this road objekt per gritting operation	2.48E-01	2.48E-01	1.65E-09
94	Sand use, natural occuring material	for this road objekt per gritting operation	2.81E-02	2.81E-02	1.87E-10
95					
96	**Salt gritting of road in winter road maintenance per gritting operation**	**for this road objekt per gritting operation**			
97	Operation of vehicle, distribution truck	for this road objekt per gritting operation			
98	Salt use, coal based rock salt	for this road objekt per gritting operation			
99					
100	**Snow clearance, snow clearance truck per drived distance**	**km**			
101					
102	**Mowing of verges per km mowed verge. Mowing width is 1.5 m**	**km mowed verge**			
103					
104	**Clearing of verges per km cleared verge. Clearing width is 1.2 m**	**km cleared verge**			
105					
106	**Road trench digging**	**m digged trench**			
107	Transport of excavated materials	m digged trench			
108	Operation of excavator	m digged trench			
109					

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	AN	AO	AP
1					
2			**Medium and low active**	**Demolition waste**	**Radioactive exposure**
3	**Activity**	**Per unit**	**cm3**	**cm3**	**manSv**
110	**Erection and removal of snow posts**	**km roadside**			
111	Erection of snow posts	km roadside			
112	Removal of snow posts	km roadside			
113					
114	**Washing of road signs per km roadside**	**km roadside**			
115					
116	**Washing of roadside posts per km roadside**	**km roadside**			
117					
118	**Forest felling/clearing, total including forest transport to lokal forest store**	**m3 felled forest**			
119	Operation of felling machine	m3 felled forest			
120	Operation of timber transporter	m3 felled forest			
121					
122	***CO2 emission due to permanent reduction (forest felling) of biomass***	***m3 felled forest***			
123					
124	**Production of galvanized steel**	**kg galvanized steel**			
125	Steel production	kg galvanized steel			
126	Zinc production	kg galvanized steel			
127					
128	**Production of Aluminium**	**kg aluminium**	**3.80E-01**	**3.80E-01**	**2.53E-09**
129	Aluminium production	kg aluminium			
130	Electric power production for aluminium production	kg aluminium	3.80E-01	3.80E-01	2.53E-09
131					
132	**Road foundation reinforcement using cement/lime columns**	**m cement/lime column**	**9.26E-02**	**9.26E-02**	**6.14E-10**
133	Cement production	m cement/lime column	6.73E-02	6.73E-02	4.49E-10
134	Quicklime production	m cement/lime column	2.53E-02	2.53E-02	1.66E-10
135	Operation of machine, diesel engine	m cement/lime column			
136					
137	**Road foundation reinforcement using concrete piles**	**m concrete pile**	**2.26E-01**	**2.26E-01**	**1.51E-09**
138	Cement production	m concrete pile	2.05E-01	2.05E-01	1.37E-09
139	Steel production	m concrete pile			
140	Crushed aggregates production	m concrete pile	1.92E-02	1.92E-02	1.28E-10
141	Extraction of pit-run gravel and sand	m concrete pile	2.18E-03	2.18E-03	1.45E-11
142	Piling, operation of machine, diesel engine	m concrete pile			
143					
144	**Production and assembly of wildlife fences**	**m wildlife fence**			
145	Production of galvanized steel	m wildlife fence			
146	Diesel use for assembly (putting up the fence)	m wildlife fence			
147					
148	**Production of hot asphalt in asphalt plant**	**tonne asphalt**	**1.07E+00**	**1.07E+00**	**7.10E-09**
149	Production of bitumen	tonne asphalt	2.27E-01	2.27E-01	1.51E-09
150	Production of crushed aggregates	tonne asphalt	2.99E-01	2.99E-01	1.99E-09
151	Electric power for asphalt plant	tonne asphalt	5.40E-01	5.40E-01	3.60E-09
152	Energy use at asphalt plant, fuel oil	tonne asphalt			
153					
154	**Production of cold asphalt in asphalt plant including emulsifier**	**tonne asphalt**	**4.75E-01**	**4.75E-01**	**3.17E-09**
155	Production of bitumen	tonne asphalt	1.51E-01	1.51E-01	1.01E-09
156	Production of crushed aggregates	tonne asphalt	3.05E-01	3.05E-01	2.03E-09
157	Electric power for emulsifier	tonne asphalt	1.91E-02	1.91E-02	1.27E-10
158	Energy use, fuel oil for heating of emulsifier	tonne asphalt			
159	Energy use, diesel oil for mobile electric power generation for asphalt plant	tonne asphalt			
160					
161	**Cement stabilisation of base course, slipform paver**	**m2 stabilised surface**			
162					
163	**Concrete road paving, wearing course including slipform paver and dowels**	**m2 concrete road**			
164	Operation of slipform paver	m2 concrete road			

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	AN	AO	AP
1					
2			**Medium and low active**	**Demolition waste**	**Radioactive exposure**
3	**Activity**	**Per unit**	**cm3**	**cm3**	**manSv**
165	Steel use for dowels	m2 concrete road			
166					
167	**Exposure of aggregate on concrete carriageway, machine operation-polyeten film**	**m2 concrete road**			
168	Machine operation, diesel engine	m2 concrete road			
169	Polyeten film	m2 concrete road			
170					
171	**Sawing and sealing of joints in concrete road construction**	**m2 concrete road**			
172	Machine operation, diesel engine	m2 concrete road			
173	EPDM-rubber	m2 concrete road			
174					
175	**Construction of sub-base at road site**	**tonne sub-base**			
176					
177	**Construction of base course**	**tonne base course**			
178					
179	**Sub-base, loading of blasted rock with excavator**	**tonne blasted rock**			
180					
181	**Diesel heating (combustion) in road marking operation**	**MJ used diesel**			
182	*Diesel combustion for use in diesel burner in road marking*	*MJ used diesel*			
183	Production of diesel	MJ used diesel			
184					
185	**Road marking with thermoplastic materials exclusive production of road marking materials**	**km marked väg**			
186	Operation of diesel vehicle	km marked väg			
187	Operation of diesel burner	km marked väg			
188					
189	**Excavation of sub-base and base course with excavator, excavation class 4**	**fixed m3**			
190					
191	**Surface milling (12 mm) of concrete road in road maintenance**	**m2 milled road area**			
192					
193	**Maintenance of concrete road, concrete paving in milled tracks, machine operation**	**m filled track**			
194					
195	**Operation of road, sweeping per km drived distance with sweeping vehicle**	**km**			
196					
197	**Surface milling of asphalt layer per area unit**	**m2 milled road area**			

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C
1	**Emissions, energy use and materials for a road**		
2	**Model variables**	**Value**	**Unit**
3	Energy use, distribution truck, outside urban areas (14 tonne load), full load and emty on return	11.934	MJ/vkm
4	Energy use, long-distance truck rural roads (32 tonne load), full load and emty on return	13.338	MJ/vkm
5	Ship transport, costal freight, energy use	0.13	MJ/tonne,km
6	Wheel loader, energy use in loading, per loaded unit (loaded m3)	3	MJ/m3
7	Excavator, energy use in truck loading, per produced unit (loaded m3)	3.32	MJ/m3
8	Dumper truck transport, energy use per transport work	6.77	MJ/Lm3,km
9	Soil (base cource etc.) compaction with rollers, energy use per asphalt area, one layer	0.6281	MJ/m2
10	Asphalt compaction with rollers, energy use per asphalt area, one layer	0.7988	MJ/m2
11	Asphalt paving wiht asphalt paver, energy use per asphalt area, one layer	0.594	MJ/m2
12	Bitumen use in adhesion layer application per area unit	0.05	kg/m2
13	Energy use, diesel, in adhesion layer application per area unit	0.00369	MJ/m2
14	Energy use, diesel, for transport vehicles at production of crushed aggregates	16.99	MJ/tonne crushed aggregates
15	Electric power use in the production of crushed aggregates	21.19	MJ/tonne crushed aggregates
16	Operation of diesel vehicles for extraction of pit-run gravel/sand	0.807	MJ/tonne gravel/sand
17	Electric power use in extraction of pit-run gravel/sand	2.398	MJ/tonne gravel/sand
18	Concrete for road construction, cement use	400	kg/m3 produced concrete
19	Concrete for road construction, use of crushed aggregates	1200	kg/m3 produced concrete
20	Concrete for road construction, use of pit-run gravel/sand	700	kg/m3 produced concrete
21	Concrete for road construction, diesel use	48.68	MJ/m3 produced concrete
22	Concrete for road construction, electric power use	16.72	MJ/m3 produced concrete
23	Sand gritting of road, amount of sand used per area unit	120	g/m2 sand gritted area
24	Sand gritting of road, gritted road area	13000	m2
25	Sand gritting of road, share of crushed materials (sand) used	50	%
26	Sand gritting of road, total vehicle (truck) distance in the sand gritting process including transport to and from the gritting road site	3	km
27	Salt gritting of road, amount of salt used per area unit	10	g/m2 salt gritted
28	Salt gritting of road, gritted road area	13000	m2
29	Salt gritting of road, total vehicle (truck) distance in the salt gritting process including transport to and from the gritting road site	3	km
30	Mowing of verges, energy use per km mowed verge. Mowing width is 1.5 m	46.3	MJ/km mowed roadside
31	Clearing of verges, energy use per km cleared verge. Clearing width is 1.2 m	92.6	MJ/km cleared roadside
32	Road trench digging, energy use for transport of excavated materials	9.62	MJ/m digged trench
33	Road trench digging, energy use for excavation	8.04	MJ/m digged trench
34	Erection of snow posts, energy use per km roadside	112.3	MJ/km roadside
35	Removal of snow posts, energy use per km roadside	80.7	MJ/km roadside
36	Washing of road signs, energy use per km roadside	56.2	MJ/km roadside
37	Washing of roadside posts, energy use per km roadside	35.1	MJ/km roadside
38	Felling/clearing of forest, energy use for felling/clearing machine per m3 felled timber	16.85	MJ/m3 felled forest
39	Felling/clearing of forest, energy use for transport equipment for transport from forest to local forest store per m3 felled timber	23.52	MJ/m3 felled forest
40	Cement/lime column, cement use per m cement/lime column	11.5	kg/m cement/lime column
41	Cement/lime column, quicklime use per m cement/lime column	11.5	kg/m cement/lime column
42	Cement/lime column, energy use, diesel, per m cement/lime column	17.55	MJ/m cement/lime column
43	Concrete pile, cement use per m concrete pile	35	kg/m concrete pile
44	Concrete pile, steel use per m concrete pile	9.5	kg/m concrete pile
45	Concrete pile, use of crushed aggregates per m concrete pile	60.5	kg/m concrete pile
46	Concrete pile, use of pit-run graval/sand per m concrete pile	60.5	kg/m concrete pile
47	Concrete pile, energy use for piling, diesel, per m concrete pile	10.18	MJ/m concrete pile
48	Wildlife fence, use of galvanized steel per m fence	3.76	kg/m wildlife fence
49	Wildlife fence, energy use, diesel, for putting up the fence per m wildlife fence	2.81	MJ/m wildlife fence
50	Hot asphalt, bitumen content per tonne asphalt	0.06	tonne/tonne asphalt
51	Hot asphalt, content of crushed aggregates per tonne asphalt	0.94	tonne/tonne asphalt
52	Hot asphalt, electric power use for asphalt plant per tonne asphalt	36	MJ/tonne asphalt
53	Hot asphalt, use of fuel oil for asphalt plant per tonne asphalt	285	MJ/tonne asphalt
54	Cold asphalt, bitumen content per tonne asphalt	0.04	tonne/tonne asphalt
55	Cold asphalt, content of crushed aggregates per tonne asphalt	0.96	tonne/tonne asphalt
56	Cold asphalt, electric power use for emulsifier per tonne asphalt	1.27	MJ/tonne asphalt
57	Cold asphalt, fuel oil for heating of emulsifier per tonne asphalt	5.81	MJ/tonne asphalt
58	Cold asphalt, diesel use for electric power generation in mobile generator at the asphalt plant per tonne asphalt	21.1	MJ/tonne asphalt
59	Cement stabilisation of base course in concrete road construction, energy use for paving machine	1.19	MJ/m2 stabilised surface
60	Concrete paving of wearing course, energy use for slipform paver per m2 concrete road	4.12	MJ/m2 concrete road
61	Concrete paving of wearing course, steel use for reinforcement bars (dowels) per m2 concrete road	1.288	kg/m2 concrete road
62	Concrete road, exposure of aggregate on concrete carriageway, energy use, diesel driven machine per m2 concrete road	0.559	MJ/m2 concrete road
63	Concrete road, exposure of aggregate on concrete carriageway, use of polyeten film per m2 concrete road	0.0476	kg/m2 concrete road
64	Sawing and sealing of joints in concrete road construction, energy use, diesel driven machine per m2 concrete road	0.494	MJ/m2 concrete road
65	Sawing and sealing of joints in concrete road construction, use of EPDM-rubber for sealing of joints per m2 concrete road	0.0747	kg/m2 concrete road
66	Construction of sub-base, energy use in MJ/tonne	7.02	MJ/tonne
67	Construction of base course, energy use i MJ/tonne	7.02	MJ/tonne
68	Loading of blasted rock with excavator, energy use in MJ/tonne blasted rock	2.05	MJ/tonne
69	Road marking, energy use for application vehicle in MJ/km marked road	596.7	MJ/km marked road
70	Road marking, energy use for diesel heater in MJ/km marked road	280.8	MJ/km marked road
71	Surface milling (12 mm) of concrete road in maintenance, energy use in MJ/m2 milled road area	72.31	MJ/m2 milled road surface
72	Concrete road maintenance, energy use for concrete filling of milled road tracks in MJ/m tracks	0.0702	MJ/m
73	Operation of road, energy use for general road sweeping, MJ/km for sweeping vehicle	35.1	MJ/km
74	Maintenance of road, milling of asphalt surface, energy use per area unit	1.56	MJ/m2 milled road surface

	A	B	C	D	E	F
1	Active calculation field:					
2				*Stored road scenarios*		
3	**Emissions, energy use and materials for a road**	**Asphalt road, 13 m, hot method**		**Concrete road, 13 m**	**Asphalt road, 13 m, hot method**	**Asphalt road, 13 m, cold method**
4	**Model variables**	**Value**	**Unit**	**Value**	**Value**	**Value**
5	Life-time of the road	40	years	40	40	40
6	Wood felling for road construction in m3 felled wood	660	m3	660	660	660
7	Share of the wood felling work that has been allocated to the road in %	10	%	10	10	10
8	Amount of excavated materials that has to be moved within the construction site in the direction of the road in m3 fixed volume	100000	m3	100000	100000	100000
9	Transport distance of excavated materials that has to be moved within the construction site in the direction of the road in km	0.5	km	0.5	0.5	0.5
10	Swellning factor (loose volume/fixed volume) for excavated materials that has to be moved within the construction site in the direction of the road	1.3		1.3	1.3	1.3
11	Amount of excavated materials from external pit that has to be transported to the road construction site in m3 fixed volume	1000	m3	1000	1000	1000
12	Transport distance for excavated materials from external pit in km	2	km	2	2	2
13	Swelling factor (loose volume/fixed volume) for excavated materials from external pit	1.3		1.3	1.3	1.3
14	Amount of excavated materials from road construction site to landfill in fixed m3	500	m3	500	500	500
15	Transport distance from road construction site to landfill in km	2	km	2	2	2
16	Swelling factor (loose volume/fixed volume) for excavated materials to landfill	1.3		1.3	1.3	1.3
17	Foundation reinforcement, concrete pile, total length concrete pile in m	2450	m	2450	2450	2450
18	Foundation reinforcement, concrete pile, transport distance, cement from cement production to concrete pile production in km	300	km	300	300	300
19	Foundation reinforcement, concrete pile, transport distance, ballast material (crushed aggregates, pit-run gravel/sand) from production site to concrete pile production in km	30	km	30	30	30
20	Foundation reinforcement, concrete pile, transport distance, concrete piles from concrete pile production to road construction site in km	300	km	300	300	300
21	Foundation reinforcement, concrete pile, load capacity for transport truck in kg	14000	kg	14000	14000	14000
22	Foundation reinforcement, cement/lime columns, total length of cement/lime columns in m	8840	m	8840	8840	8840
23	Foundation reinforcement, cement/lime columns, transport distance, quicklime from quicklime production to road construction site in km	300	km	300	300	300
24	Foundation reinforcement, cement/lime columns, transport distance, cement from cement production to road construction site in km	300	km	300	300	300
25	Foundation reinforcement, cement/lime columns, load capacity for transport truck in kg	14000	kg	14000	14000	14000
26	Road sub-base (unbound), amount of blasted rock in tonne	20000	tonne	20000	20000	20000
27	Road sub-base (unbound), transport distance from production site (blasted rock) to road construction site in km	5	km	5	5	5
28	Road sub-base (unbound), load capacity for transport truck in tonne	14	tonne	14	14	14
29	Road sub-base (unbound), area in m2	13000	m2	13000	13000	13000
30	Road sub-base (unbound), thickness in m	1	m	1	1	1
31	Road sub-base (unbound), thickness of layers for each rolling operation	0.5	m	0.5	0.5	0.5
32	Road base course (unbound), amount of crushed aggregates in tonne	5000	tonne	5000	5000	5000
33	Road base course (unbound), amount of pit-run gravel/sand in tonne	5000	tonne	5000	5000	5000
34	Road base course (unbound), transport distance for crushed aggregates between production site and road construction site in km	20	km	20	20	20
35	Road base course (unbound), transport distance for pit-run gravel/sand between production site and road construction site in km	20	km	20	20	20
36	Road base course (unbound), load capacity for transport truck in tonne	14	tonne	14	14	14
37	Road base course (unbound), area in m2	13000	m2	13000	13000	13000

	A	B	C	D	E	F
3	**Emissions, energy use and materials for a road**	**Asphalt road, 13 m, hot method**		**Concrete road, 13 m**	**Asphalt road, 13 m, hot method**	**Asphalt road, 13 m, cold method**
4	**Model variables**	**Value**	**Unit**	**Value**	**Value**	**Value**
38	Road base course (unbound), thickness in m	0.5	m	0.5	0.5	0.5
39	Road base course (unbound), thickness of layers for each rolling operation	0.5	m	0.5	0.5	0.5
40	Asphalt pavement, hot method, area of asphalt pavement in m2	13000	m2		13000	
41	Asphalt pavement, hot method, total amount of asphalt in tonne	2470	tonne		2470	
42	Asphalt pavement, hot method, number of asphalt layers	2	layer		2	
43	Asphalt pavement, hot method, transport distance for crushed aggregates from production site to asphalt plant in km	5	km		5	
44	km	400	km		400	
45	Asphalt pavement, hot method, transport distance of asphalt from asphalt plant to road construction site in km	30	km		30	
46	Asphalt pavement, hot method, load capacity for transport truck in tonne	14	tonne	14	14	14
47	Asphalt pavement, cold method, area of asphalt pavement, in m2		m2			13000
48	Asphalt pavement, cold method, total amount of asphalt in tonne		tonne			2470
49	Asphalt pavement, cold method, number of asphalt layers		layer			2
50	Asphalt pavement, cold method, transport distance for crushed aggregates from production site to asphalt plant in km		km			10
51	Asphalt pavement, cold method, transport distance for bitumen from local production store to emulsifier in km		km			400
52	Asphalt pavement, cold method, transport distance for bitumen emulsion from emulsifier to asphalt plant in km		km			100
53	Asphalt pavement, cold method, transport distance for cold asphalt from asphalt plant to road construction site in km		km			2
54	Asphalt pavement, cold method, load capacity for transport truck in tonne	14	tonne	14	14	14
55	Cement stabilisation of base course, stabilised road area in m2		m2	13000		
56	Cement stabilisation of base course, amount of cement used in kg		kg	1000		
57	Cement stabilisation of base course, transport distance for cement from cement production to road construction site in km		km	300		
58	Cement stabilisation of base course, load capacity for transport truck in tonne	14	tonne	14	14	14
59	Concrete paving, wearing course, road area in m2		m2	13000		
60	Concrete paving, wearing course, amount of concrete used in m3		m3	1950		
61	Concrete paving, wearing course, transport distance for crushed aggregates from production site to concrete production site in km		km	10		
62	Concrete paving, wearing course, transport distance for pit-run gravel/sand from production site to concrete production in km		km	10		
63	Concrete paving, wearing course, transport distance for cement from cement production to concrete production in km		km	300		
64	Concrete paving, wearing course, transport distance for road concrete from concrete production to road construction site in km		km	2		
65	Concrete paving, wearing course, load capacity for transport truck in tonne	14	tonne	14	14	14
66	Road marking, distance of marked road in km	1	km	1	1	1
67	Wildlife fence, length of fence in m	2000	m	2000	2000	2000
68	Other railing and fences, amount of galvanized steel used in kg	2000	kg	2000	2000	2000
69	Road signs, reflectors etc., amount of galvanized steel used in kg	500	kg	500	500	500
70	Road signs, reflectors etc., amount of aluminium used in kg	50	kg	50	50	50
71	Ilumination and traffic lights, amount of galvanized steel used in kg	10000	kg	10000	10000	10000
72	Ilumination and traffic lights, amount of aluminium used in kg	50	kg	50	50	50
73	Excavation of road in road maintenance, amount of excavated materials in m3	20000	m3		20000	20000
74	Excavation of road in road maintenance, number of excavations during the calculation period	1	st		1	1
75	Excavation of road in road maintenance, amount of excavated materials to external store/landfill in tonne	5000	tonne		5000	5000

	A	B	C	D	E	F
3	**Emissions, energy use and materials for a road**	**Asphalt road, 13 m, hot method**		**Concrete road, 13 m**	**Asphalt road, 13 m, hot method**	**Asphalt road, 13 m, cold method**
4	**Model variables**	**Value**	**Unit**	**Value**	**Value**	**Value**
76	Excavation of road in road maintenance, transport distance for excavated materials in km	10	km		10	10
77	Excavation of road in road maintenance, load capacity for transport truck in tonne	14	tonne	14	14	14
78	Reconstruction of base course (unbound), amount of crushed aggregates in tonne	5000	tonne		5000	5000
79	Reconstruction of base course (unbound), amount of pit-run gravel/sand in tonne	5000	tonne		5000	5000
80	Reconstruction of base course (unbound), transport distance for crushed aggregates from production to road construction site in km	20	km		20	20
81	Reconstruction of base course (unbound), transport distance from pit-run gravel/sand extraction to road construction site in km	20	km		20	20
82	Reconstruction of base course (unbound), load capacity for transport truck in tonne	14	tonne	14	14	14
83	Reconstruction of base course (unbound), area in m2	13000	m2		13000	13000
84	Reconstruction of base course (unbound), thickness in m	0.5	m		0.5	0.5
85	Reconstruction of base course (unbound), thickness of layers for each rolling operation	0.5	m	0.5	0.5	0.5
86	Surface milling of asphalt pavement, milled asphalt area in m2	13000	m2		13000	13000
87	Surface milling of asphalt pavement, number of milling operations during the calculation period	6	times		6	6
88	Adhesive layer (bitumen emulsion) application in maintenance of asphalt pavement, application area in m2	13000	m2		13000	13000
89	Adhesive layer (bitumen emulsion) application in maintenance of asphalt pavement, number of applications during the calculation period	6	times		6	6
90	Maintenance, asphalt pavement, hot method, area of asphalt pavement in m2	13000	m2		13000	
91	Maintenance, asphalt pavement, hot method, total amount of asphalt used in tonne	1235	tonne		1235	
92	Maintenance, asphalt pavement, hot method, number of asphalt layers	1	lager		1	
93	Maintenance, asphalt pavement, hot method, transport distance for crushed aggregates from production to asphalt plant in km	5	km		5	
94	Maintenance, asphalt pavement, hot method, transport distance for bitumen from local production store to asphalt plant in km	400	km		400	
95	Maintenance, asphalt pavement, hot method, transport distance for asphalt from asphalt plant to road construction site in km	30	km		30	
96	Maintenance, asphalt pavement, hot method, load capacity for transport truck in tonne	14	tonne	14	14	14
97	Maintenance, asphalt pavement, cold method, area of asphalt pavement in m2		m2			13000
98	Maintenance, asphalt pavement, cold method, total amount of asphalt used in tonne		tonne			1235
99	Maintenance, asphalt pavement, cold method, number of asphalt layers		layer			1
100	Maintenance, asphalt pavement, cold method, transport distance for crushed aggregates from production site to asphalt plant in km		km			10
101	Maintenance, asphalt pavement, cold method, transport distance for bitumen from local production store to emulsifier in km		km			400
102	Maintenance, asphalt pavement, cold method, transport distance for bitumen emulsion from emulsifier to asphalt plant in km		km			100
103	Maintenance, asphalt pavement, cold method, transport distance for cold asphalt from asphalt plant to road construction site in km		km			2
104	Maintenance, asphalt pavement, cold method, load capacity for transport truck in tonne	14	tonne	14	14	14
105	Maintenance, asphalt pavement, number of maintenance operations with new asphalt layers during the calculation period	6	times		6	6
106	Maintenance, concrete road, milled concrete road area in m2		m2	13000		
107	Maintenance, concrete road, number of milling operations during the calculation period		times	1		
108	Maintenance, concrete road, length of new sealed joints in m		m	3600		
109	Maintenance, concrete road, amount of joint sealing materials per meter joint		kg/m	0.24		
110	Maintenance, concrete road, number of joint sealing operations during the calculation period		times	6		

	A	B	C	D	E	F
3	**Emissions, energy use and materials for a road**	**Asphalt road, 13 m, hot method**		**Concrete road, 13 m**	**Asphalt road, 13 m, hot method**	**Asphalt road, 13 m, cold method**
4	**Model variables**	**Value**	**Unit**	**Value**	**Value**	**Value**
111	Maintenance, concrete road, road track milling for concrete filling, milling width in m		m	2		
112	Maintenance, concrete road, road track milling for concrete filling, milling length in m		m	2000		
113	Maintenance, concrete road, road track milling for concrete filling, milling depth in m		m	0.05		
114	Maintenance, concrete road, number of road track milling operations during the calculation period		times	1		
115	Maintenance, concrete road, transport distance for crushed aggregates from crushed aggregates production to concrete production in km		km	1		
116	Maintenance, concrete road, transport distance for pit-run gravel/sand from pit-run gravel/sand extraction site to concrete production in km		km	1		
117	km		km	300		
118	Maintenance, concrete road, transport distance for road concrete from concrete production to road construction site in km		km	20		
119	Maintenance, concrete road, load capacity for transport truck in tonne	14	tonne	14	14	14
120	Maintenance, road marking, legnth of marked road in km	1	km	1	1	1
121	Maintenance, road marking, number of road marking operation during the calculation period	10	times	10	10	10
122	Operation of road, snow clearance, distance for snow clearance vehicle per snow clearance operation in km	3	km	3	3	3
123	Operation of road, snow clearance, number of snow clearance operations per year	10	times	10	10	10
124	Operation of road, sand gritting, number of sand gritting operations per year	2	times	2	2	2
125	Operation of road, salt gritting, number of salt gritting operations per year	40	times	40	40	40
126	Operation of road, sweeping, driving distance for sweep vehicle per operation in km	3	km	3	3	3
127	Operation of road, sweeping, number of sweeping operations per year	2	times	2	2	2
128	Operation of road, mowing of verges, distance mowed verges per operation in km	2	km	2	2	2
129	Operation of road, mowing of verges, width of mowed verges in m	3	m	3	3	3
130	Operation of road, mowing of verges, number of mowing operations per year	3	times	3	3	3
131	Operation of road, clearance of verges, distance of cleared verges per operation in km	2	km	2	2	2
132	Operation of road, clearance of verges, width of cleared verges in m	5	m	5	5	5
133	Operation of road, clearance of verges, number pf clearing operation per year	0.3	times	0.3	0.3	0.3
134	Operation of road, washing of roadside posts, distance washed roadside per operation in km	2	km	2	2	2
135	Operation of road, washing of roadside posts, number of washing operation for roadside postes per year	10	times	10	10	10
136	Operation of road, washing of road signs, distance washed roadside in km	2	km	2	2	2
137	Operation of road, washing of road signs, number of washing operations per year	2	times	2	2	2
138	Operation of road, erection and removal of snow posts, roadside distance with snow posts in km	2	km	2	2	2
139	Operation of road, erection and removal of snow posts, number of operations per year	1	times	1	1	1
140	Operation of road, road trench digging, length of digged trench in m	2000	m	2000	2000	2000
141	Operation of road, road trench digging, number of digging operations during the calculation period	3	times	3	3	3
142	Operation of road, electric power for road lighting, illuminated road area in m2	13000	m2	13000	13000	13000
143	Operation of road, electric power for road lighting, effect per illuminated area in W/m2	0.5	W/m2	0.5	0.5	0.5
144	Operation of road, electric power for road lighting, number of lighting hours per year	4380	h/year	4380	4380	4380
145	Operation of road, electric power for traffic control, total electric effect for the calculated road object in W	1000	W	1000	1000	1000
146	Operation of road, electric power for traffic control, operation time for traffic control, hours per year	8760	h/year	8760	8760	8760
147	Other vehicle (complementary activities) use in road operation as percent of calculated vehicle use in road operation	15	%	15	15	15

	A	B	C	D	E	F	G	H	I
1			Material/Energy resources						
2			(Energy, electricity) *)	Natural gas	Oil	Coal	Biomass fuel	Peat	Uranium
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
4	**Construction of road, total:**	**Road object**	**6.16E+05**	**3.45E+05**	**4.29E+06**	**2.20E+06**	**1.74E+04**	**1.74E+03**	**6.19E+05**
5	**Forest felling/clearence for road construction**	**Road object**			**2.93E+03**				
6	**CO2 emission due to permanent reduction of biomass**	**Road object**							
7	**Excavation with excavator in the road direction**	**Road object**			**3.65E+05**				
8	**Excavation with wheel loader in the direction of the road**	**Road object**			**3.30E+05**				
9	**Transport of excavated materials with dumper truck in the direction of the road**	**Road object**			**4.84E+05**				
10	**Excavation with excavator in external site for filling materials**	**Road object**			**3.65E+03**				
11	**Excavation with wheel loader in external site for filling materials**	**Road object**			**3.30E+03**				
12	**Transport with dumper truck of excavated materials from external site to road construction site**	**Road object**			**1.94E+04**				
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**	**Road object**			**1.83E+03**				
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**	**Road object**			**1.65E+03**				
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**	**Road object**			**9.68E+03**				
16	**Foundation reinforcement, concrete pile**	**Road object**	**1.45E+05**	**4.18E+04**	**4.13E+05**	**6.89E+05**	**1.66E+03**	**1.66E+02**	**5.91E+04**
17	Pile-driving and materials to concrete pile	Road object	1.45E+05	4.18E+04	1.20E+05	6.89E+05	1.66E+03	1.66E+02	5.91E+04
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production	Road object			1.67E+04				
19	Transport of cement to concrete pile production	Road object			4.82E+04				
20	Transport of concrete pile from production site to road construction site	Road object			2.28E+05				
21	**Foundation reinforcement, cement/lime columns**	**Road object**	**5.43E+04**	**5.01E+02**	**3.82E+05**	**1.20E+06**	**2.39E+03**	**2.39E+02**	**8.68E+04**
22	Foundation reinforcements work, quicklime and cement for the work	Road object	5.43E+04	5.01E+02	2.68E+05	1.20E+06	2.39E+03	2.39E+02	8.68E+04
23	Transport of cement to road construction site	Road object			5.72E+04				
24	Transport of quicklime to road construction site	Road object			5.72E+04				
25	**Construction of road sub-base (unbound)**	**Road object**			**4.05E+05**				
26	Loading of blasted rock	Road object			4.51E+04				
27	Transport of blasted rock	Road object			1.88E+05				
28	Construction of road sub-base (unbound) at the road site	Road object			1.54E+05				
29	Rolling of layers	Road object			1.80E+04				
30	**Construction of road base course (unbound)**	**Road object**	**1.18E+05**	**1.10E+03**	**5.67E+05**	**4.72E+03**	**5.31E+03**	**5.31E+02**	**1.89E+05**
31	Production of crushed aggregates	Road object	1.06E+05	9.85E+02	1.00E+05	4.24E+03	4.77E+03	4.77E+02	1.70E+05
32	Extraction of pit-run gravel/sand	Road object	1.20E+04	1.12E+02	5.21E+03	4.80E+02	5.40E+02	5.40E+01	1.92E+04
33	Transport of crushed aggregates	Road object			1.88E+05				
34	Transport of pit-run gravel/sand	Road object			1.88E+05				
35	Construction of road base course (unbound) at the road site	Road object			7.72E+04				
36	Rolling of layers	Road object			8.98E+03				
37	**Asphalt pavement, hot method**	**Road object**	**1.99E+05**	**2.65E+05**	**1.22E+06**	**7.02E+03**	**7.90E+03**	**7.90E+02**	**2.81E+05**
38	Production of hot asphalt	Road object	1.99E+05	2.65E+05	9.13E+05	7.02E+03	7.90E+03	7.90E+02	2.81E+05
39	Transport of crushed aggregates to asphalt plant	Road object			2.18E+04				
40	Transport of bitumen to sphalt plant	Road object			1.11E+05				
41	Transport of asphalt from asphalt plant to road construction site	Road object			1.39E+05				
42	Paving of asphalt layers	Road object			1.70E+04				
43	Rolling of asphalt layers	Road object			2.28E+04				
44	**Asphalt pavement, cold method**	**Road object**							
45	Production of cold asphalt	Road object							
46	Transport of crushed aggregates to asphalt plant	Road object							
47	Transport of bitumen to emulsifier	Road object							
48	Transport of bitumen emulsion from emulsifier to asphalt plant	Road object							
49	Transport of asphalt from asphalt plant to road construction site	Road object							
50	Paving of asphalt layers	Road object							
51	Rolling of asphalt layers	Road object							

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I
1			**Material/Energy resources**						
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
52	**Cement stabilisation of base course**	**Road object**							
53	Cement stabilisation, operation of slipform paver	Road object							
54	Production of cement	Road object							
55	Transport of cement from production to road construction site	Road object							
56	**Concrete paving, wearing course**	**Road object**							
57	Production of road concrete	Road object							
58	Transport of crushed aggregates to concrete production	Road object							
59	Transport of pit-run gravel/sand to concrete production	Road object							
60	Transport of cement to concrete production	Road object							
61	Transport of road concrete from production to road construction site	Road object							
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)	Road object							
63	Exposure of aggregate on concrete carriageway	Road object							
64	Sawing and sealing of joints in concrete road construction	Road object							
65	**Road marking**	**Road object**			**9.65E+02**				
66	**Production and assembly of wildlife fences**	**Road object**	**3.53E+04**	**1.35E+04**	**3.34E+04**	**1.15E+05**			
67	**Other railing and fences, amount of galvanized steel used**	**Road object**	**9.39E+03**	**3.60E+03**	**7.23E+03**	**3.05E+04**			
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**Road object**	**4.88E+03**	**1.00E+03**	**2.37E+03**	**7.66E+03**	**5.69E+01**	**5.69E+00**	**2.02E+03**
69	Galvanized steel	Road object	2.35E+03	9.01E+02	1.81E+03	7.61E+03			
70	Aluminium	Road object	2.53E+03	1.02E+02	5.61E+02	5.06E+01	5.69E+01	5.69E+00	2.02E+03
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**Road object**	**4.95E+04**	**1.81E+04**	**3.67E+04**	**1.52E+05**	**5.69E+01**	**5.69E+00**	**2.02E+03**
72	Galvanized steel	Road object	4.70E+04	1.80E+04	3.61E+04	1.52E+05			
73	Aluminium	Road object	2.53E+03	1.02E+02	5.61E+02	5.06E+01	5.69E+01	5.69E+00	2.02E+03
74									
75	**Maintenance of road, total:**	**Road object**	**2.19E+05**	**1.41E+05**	**2.29E+06**	**8.27E+03**	**9.30E+03**	**9.30E+02**	**3.31E+05**
76	**Excavation of road and sub-base with excavator**	**Road object**			**8.76E+04**				
77	**Transport removal of excavated materials from the entire road**	**Road object**			**9.38E+04**				
78	**Reconstruction of base course (unbound)**	**Road object**	**1.18E+05**	**1.10E+03**	**5.67E+05**	**4.72E+03**	**5.31E+03**	**5.31E+02**	**1.89E+05**
79	Production of crushed aggregates	Road object	1.06E+05	9.85E+02	1.00E+05	4.24E+03	4.77E+03	4.77E+02	1.70E+05
80	Extraction of pit-run gravel/sand	Road object	1.20E+04	1.12E+02	5.21E+03	4.80E+02	5.40E+02	5.40E+01	1.92E+04
81	Transport of crushed aggregates	Road object			1.88E+05				
82	Transport of pit-run gravel/sand	Road object			1.88E+05				
83	Construction of new base course (unbound) at road site	Road object			7.72E+04				
84	Rolling of layers	Road object			8.98E+03				
85	**Surface milling of asphalt pavement**	**Road object**			**1.34E+05**				
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**Road object**	**1.61E+03**	**6.95E+03**	**4.43E+03**	**3.93E+01**	**4.42E+01**	**4.42E+00**	**1.57E+03**
87	**Asphalt pavement, hot method**	**Road object**	**9.97E+04**	**1.33E+05**	**1.39E+06**	**3.51E+03**	**3.95E+03**	**3.95E+02**	**1.40E+05**
88	Production of hot asphalt	Road object	9.97E+04	1.33E+05	4.56E+05	3.51E+03	3.95E+03	3.95E+02	1.40E+05
89	Transport of crushed aggregates to asphalt plant	Road object			6.53E+04				
90	Transport of bitumen to asphalt plant	Road object			3.34E+05				
91	Transport of asphalt from asphalt plant to road construction site	Road object			4.17E+05				
92	Asphalt paving	Road object			5.10E+04				
93	Asphalt rolling	Road object			6.85E+04				
94	**Asphalt pavement, cold method**	**Road object**							
95	Production of cold asphalt	Road object							
96	Transport of crushed aggregates to asphalt plant	Road object							
97	Transport of bitumen to emulsifier	Road object							
98	Transport of bitumen emulsion from emulsifier to asphalt plant	Road object							
99	Transport of asphalt from asphalt plant to road construction site	Road object							

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I
1			**Material/Energy resources**						
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
100	Asphalt paving	Road object							
101	Asphalt rolling	Road object							
102	**Maintenance of concrete road**	**Road object**							
103	Milling of wearing cource	Road object							
104	Resealing of joints, use of EPDM-rubber	Road object							
105	Road track milling for concrete filling	Road object							
106	Concrete production for concrete filling	Road object							
107	Machine operation for concrete filling	Road object							
108	Transport of crushed aggregates to concrete production	Road object							
109	Transport of pit-run gravel/sand to concrete production	Road object							
110	Transport of cement to concrete production	Road object							
111	Transport of concrete from production site to road construction site	Road object							
112	**Maintenance of road marking**	**Road object**			**9.65E+03**				
113									
114	**Operation of road, total:**	**Road object**	**5.36E+06**	**4.99E+04**	**6.97E+05**	**5.22E+05**	**2.41E+05**	**2.41E+04**	**8.58E+06**
115	**Snow clearance**	**Road object**			**2.05E+04**				
116	**Sand gritting of road in winter road maintenance**	**Road object**	**1.47E+03**	**1.37E+01**	**4.47E+03**	**5.89E+01**	**6.62E+01**	**6.62E+00**	**2.36E+03**
117	Vehicle operation, distribution truck	Road object			3.15E+03				
118	Production of sand used, crushed material	Road object	1.32E+03	1.23E+01	1.25E+03	5.29E+01	5.95E+01	5.95E+00	2.12E+03
119	Production of sand used, natural material	Road object	1.50E+02	1.39E+00	6.50E+01	5.99E+00	6.73E+00	6.73E-01	2.39E+02
120	**Salt gritting of road in winter road maintenance**	**Road object**			**6.30E+04**	**3.08E+05**			
121	Vehicle operation, distribution truck	Road object			6.30E+04				
122	Production of salt used, coal based production	Road object				3.08E+05			
123	**Sweeping**	**Road object**			**9.27E+03**				
124	**Mowing of verges**	**Road object**			**2.44E+04**				
125	**Clearance of verges**	**Road object**			**1.22E+04**				
126	**Washing of roadside posts**	**Road object**			**3.09E+04**				
127	**Washing of road signs**	**Road object**			**9.89E+03**				
128	**Erection and removal of snow posts**	**Road object**			**1.70E+04**				
129	**Digging of road trenches**	**Road object**			**1.17E+05**				
130	**Lighting and traffic lights, electric power production**	**Road object**	**5.36E+06**	**4.99E+04**	**3.43E+05**	**2.14E+05**	**2.41E+05**	**2.41E+04**	**8.58E+06**
131	Lighting	Road object	4.10E+06	3.81E+04	2.62E+05	1.64E+05	1.84E+05	1.84E+04	6.56E+06
132	Traffic lights	Road object	1.26E+06	1.17E+04	8.07E+04	5.05E+04	5.68E+04	5.68E+03	2.02E+06
133	**Other vehicle use (complementary activities) in operation procedures**	**Road object**			**4.60E+04**				
134									
135	**Total sum:**	**Road object**	**6.20E+06**	**5.36E+05**	**7.28E+06**	**2.73E+06**	**2.68E+05**	**2.68E+04**	**9.53E+06**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**1.82E+05**	**1.48E+08**	**5.15E+09**	**7.47E+09**	**4.96E+08**	**2.92E+08**	**2.92E+08**	**3.36E+08**	**2.92E+08**
5	**Forest felling/clearence for road construction**									
6	**CO2 emission due to permanent reduction of biomass**									
7	**Excavation with excavator in the road direction**									
8	**Excavation with wheel loader in the direction of the road**									
9	**Transport of excavated materials with dumper truck in the direction of the road**									
10	**Excavation with excavator in external site for filling materials**									
11	**Excavation with wheel loader in external site for filling materials**									
12	**Transport with dumper truck of excavated materials from external site to road construction site**									
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**									
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**									
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**									
16	**Foundation reinforcement, concrete pile**	**1.74E+04**		**1.48E+08**	**1.48E+08**	**1.34E+08**	**1.34E+08**	**1.34E+08**	**1.57E+08**	**1.34E+08**
17	Pile-driving and materials to concrete pile	1.74E+04		1.48E+08	1.48E+08	1.34E+08	1.34E+08	1.34E+08	1.57E+08	1.34E+08
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production									
19	Transport of cement to concrete pile production									
20	Transport of concrete pile from production site to road construction site									
21	**Foundation reinforcement, cement/lime columns**	**2.55E+04**				**3.62E+08**	**1.59E+08**	**1.59E+08**	**1.59E+08**	**1.59E+08**
22	Foundation reinforcements work, quicklime and cement for the work	2.55E+04				3.62E+08	1.59E+08	1.59E+08	1.59E+08	1.59E+08
23	Transport of cement to road construction site									
24	Transport of quicklime to road construction site									
25	**Construction of road sub-base (unbound)**									
26	Loading of blasted rock									
27	Transport of blasted rock									
28	Construction of road sub-base (unbound) at the road site									
29	Rolling of layers									
30	**Construction of road base course (unbound)**	**5.54E+04**		**5.00E+09**	**5.00E+09**					
31	Production of crushed aggregates	4.98E+04			5.00E+09					
32	Extraction of pit-run gravel/sand	5.64E+03		5.00E+09						
33	Transport of crushed aggregates									
34	Transport of pit-run gravel/sand									
35	Construction of road base course (unbound) at the road site									
36	Rolling of layers									
37	**Asphalt pavement, hot method**	**8.25E+04**	**1.48E+08**		**2.32E+09**					
38	Production of hot asphalt	8.25E+04	1.48E+08		2.32E+09					
39	Transport of crushed aggregates to asphalt plant									
40	Transport of bitumen to sphalt plant									
41	Transport of asphalt from asphalt plant to road construction site									
42	Paving of asphalt layers									
43	Rolling of asphalt layers									
44	**Asphalt pavement, cold method**									
45	Production of cold asphalt									
46	Transport of crushed aggregates to asphalt plant									
47	Transport of bitumen to emulsifier									
48	Transport of bitumen emulsion from emulsifier to asphalt plant									
49	Transport of asphalt from asphalt plant to road construction site									
50	Paving of asphalt layers									
51	Rolling of asphalt layers									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**									
53	Cement stabilisation, operation of slipform paver									
54	Production of cement									
55	Transport of cement from production to road construction site									
56	**Concrete paving, wearing course**									
57	Production of road concrete									
58	Transport of crushed aggregates to concrete production									
59	Transport of pit-run gravel/sand to concrete production									
60	Transport of cement to concrete production									
61	Transport of road concrete from production to road construction site									
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)									
63	Exposure of aggregate on concrete carriageway									
64	Sawing and sealing of joints in concrete road construction									
65	**Road marking**									
66	**Production and assembly of wildlife fences**								**7.48E+06**	**3.76E+04**
67	**Other railing and fences, amount of galvanized steel used**								**1.99E+06**	**1.00E+04**
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**5.95E+02**				**1.09E+03**	**3.90E+03**	**1.25E+04**	**4.98E+05**	**2.50E+03**
69	Galvanized steel								4.98E+05	2.50E+03
70	Aluminium	5.95E+02				1.09E+03	3.90E+03	1.25E+04		
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**5.95E+02**				**1.09E+03**	**3.90E+03**	**1.25E+04**	**9.95E+06**	**5.00E+04**
72	Galvanized steel								9.95E+06	5.00E+04
73	Aluminium	5.95E+02				1.09E+03	3.90E+03	1.25E+04		
74										
75	**Maintenance of road, total:**	**9.71E+04**	**7.80E+07**	**5.00E+09**	**6.16E+09**					
76	**Excavation of road and sub-base with excavator**									
77	**Transport removal of excavated materials from the entire road**									
78	**Reconstruction of base course (unbound)**	**5.54E+04**		**5.00E+09**	**5.00E+09**					
79	Production of crushed aggregates	4.98E+04			5.00E+09					
80	Extraction of pit-run gravel/sand	5.64E+03		5.00E+09						
81	Transport of crushed aggregates									
82	Transport of pit-run gravel/sand									
83	Construction of new base course (unbound) at road site									
84	Rolling of layers									
85	**Surface milling of asphalt pavement**									
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**4.62E+02**	**3.90E+06**							
87	**Asphalt pavement, hot method**	**4.12E+04**	**7.41E+07**		**1.16E+09**					
88	Production of hot asphalt	4.12E+04	7.41E+07		1.16E+09					
89	Transport of crushed aggregates to asphalt plant									
90	Transport of bitumen to asphalt plant									
91	Transport of asphalt from asphalt plant to road construction site									
92	Asphalt paving									
93	Asphalt rolling									
94	**Asphalt pavement, cold method**									
95	Production of cold asphalt									
96	Transport of crushed aggregates to asphalt plant									
97	Transport of bitumen to emulsifier									
98	Transport of bitumen emulsion from emulsifier to asphalt plant									
99	Transport of asphalt from asphalt plant to road construction site									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving									
101	Asphalt rolling									
102	**Maintenance of concrete road**									
103	Milling of wearing cource									
104	Resealing of joints, use of EPDM-rubber									
105	Road track milling for concrete filling									
106	Concrete production for concrete filling									
107	Machine operation for concrete filling									
108	Transport of crushed aggregates to concrete production									
109	Transport of pit-run gravel/sand to concrete production									
110	Transport of cement to concrete production									
111	Transport of concrete from production site to road construction site									
112	**Maintenance of road marking**									
113										
114	**Operation of road, total:**	**2.52E+06**		**6.24E+07**	**6.24E+07**		**2.08E+08**			
115	**Snow clearance**									
116	**Sand gritting of road in winter road maintenance**	**6.92E+02**		**6.24E+07**	**6.24E+07**					
117	Vehicle operation, distribution truck									
118	Production of sand used, crushed material	6.21E+02			6.24E+07					
119	Production of sand used, natural material	7.03E+01		6.24E+07						
120	**Salt gritting of road in winter road maintenance**						**2.08E+08**			
121	Vehicle operation, distribution truck									
122	Production of salt used, coal based production						2.08E+08			
123	**Sweeping**									
124	**Mowing of verges**									
125	**Clearance of verges**									
126	**Washing of roadside posts**									
127	**Washing of road signs**									
128	**Erection and removal of snow posts**									
129	**Digging of road trenches**									
130	**Lighting and traffic lights, electric power production**	**2.52E+06**								
131	Lighting	1.93E+06								
132	Traffic lights	5.93E+05								
133	**Other vehicle use (complementary activities) in operation procedures**									
134										
135	**Total sum:**	**2.80E+06**	**2.26E+08**	**1.02E+10**	**1.37E+10**	**4.96E+08**	**5.00E+08**	**2.92E+08**	**3.36E+08**	**2.92E+08**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**8.41E+05**	**3.00E+06**	**3.46E+05**	**1.78E+09**	**1.38E+05**	**3.95E+05**	**3.22E+04**	**5.21E+04**	**6.06E+03**	**1.96E+06**
5	**Forest felling/clearence for road construction**	**1.01E+02**	**1.90E+03**	**2.27E+02**	**2.10E+05**	**1.37E+02**	**1.33E-01**			**4.26E+00**	**7.59E+01**
6	**CO2 emission due to permanent reduction of biomass**				**1.02E+09**						
7	**Excavation with excavator in the road direction**	**1.26E+04**	**2.37E+05**	**2.83E+04**	**2.62E+07**	**1.71E+04**	**1.66E+01**			**5.31E+02**	**9.46E+03**
8	**Excavation with wheel loader in the direction of the road**	**1.14E+04**	**2.14E+05**	**2.55E+04**	**2.37E+07**	**1.54E+04**	**1.50E+01**			**4.80E+02**	**8.54E+03**
9	**Transport of excavated materials with dumper truck in the direction of the road**	**1.67E+04**	**3.14E+05**	**3.75E+04**	**3.48E+07**	**2.26E+04**	**2.20E+01**			**7.04E+02**	**1.25E+04**
10	**Excavation with excavator in external site for filling materials**	**1.26E+02**	**2.37E+03**	**2.83E+02**	**2.62E+05**	**1.71E+02**	**1.66E-01**			**5.31E+00**	**9.46E+01**
11	**Excavation with wheel loader in external site for filling materials**	**1.14E+02**	**2.14E+03**	**2.55E+02**	**2.37E+05**	**1.54E+02**	**1.50E-01**			**4.80E+00**	**8.54E+01**
12	**Transport with dumper truck of excavated materials from external site to road construction site**	**6.69E+02**	**1.26E+04**	**1.50E+03**	**1.39E+06**	**9.05E+02**	**8.80E-01**			**2.82E+01**	**5.01E+02**
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**	**6.31E+01**	**1.19E+03**	**1.41E+02**	**1.31E+05**	**8.53E+01**	**8.30E-02**			**2.66E+00**	**4.73E+01**
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**	**5.70E+01**	**1.07E+03**	**1.28E+02**	**1.19E+05**	**7.71E+01**	**7.50E-02**			**2.40E+00**	**4.27E+01**
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**	**3.34E+02**	**6.28E+03**	**7.49E+02**	**6.95E+05**	**4.52E+02**	**4.40E-01**			**1.41E+01**	**2.51E+02**
16	**Foundation reinforcement, concrete pile**	**2.68E+05**	**4.39E+05**	**4.70E+04**	**1.44E+08**	**1.16E+04**	**2.12E+05**	**4.06E+01**	**2.79E+04**	**1.18E+03**	**1.00E+06**
17	Pile-driving and materials to concrete pile	2.58E+05	3.05E+05	2.57E+04	1.23E+08	1.42E+03	2.12E+05	4.06E+01	2.79E+04	7.58E+02	9.99E+05
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production	5.76E+02	7.64E+03	1.21E+03	1.20E+06	5.82E+02	7.58E-01			2.43E+01	1.29E+02
19	Transport of cement to concrete pile production	1.67E+03	2.21E+04	3.51E+03	3.46E+06	1.68E+03	2.19E+00			7.02E+01	3.72E+02
20	Transport of concrete pile from production site to road construction site	7.88E+03	1.05E+05	1.66E+04	1.64E+07	7.96E+03	1.04E+01			3.32E+02	1.76E+03
21	**Foundation reinforcement, cement/lime columns**	**2.07E+05**	**6.97E+05**	**5.92E+04**	**3.09E+08**	**1.20E+04**	**2.00E+01**	**2.18E+03**		**4.31E+02**	**1.08E+05**
22	Foundation reinforcements work, quicklime and cement for the work	2.03E+05	6.45E+05	5.09E+04	3.01E+08	7.97E+03	1.48E+01	2.18E+03		2.65E+02	1.07E+05
23	Transport of cement to road construction site	1.98E+03	2.62E+04	4.17E+03	4.11E+06	2.00E+03	2.60E+00			8.32E+01	4.41E+02
24	Transport of quicklime to road construction site	1.98E+03	2.62E+04	4.17E+03	4.11E+06	2.00E+03	2.60E+00			8.32E+01	4.41E+02
25	**Construction of road sub-base (unbound)**	**1.40E+04**	**2.27E+05**	**3.05E+04**	**2.91E+07**	**1.67E+04**	**1.84E+01**			**5.89E+02**	**7.08E+03**
26	Loading of blasted rock	1.56E+03	2.93E+04	3.49E+03	3.24E+06	2.11E+03	2.05E+00			6.56E+01	1.17E+03
27	Transport of blasted rock	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
28	Construction of road sub-base (unbound) at the road site	5.34E+03	1.00E+05	1.20E+04	1.11E+07	7.22E+03	7.02E+00			2.25E+02	4.00E+03
29	Rolling of layers	6.21E+02	1.17E+04	1.39E+03	1.29E+06	8.39E+02	8.17E-01			2.61E+01	4.65E+02
30	**Construction of road base course (unbound)**	**2.01E+04**	**2.92E+05**	**4.18E+04**	**4.06E+07**	**2.17E+04**	**4.19E+01**	**1.30E+02**		**8.63E+02**	**7.67E+03**
31	Production of crushed aggregates	3.94E+03	6.16E+04	7.45E+03	7.11E+06	4.37E+03	1.91E+01	1.17E+02		1.80E+02	2.43E+03
32	Extraction of pit-run gravel/sand	2.34E+02	2.99E+03	3.69E+02	3.64E+05	2.07E+02	1.88E+00	1.32E+01		1.15E+01	1.16E+02
33	Transport of crushed aggregates	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
34	Transport of pit-run gravel/sand	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
35	Construction of road base course (unbound) at the road site	2.67E+03	5.01E+04	5.98E+03	5.55E+06	3.61E+03	3.51E+00			1.12E+02	2.00E+03
36	Rolling of layers	3.10E+02	5.83E+03	6.95E+02	6.45E+05	4.20E+02	4.08E-01			1.31E+01	2.33E+02
37	**Asphalt pavement, hot method**	**1.39E+05**	**4.43E+05**	**5.21E+04**	**1.07E+08**	**1.79E+04**	**4.07E+01**	**2.98E+04**		**5.90E+02**	**1.25E+04**
38	Production of hot asphalt	1.28E+05	2.93E+05	2.92E+04	8.49E+07	6.58E+03	2.65E+01	2.98E+04		1.37E+02	9.37E+03
39	Transport of crushed aggregates to asphalt plant	7.52E+02	9.98E+03	1.59E+03	1.56E+06	7.60E+02	9.90E-01			3.17E+01	1.68E+02
40	Transport of bitumen to sphalt plant	3.84E+03	5.09E+04	8.10E+03	7.98E+06	3.88E+03	5.05E+00			1.62E+02	8.57E+02
41	Transport of asphalt from asphalt plant to road construction site	4.80E+03	6.37E+04	1.01E+04	9.98E+06	4.85E+03	6.32E+00			2.02E+02	1.07E+03
42	Paving of asphalt layers	5.87E+02	1.10E+04	1.31E+03	1.22E+06	7.94E+02	7.72E-01			2.47E+01	4.40E+02
43	Rolling of asphalt layers	7.89E+02	1.48E+04	1.77E+03	1.64E+06	1.07E+03	1.04E+00			3.32E+01	5.91E+02
44	**Asphalt pavement, cold method**										
45	Production of cold asphalt										
46	Transport of crushed aggregates to asphalt plant										
47	Transport of bitumen to emulsifier										
48	Transport of bitumen emulsion from emulsifier to asphalt plant										
49	Transport of asphalt from asphalt plant to road construction site										
50	Paving of asphalt layers										
51	Rolling of asphalt layers										

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**										
53	Cement stabilisation, operation of slipform paver										
54	Production of cement										
55	Transport of cement from production to road construction site										
56	**Concrete paving, wearing course**										
57	Production of road concrete										
58	Transport of crushed aggregates to concrete production										
59	Transport of pit-run gravel/sand to concrete production										
60	Transport of cement to concrete production										
61	Transport of road concrete from production to road construction site										
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)										
63	Exposure of aggregate on concrete carriageway										
64	Sawing and sealing of joints in concrete road construction										
65	**Road marking**	**3.33E+01**	**4.83E+02**	**6.49E+01**	**6.93E+04**	**3.58E+01**	**2.98E-02**			**9.55E-01**	**2.27E+01**
66	**Production and assembly of wildlife fences**	**5.62E+04**	**4.10E+04**	**8.11E+03**	**1.71E+07**	**2.89E+02**	**6.86E+04**		**9.08E+03**	**2.38E+02**	**2.94E+05**
67	**Other railing and fences, amount of galvanized steel used**	**1.49E+04**	**9.83E+03**	**2.03E+03**	**4.42E+06**		**1.82E+04**		**2.42E+03**	**6.09E+01**	**7.81E+04**
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**4.08E+03**	**2.71E+03**	**5.45E+02**	**1.17E+06**	**7.00E+01**	**4.56E+03**	**1.39E+00**	**6.04E+02**	**1.58E+01**	**2.23E+04**
69	Galvanized steel	3.72E+03	2.46E+03	5.07E+02	1.11E+06		4.56E+03		6.04E+02	1.52E+01	1.95E+04
70	Aluminium	3.53E+02	2.52E+02	3.77E+01	6.63E+04	7.00E+01	1.77E-01	1.39E+00		5.31E-01	2.77E+03
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**7.48E+04**	**4.94E+04**	**1.02E+04**	**2.22E+07**	**7.00E+01**	**9.12E+04**	**1.39E+00**	**1.21E+04**	**3.05E+02**	**3.93E+05**
72	Galvanized steel	7.44E+04	4.91E+04	1.01E+04	2.21E+07		9.12E+04		1.21E+04	3.05E+02	3.90E+05
73	Aluminium	3.53E+02	2.52E+02	3.77E+01	6.63E+04	7.00E+01	1.77E-01	1.39E+00		5.31E-01	2.77E+03
74											
75	**Maintenance of road, total:**	**1.30E+05**	**1.09E+06**	**1.50E+05**	**1.74E+08**	**7.32E+04**	**1.12E+02**	**1.58E+04**		**2.76E+03**	**2.85E+04**
76	**Excavation of road and sub-base with excavator**	**3.02E+03**	**5.68E+04**	**6.78E+03**	**6.29E+06**	**4.09E+03**	**3.98E+00**			**1.27E+02**	**2.27E+03**
77	**Transport removal of excavated materials from the entire road**	**3.24E+03**	**4.30E+04**	**6.83E+03**	**6.73E+06**	**3.27E+03**	**4.26E+00**			**1.36E+02**	**7.23E+02**
78	**Reconstruction of base course (unbound)**	**2.01E+04**	**2.92E+05**	**4.18E+04**	**4.06E+07**	**2.17E+04**	**4.19E+01**	**1.30E+02**		**8.63E+02**	**7.67E+03**
79	Production of crushed aggregates	3.94E+03	6.16E+04	7.45E+03	7.11E+06	4.37E+03	1.91E+01	1.17E+02		1.80E+02	2.43E+03
80	Extraction of pit-run gravel/sand	2.34E+02	2.99E+03	3.69E+02	3.64E+05	2.07E+02	1.88E+00	1.32E+01		1.15E+01	1.16E+02
81	Transport of crushed aggregates	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
82	Transport of pit-run gravel/sand	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
83	Construction of new base course (unbound) at road site	2.67E+03	5.01E+04	5.98E+03	5.55E+06	3.61E+03	3.51E+00			1.12E+02	2.00E+03
84	Rolling of layers	3.10E+02	5.83E+03	6.95E+02	6.45E+05	4.20E+02	4.08E-01			1.31E+01	2.33E+02
85	**Surface milling of asphalt pavement**	**4.62E+03**	**8.69E+04**	**1.04E+04**	**9.61E+06**	**6.25E+03**	**6.08E+00**			**1.95E+02**	**3.47E+03**
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**2.40E+03**	**4.17E+03**	**4.56E+02**	**6.97E+05**	**1.35E+02**	**1.52E-01**	**7.81E+02**		**8.73E-01**	**3.98E+01**
87	**Asphalt pavement, hot method**	**9.65E+04**	**5.98E+05**	**8.33E+04**	**1.10E+08**	**3.74E+04**	**5.58E+01**	**1.49E+04**		**1.43E+03**	**1.41E+04**
88	Production of hot asphalt	6.42E+04	1.46E+05	1.46E+04	4.24E+07	3.29E+03	1.33E+01	1.49E+04		6.84E+01	4.69E+03
89	Transport of crushed aggregates to asphalt plant	2.26E+03	2.99E+04	4.76E+03	4.69E+06	2.28E+03	2.97E+00			9.50E+01	5.04E+02
90	Transport of bitumen to asphalt plant	1.15E+04	1.53E+05	2.43E+04	2.40E+07	1.16E+04	1.52E+01			4.85E+02	2.57E+03
91	Transport of asphalt from asphalt plant to road construction site	1.44E+04	1.91E+05	3.04E+04	2.99E+07	1.46E+04	1.89E+01			6.06E+02	3.21E+03
92	Asphalt paving	1.76E+03	3.31E+04	3.94E+03	3.66E+06	2.38E+03	2.32E+00			7.41E+01	1.32E+03
93	Asphalt rolling	2.37E+03	4.45E+04	5.30E+03	4.92E+06	3.20E+03	3.12E+00			9.97E+01	1.77E+03
94	**Asphalt pavement, cold method**										
95	Production of cold asphalt										
96	Transport of crushed aggregates to asphalt plant										
97	Transport of bitumen to emulsifier										
98	Transport of bitumen emulsion from emulsifier to asphalt plant										
99	Transport of asphalt from asphalt plant to road construction site										

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving										
101	Asphalt rolling										
102	**Maintenance of concrete road**										
103	Milling of wearing cource										
104	Resealing of joints, use of EPDM-rubber										
105	Road track milling for concrete filling										
106	Concrete production for concrete filling										
107	Machine operation for concrete filling										
108	Transport of crushed aggregates to concrete production										
109	Transport of pit-run gravel/sand to concrete production										
110	Transport of cement to concrete production										
111	Transport of concrete from production site to road construction site										
112	**Maintenance of road marking**	**3.33E+02**	**4.83E+03**	**6.49E+02**	**6.93E+05**	**3.58E+02**	**2.98E-01**			**9.55E+00**	**2.27E+02**
113											
114	**Operation of road, total:**	**2.02E+05**	**3.53E+05**	**4.45E+04**	**7.41E+07**	**1.54E+04**	**7.67E+02**	**5.90E+03**		**2.77E+03**	**7.73E+03**
115	**Snow clearance**	**7.07E+02**	**9.38E+03**	**1.49E+03**	**1.47E+06**	**7.15E+02**	**9.31E-01**			**2.98E+01**	**1.58E+02**
116	**Sand gritting of road in winter road maintenance**	**1.61E+02**	**2.25E+03**	**3.27E+02**	**3.20E+05**	**1.67E+02**	**4.05E-01**	**1.62E+00**		**6.98E+00**	**5.60E+01**
117	Vehicle operation, distribution truck	1.09E+02	1.44E+03	2.30E+02	2.26E+05	1.10E+02	1.43E-01			4.58E+00	2.43E+01
118	Production of sand used, crushed material	4.91E+01	7.69E+02	9.30E+01	8.88E+04	5.45E+01	2.38E-01	1.45E+00		2.25E+00	3.03E+01
119	Production of sand used, natural material	2.92E+00	3.73E+01	4.60E+00	4.55E+03	2.59E+00	2.35E-02	1.65E-01		1.43E-01	1.44E+00
120	**Salt gritting of road in winter road maintenance**	**1.56E+05**	**1.21E+05**	**1.08E+04**	**3.28E+07**	**2.20E+03**	**2.86E+00**			**9.17E+01**	**4.86E+02**
121	Vehicle operation, distribution truck	2.18E+03	2.89E+04	4.59E+03	4.53E+06	2.20E+03	2.86E+00			9.17E+01	4.86E+02
122	Production of salt used, coal based production	1.54E+05	9.24E+04	6.24E+03	2.83E+07						
123	**Sweeping**	**3.20E+02**	**6.02E+03**	**7.17E+02**	**6.65E+05**	**4.33E+02**	**4.21E-01**			**1.35E+01**	**2.40E+02**
124	**Mowing of verges**	**8.45E+02**	**1.59E+04**	**1.89E+03**	**1.76E+06**	**1.14E+03**	**1.11E+00**			**3.56E+01**	**6.33E+02**
125	**Clearance of verges**	**4.22E+02**	**7.94E+03**	**9.46E+02**	**8.78E+05**	**5.71E+02**	**5.56E-01**			**1.78E+01**	**3.16E+02**
126	**Washing of roadside posts**	**1.07E+03**	**2.01E+04**	**2.39E+03**	**2.22E+06**	**1.44E+03**	**1.40E+00**			**4.49E+01**	**8.00E+02**
127	**Washing of road signs**	**3.42E+02**	**6.42E+03**	**7.65E+02**	**7.10E+05**	**4.62E+02**	**4.50E-01**			**1.44E+01**	**2.56E+02**
128	**Erection and removal of snow posts**	**5.87E+02**	**1.10E+04**	**1.31E+03**	**1.22E+06**	**7.94E+02**	**7.72E-01**			**2.47E+01**	**4.40E+02**
129	**Digging of road trenches**	**4.03E+03**	**7.57E+04**	**9.02E+03**	**8.37E+06**	**5.45E+03**	**5.30E+00**			**1.70E+02**	**3.02E+03**
130	**Lighting and traffic lights, electric power production**	**3.59E+04**	**4.93E+04**	**1.13E+04**	**2.04E+07**		**7.51E+02**	**5.90E+03**		**2.25E+03**	**3.75E+02**
131	Lighting	2.75E+04	3.77E+04	8.61E+03	1.56E+07		5.74E+02	4.51E+03		1.72E+03	2.87E+02
132	Traffic lights	8.45E+03	1.16E+04	2.65E+03	4.79E+06		1.77E+02	1.39E+03		5.30E+02	8.83E+01
133	**Other vehicle use (complementary activities) in operation procedures**	**1.59E+03**	**2.74E+04**	**3.50E+03**	**3.31E+06**	**2.00E+03**	**2.09E+00**			**6.70E+01**	**9.56E+02**
134											
135	**Total sum:**	**1.17E+06**	**4.43E+06**	**5.41E+05**	**2.03E+09**	**2.26E+05**	**3.96E+05**	**5.39E+04**	**5.21E+04**	**1.16E+04**	**1.99E+06**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**2.82E+03**	**5.58E+04**	**2.96E+02**	**1.62E+03**	**2.96E+02**	**1.16E+03**	**1.65E+03**	**6.52E+04**	**2.62E+04**
5	**Forest felling/clearence for road construction**		**3.20E+00**		**5.06E-01**		**1.07E+00**	**1.52E+00**		
6	**CO2 emission due to permanent reduction of biomass**									
7	**Excavation with excavator in the road direction**		**3.98E+02**		**6.31E+01**		**1.33E+02**	**1.89E+02**		
8	**Excavation with wheel loader in the direction of the road**		**3.60E+02**		**5.70E+01**		**1.20E+02**	**1.71E+02**		
9	**Transport of excavated materials with dumper truck in the direction of the road**		**5.28E+02**		**8.36E+01**		**1.76E+02**	**2.51E+02**		
10	**Excavation with excavator in external site for filling materials**		**3.98E+00**		**6.31E-01**		**1.33E+00**	**1.89E+00**		
11	**Excavation with wheel loader in external site for filling materials**		**3.60E+00**		**5.70E-01**		**1.20E+00**	**1.71E+00**		
12	**Transport with dumper truck of excavated materials from external site to road construction site**		**2.11E+01**		**3.34E+00**		**7.04E+00**	**1.00E+01**		
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**		**1.99E+00**		**3.15E-01**		**6.64E-01**	**9.46E-01**		
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**		**1.80E+00**		**2.85E-01**		**6.00E-01**	**8.55E-01**		
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**		**1.06E+01**		**1.67E+00**		**3.52E+00**	**5.02E+00**		
16	**Foundation reinforcement, concrete pile**		**5.69E+02**		**2.30E+02**		**1.18E+02**	**1.68E+02**	**2.59E+03**	**2.59E+03**
17	Pile-driving and materials to concrete pile		2.50E+02		1.79E+02		1.10E+01	1.57E+01	2.59E+03	2.59E+03
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production		1.82E+01		2.88E+00		6.06E+00	8.64E+00		
19	Transport of cement to concrete pile production		5.26E+01		8.33E+00		1.75E+01	2.50E+01		
20	Transport of concrete pile from production site to road construction site		2.49E+02		3.94E+01		8.30E+01	1.18E+02		
21	**Foundation reinforcement, cement/lime columns**		**3.11E+02**		**4.92E+01**		**1.04E+02**	**1.48E+02**	**2.88E+03**	**2.88E+03**
22	Foundation reinforcements work, quicklime and cement for the work		1.86E+02		2.95E+01		6.21E+01	8.84E+01	2.88E+03	2.88E+03
23	Transport of cement to road construction site		6.24E+01		9.88E+00		2.08E+01	2.96E+01		
24	Transport of quicklime to road construction site		6.24E+01		9.88E+00		2.08E+01	2.96E+01		
25	**Construction of road sub-base (unbound)**		**4.42E+02**		**7.00E+01**		**1.47E+02**	**2.10E+02**		
26	Loading of blasted rock		4.92E+01		7.79E+00		1.64E+01	2.34E+01		
27	Transport of blasted rock		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
28	Construction of road sub-base (unbound) at the road site		1.68E+02		2.67E+01		5.62E+01	8.00E+01		
29	Rolling of layers		1.96E+01		3.10E+00		6.53E+00	9.31E+00		
30	**Construction of road base course (unbound)**		**6.10E+02**		**9.66E+01**		**2.03E+02**	**2.90E+02**	**8.26E+03**	**8.26E+03**
31	Production of crushed aggregates		1.02E+02		1.61E+01		3.40E+01	4.84E+01	7.42E+03	7.42E+03
32	Extraction of pit-run gravel/sand		4.84E+00		7.67E-01		1.61E+00	2.30E+00	8.39E+02	8.39E+02
33	Transport of crushed aggregates		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
34	Transport of pit-run gravel/sand		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
35	Construction of road base course (unbound) at the road site		8.42E+01		1.33E+01		2.81E+01	4.00E+01		
36	Rolling of layers		9.80E+00		1.55E+00		3.27E+00	4.65E+00		
37	**Asphalt pavement, hot method**	**2.82E+03**	**5.14E+04**	**2.96E+02**	**8.07E+02**	**2.96E+02**	**1.39E+02**	**1.96E+02**	**5.13E+04**	**1.23E+04**
38	Production of hot asphalt	2.82E+03	5.11E+04	2.96E+02	7.53E+02	2.96E+02	2.54E+01	3.49E+01	5.13E+04	1.23E+04
39	Transport of crushed aggregates to asphalt plant		2.38E+01		3.76E+00		7.92E+00	1.13E+01		
40	Transport of bitumen to sphalt plant		1.21E+02		1.92E+01		4.04E+01	5.76E+01		
41	Transport of asphalt from asphalt plant to road construction site		1.52E+02		2.40E+01		5.05E+01	7.20E+01		
42	Paving of asphalt layers		1.85E+01		2.93E+00		6.18E+00	8.80E+00		
43	Rolling of asphalt layers		2.49E+01		3.95E+00		8.31E+00	1.18E+01		
44	**Asphalt pavement, cold method**									
45	Production of cold asphalt									
46	Transport of crushed aggregates to asphalt plant									
47	Transport of bitumen to emulsifier									
48	Transport of bitumen emulsion from emulsifier to asphalt plant									
49	Transport of asphalt from asphalt plant to road construction site									
50	Paving of asphalt layers									
51	Rolling of asphalt layers									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**									
53	Cement stabilisation, operation of slipform paver									
54	Production of cement									
55	Transport of cement from production to road construction site									
56	**Concrete paving, wearing course**									
57	Production of road concrete									
58	Transport of crushed aggregates to concrete production									
59	Transport of pit-run gravel/sand to concrete production									
60	Transport of cement to concrete production									
61	Transport of road concrete from production to road construction site									
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)									
63	Exposure of aggregate on concrete carriageway									
64	Sawing and sealing of joints in concrete road construction									
65	**Road marking**		**1.05E+00**		**1.67E-01**		**3.51E-01**	**5.00E-01**		
66	**Production and assembly of wildlife fences**		**7.72E+01**		**5.76E+01**		**2.25E+00**	**3.20E+00**		
67	**Other railing and fences, amount of galvanized steel used**		**1.87E+01**		**1.50E+01**					
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**		**4.55E+02**		**3.76E+00**				**9.11E+01**	**9.11E+01**
69	Galvanized steel		4.68E+00		3.76E+00					
70	Aluminium		4.50E+02						9.11E+01	9.11E+01
71	**Lighting and traffic lights, use of galvanized steel and aluminium**		**5.44E+02**		**7.52E+01**				**9.11E+01**	**9.11E+01**
72	Galvanized steel		9.37E+01		7.52E+01					
73	Aluminium		4.50E+02						9.11E+01	9.11E+01
74										
75	**Maintenance of road, total:**	**1.48E+03**	**2.89E+04**	**1.56E+02**	**7.10E+02**	**1.56E+02**	**6.75E+02**	**9.61E+02**	**3.50E+04**	**1.45E+04**
76	**Excavation of road and sub-base with excavator**		**9.55E+01**		**1.51E+01**		**3.18E+01**	**4.54E+01**		
77	**Transport removal of excavated materials from the entire road**		**1.02E+02**		**1.62E+01**		**3.41E+01**	**4.86E+01**		
78	**Reconstruction of base course (unbound)**		**6.10E+02**		**9.66E+01**		**2.03E+02**	**2.90E+02**	**8.26E+03**	**8.26E+03**
79	Production of crushed aggregates		1.02E+02		1.61E+01		3.40E+01	4.84E+01	7.42E+03	7.42E+03
80	Extraction of pit-run gravel/sand		4.84E+00		7.67E-01		1.61E+00	2.30E+00	8.39E+02	8.39E+02
81	Transport of crushed aggregates		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
82	Transport of pit-run gravel/sand		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
83	Construction of new base course (unbound) at road site		8.42E+01		1.33E+01		2.81E+01	4.00E+01		
84	Rolling of layers		9.80E+00		1.55E+00		3.27E+00	4.65E+00		
85	**Surface milling of asphalt pavement**		**1.46E+02**		**2.31E+01**		**4.87E+01**	**6.94E+01**		
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**7.41E+01**	**1.34E+03**	**7.80E+00**	**1.97E+01**	**7.80E+00**	**3.69E-01**	**4.90E-01**	**1.09E+03**	**6.88E+01**
87	**Asphalt pavement, hot method**	**1.41E+03**	**2.65E+04**	**1.48E+02**	**5.38E+02**	**1.48E+02**	**3.53E+02**	**5.02E+02**	**2.56E+04**	**6.14E+03**
88	Production of hot asphalt	1.41E+03	2.55E+04	1.48E+02	3.77E+02	1.48E+02	1.27E+01	1.74E+01	2.56E+04	6.14E+03
89	Transport of crushed aggregates to asphalt plant		7.13E+01		1.13E+01		2.38E+01	3.38E+01		
90	Transport of bitumen to asphalt plant		3.64E+02		5.76E+01		1.21E+02	1.73E+02		
91	Transport of asphalt from asphalt plant to road construction site		4.55E+02		7.20E+01		1.52E+02	2.16E+02		
92	Asphalt paving		5.56E+01		8.80E+00		1.85E+01	2.64E+01		
93	Asphalt rolling		7.48E+01		1.18E+01		2.49E+01	3.55E+01		
94	**Asphalt pavement, cold method**									
95	Production of cold asphalt									
96	Transport of crushed aggregates to asphalt plant									
97	Transport of bitumen to emulsifier									
98	Transport of bitumen emulsion from emulsifier to asphalt plant									
99	Transport of asphalt from asphalt plant to road construction site									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving									
101	Asphalt rolling									
102	**Maintenance of concrete road**									
103	Milling of wearing cource									
104	Resealing of joints, use of EPDM-rubber									
105	Road track milling for concrete filling									
106	Concrete production for concrete filling									
107	Machine operation for concrete filling									
108	Transport of crushed aggregates to concrete production									
109	Transport of pit-run gravel/sand to concrete production									
110	Transport of cement to concrete production									
111	Transport of concrete from production site to road construction site									
112	**Maintenance of road marking**		**1.05E+01**		**1.67E+00**		**3.51E+00**	**5.00E+00**		
113										
114	**Operation of road, total:**		**3.86E+02**		**6.12E+01**		**1.29E+02**	**1.84E+02**	**3.75E+05**	**3.75E+05**
115	**Snow clearance**		**2.23E+01**		**3.54E+00**		**7.45E+00**	**1.06E+01**		
116	**Sand gritting of road in winter road maintenance**		**4.77E+00**		**7.55E-01**		**1.59E+00**	**2.27E+00**	**1.03E+02**	**1.03E+02**
117	Vehicle operation, distribution truck		3.44E+00		5.44E-01		1.15E+00	1.63E+00		
118	Production of sand used, crushed material		1.27E+00		2.01E-01		4.24E-01	6.04E-01	9.26E+01	9.26E+01
119	Production of sand used, natural material		6.04E-02		9.57E-03		2.01E-02	2.87E-02	1.05E+01	1.05E+01
120	**Salt gritting of road in winter road maintenance**		**6.87E+01**		**1.09E+01**		**2.29E+01**	**3.27E+01**		
121	Vehicle operation, distribution truck		6.87E+01		1.09E+01		2.29E+01	3.27E+01		
122	Production of salt used, coal based production									
123	**Sweeping**		**1.01E+01**		**1.60E+00**		**3.37E+00**	**4.80E+00**		
124	**Mowing of verges**		**2.67E+01**		**4.22E+00**		**8.89E+00**	**1.27E+01**		
125	**Clearance of verges**		**1.33E+01**		**2.11E+00**		**4.44E+00**	**6.33E+00**		
126	**Washing of roadside posts**		**3.37E+01**		**5.34E+00**		**1.12E+01**	**1.60E+01**		
127	**Washing of road signs**		**1.08E+01**		**1.71E+00**		**3.60E+00**	**5.13E+00**		
128	**Erection and removal of snow posts**		**1.85E+01**		**2.93E+00**		**6.18E+00**	**8.80E+00**		
129	**Digging of road trenches**		**1.27E+02**		**2.01E+01**		**4.24E+01**	**6.04E+01**		
130	**Lighting and traffic lights, electric power production**								**3.75E+05**	**3.75E+05**
131	Lighting								2.87E+05	2.87E+05
132	Traffic lights								8.83E+04	8.83E+04
133	**Other vehicle use (complementary activities) in operation procedures**		**5.02E+01**		**7.95E+00**		**1.67E+01**	**2.39E+01**		
134										
135	**Total sum:**	**4.30E+03**	**8.50E+04**	**4.52E+02**	**2.39E+03**	**4.52E+02**	**1.96E+03**	**2.79E+03**	**4.76E+05**	**4.16E+05**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AL	AM	AN	AO	AP
1			Radioactive waste			
2		Hazardous chemical waste	Highly active	Medium and low active	Demolition waste	Radioactive exposure
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
4	**Construction of road, total:**	**3.90E+04**	**5.42E+02**	**5.81E+03**	**5.81E+03**	**3.87E-05**
5	**Forest felling/clearence for road construction**					
6	**CO2 emission due to permanent reduction of biomass**					
7	**Excavation with excavator in the road direction**					
8	**Excavation with wheel loader in the direction of the road**					
9	**Transport of excavated materials with dumper truck in the direction of the road**					
10	**Excavation with excavator in external site for filling materials**					
11	**Excavation with wheel loader in external site for filling materials**					
12	**Transport with dumper truck of excavated materials from external site to road construction site**					
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**					
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**					
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**					
16	**Foundation reinforcement, concrete pile**		**5.17E+01**	**5.54E+02**	**5.54E+02**	**3.69E-06**
17	Pile-driving and materials to concrete pile		5.17E+01	5.54E+02	5.54E+02	3.69E-06
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production					
19	Transport of cement to concrete pile production					
20	Transport of concrete pile from production site to road construction site					
21	**Foundation reinforcement, cement/lime columns**		**7.58E+01**	**8.18E+02**	**8.18E+02**	**5.43E-06**
22	Foundation reinforcements work, quicklime and cement for the work		7.58E+01	8.18E+02	8.18E+02	5.43E-06
23	Transport of cement to road construction site					
24	Transport of quicklime to road construction site					
25	**Construction of road sub-base (unbound)**					
26	Loading of blasted rock					
27	Transport of blasted rock					
28	Construction of road sub-base (unbound) at the road site					
29	Rolling of layers					
30	**Construction of road base course (unbound)**		**1.65E+02**	**1.77E+03**	**1.77E+03**	**1.18E-05**
31	Production of crushed aggregates		1.48E+02	1.59E+03	1.59E+03	1.06E-05
32	Extraction of pit-run gravel/sand		1.68E+01	1.80E+02	1.80E+02	1.20E-06
33	Transport of crushed aggregates					
34	Transport of pit-run gravel/sand					
35	Construction of road base course (unbound) at the road site					
36	Rolling of layers					
37	**Asphalt pavement, hot method**	**3.90E+04**	**2.46E+02**	**2.63E+03**	**2.63E+03**	**1.75E-05**
38	Production of hot asphalt	3.90E+04	2.46E+02	2.63E+03	2.63E+03	1.75E-05
39	Transport of crushed aggregates to asphalt plant					
40	Transport of bitumen to sphalt plant					
41	Transport of asphalt from asphalt plant to road construction site					
42	Paving of asphalt layers					
43	Rolling of asphalt layers					
44	**Asphalt pavement, cold method**					
45	Production of cold asphalt					
46	Transport of crushed aggregates to asphalt plant					
47	Transport of bitumen to emulsifier					
48	Transport of bitumen emulsion from emulsifier to asphalt plant					
49	Transport of asphalt from asphalt plant to road construction site					
50	Paving of asphalt layers					
51	Rolling of asphalt layers					

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AL	AM	AN	AO	AP
1			Radioactive waste			
2		Hazardous chemical waste	Highly active	Medium and low active	Demolition waste	Radioactive exposure
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
52	**Cement stabilisation of base course**					
53	Cement stabilisation, operation of slipform paver					
54	Production of cement					
55	Transport of cement from production to road construction site					
56	**Concrete paving, wearing course**					
57	Production of road concrete					
58	Transport of crushed aggregates to concrete production					
59	Transport of pit-run gravel/sand to concrete production					
60	Transport of cement to concrete production					
61	Transport of road concrete from production to road construction site					
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)					
63	Exposure of aggregate on concrete carriageway					
64	Sawing and sealing of joints in concrete road construction					
65	**Road marking**					
66	**Production and assembly of wildlife fences**					
67	**Other railing and fences, amount of galvanized steel used**					
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**		**1.77E+00**	**1.90E+01**	**1.90E+01**	**1.27E-07**
69	Galvanized steel					
70	Aluminium		1.77E+00	1.90E+01	1.90E+01	1.27E-07
71	**Lighting and traffic lights, use of galvanized steel and aluminium**		**1.77E+00**	**1.90E+01**	**1.90E+01**	**1.27E-07**
72	Galvanized steel					
73	Aluminium		1.77E+00	1.90E+01	1.90E+01	1.27E-07
74						
75	**Maintenance of road, total:**	**2.05E+04**	**2.89E+02**	**3.10E+03**	**3.10E+03**	**2.07E-05**
76	**Excavation of road and sub-base with excavator**					
77	**Transport removal of excavated materials from the entire road**					
78	**Reconstruction of base course (unbound)**		**1.65E+02**	**1.77E+03**	**1.77E+03**	**1.18E-05**
79	Production of crushed aggregates		1.48E+02	1.59E+03	1.59E+03	1.06E-05
80	Extraction of pit-run gravel/sand		1.68E+01	1.80E+02	1.80E+02	1.20E-06
81	Transport of crushed aggregates					
82	Transport of pit-run gravel/sand					
83	Construction of new base course (unbound) at road site					
84	Rolling of layers					
85	**Surface milling of asphalt pavement**					
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**1.03E+03**	**1.38E+00**	**1.47E+01**	**1.47E+01**	**9.83E-08**
87	**Asphalt pavement, hot method**	**1.95E+04**	**1.23E+02**	**1.32E+03**	**1.32E+03**	**8.77E-06**
88	Production of hot asphalt	1.95E+04	1.23E+02	1.32E+03	1.32E+03	8.77E-06
89	Transport of crushed aggregates to asphalt plant					
90	Transport of bitumen to asphalt plant					
91	Transport of asphalt from asphalt plant to road construction site					
92	Asphalt paving					
93	Asphalt rolling					
94	**Asphalt pavement, cold method**					
95	Production of cold asphalt					
96	Transport of crushed aggregates to asphalt plant					
97	Transport of bitumen to emulsifier					
98	Transport of bitumen emulsion from emulsifier to asphalt plant					
99	Transport of asphalt from asphalt plant to road construction site					

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AL	AM	AN	AO	AP
1			**Radioactive waste**			
2		**Hazardous chemical waste**	**Highly active**	**Medium and low active**	**Demolition waste**	**Radioactive exposure**
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
100	Asphalt paving					
101	Asphalt rolling					
102	**Maintenance of concrete road**					
103	Milling of wearing cource					
104	Resealing of joints, use of EPDM-rubber					
105	Road track milling for concrete filling					
106	Concrete production for concrete filling					
107	Machine operation for concrete filling					
108	Transport of crushed aggregates to concrete production					
109	Transport of pit-run gravel/sand to concrete production					
110	Transport of cement to concrete production					
111	Transport of concrete from production site to road construction site					
112	**Maintenance of road marking**					
113						
114	**Operation of road, total:**		**7.51E+03**	**8.04E+04**	**8.04E+04**	**5.36E-04**
115	**Snow clearance**					
116	**Sand gritting of road in winter road maintenance**		**2.06E+00**	**2.21E+01**	**2.21E+01**	**1.47E-07**
117	Vehicle operation, distribution truck					
118	Production of sand used, crushed material		1.85E+00	1.98E+01	1.98E+01	1.32E-07
119	Production of sand used, natural material		2.09E-01	2.24E+00	2.24E+00	1.50E-08
120	**Salt gritting of road in winter road maintenance**					
121	Vehicle operation, distribution truck					
122	Production of salt used, coal based production					
123	**Sweeping**					
124	**Mowing of verges**					
125	**Clearance of verges**					
126	**Washing of roadside posts**					
127	**Washing of road signs**					
128	**Erection and removal of snow posts**					
129	**Digging of road trenches**					
130	**Lighting and traffic lights, electric power production**		**7.51E+03**	**8.04E+04**	**8.04E+04**	**5.36E-04**
131	Lighting		5.74E+03	6.15E+04	6.15E+04	4.10E-04
132	Traffic lights		1.77E+03	1.89E+04	1.89E+04	1.26E-04
133	**Other vehicle use (complementary activities) in operation procedures**					
134						
135	**Total sum:**	**5.95E+04**	**8.34E+03**	**8.94E+04**	**8.94E+04**	**5.96E-04**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I
1			Material/Energy resources						
2			(Energy, electricity) *)	Natural gas	Oil	Coal	Biomass fuel	Peat	Uranium
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
4	**Construction of road, total:**	**Road object**	**5.11E+05**	**2.56E+05**	**3.49E+06**	**2.20E+06**	**1.30E+04**	**1.30E+03**	**4.64E+05**
5	**Forest felling/clearence for road construction**	**Road object**			**2.93E+03**				
6	**CO2 emission due to permanent reduction of biomass**	**Road object**							
7	**Excavation with excavator in the road direction**	**Road object**			**3.65E+05**				
8	**Excavation with wheel loader in the direction of the road**	**Road object**			**3.30E+05**				
9	**Transport of excavated materials with dumper truck in the direction of the road**	**Road object**			**4.84E+05**				
10	**Excavation with excavator in external site for filling materials**	**Road object**			**3.65E+03**				
11	**Excavation with wheel loader in external site for filling materials**	**Road object**			**3.30E+03**				
12	**Transport with dumper truck of excavated materials from external site to road construction site**	**Road object**			**1.94E+04**				
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**	**Road object**			**1.83E+03**				
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**	**Road object**			**1.65E+03**				
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**	**Road object**			**9.68E+03**				
16	**Foundation reinforcement, concrete pile**	**Road object**	**1.45E+05**	**4.18E+04**	**4.13E+05**	**6.89E+05**	**1.66E+03**	**1.66E+02**	**5.91E+04**
17	Pile-driving and materials to concrete pile	Road object	1.45E+05	4.18E+04	1.20E+05	6.89E+05	1.66E+03	1.66E+02	5.91E+04
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production	Road object			1.67E+04				
19	Transport of cement to concrete pile production	Road object			4.82E+04				
20	Transport of concrete pile from production site to road construction site	Road object			2.28E+05				
21	**Foundation reinforcement, cement/lime columns**	**Road object**	**5.43E+04**	**5.01E+02**	**3.82E+05**	**1.20E+06**	**2.39E+03**	**2.39E+02**	**8.68E+04**
22	Foundation reinforcements work, quicklime and cement for the work	Road object	5.43E+04	5.01E+02	2.68E+05	1.20E+06	2.39E+03	2.39E+02	8.68E+04
23	Transport of cement to road construction site	Road object			5.72E+04				
24	Transport of quicklime to road construction site	Road object			5.72E+04				
25	**Construction of road sub-base (unbound)**	**Road object**			**4.05E+05**				
26	Loading of blasted rock	Road object			4.51E+04				
27	Transport of blasted rock	Road object			1.88E+05				
28	Construction of road sub-base (unbound) at the road site	Road object			1.54E+05				
29	Rolling of layers	Road object			1.80E+04				
30	**Construction of road base course (unbound)**	**Road object**	**1.18E+05**	**1.10E+03**	**5.67E+05**	**4.72E+03**	**5.31E+03**	**5.31E+02**	**1.89E+05**
31	Production of crushed aggregates	Road object	1.06E+05	9.85E+02	1.00E+05	4.24E+03	4.77E+03	4.77E+02	1.70E+05
32	Extraction of pit-run gravel/sand	Road object	1.20E+04	1.12E+02	5.21E+03	4.80E+02	5.40E+02	5.40E+01	1.92E+04
33	Transport of crushed aggregates	Road object			1.88E+05				
34	Transport of pit-run gravel/sand	Road object			1.88E+05				
35	Construction of road base course (unbound) at the road site	Road object			7.72E+04				
36	Rolling of layers	Road object			8.98E+03				
37	**Asphalt pavement, hot method**	**Road object**							
38	Production of hot asphalt	Road object							
39	Transport of crushed aggregates to asphalt plant	Road object							
40	Transport of bitumen to sphalt plant	Road object							
41	Transport of asphalt from asphalt plant to road construction site	Road object							
42	Paving of asphalt layers	Road object							
43	Rolling of asphalt layers	Road object							
44	**Asphalt pavement, cold method**	**Road object**	**9.43E+04**	**1.77E+05**	**4.20E+05**	**3.13E+03**	**3.52E+03**	**3.52E+02**	**1.25E+05**
45	Production of cold asphalt	Road object	9.43E+04	1.77E+05	2.24E+05	3.13E+03	3.52E+03	3.52E+02	1.25E+05
46	Transport of crushed aggregates to asphalt plant	Road object			4.45E+04				
47	Transport of bitumen to emulsifier	Road object			7.41E+04				
48	Transport of bitumen emulsion from emulsifier to asphalt plant	Road object			2.85E+04				
49	Transport of asphalt from asphalt plant to road construction site	Road object			9.26E+03				
50	Paving of asphalt layers	Road object			1.70E+04				
51	Rolling of asphalt layers	Road object			2.28E+04				

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I
1			**Material/Energy resources**						
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
52	**Cement stabilisation of base course**	**Road object**							
53	Cement stabilisation, operation of slipform paver	Road object							
54	Production of cement	Road object							
55	Transport of cement from production to road construction site	Road object							
56	**Concrete paving, wearing course**	**Road object**							
57	Production of road concrete	Road object							
58	Transport of crushed aggregates to concrete production	Road object							
59	Transport of pit-run gravel/sand to concrete production	Road object							
60	Transport of cement to concrete production	Road object							
61	Transport of road concrete from production to road construction site	Road object							
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)	Road object							
63	Exposure of aggregate on concrete carriageway	Road object							
64	Sawing and sealing of joints in concrete road construction	Road object							
65	**Road marking**	**Road object**			**9.65E+02**				
66	**Production and assembly of wildlife fences**	**Road object**	**3.53E+04**	**1.35E+04**	**3.34E+04**	**1.15E+05**			
67	**Other railing and fences, amount of galvanized steel used**	**Road object**	**9.39E+03**	**3.60E+03**	**7.23E+03**	**3.05E+04**			
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**Road object**	**4.88E+03**	**1.00E+03**	**2.37E+03**	**7.66E+03**	**5.69E+01**	**5.69E+00**	**2.02E+03**
69	Galvanized steel	Road object	2.35E+03	9.01E+02	1.81E+03	7.61E+03			
70	Aluminium	Road object	2.53E+03	1.02E+02	5.61E+02	5.06E+01	5.69E+01	5.69E+00	2.02E+03
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**Road object**	**4.95E+04**	**1.81E+04**	**3.67E+04**	**1.52E+05**	**5.69E+01**	**5.69E+00**	**2.02E+03**
72	Galvanized steel	Road object	4.70E+04	1.80E+04	3.61E+04	1.52E+05			
73	Aluminium	Road object	2.53E+03	1.02E+02	5.61E+02	5.06E+01	5.69E+01	5.69E+00	2.02E+03
74									
75	**Maintenance of road, total:**	**Road object**	**4.02E+05**	**5.38E+05**	**2.16E+06**	**1.42E+04**	**1.59E+04**	**1.59E+03**	**5.66E+05**
76	**Excavation of road and sub-base with excavator**	**Road object**			**8.76E+04**				
77	**Transport removal of excavated materials from the entire road**	**Road object**			**9.38E+04**				
78	**Reconstruction of base course (unbound)**	**Road object**	**1.18E+05**	**1.10E+03**	**5.67E+05**	**4.72E+03**	**5.31E+03**	**5.31E+02**	**1.89E+05**
79	Production of crushed aggregates	Road object	1.06E+05	9.85E+02	1.00E+05	4.24E+03	4.77E+03	4.77E+02	1.70E+05
80	Extraction of pit-run gravel/sand	Road object	1.20E+04	1.12E+02	5.21E+03	4.80E+02	5.40E+02	5.40E+01	1.92E+04
81	Transport of crushed aggregates	Road object			1.88E+05				
82	Transport of pit-run gravel/sand	Road object			1.88E+05				
83	Construction of new base course (unbound) at road site	Road object			7.72E+04				
84	Rolling of layers	Road object			8.98E+03				
85	**Surface milling of asphalt pavement**	**Road object**			**1.34E+05**				
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**Road object**	**1.61E+03**	**6.95E+03**	**4.43E+03**	**3.93E+01**	**4.42E+01**	**4.42E+00**	**1.57E+03**
87	**Asphalt pavement, hot method**	**Road object**							
88	Production of hot asphalt	Road object							
89	Transport of crushed aggregates to asphalt plant	Road object							
90	Transport of bitumen to asphalt plant	Road object							
91	Transport of asphalt from asphalt plant to road construction site	Road object							
92	Asphalt paving	Road object							
93	Asphalt rolling	Road object							
94	**Asphalt pavement, cold method**	**Road object**	**2.83E+05**	**5.30E+05**	**1.26E+06**	**9.39E+03**	**1.06E+04**	**1.06E+03**	**3.76E+05**
95	Production of cold asphalt	Road object	2.83E+05	5.30E+05	6.71E+05	9.39E+03	1.06E+04	1.06E+03	3.76E+05
96	Transport of crushed aggregates to asphalt plant	Road object			1.33E+05				
97	Transport of bitumen to emulsifier	Road object			2.22E+05				
98	Transport of bitumen emulsion from emulsifier to asphalt plant	Road object			8.55E+04				
99	Transport of asphalt from asphalt plant to road construction site	Road object			2.78E+04				

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I
1			**Material/Energy resources**						
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
100	Asphalt paving	Road object			5.10E+04				
101	Asphalt rolling	Road object			6.85E+04				
102	**Maintenance of concrete road**	**Road object**							
103	Milling of wearing cource	Road object							
104	Resealing of joints, use of EPDM-rubber	Road object							
105	Road track milling for concrete filling	Road object							
106	Concrete production for concrete filling	Road object							
107	Machine operation for concrete filling	Road object							
108	Transport of crushed aggregates to concrete production	Road object							
109	Transport of pit-run gravel/sand to concrete production	Road object							
110	Transport of cement to concrete production	Road object							
111	Transport of concrete from production site to road construction site	Road object							
112	**Maintenance of road marking**	**Road object**			**9.65E+03**				
113									
114	**Operation of road, total:**	**Road object**	**5.36E+06**	**4.99E+04**	**6.97E+05**	**5.22E+05**	**2.41E+05**	**2.41E+04**	**8.58E+06**
115	**Snow clearance**	**Road object**			**2.05E+04**				
116	**Sand gritting of road in winter road maintenance**	**Road object**	**1.47E+03**	**1.37E+01**	**4.47E+03**	**5.89E+01**	**6.62E+01**	**6.62E+00**	**2.36E+03**
117	Vehicle operation, distribution truck	Road object			3.15E+03				
118	Production of sand used, crushed material	Road object	1.32E+03	1.23E+01	1.25E+03	5.29E+01	5.95E+01	5.95E+00	2.12E+03
119	Production of sand used, natural material	Road object	1.50E+02	1.39E+00	6.50E+01	5.99E+00	6.73E+00	6.73E-01	2.39E+02
120	**Salt gritting of road in winter road maintenance**	**Road object**			**6.30E+04**	**3.08E+05**			
121	Vehicle operation, distribution truck	Road object			6.30E+04				
122	Production of salt used, coal based production	Road object				3.08E+05			
123	**Sweeping**	**Road object**			**9.27E+03**				
124	**Mowing of verges**	**Road object**			**2.44E+04**				
125	**Clearance of verges**	**Road object**			**1.22E+04**				
126	**Washing of roadside posts**	**Road object**			**3.09E+04**				
127	**Washing of road signs**	**Road object**			**9.89E+03**				
128	**Erection and removal of snow posts**	**Road object**			**1.70E+04**				
129	**Digging of road trenches**	**Road object**			**1.17E+05**				
130	**Lighting and traffic lights, electric power production**	**Road object**	**5.36E+06**	**4.99E+04**	**3.43E+05**	**2.14E+05**	**2.41E+05**	**2.41E+04**	**8.58E+06**
131	Lighting	Road object	4.10E+06	3.81E+04	2.62E+05	1.64E+05	1.84E+05	1.84E+04	6.56E+06
132	Traffic lights	Road object	1.26E+06	1.17E+04	8.07E+04	5.05E+04	5.68E+04	5.68E+03	2.02E+06
133	**Other vehicle use (complementary activities) in operation procedures**	**Road object**			**4.60E+04**				
134									
135	**Total sum:**	**Road object**	**6.28E+06**	**8.44E+05**	**6.34E+06**	**2.74E+06**	**2.70E+05**	**2.70E+04**	**9.61E+06**

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	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**1.36E+05**	**9.88E+07**	**5.15E+09**	**7.52E+09**	**4.96E+08**	**2.92E+08**	**2.92E+08**	**3.36E+08**	**2.92E+08**
5	**Forest felling/clearence for road construction**									
6	**CO2 emission due to permanent reduction of biomass**									
7	**Excavation with excavator in the road direction**									
8	**Excavation with wheel loader in the direction of the road**									
9	**Transport of excavated materials with dumper truck in the direction of the road**									
10	**Excavation with excavator in external site for filling materials**									
11	**Excavation with wheel loader in external site for filling materials**									
12	**Transport with dumper truck of excavated materials from external site to road construction site**									
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**									
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**									
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**									
16	**Foundation reinforcement, concrete pile**	**1.74E+04**		**1.48E+08**	**1.48E+08**	**1.34E+08**	**1.34E+08**	**1.34E+08**	**1.57E+08**	**1.34E+08**
17	Pile-driving and materials to concrete pile	1.74E+04		1.48E+08	1.48E+08	1.34E+08	1.34E+08	1.34E+08	1.57E+08	1.34E+08
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production									
19	Transport of cement to concrete pile production									
20	Transport of concrete pile from production site to road construction site									
21	**Foundation reinforcement, cement/lime columns**	**2.55E+04**				**3.62E+08**	**1.59E+08**	**1.59E+08**	**1.59E+08**	**1.59E+08**
22	Foundation reinforcements work, quicklime and cement for the work	2.55E+04				3.62E+08	1.59E+08	1.59E+08	1.59E+08	1.59E+08
23	Transport of cement to road construction site									
24	Transport of quicklime to road construction site									
25	**Construction of road sub-base (unbound)**									
26	Loading of blasted rock									
27	Transport of blasted rock									
28	Construction of road sub-base (unbound) at the road site									
29	Rolling of layers									
30	**Construction of road base course (unbound)**	**5.54E+04**		**5.00E+09**	**5.00E+09**					
31	Production of crushed aggregates	4.98E+04			5.00E+09					
32	Extraction of pit-run gravel/sand	5.64E+03		5.00E+09						
33	Transport of crushed aggregates									
34	Transport of pit-run gravel/sand									
35	Construction of road base course (unbound) at the road site									
36	Rolling of layers									
37	**Asphalt pavement, hot method**									
38	Production of hot asphalt									
39	Transport of crushed aggregates to asphalt plant									
40	Transport of bitumen to sphalt plant									
41	Transport of asphalt from asphalt plant to road construction site									
42	Paving of asphalt layers									
43	Rolling of asphalt layers									
44	**Asphalt pavement, cold method**	**3.68E+04**	**9.88E+07**		**2.37E+09**					
45	Production of cold asphalt	3.68E+04	9.88E+07		2.37E+09					
46	Transport of crushed aggregates to asphalt plant									
47	Transport of bitumen to emulsifier									
48	Transport of bitumen emulsion from emulsifier to asphalt plant									
49	Transport of asphalt from asphalt plant to road construction site									
50	Paving of asphalt layers									
51	Rolling of asphalt layers									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**									
53	Cement stabilisation, operation of slipform paver									
54	Production of cement									
55	Transport of cement from production to road construction site									
56	**Concrete paving, wearing course**									
57	Production of road concrete									
58	Transport of crushed aggregates to concrete production									
59	Transport of pit-run gravel/sand to concrete production									
60	Transport of cement to concrete production									
61	Transport of road concrete from production to road construction site									
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)									
63	Exposure of aggregate on concrete carriageway									
64	Sawing and sealing of joints in concrete road construction									
65	**Road marking**									
66	**Production and assembly of wildlife fences**								**7.48E+06**	**3.76E+04**
67	**Other railing and fences, amount of galvanized steel used**								**1.99E+06**	**1.00E+04**
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**5.95E+02**				**1.09E+03**	**3.90E+03**	**1.25E+04**	**4.98E+05**	**2.50E+03**
69	Galvanized steel								4.98E+05	2.50E+03
70	Aluminium	5.95E+02				1.09E+03	3.90E+03	1.25E+04		
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**5.95E+02**				**1.09E+03**	**3.90E+03**	**1.25E+04**	**9.95E+06**	**5.00E+04**
72	Galvanized steel								9.95E+06	5.00E+04
73	Aluminium	5.95E+02				1.09E+03	3.90E+03	1.25E+04		
74										
75	**Maintenance of road, total:**	**1.66E+05**	**3.00E+08**	**5.00E+09**	**1.21E+10**					
76	**Excavation of road and sub-base with excavator**									
77	**Transport removal of excavated materials from the entire road**									
78	**Reconstruction of base course (unbound)**	**5.54E+04**		**5.00E+09**	**5.00E+09**					
79	Production of crushed aggregates	4.98E+04			5.00E+09					
80	Extraction of pit-run gravel/sand	5.64E+03		5.00E+09						
81	Transport of crushed aggregates									
82	Transport of pit-run gravel/sand									
83	Construction of new base course (unbound) at road site									
84	Rolling of layers									
85	**Surface milling of asphalt pavement**									
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**4.62E+02**	**3.90E+06**							
87	**Asphalt pavement, hot method**									
88	Production of hot asphalt									
89	Transport of crushed aggregates to asphalt plant									
90	Transport of bitumen to asphalt plant									
91	Transport of asphalt from asphalt plant to road construction site									
92	Asphalt paving									
93	Asphalt rolling									
94	**Asphalt pavement, cold method**	**1.10E+05**	**2.96E+08**		**7.11E+09**					
95	Production of cold asphalt	1.10E+05	2.96E+08		7.11E+09					
96	Transport of crushed aggregates to asphalt plant									
97	Transport of bitumen to emulsifier									
98	Transport of bitumen emulsion from emulsifier to asphalt plant									
99	Transport of asphalt from asphalt plant to road construction site									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving									
101	Asphalt rolling									
102	**Maintenance of concrete road**									
103	Milling of wearing cource									
104	Resealing of joints, use of EPDM-rubber									
105	Road track milling for concrete filling									
106	Concrete production for concrete filling									
107	Machine operation for concrete filling									
108	Transport of crushed aggregates to concrete production									
109	Transport of pit-run gravel/sand to concrete production									
110	Transport of cement to concrete production									
111	Transport of concrete from production site to road construction site									
112	**Maintenance of road marking**									
113										
114	**Operation of road, total:**	**2.52E+06**		**6.24E+07**	**6.24E+07**		**2.08E+08**			
115	**Snow clearance**									
116	**Sand gritting of road in winter road maintenance**	**6.92E+02**		**6.24E+07**	**6.24E+07**					
117	Vehicle operation, distribution truck									
118	Production of sand used, crushed material	6.21E+02			6.24E+07					
119	Production of sand used, natural material	7.03E+01		6.24E+07						
120	**Salt gritting of road in winter road maintenance**						**2.08E+08**			
121	Vehicle operation, distribution truck									
122	Production of salt used, coal based production						2.08E+08			
123	**Sweeping**									
124	**Mowing of verges**									
125	**Clearance of verges**									
126	**Washing of roadside posts**									
127	**Washing of road signs**									
128	**Erection and removal of snow posts**									
129	**Digging of road trenches**									
130	**Lighting and traffic lights, electric power production**	**2.52E+06**								
131	Lighting	1.93E+06								
132	Traffic lights	5.93E+05								
133	**Other vehicle use (complementary activities) in operation procedures**									
134										
135	**Total sum:**	**2.82E+06**	**3.99E+08**	**1.02E+10**	**1.97E+10**	**4.96E+08**	**5.00E+08**	**2.92E+08**	**3.36E+08**	**2.92E+08**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**7.73E+05**	**2.82E+06**	**3.28E+05**	**1.71E+09**	**1.35E+05**	**3.95E+05**	**2.22E+04**	**5.21E+04**	**5.93E+03**	**1.95E+06**
5	**Forest felling/clearence for road construction**	**1.01E+02**	**1.90E+03**	**2.27E+02**	**2.10E+05**	**1.37E+02**	**1.33E-01**			**4.26E+00**	**7.59E+01**
6	**CO2 emission due to permanent reduction of biomass**				**1.02E+09**						
7	**Excavation with excavator in the road direction**	**1.26E+04**	**2.37E+05**	**2.83E+04**	**2.62E+07**	**1.71E+04**	**1.66E+01**			**5.31E+02**	**9.46E+03**
8	**Excavation with wheel loader in the direction of the road**	**1.14E+04**	**2.14E+05**	**2.55E+04**	**2.37E+07**	**1.54E+04**	**1.50E+01**			**4.80E+02**	**8.54E+03**
9	**Transport of excavated materials with dumper truck in the direction of the road**	**1.67E+04**	**3.14E+05**	**3.75E+04**	**3.48E+07**	**2.26E+04**	**2.20E+01**			**7.04E+02**	**1.25E+04**
10	**Excavation with excavator in external site for filling materials**	**1.26E+02**	**2.37E+03**	**2.83E+02**	**2.62E+05**	**1.71E+02**	**1.66E-01**			**5.31E+00**	**9.46E+01**
11	**Excavation with wheel loader in external site for filling materials**	**1.14E+02**	**2.14E+03**	**2.55E+02**	**2.37E+05**	**1.54E+02**	**1.50E-01**			**4.80E+00**	**8.54E+01**
12	**Transport with dumper truck of excavated materials from external site to road construction site**	**6.69E+02**	**1.26E+04**	**1.50E+03**	**1.39E+06**	**9.05E+02**	**8.80E-01**			**2.82E+01**	**5.01E+02**
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**	**6.31E+01**	**1.19E+03**	**1.41E+02**	**1.31E+05**	**8.53E+01**	**8.30E-02**			**2.66E+00**	**4.73E+01**
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**	**5.70E+01**	**1.07E+03**	**1.28E+02**	**1.19E+05**	**7.71E+01**	**7.50E-02**			**2.40E+00**	**4.27E+01**
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**	**3.34E+02**	**6.28E+03**	**7.49E+02**	**6.95E+05**	**4.52E+02**	**4.40E-01**			**1.41E+01**	**2.51E+02**
16	**Foundation reinforcement, concrete pile**	**2.68E+05**	**4.39E+05**	**4.70E+04**	**1.44E+08**	**1.16E+04**	**2.12E+05**	**4.06E+01**	**2.79E+04**	**1.18E+03**	**1.00E+06**
17	Pile-driving and materials to concrete pile	2.58E+05	3.05E+05	2.57E+04	1.23E+08	1.42E+03	2.12E+05	4.06E+01	2.79E+04	7.58E+02	9.99E+05
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production	5.76E+02	7.64E+03	1.21E+03	1.20E+06	5.82E+02	7.58E-01			2.43E+01	1.29E+02
19	Transport of cement to concrete pile production	1.67E+03	2.21E+04	3.51E+03	3.46E+06	1.68E+03	2.19E+00			7.02E+01	3.72E+02
20	Transport of concrete pile from production site to road construction site	7.88E+03	1.05E+05	1.66E+04	1.64E+07	7.96E+03	1.04E+01			3.32E+02	1.76E+03
21	**Foundation reinforcement, cement/lime columns**	**2.07E+05**	**6.97E+05**	**5.92E+04**	**3.09E+08**	**1.20E+04**	**2.00E+01**	**2.18E+03**		**4.31E+02**	**1.08E+05**
22	Foundation reinforcements work, quicklime and cement for the work	2.03E+05	6.45E+05	5.09E+04	3.01E+08	7.97E+03	1.48E+01	2.18E+03		2.65E+02	1.07E+05
23	Transport of cement to road construction site	1.98E+03	2.62E+04	4.17E+03	4.11E+06	2.00E+03	2.60E+00			8.32E+01	4.41E+02
24	Transport of quicklime to road construction site	1.98E+03	2.62E+04	4.17E+03	4.11E+06	2.00E+03	2.60E+00			8.32E+01	4.41E+02
25	**Construction of road sub-base (unbound)**	**1.40E+04**	**2.27E+05**	**3.05E+04**	**2.91E+07**	**1.67E+04**	**1.84E+01**			**5.89E+02**	**7.08E+03**
26	Loading of blasted rock	1.56E+03	2.93E+04	3.49E+03	3.24E+06	2.11E+03	2.05E+00			6.56E+01	1.17E+03
27	Transport of blasted rock	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
28	Construction of road sub-base (unbound) at the road site	5.34E+03	1.00E+05	1.20E+04	1.11E+07	7.22E+03	7.02E+00			2.25E+02	4.00E+03
29	Rolling of layers	6.21E+02	1.17E+04	1.39E+03	1.29E+06	8.39E+02	8.17E-01			2.61E+01	4.65E+02
30	**Construction of road base course (unbound)**	**2.01E+04**	**2.92E+05**	**4.18E+04**	**4.06E+07**	**2.17E+04**	**4.19E+01**	**1.30E+02**		**8.63E+02**	**7.67E+03**
31	Production of crushed aggregates	3.94E+03	6.16E+04	7.45E+03	7.11E+06	4.37E+03	1.91E+01	1.17E+02		1.80E+02	2.43E+03
32	Extraction of pit-run gravel/sand	2.34E+02	2.99E+03	3.69E+02	3.64E+05	2.07E+02	1.88E+00	1.32E+01		1.15E+01	1.16E+02
33	Transport of crushed aggregates	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
34	Transport of pit-run gravel/sand	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
35	Construction of road base course (unbound) at the road site	2.67E+03	5.01E+04	5.98E+03	5.55E+06	3.61E+03	3.51E+00			1.12E+02	2.00E+03
36	Rolling of layers	3.10E+02	5.83E+03	6.95E+02	6.45E+05	4.20E+02	4.08E-01			1.31E+01	2.33E+02
37	**Asphalt pavement, hot method**										
38	Production of hot asphalt										
39	Transport of crushed aggregates to asphalt plant										
40	Transport of bitumen to sphalt plant										
41	Transport of asphalt from asphalt plant to road construction site										
42	Paving of asphalt layers										
43	Rolling of asphalt layers										
44	**Asphalt pavement, cold method**	**7.19E+04**	**2.67E+05**	**3.36E+04**	**3.98E+07**	**1.51E+04**	**2.45E+01**	**1.98E+04**		**4.66E+02**	**5.82E+03**
45	Production of cold asphalt	6.51E+04	1.69E+05	1.91E+04	2.57E+07	7.79E+03	1.56E+01	1.98E+04		1.81E+02	3.58E+03
46	Transport of crushed aggregates to asphalt plant	1.54E+03	2.04E+04	3.24E+03	3.19E+06	1.55E+03	2.02E+00			6.47E+01	3.43E+02
47	Transport of bitumen to emulsifier	2.56E+03	3.40E+04	5.40E+03	5.32E+06	2.59E+03	3.37E+00			1.08E+02	5.71E+02
48	Transport of bitumen emulsion from emulsifier to asphalt plant	9.85E+02	1.31E+04	2.08E+03	2.05E+06	9.95E+02	1.30E+00			4.15E+01	2.20E+02
49	Transport of asphalt from asphalt plant to road construction site	3.20E+02	4.25E+03	6.75E+02	6.65E+05	3.23E+02	4.21E-01			1.35E+01	7.14E+01
50	Paving of asphalt layers	5.87E+02	1.10E+04	1.31E+03	1.22E+06	7.94E+02	7.72E-01			2.47E+01	4.40E+02
51	Rolling of asphalt layers	7.89E+02	1.48E+04	1.77E+03	1.64E+06	1.07E+03	1.04E+00			3.32E+01	5.91E+02

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**										
53	Cement stabilisation, operation of slipform paver										
54	Production of cement										
55	Transport of cement from production to road construction site										
56	**Concrete paving, wearing course**										
57	Production of road concrete										
58	Transport of crushed aggregates to concrete production										
59	Transport of pit-run gravel/sand to concrete production										
60	Transport of cement to concrete production										
61	Transport of road concrete from production to road construction site										
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)										
63	Exposure of aggregate on concrete carriageway										
64	Sawing and sealing of joints in concrete road construction										
65	**Road marking**	**3.33E+01**	**4.83E+02**	**6.49E+01**	**6.93E+04**	**3.58E+01**	**2.98E-02**			**9.55E-01**	**2.27E+01**
66	**Production and assembly of wildlife fences**	**5.62E+04**	**4.10E+04**	**8.11E+03**	**1.71E+07**	**2.89E+02**	**6.86E+04**		**9.08E+03**	**2.38E+02**	**2.94E+05**
67	**Other railing and fences, amount of galvanized steel used**	**1.49E+04**	**9.83E+03**	**2.03E+03**	**4.42E+06**		**1.82E+04**		**2.42E+03**	**6.09E+01**	**7.81E+04**
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**4.08E+03**	**2.71E+03**	**5.45E+02**	**1.17E+06**	**7.00E+01**	**4.56E+03**	**1.39E+00**	**6.04E+02**	**1.58E+01**	**2.23E+04**
69	Galvanized steel	3.72E+03	2.46E+03	5.07E+02	1.11E+06		4.56E+03		6.04E+02	1.52E+01	1.95E+04
70	Aluminium	3.53E+02	2.52E+02	3.77E+01	6.63E+04	7.00E+01	1.77E-01	1.39E+00		5.31E-01	2.77E+03
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**7.48E+04**	**4.94E+04**	**1.02E+04**	**2.22E+07**	**7.00E+01**	**9.12E+04**	**1.39E+00**	**1.21E+04**	**3.05E+02**	**3.93E+05**
72	Galvanized steel	7.44E+04	4.91E+04	1.01E+04	2.21E+07		9.12E+04		1.21E+04	3.05E+02	3.90E+05
73	Aluminium	3.53E+02	2.52E+02	3.77E+01	6.63E+04	7.00E+01	1.77E-01	1.39E+00		5.31E-01	2.77E+03
74											
75	**Maintenance of road, total:**	**2.49E+05**	**1.29E+06**	**1.68E+05**	**1.84E+08**	**8.11E+04**	**1.30E+02**	**6.04E+04**		**2.73E+03**	**3.18E+04**
76	**Excavation of road and sub-base with excavator**	**3.02E+03**	**5.68E+04**	**6.78E+03**	**6.29E+06**	**4.09E+03**	**3.98E+00**			**1.27E+02**	**2.27E+03**
77	**Transport removal of excavated materials from the entire road**	**3.24E+03**	**4.30E+04**	**6.83E+03**	**6.73E+06**	**3.27E+03**	**4.26E+00**			**1.36E+02**	**7.23E+02**
78	**Reconstruction of base course (unbound)**	**2.01E+04**	**2.92E+05**	**4.18E+04**	**4.06E+07**	**2.17E+04**	**4.19E+01**	**1.30E+02**		**8.63E+02**	**7.67E+03**
79	Production of crushed aggregates	3.94E+03	6.16E+04	7.45E+03	7.11E+06	4.37E+03	1.91E+01	1.17E+02		1.80E+02	2.43E+03
80	Extraction of pit-run gravel/sand	2.34E+02	2.99E+03	3.69E+02	3.64E+05	2.07E+02	1.88E+00	1.32E+01		1.15E+01	1.16E+02
81	Transport of crushed aggregates	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
82	Transport of pit-run gravel/sand	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
83	Construction of new base course (unbound) at road site	2.67E+03	5.01E+04	5.98E+03	5.55E+06	3.61E+03	3.51E+00			1.12E+02	2.00E+03
84	Rolling of layers	3.10E+02	5.83E+03	6.95E+02	6.45E+05	4.20E+02	4.08E-01			1.31E+01	2.33E+02
85	**Surface milling of asphalt pavement**	**4.62E+03**	**8.69E+04**	**1.04E+04**	**9.61E+06**	**6.25E+03**	**6.08E+00**			**1.95E+02**	**3.47E+03**
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**2.40E+03**	**4.17E+03**	**4.56E+02**	**6.97E+05**	**1.35E+02**	**1.52E-01**	**7.81E+02**		**8.73E-01**	**3.98E+01**
87	**Asphalt pavement, hot method**										
88	Production of hot asphalt										
89	Transport of crushed aggregates to asphalt plant										
90	Transport of bitumen to asphalt plant										
91	Transport of asphalt from asphalt plant to road construction site										
92	Asphalt paving										
93	Asphalt rolling										
94	**Asphalt pavement, cold method**	**2.16E+05**	**8.00E+05**	**1.01E+05**	**1.19E+08**	**4.53E+04**	**7.35E+01**	**5.95E+04**		**1.40E+03**	**1.74E+04**
95	Production of cold asphalt	1.95E+05	5.07E+05	5.73E+04	7.71E+07	2.34E+04	4.67E+01	5.95E+04		5.42E+02	1.07E+04
96	Transport of crushed aggregates to asphalt plant	4.61E+03	6.11E+04	9.72E+03	9.58E+06	4.66E+03	6.06E+00			1.94E+02	1.03E+03
97	Transport of bitumen to emulsifier	7.68E+03	1.02E+05	1.62E+04	1.60E+07	7.76E+03	1.01E+01			3.23E+02	1.71E+03
98	Transport of bitumen emulsion from emulsifier to asphalt plant	2.95E+03	3.92E+04	6.23E+03	6.14E+06	2.99E+03	3.89E+00			1.24E+02	6.59E+02
99	Transport of asphalt from asphalt plant to road construction site	9.60E+02	1.27E+04	2.02E+03	2.00E+06	9.70E+02	1.26E+00			4.04E+01	2.14E+02

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving	1.76E+03	3.31E+04	3.94E+03	3.66E+06	2.38E+03	2.32E+00			7.41E+01	1.32E+03
101	Asphalt rolling	2.37E+03	4.45E+04	5.30E+03	4.92E+06	3.20E+03	3.12E+00			9.97E+01	1.77E+03
102	**Maintenance of concrete road**										
103	Milling of wearing cource										
104	Resealing of joints, use of EPDM-rubber										
105	Road track milling for concrete filling										
106	Concrete production for concrete filling										
107	Machine operation for concrete filling										
108	Transport of crushed aggregates to concrete production										
109	Transport of pit-run gravel/sand to concrete production										
110	Transport of cement to concrete production										
111	Transport of concrete from production site to road construction site										
112	**Maintenance of road marking**	**3.33E+02**	**4.83E+03**	**6.49E+02**	**6.93E+05**	**3.58E+02**	**2.98E-01**			**9.55E+00**	**2.27E+02**
113											
114	**Operation of road, total:**	**2.02E+05**	**3.53E+05**	**4.45E+04**	**7.41E+07**	**1.54E+04**	**7.67E+02**	**5.90E+03**		**2.77E+03**	**7.73E+03**
115	**Snow clearance**	**7.07E+02**	**9.38E+03**	**1.49E+03**	**1.47E+06**	**7.15E+02**	**9.31E-01**			**2.98E+01**	**1.58E+02**
116	**Sand gritting of road in winter road maintenance**	**1.61E+02**	**2.25E+03**	**3.27E+02**	**3.20E+05**	**1.67E+02**	**4.05E-01**	**1.62E+00**		**6.98E+00**	**5.60E+01**
117	Vehicle operation, distribution truck	1.09E+02	1.44E+03	2.30E+02	2.26E+05	1.10E+02	1.43E-01			4.58E+00	2.43E+01
118	Production of sand used, crushed material	4.91E+01	7.69E+02	9.30E+01	8.88E+04	5.45E+01	2.38E-01	1.45E+00		2.25E+00	3.03E+01
119	Production of sand used, natural material	2.92E+00	3.73E+01	4.60E+00	4.55E+03	2.59E+00	2.35E-02	1.65E-01		1.43E-01	1.44E+00
120	**Salt gritting of road in winter road maintenance**	**1.56E+05**	**1.21E+05**	**1.08E+04**	**3.28E+07**	**2.20E+03**	**2.86E+00**			**9.17E+01**	**4.86E+02**
121	Vehicle operation, distribution truck	2.18E+03	2.89E+04	4.59E+03	4.53E+06	2.20E+03	2.86E+00			9.17E+01	4.86E+02
122	Production of salt used, coal based production	1.54E+05	9.24E+04	6.24E+03	2.83E+07						
123	**Sweeping**	**3.20E+02**	**6.02E+03**	**7.17E+02**	**6.65E+05**	**4.33E+02**	**4.21E-01**			**1.35E+01**	**2.40E+02**
124	**Mowing of verges**	**8.45E+02**	**1.59E+04**	**1.89E+03**	**1.76E+06**	**1.14E+03**	**1.11E+00**			**3.56E+01**	**6.33E+02**
125	**Clearance of verges**	**4.22E+02**	**7.94E+03**	**9.46E+02**	**8.78E+05**	**5.71E+02**	**5.56E-01**			**1.78E+01**	**3.16E+02**
126	**Washing of roadside posts**	**1.07E+03**	**2.01E+04**	**2.39E+03**	**2.22E+06**	**1.44E+03**	**1.40E+00**			**4.49E+01**	**8.00E+02**
127	**Washing of road signs**	**3.42E+02**	**6.42E+03**	**7.65E+02**	**7.10E+05**	**4.62E+02**	**4.50E-01**			**1.44E+01**	**2.56E+02**
128	**Erection and removal of snow posts**	**5.87E+02**	**1.10E+04**	**1.31E+03**	**1.22E+06**	**7.94E+02**	**7.72E-01**			**2.47E+01**	**4.40E+02**
129	**Digging of road trenches**	**4.03E+03**	**7.57E+04**	**9.02E+03**	**8.37E+06**	**5.45E+03**	**5.30E+00**			**1.70E+02**	**3.02E+03**
130	**Lighting and traffic lights, electric power production**	**3.59E+04**	**4.93E+04**	**1.13E+04**	**2.04E+07**		**7.51E+02**	**5.90E+03**		**2.25E+03**	**3.75E+02**
131	Lighting	2.75E+04	3.77E+04	8.61E+03	1.56E+07		5.74E+02	4.51E+03		1.72E+03	2.87E+02
132	Traffic lights	8.45E+03	1.16E+04	2.65E+03	4.79E+06		1.77E+02	1.39E+03		5.30E+02	8.83E+01
133	**Other vehicle use (complementary activities) in operation procedures**	**1.59E+03**	**2.74E+04**	**3.50E+03**	**3.31E+06**	**2.00E+03**	**2.09E+00**			**6.70E+01**	**9.56E+02**
134											
135	**Total sum:**	**1.22E+06**	**4.46E+06**	**5.40E+05**	**1.97E+09**	**2.31E+05**	**3.96E+05**	**8.85E+04**	**5.21E+04**	**1.14E+04**	**1.99E+06**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**1.88E+03**	**3.87E+04**	**1.98E+02**	**1.36E+03**	**1.98E+02**	**1.13E+03**	**1.61E+03**	**4.54E+04**	**1.94E+04**
5	**Forest felling/clearence for road construction**		**3.20E+00**		**5.06E-01**		**1.07E+00**	**1.52E+00**		
6	**CO2 emission due to permanent reduction of biomass**									
7	**Excavation with excavator in the road direction**		**3.98E+02**		**6.31E+01**		**1.33E+02**	**1.89E+02**		
8	**Excavation with wheel loader in the direction of the road**		**3.60E+02**		**5.70E+01**		**1.20E+02**	**1.71E+02**		
9	**Transport of excavated materials with dumper truck in the direction of the road**		**5.28E+02**		**8.36E+01**		**1.76E+02**	**2.51E+02**		
10	**Excavation with excavator in external site for filling materials**		**3.98E+00**		**6.31E-01**		**1.33E+00**	**1.89E+00**		
11	**Excavation with wheel loader in external site for filling materials**		**3.60E+00**		**5.70E-01**		**1.20E+00**	**1.71E+00**		
12	**Transport with dumper truck of excavated materials from external site to road construction site**		**2.11E+01**		**3.34E+00**		**7.04E+00**	**1.00E+01**		
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**		**1.99E+00**		**3.15E-01**		**6.64E-01**	**9.46E-01**		
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**		**1.80E+00**		**2.85E-01**		**6.00E-01**	**8.55E-01**		
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**		**1.06E+01**		**1.67E+00**		**3.52E+00**	**5.02E+00**		
16	**Foundation reinforcement, concrete pile**		**5.69E+02**		**2.30E+02**		**1.18E+02**	**1.68E+02**	**2.59E+03**	**2.59E+03**
17	Pile-driving and materials to concrete pile		2.50E+02		1.79E+02		1.10E+01	1.57E+01	2.59E+03	2.59E+03
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production		1.82E+01		2.88E+00		6.06E+00	8.64E+00		
19	Transport of cement to concrete pile production		5.26E+01		8.33E+00		1.75E+01	2.50E+01		
20	Transport of concrete pile from production site to road construction site		2.49E+02		3.94E+01		8.30E+01	1.18E+02		
21	**Foundation reinforcement, cement/lime columns**		**3.11E+02**		**4.92E+01**		**1.04E+02**	**1.48E+02**	**2.88E+03**	**2.88E+03**
22	Foundation reinforcements work, quicklime and cement for the work		1.86E+02		2.95E+01		6.21E+01	8.84E+01	2.88E+03	2.88E+03
23	Transport of cement to road construction site		6.24E+01		9.88E+00		2.08E+01	2.96E+01		
24	Transport of quicklime to road construction site		6.24E+01		9.88E+00		2.08E+01	2.96E+01		
25	**Construction of road sub-base (unbound)**		**4.42E+02**		**7.00E+01**		**1.47E+02**	**2.10E+02**		
26	Loading of blasted rock		4.92E+01		7.79E+00		1.64E+01	2.34E+01		
27	Transport of blasted rock		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
28	Construction of road sub-base (unbound) at the road site		1.68E+02		2.67E+01		5.62E+01	8.00E+01		
29	Rolling of layers		1.96E+01		3.10E+00		6.53E+00	9.31E+00		
30	**Construction of road base course (unbound)**		**6.10E+02**		**9.66E+01**		**2.03E+02**	**2.90E+02**	**8.26E+03**	**8.26E+03**
31	Production of crushed aggregates		1.02E+02		1.61E+01		3.40E+01	4.84E+01	7.42E+03	7.42E+03
32	Extraction of pit-run gravel/sand		4.84E+00		7.67E-01		1.61E+00	2.30E+00	8.39E+02	8.39E+02
33	Transport of crushed aggregates		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
34	Transport of pit-run gravel/sand		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
35	Construction of road base course (unbound) at the road site		8.42E+01		1.33E+01		2.81E+01	4.00E+01		
36	Rolling of layers		9.80E+00		1.55E+00		3.27E+00	4.65E+00		
37	**Asphalt pavement, hot method**									
38	Production of hot asphalt									
39	Transport of crushed aggregates to asphalt plant									
40	Transport of bitumen to sphalt plant									
41	Transport of asphalt from asphalt plant to road construction site									
42	Paving of asphalt layers									
43	Rolling of asphalt layers									
44	**Asphalt pavement, cold method**	**1.88E+03**	**3.43E+04**	**1.98E+02**	**5.49E+02**	**1.98E+02**	**1.15E+02**	**1.63E+02**	**3.15E+04**	**5.48E+03**
45	Production of cold asphalt	1.88E+03	3.41E+04	1.98E+02	5.15E+02	1.98E+02	4.34E+01	6.09E+01	3.15E+04	5.48E+03
46	Transport of crushed aggregates to asphalt plant		4.85E+01		7.68E+00		1.62E+01	2.30E+01		
47	Transport of bitumen to emulsifier		8.09E+01		1.28E+01		2.70E+01	3.84E+01		
48	Transport of bitumen emulsion from emulsifier to asphalt plant		3.11E+01		4.92E+00		1.04E+01	1.48E+01		
49	Transport of asphalt from asphalt plant to road construction site		1.01E+01		1.60E+00		3.37E+00	4.80E+00		
50	Paving of asphalt layers		1.85E+01		2.93E+00		6.18E+00	8.80E+00		
51	Rolling of asphalt layers		2.49E+01		3.95E+00		8.31E+00	1.18E+01		

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**									
53	Cement stabilisation, operation of slipform paver									
54	Production of cement									
55	Transport of cement from production to road construction site									
56	**Concrete paving, wearing course**									
57	Production of road concrete									
58	Transport of crushed aggregates to concrete production									
59	Transport of pit-run gravel/sand to concrete production									
60	Transport of cement to concrete production									
61	Transport of road concrete from production to road construction site									
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)									
63	Exposure of aggregate on concrete carriageway									
64	Sawing and sealing of joints in concrete road construction									
65	**Road marking**		**1.05E+00**		**1.67E-01**		**3.51E-01**	**5.00E-01**		
66	**Production and assembly of wildlife fences**		**7.72E+01**		**5.76E+01**		**2.25E+00**	**3.20E+00**		
67	**Other railing and fences, amount of galvanized steel used**		**1.87E+01**		**1.50E+01**					
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**		**4.55E+02**		**3.76E+00**				**9.11E+01**	**9.11E+01**
69	Galvanized steel		4.68E+00		3.76E+00					
70	Aluminium		4.50E+02						9.11E+01	9.11E+01
71	**Lighting and traffic lights, use of galvanized steel and aluminium**		**5.44E+02**		**7.52E+01**				**9.11E+01**	**9.11E+01**
72	Galvanized steel		9.37E+01		7.52E+01					
73	Aluminium		4.50E+02						9.11E+01	9.11E+01
74										
75	**Maintenance of road, total:**	**5.71E+03**	**1.05E+05**	**6.01E+02**	**1.82E+03**	**6.01E+02**	**6.66E+02**	**9.46E+02**	**1.04E+05**	**2.48E+04**
76	**Excavation of road and sub-base with excavator**		**9.55E+01**		**1.51E+01**		**3.18E+01**	**4.54E+01**		
77	**Transport removal of excavated materials from the entire road**		**1.02E+02**		**1.62E+01**		**3.41E+01**	**4.86E+01**		
78	**Reconstruction of base course (unbound)**		**6.10E+02**		**9.66E+01**		**2.03E+02**	**2.90E+02**	**8.26E+03**	**8.26E+03**
79	Production of crushed aggregates		1.02E+02		1.61E+01		3.40E+01	4.84E+01	7.42E+03	7.42E+03
80	Extraction of pit-run gravel/sand		4.84E+00		7.67E-01		1.61E+00	2.30E+00	8.39E+02	8.39E+02
81	Transport of crushed aggregates		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
82	Transport of pit-run gravel/sand		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
83	Construction of new base course (unbound) at road site		8.42E+01		1.33E+01		2.81E+01	4.00E+01		
84	Rolling of layers		9.80E+00		1.55E+00		3.27E+00	4.65E+00		
85	**Surface milling of asphalt pavement**		**1.46E+02**		**2.31E+01**		**4.87E+01**	**6.94E+01**		
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**7.41E+01**	**1.34E+03**	**7.80E+00**	**1.97E+01**	**7.80E+00**	**3.69E-01**	**4.90E-01**	**1.09E+03**	**6.88E+01**
87	**Asphalt pavement, hot method**									
88	Production of hot asphalt									
89	Transport of crushed aggregates to asphalt plant									
90	Transport of bitumen to asphalt plant									
91	Transport of asphalt from asphalt plant to road construction site									
92	Asphalt paving									
93	Asphalt rolling									
94	**Asphalt pavement, cold method**	**5.63E+03**	**1.03E+05**	**5.93E+02**	**1.65E+03**	**5.93E+02**	**3.44E+02**	**4.88E+02**	**9.44E+04**	**1.64E+04**
95	Production of cold asphalt	5.63E+03	1.02E+05	5.93E+02	1.54E+03	5.93E+02	1.30E+02	1.83E+02	9.44E+04	1.64E+04
96	Transport of crushed aggregates to asphalt plant		1.46E+02		2.30E+01		4.85E+01	6.91E+01		
97	Transport of bitumen to emulsifier		2.43E+02		3.84E+01		8.09E+01	1.15E+02		
98	Transport of bitumen emulsion from emulsifier to asphalt plant		9.33E+01		1.48E+01		3.11E+01	4.43E+01		
99	Transport of asphalt from asphalt plant to road construction site		3.03E+01		4.80E+00		1.01E+01	1.44E+01		

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving		5.56E+01		8.80E+00		1.85E+01	2.64E+01		
101	Asphalt rolling		7.48E+01		1.18E+01		2.49E+01	3.55E+01		
102	**Maintenance of concrete road**									
103	Milling of wearing cource									
104	Resealing of joints, use of EPDM-rubber									
105	Road track milling for concrete filling									
106	Concrete production for concrete filling									
107	Machine operation for concrete filling									
108	Transport of crushed aggregates to concrete production									
109	Transport of pit-run gravel/sand to concrete production									
110	Transport of cement to concrete production									
111	Transport of concrete from production site to road construction site									
112	**Maintenance of road marking**		**1.05E+01**		**1.67E+00**		**3.51E+00**	**5.00E+00**		
113										
114	**Operation of road, total:**		**3.86E+02**		**6.12E+01**		**1.29E+02**	**1.84E+02**	**3.75E+05**	**3.75E+05**
115	**Snow clearance**		**2.23E+01**		**3.54E+00**		**7.45E+00**	**1.06E+01**		
116	**Sand gritting of road in winter road maintenance**		**4.77E+00**		**7.55E-01**		**1.59E+00**	**2.27E+00**	**1.03E+02**	**1.03E+02**
117	Vehicle operation, distribution truck		3.44E+00		5.44E-01		1.15E+00	1.63E+00		
118	Production of sand used, crushed material		1.27E+00		2.01E-01		4.24E-01	6.04E-01	9.26E+01	9.26E+01
119	Production of sand used, natural material		6.04E-02		9.57E-03		2.01E-02	2.87E-02	1.05E+01	1.05E+01
120	**Salt gritting of road in winter road maintenance**		**6.87E+01**		**1.09E+01**		**2.29E+01**	**3.27E+01**		
121	Vehicle operation, distribution truck		6.87E+01		1.09E+01		2.29E+01	3.27E+01		
122	Production of salt used, coal based production									
123	**Sweeping**		**1.01E+01**		**1.60E+00**		**3.37E+00**	**4.80E+00**		
124	**Mowing of verges**		**2.67E+01**		**4.22E+00**		**8.89E+00**	**1.27E+01**		
125	**Clearance of verges**		**1.33E+01**		**2.11E+00**		**4.44E+00**	**6.33E+00**		
126	**Washing of roadside posts**		**3.37E+01**		**5.34E+00**		**1.12E+01**	**1.60E+01**		
127	**Washing of road signs**		**1.08E+01**		**1.71E+00**		**3.60E+00**	**5.13E+00**		
128	**Erection and removal of snow posts**		**1.85E+01**		**2.93E+00**		**6.18E+00**	**8.80E+00**		
129	**Digging of road trenches**		**1.27E+02**		**2.01E+01**		**4.24E+01**	**6.04E+01**		
130	**Lighting and traffic lights, electric power production**								**3.75E+05**	**3.75E+05**
131	Lighting								2.87E+05	2.87E+05
132	Traffic lights								8.83E+04	8.83E+04
133	**Other vehicle use (complementary activities) in operation procedures**		**5.02E+01**		**7.95E+00**		**1.67E+01**	**2.39E+01**		
134										
135	**Total sum:**	**7.58E+03**	**1.44E+05**	**7.98E+02**	**3.24E+03**	**7.98E+02**	**1.93E+03**	**2.74E+03**	**5.24E+05**	**4.20E+05**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AL	AM	AN	AO	AP
1			Radioactive waste			
2		Hazardous chemical waste	Highly active	Medium and low active	Demolition waste	Radioactive exposure
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
4	**Construction of road, total:**	**2.60E+04**	**4.06E+02**	**4.35E+03**	**4.35E+03**	**2.90E-05**
5	**Forest felling/clearence for road construction**					
6	**CO2 emission due to permanent reduction of biomass**					
7	**Excavation with excavator in the road direction**					
8	**Excavation with wheel loader in the direction of the road**					
9	**Transport of excavated materials with dumper truck in the direction of the road**					
10	**Excavation with excavator in external site for filling materials**					
11	**Excavation with wheel loader in external site for filling materials**					
12	**Transport with dumper truck of excavated materials from external site to road construction site**					
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**					
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**					
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**					
16	**Foundation reinforcement, concrete pile**		**5.17E+01**	**5.54E+02**	**5.54E+02**	**3.69E-06**
17	Pile-driving and materials to concrete pile		5.17E+01	5.54E+02	5.54E+02	3.69E-06
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production					
19	Transport of cement to concrete pile production					
20	Transport of concrete pile from production site to road construction site					
21	**Foundation reinforcement, cement/lime columns**		**7.58E+01**	**8.18E+02**	**8.18E+02**	**5.43E-06**
22	Foundation reinforcements work, quicklime and cement for the work		7.58E+01	8.18E+02	8.18E+02	5.43E-06
23	Transport of cement to road construction site					
24	Transport of quicklime to road construction site					
25	**Construction of road sub-base (unbound)**					
26	Loading of blasted rock					
27	Transport of blasted rock					
28	Construction of road sub-base (unbound) at the road site					
29	Rolling of layers					
30	**Construction of road base course (unbound)**		**1.65E+02**	**1.77E+03**	**1.77E+03**	**1.18E-05**
31	Production of crushed aggregates		1.48E+02	1.59E+03	1.59E+03	1.06E-05
32	Extraction of pit-run gravel/sand		1.68E+01	1.80E+02	1.80E+02	1.20E-06
33	Transport of crushed aggregates					
34	Transport of pit-run gravel/sand					
35	Construction of road base course (unbound) at the road site					
36	Rolling of layers					
37	**Asphalt pavement, hot method**					
38	Production of hot asphalt					
39	Transport of crushed aggregates to asphalt plant					
40	Transport of bitumen to sphalt plant					
41	Transport of asphalt from asphalt plant to road construction site					
42	Paving of asphalt layers					
43	Rolling of asphalt layers					
44	**Asphalt pavement, cold method**	**2.60E+04**	**1.10E+02**	**1.17E+03**	**1.17E+03**	**7.83E-06**
45	Production of cold asphalt	2.60E+04	1.10E+02	1.17E+03	1.17E+03	7.83E-06
46	Transport of crushed aggregates to asphalt plant					
47	Transport of bitumen to emulsifier					
48	Transport of bitumen emulsion from emulsifier to asphalt plant					
49	Transport of asphalt from asphalt plant to road construction site					
50	Paving of asphalt layers					
51	Rolling of asphalt layers					

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	A	AL	AM	AN	AO	AP
1			Radioactive waste			
2		Hazardous chemical waste	Highly active	Medium and low active	Demolition waste	Radioactive exposure
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
52	**Cement stabilisation of base course**					
53	Cement stabilisation, operation of slipform paver					
54	Production of cement					
55	Transport of cement from production to road construction site					
56	**Concrete paving, wearing course**					
57	Production of road concrete					
58	Transport of crushed aggregates to concrete production					
59	Transport of pit-run gravel/sand to concrete production					
60	Transport of cement to concrete production					
61	Transport of road concrete from production to road construction site					
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)					
63	Exposure of aggregate on concrete carriageway					
64	Sawing and sealing of joints in concrete road construction					
65	**Road marking**					
66	**Production and assembly of wildlife fences**					
67	**Other railing and fences, amount of galvanized steel used**					
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**		**1.77E+00**	**1.90E+01**	**1.90E+01**	**1.27E-07**
69	Galvanized steel					
70	Aluminium		1.77E+00	1.90E+01	1.90E+01	1.27E-07
71	**Lighting and traffic lights, use of galvanized steel and aluminium**		**1.77E+00**	**1.90E+01**	**1.90E+01**	**1.27E-07**
72	Galvanized steel					
73	Aluminium		1.77E+00	1.90E+01	1.90E+01	1.27E-07
74						
75	**Maintenance of road, total:**	**7.90E+04**	**4.95E+02**	**5.31E+03**	**5.31E+03**	**3.54E-05**
76	**Excavation of road and sub-base with excavator**					
77	**Transport removal of excavated materials from the entire road**					
78	**Reconstruction of base course (unbound)**		**1.65E+02**	**1.77E+03**	**1.77E+03**	**1.18E-05**
79	Production of crushed aggregates		1.48E+02	1.59E+03	1.59E+03	1.06E-05
80	Extraction of pit-run gravel/sand		1.68E+01	1.80E+02	1.80E+02	1.20E-06
81	Transport of crushed aggregates					
82	Transport of pit-run gravel/sand					
83	Construction of new base course (unbound) at road site					
84	Rolling of layers					
85	**Surface milling of asphalt pavement**					
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**1.03E+03**	**1.38E+00**	**1.47E+01**	**1.47E+01**	**9.83E-08**
87	**Asphalt pavement, hot method**					
88	Production of hot asphalt					
89	Transport of crushed aggregates to asphalt plant					
90	Transport of bitumen to asphalt plant					
91	Transport of asphalt from asphalt plant to road construction site					
92	Asphalt paving					
93	Asphalt rolling					
94	**Asphalt pavement, cold method**	**7.80E+04**	**3.29E+02**	**3.52E+03**	**3.52E+03**	**2.35E-05**
95	Production of cold asphalt	7.80E+04	3.29E+02	3.52E+03	3.52E+03	2.35E-05
96	Transport of crushed aggregates to asphalt plant					
97	Transport of bitumen to emulsifier					
98	Transport of bitumen emulsion from emulsifier to asphalt plant					
99	Transport of asphalt from asphalt plant to road construction site					

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AL	AM	AN	AO	AP
1			**Radioactive waste**			
2		**Hazardous chemical waste**	**Highly active**	**Medium and low active**	**Demolition waste**	**Radioactive exposure**
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
100	Asphalt paving					
101	Asphalt rolling					
102	**Maintenance of concrete road**					
103	Milling of wearing cource					
104	Resealing of joints, use of EPDM-rubber					
105	Road track milling for concrete filling					
106	Concrete production for concrete filling					
107	Machine operation for concrete filling					
108	Transport of crushed aggregates to concrete production					
109	Transport of pit-run gravel/sand to concrete production					
110	Transport of cement to concrete production					
111	Transport of concrete from production site to road construction site					
112	**Maintenance of road marking**					
113						
114	**Operation of road, total:**		**7.51E+03**	**8.04E+04**	**8.04E+04**	**5.36E-04**
115	**Snow clearance**					
116	**Sand gritting of road in winter road maintenance**		**2.06E+00**	**2.21E+01**	**2.21E+01**	**1.47E-07**
117	Vehicle operation, distribution truck					
118	Production of sand used, crushed material		1.85E+00	1.98E+01	1.98E+01	1.32E-07
119	Production of sand used, natural material		2.09E-01	2.24E+00	2.24E+00	1.50E-08
120	**Salt gritting of road in winter road maintenance**					
121	Vehicle operation, distribution truck					
122	Production of salt used, coal based production					
123	**Sweeping**					
124	**Mowing of verges**					
125	**Clearance of verges**					
126	**Washing of roadside posts**					
127	**Washing of road signs**					
128	**Erection and removal of snow posts**					
129	**Digging of road trenches**					
130	**Lighting and traffic lights, electric power production**		**7.51E+03**	**8.04E+04**	**8.04E+04**	**5.36E-04**
131	Lighting		5.74E+03	6.15E+04	6.15E+04	4.10E-04
132	Traffic lights		1.77E+03	1.89E+04	1.89E+04	1.26E-04
133	**Other vehicle use (complementary activities) in operation procedures**					
134						
135	**Total sum:**	**1.05E+05**	**8.41E+03**	**9.01E+04**	**9.01E+04**	**6.01E-04**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I
1			Material/Energy resources						
2			(Energy, electricity) *)	Natural gas	Oil	Coal	Biomass fuel	Peat	Uranium
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
4	**Construction of road, total:**	**Road object**	**8.94E+05**	**1.41E+05**	**4.56E+06**	**5.49E+06**	**2.70E+04**	**2.70E+03**	**9.63E+05**
5	**Forest felling/clearence for road construction**	**Road object**			**2.93E+03**				
6	**CO2 emission due to permanent reduction of biomass**	**Road object**							
7	**Excavation with excavator in the road direction**	**Road object**			**3.65E+05**				
8	**Excavation with wheel loader in the direction of the road**	**Road object**			**3.30E+05**				
9	**Transport of excavated materials with dumper truck in the direction of the road**	**Road object**			**4.84E+05**				
10	**Excavation with excavator in external site for filling materials**	**Road object**			**3.65E+03**				
11	**Excavation with wheel loader in external site for filling materials**	**Road object**			**3.30E+03**				
12	**Transport with dumper truck of excavated materials from external site to road construction site**	**Road object**			**1.94E+04**				
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**	**Road object**			**1.83E+03**				
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**	**Road object**			**1.65E+03**				
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**	**Road object**			**9.68E+03**				
16	**Foundation reinforcement, concrete pile**	**Road object**	**1.45E+05**	**4.18E+04**	**4.13E+05**	**6.89E+05**	**1.66E+03**	**1.66E+02**	**5.91E+04**
17	Pile-driving and materials to concrete pile	Road object	1.45E+05	4.18E+04	1.20E+05	6.89E+05	1.66E+03	1.66E+02	5.91E+04
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production	Road object			1.67E+04				
19	Transport of cement to concrete pile production	Road object			4.82E+04				
20	Transport of concrete pile from production site to road construction site	Road object			2.28E+05				
21	**Foundation reinforcement, cement/lime columns**	**Road object**	**5.43E+04**	**5.01E+02**	**3.82E+05**	**1.20E+06**	**2.39E+03**	**2.39E+02**	**8.68E+04**
22	Foundation reinforcements work, quicklime and cement for the work	Road object	5.43E+04	5.01E+02	2.68E+05	1.20E+06	2.39E+03	2.39E+02	8.68E+04
23	Transport of cement to road construction site	Road object			5.72E+04				
24	Transport of quicklime to road construction site	Road object			5.72E+04				
25	**Construction of road sub-base (unbound)**	**Road object**			**4.05E+05**				
26	Loading of blasted rock	Road object			4.51E+04				
27	Transport of blasted rock	Road object			1.88E+05				
28	Construction of road sub-base (unbound) at the road site	Road object			1.54E+05				
29	Rolling of layers	Road object			1.80E+04				
30	**Construction of road base course (unbound)**	**Road object**	**1.18E+05**	**1.10E+03**	**5.67E+05**	**4.72E+03**	**5.31E+03**	**5.31E+02**	**1.89E+05**
31	Production of crushed aggregates	Road object	1.06E+05	9.85E+02	1.00E+05	4.24E+03	4.77E+03	4.77E+02	1.70E+05
32	Extraction of pit-run gravel/sand	Road object	1.20E+04	1.12E+02	5.21E+03	4.80E+02	5.40E+02	5.40E+01	1.92E+04
33	Transport of crushed aggregates	Road object			1.88E+05				
34	Transport of pit-run gravel/sand	Road object			1.88E+05				
35	Construction of road base course (unbound) at the road site	Road object			7.72E+04				
36	Rolling of layers	Road object			8.98E+03				
37	**Asphalt pavement, hot method**	**Road object**							
38	Production of hot asphalt	Road object							
39	Transport of crushed aggregates to asphalt plant	Road object							
40	Transport of bitumen to sphalt plant	Road object							
41	Transport of asphalt from asphalt plant to road construction site	Road object							
42	Paving of asphalt layers	Road object							
43	Rolling of asphalt layers	Road object							
44	**Asphalt pavement, cold method**	**Road object**							
45	Production of cold asphalt	Road object							
46	Transport of crushed aggregates to asphalt plant	Road object							
47	Transport of bitumen to emulsifier	Road object							
48	Transport of bitumen emulsion from emulsifier to asphalt plant	Road object							
49	Transport of asphalt from asphalt plant to road construction site	Road object							
50	Paving of asphalt layers	Road object							
51	Rolling of asphalt layers	Road object							

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	A	B	C	D	E	F	G	H	I
1			**Material/Energy resources**						
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
52	**Cement stabilisation of base course**	**Road object**	**3.90E+02**	**3.63E+00**	**5.80E+05**	**3.88E+03**	**1.76E+01**	**1.76E+00**	**6.24E+02**
53	Cement stabilisation, operation of slipform paver	Road object			1.70E+04				
54	Production of cement	Road object	3.90E+02	3.63E+00	6.56E+01	3.88E+03	1.76E+01	1.76E+00	6.24E+02
55	Transport of cement from production to road construction site	Road object			5.63E+05				
56	**Concrete paving, wearing course**	**Road object**	**4.77E+05**	**6.13E+04**	**9.08E+05**	**3.29E+06**	**1.75E+04**	**1.75E+03**	**6.23E+05**
57	Production of road concrete	Road object	3.90E+05	3.62E+03	2.06E+05	3.03E+06	1.75E+04	1.75E+03	6.23E+05
58	Transport of crushed aggregates to concrete production	Road object			4.39E+04				
59	Transport of pit-run gravel/sand to concrete production	Road object			2.56E+04				
60	Transport of cement to concrete production	Road object			4.39E+05				
61	Transport of road concrete from production to road construction site	Road object			1.68E+04				
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)	Road object	7.77E+04	2.98E+04	1.19E+05	2.56E+05			
63	Exposure of aggregate on concrete carriageway	Road object	4.88E+03	2.79E+04	3.02E+04	1.71E+03			
64	Sawing and sealing of joints in concrete road construction	Road object	4.86E+03		2.75E+04	5.44E+03			
65	**Road marking**	**Road object**			**9.65E+02**				
66	**Production and assembly of wildlife fences**	**Road object**	**3.53E+04**	**1.35E+04**	**3.34E+04**	**1.15E+05**			
67	**Other railing and fences, amount of galvanized steel used**	**Road object**	**9.39E+03**	**3.60E+03**	**7.23E+03**	**3.05E+04**			
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**Road object**	**4.88E+03**	**1.00E+03**	**2.37E+03**	**7.66E+03**	**5.69E+01**	**5.69E+00**	**2.02E+03**
69	Galvanized steel	Road object	2.35E+03	9.01E+02	1.81E+03	7.61E+03			
70	Aluminium	Road object	2.53E+03	1.02E+02	5.61E+02	5.06E+01	5.69E+01	5.69E+00	2.02E+03
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**Road object**	**4.95E+04**	**1.81E+04**	**3.67E+04**	**1.52E+05**	**5.69E+01**	**5.69E+00**	**2.02E+03**
72	Galvanized steel	Road object	4.70E+04	1.80E+04	3.61E+04	1.52E+05			
73	Aluminium	Road object	2.53E+03	1.02E+02	5.61E+02	5.06E+01	5.69E+01	5.69E+00	2.02E+03
74									
75	**Maintenance of road, total:**	**Road object**	**6.59E+04**	**3.72E+02**	**2.56E+06**	**3.39E+05**	**1.80E+03**	**1.80E+02**	**6.39E+04**
76	**Excavation of road and sub-base with excavator**	**Road object**							
77	**Transport removal of excavated materials from the entire road**	**Road object**							
78	**Reconstruction of base course (unbound)**	**Road object**							
79	Production of crushed aggregates	Road object							
80	Extraction of pit-run gravel/sand	Road object							
81	Transport of crushed aggregates	Road object							
82	Transport of pit-run gravel/sand	Road object							
83	Construction of new base course (unbound) at road site	Road object							
84	Rolling of layers	Road object							
85	**Surface milling of asphalt pavement**	**Road object**							
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**	**Road object**							
87	**Asphalt pavement, hot method**	**Road object**							
88	Production of hot asphalt	Road object							
89	Transport of crushed aggregates to asphalt plant	Road object							
90	Transport of bitumen to asphalt plant	Road object							
91	Transport of asphalt from asphalt plant to road construction site	Road object							
92	Asphalt paving	Road object							
93	Asphalt rolling	Road object							
94	**Asphalt pavement, cold method**	**Road object**							
95	Production of cold asphalt	Road object							
96	Transport of crushed aggregates to asphalt plant	Road object							
97	Transport of bitumen to emulsifier	Road object							
98	Transport of bitumen emulsion from emulsifier to asphalt plant	Road object							
99	Transport of asphalt from asphalt plant to road construction site	Road object							

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	C	D	E	F	G	H	I
1			**Material/Energy resources**						
2			**(Energy, electricity) *)**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**
100	Asphalt paving	Road object							
101	Asphalt rolling	Road object							
102	**Maintenance of concrete road**	**Road object**	**6.59E+04**	**3.72E+02**	**2.55E+06**	**3.39E+05**	**1.80E+03**	**1.80E+02**	**6.39E+04**
103	Milling of wearing cource	Road object			1.03E+06				
104	Resealing of joints, use of EPDM-rubber	Road object	2.59E+04		1.09E+05	2.90E+04			
105	Road track milling for concrete filling	Road object			1.33E+06				
106	Concrete production for concrete filling	Road object	4.00E+04	3.72E+02	2.11E+04	3.10E+05	1.80E+03	1.80E+02	6.39E+04
107	Machine operation for concrete filling	Road object			1.54E+02				
108	Transport of crushed aggregates to concrete production	Road object			4.50E+02				
109	Transport of pit-run gravel/sand to concrete production	Road object			2.63E+02				
110	Transport of cement to concrete production	Road object			4.50E+04				
111	Transport of concrete from production site to road construction site	Road object			1.73E+04				
112	**Maintenance of road marking**	**Road object**			**9.65E+03**				
113									
114	**Operation of road, total:**	**Road object**	**5.36E+06**	**4.99E+04**	**6.97E+05**	**5.22E+05**	**2.41E+05**	**2.41E+04**	**8.58E+06**
115	**Snow clearance**	**Road object**			**2.05E+04**				
116	**Sand gritting of road in winter road maintenance**	**Road object**	**1.47E+03**	**1.37E+01**	**4.47E+03**	**5.89E+01**	**6.62E+01**	**6.62E+00**	**2.36E+03**
117	Vehicle operation, distribution truck	Road object			3.15E+03				
118	Production of sand used, crushed material	Road object	1.32E+03	1.23E+01	1.25E+03	5.29E+01	5.95E+01	5.95E+00	2.12E+03
119	Production of sand used, natural material	Road object	1.50E+02	1.39E+00	6.50E+01	5.99E+00	6.73E+00	6.73E-01	2.39E+02
120	**Salt gritting of road in winter road maintenance**	**Road object**			**6.30E+04**	**3.08E+05**			
121	Vehicle operation, distribution truck	Road object			6.30E+04				
122	Production of salt used, coal based production	Road object				3.08E+05			
123	**Sweeping**	**Road object**			**9.27E+03**				
124	**Mowing of verges**	**Road object**			**2.44E+04**				
125	**Clearance of verges**	**Road object**			**1.22E+04**				
126	**Washing of roadside posts**	**Road object**			**3.09E+04**				
127	**Washing of road signs**	**Road object**			**9.89E+03**				
128	**Erection and removal of snow posts**	**Road object**			**1.70E+04**				
129	**Digging of road trenches**	**Road object**			**1.17E+05**				
130	**Lighting and traffic lights, electric power production**	**Road object**	**5.36E+06**	**4.99E+04**	**3.43E+05**	**2.14E+05**	**2.41E+05**	**2.41E+04**	**8.58E+06**
131	Lighting	Road object	4.10E+06	3.81E+04	2.62E+05	1.64E+05	1.84E+05	1.84E+04	6.56E+06
132	Traffic lights	Road object	1.26E+06	1.17E+04	8.07E+04	5.05E+04	5.68E+04	5.68E+03	2.02E+06
133	**Other vehicle use (complementary activities) in operation procedures**	**Road object**			**4.60E+04**				
134									
135	**Total sum:**	**Road object**	**6.32E+06**	**1.91E+05**	**7.82E+06**	**6.35E+06**	**2.70E+05**	**2.70E+04**	**9.61E+06**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**2.83E+05**		**6.51E+09**	**7.49E+09**	**1.71E+09**	**1.51E+09**	**1.51E+09**	**1.57E+09**	**1.51E+09**
5	**Forest felling/clearence for road construction**									
6	**CO2 emission due to permanent reduction of biomass**									
7	**Excavation with excavator in the road direction**									
8	**Excavation with wheel loader in the direction of the road**									
9	**Transport of excavated materials with dumper truck in the direction of the road**									
10	**Excavation with excavator in external site for filling materials**									
11	**Excavation with wheel loader in external site for filling materials**									
12	**Transport with dumper truck of excavated materials from external site to road construction site**									
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**									
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**									
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**									
16	**Foundation reinforcement, concrete pile**	**1.74E+04**		**1.48E+08**	**1.48E+08**	**1.34E+08**	**1.34E+08**	**1.34E+08**	**1.57E+08**	**1.34E+08**
17	Pile-driving and materials to concrete pile	1.74E+04		1.48E+08	1.48E+08	1.34E+08	1.34E+08	1.34E+08	1.57E+08	1.34E+08
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production									
19	Transport of cement to concrete pile production									
20	Transport of concrete pile from production site to road construction site									
21	**Foundation reinforcement, cement/lime columns**	**2.55E+04**				**3.62E+08**	**1.59E+08**	**1.59E+08**	**1.59E+08**	**1.59E+08**
22	Foundation reinforcements work, quicklime and cement for the work	2.55E+04				3.62E+08	1.59E+08	1.59E+08	1.59E+08	1.59E+08
23	Transport of cement to road construction site									
24	Transport of quicklime to road construction site									
25	**Construction of road sub-base (unbound)**									
26	Loading of blasted rock									
27	Transport of blasted rock									
28	Construction of road sub-base (unbound) at the road site									
29	Rolling of layers									
30	**Construction of road base course (unbound)**	**5.54E+04**		**5.00E+09**	**5.00E+09**					
31	Production of crushed aggregates	4.98E+04			5.00E+09					
32	Extraction of pit-run gravel/sand	5.64E+03		5.00E+09						
33	Transport of crushed aggregates									
34	Transport of pit-run gravel/sand									
35	Construction of road base course (unbound) at the road site									
36	Rolling of layers									
37	**Asphalt pavement, hot method**									
38	Production of hot asphalt									
39	Transport of crushed aggregates to asphalt plant									
40	Transport of bitumen to sphalt plant									
41	Transport of asphalt from asphalt plant to road construction site									
42	Paving of asphalt layers									
43	Rolling of asphalt layers									
44	**Asphalt pavement, cold method**									
45	Production of cold asphalt									
46	Transport of crushed aggregates to asphalt plant									
47	Transport of bitumen to emulsifier									
48	Transport of bitumen emulsion from emulsifier to asphalt plant									
49	Transport of asphalt from asphalt plant to road construction site									
50	Paving of asphalt layers									
51	Rolling of asphalt layers									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**	**1.83E+02**				**1.56E+06**	**1.56E+06**	**1.56E+06**	**1.56E+06**	**1.56E+06**
53	Cement stabilisation, operation of slipform paver									
54	Production of cement	1.83E+02				1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06
55	Transport of cement from production to road construction site									
56	**Concrete paving, wearing course**	**1.83E+05**		**1.37E+09**	**2.34E+09**	**1.22E+09**	**1.22E+09**	**1.22E+09**	**1.23E+09**	**1.22E+09**
57	Production of road concrete	1.83E+05		1.37E+09	2.34E+09	1.22E+09	1.22E+09	1.22E+09	1.22E+09	1.22E+09
58	Transport of crushed aggregates to concrete production									
59	Transport of pit-run gravel/sand to concrete production									
60	Transport of cement to concrete production									
61	Transport of road concrete from production to road construction site									
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)								1.67E+07	
63	Exposure of aggregate on concrete carriageway									
64	Sawing and sealing of joints in concrete road construction									
65	**Road marking**									
66	**Production and assembly of wildlife fences**								**7.48E+06**	**3.76E+04**
67	**Other railing and fences, amount of galvanized steel used**								**1.99E+06**	**1.00E+04**
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**5.95E+02**				**1.09E+03**	**3.90E+03**	**1.25E+04**	**4.98E+05**	**2.50E+03**
69	Galvanized steel								4.98E+05	2.50E+03
70	Aluminium	5.95E+02				1.09E+03	3.90E+03	1.25E+04		
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**5.95E+02**				**1.09E+03**	**3.90E+03**	**1.25E+04**	**9.95E+06**	**5.00E+04**
72	Galvanized steel								9.95E+06	5.00E+04
73	Aluminium	5.95E+02				1.09E+03	3.90E+03	1.25E+04		
74										
75	**Maintenance of road, total:**	**1.88E+04**		**1.40E+08**	**2.40E+08**	**1.25E+08**	**1.25E+08**	**1.25E+08**	**1.25E+08**	**1.25E+08**
76	**Excavation of road and sub-base with excavator**									
77	**Transport removal of excavated materials from the entire road**									
78	**Reconstruction of base course (unbound)**									
79	Production of crushed aggregates									
80	Extraction of pit-run gravel/sand									
81	Transport of crushed aggregates									
82	Transport of pit-run gravel/sand									
83	Construction of new base course (unbound) at road site									
84	Rolling of layers									
85	**Surface milling of asphalt pavement**									
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**									
87	**Asphalt pavement, hot method**									
88	Production of hot asphalt									
89	Transport of crushed aggregates to asphalt plant									
90	Transport of bitumen to asphalt plant									
91	Transport of asphalt from asphalt plant to road construction site									
92	Asphalt paving									
93	Asphalt rolling									
94	**Asphalt pavement, cold method**									
95	Production of cold asphalt									
96	Transport of crushed aggregates to asphalt plant									
97	Transport of bitumen to emulsifier									
98	Transport of bitumen emulsion from emulsifier to asphalt plant									
99	Transport of asphalt from asphalt plant to road construction site									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	J	K	L	M	N	O	P	Q	R
1										
2		**Hydro power**	**Bitumen**	**Pit-run gravel/sand**	**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**
3	**Activity**	**MJ**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving									
101	Asphalt rolling									
102	**Maintenance of concrete road**	**1.88E+04**		**1.40E+08**	**2.40E+08**	**1.25E+08**	**1.25E+08**	**1.25E+08**	**1.25E+08**	**1.25E+08**
103	Milling of wearing cource									
104	Resealing of joints, use of EPDM-rubber									
105	Road track milling for concrete filling									
106	Concrete production for concrete filling	1.88E+04		1.40E+08	2.40E+08	1.25E+08	1.25E+08	1.25E+08	1.25E+08	1.25E+08
107	Machine operation for concrete filling									
108	Transport of crushed aggregates to concrete production									
109	Transport of pit-run gravel/sand to concrete production									
110	Transport of cement to concrete production									
111	Transport of concrete from production site to road construction site									
112	**Maintenance of road marking**									
113										
114	**Operation of road, total:**	**2.52E+06**		**6.24E+07**	**6.24E+07**		**2.08E+08**			
115	**Snow clearance**									
116	**Sand gritting of road in winter road maintenance**	**6.92E+02**		**6.24E+07**	**6.24E+07**					
117	Vehicle operation, distribution truck									
118	Production of sand used, crushed material	6.21E+02			6.24E+07					
119	Production of sand used, natural material	7.03E+01		6.24E+07						
120	**Salt gritting of road in winter road maintenance**						**2.08E+08**			
121	Vehicle operation, distribution truck									
122	Production of salt used, coal based production						2.08E+08			
123	**Sweeping**									
124	**Mowing of verges**									
125	**Clearance of verges**									
126	**Washing of roadside posts**									
127	**Washing of road signs**									
128	**Erection and removal of snow posts**									
129	**Digging of road trenches**									
130	**Lighting and traffic lights, electric power production**	**2.52E+06**								
131	Lighting	1.93E+06								
132	Traffic lights	5.93E+05								
133	**Other vehicle use (complementary activities) in operation procedures**									
134										
135	**Total sum:**	**2.82E+06**		**6.72E+09**	**7.79E+09**	**1.84E+09**	**1.84E+09**	**1.64E+09**	**1.70E+09**	**1.64E+09**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**1.66E+06**	**4.86E+06**	**4.11E+05**	**2.44E+09**	**1.82E+05**	**5.51E+05**	**2.78E+03**	**9.07E+04**	**8.07E+03**	**3.40E+06**
5	**Forest felling/clearence for road construction**	**1.01E+02**	**1.90E+03**	**2.27E+02**	**2.10E+05**	**1.37E+02**	**1.33E-01**			**4.26E+00**	**7.59E+01**
6	**CO2 emission due to permanent reduction of biomass**				**1.02E+09**						
7	**Excavation with excavator in the road direction**	**1.26E+04**	**2.37E+05**	**2.83E+04**	**2.62E+07**	**1.71E+04**	**1.66E+01**			**5.31E+02**	**9.46E+03**
8	**Excavation with wheel loader in the direction of the road**	**1.14E+04**	**2.14E+05**	**2.55E+04**	**2.37E+07**	**1.54E+04**	**1.50E+01**			**4.80E+02**	**8.54E+03**
9	**Transport of excavated materials with dumper truck in the direction of the road**	**1.67E+04**	**3.14E+05**	**3.75E+04**	**3.48E+07**	**2.26E+04**	**2.20E+01**			**7.04E+02**	**1.25E+04**
10	**Excavation with excavator in external site for filling materials**	**1.26E+02**	**2.37E+03**	**2.83E+02**	**2.62E+05**	**1.71E+02**	**1.66E-01**			**5.31E+00**	**9.46E+01**
11	**Excavation with wheel loader in external site for filling materials**	**1.14E+02**	**2.14E+03**	**2.55E+02**	**2.37E+05**	**1.54E+02**	**1.50E-01**			**4.80E+00**	**8.54E+01**
12	**Transport with dumper truck of excavated materials from external site to road construction site**	**6.69E+02**	**1.26E+04**	**1.50E+03**	**1.39E+06**	**9.05E+02**	**8.80E-01**			**2.82E+01**	**5.01E+02**
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**	**6.31E+01**	**1.19E+03**	**1.41E+02**	**1.31E+05**	**8.53E+01**	**8.30E-02**			**2.66E+00**	**4.73E+01**
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**	**5.70E+01**	**1.07E+03**	**1.28E+02**	**1.19E+05**	**7.71E+01**	**7.50E-02**			**2.40E+00**	**4.27E+01**
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**	**3.34E+02**	**6.28E+03**	**7.49E+02**	**6.95E+05**	**4.52E+02**	**4.40E-01**			**1.41E+01**	**2.51E+02**
16	**Foundation reinforcement, concrete pile**	**2.68E+05**	**4.39E+05**	**4.70E+04**	**1.44E+08**	**1.16E+04**	**2.12E+05**	**4.06E+01**	**2.79E+04**	**1.18E+03**	**1.00E+06**
17	Pile-driving and materials to concrete pile	2.58E+05	3.05E+05	2.57E+04	1.23E+08	1.42E+03	2.12E+05	4.06E+01	2.79E+04	7.58E+02	9.99E+05
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production	5.76E+02	7.64E+03	1.21E+03	1.20E+06	5.82E+02	7.58E-01			2.43E+01	1.29E+02
19	Transport of cement to concrete pile production	1.67E+03	2.21E+04	3.51E+03	3.46E+06	1.68E+03	2.19E+00			7.02E+01	3.72E+02
20	Transport of concrete pile from production site to road construction site	7.88E+03	1.05E+05	1.66E+04	1.64E+07	7.96E+03	1.04E+01			3.32E+02	1.76E+03
21	**Foundation reinforcement, cement/lime columns**	**2.07E+05**	**6.97E+05**	**5.92E+04**	**3.09E+08**	**1.20E+04**	**2.00E+01**	**2.18E+03**		**4.31E+02**	**1.08E+05**
22	Foundation reinforcements work, quicklime and cement for the work	2.03E+05	6.45E+05	5.09E+04	3.01E+08	7.97E+03	1.48E+01	2.18E+03		2.65E+02	1.07E+05
23	Transport of cement to road construction site	1.98E+03	2.62E+04	4.17E+03	4.11E+06	2.00E+03	2.60E+00			8.32E+01	4.41E+02
24	Transport of quicklime to road construction site	1.98E+03	2.62E+04	4.17E+03	4.11E+06	2.00E+03	2.60E+00			8.32E+01	4.41E+02
25	**Construction of road sub-base (unbound)**	**1.40E+04**	**2.27E+05**	**3.05E+04**	**2.91E+07**	**1.67E+04**	**1.84E+01**			**5.89E+02**	**7.08E+03**
26	Loading of blasted rock	1.56E+03	2.93E+04	3.49E+03	3.24E+06	2.11E+03	2.05E+00			6.56E+01	1.17E+03
27	Transport of blasted rock	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
28	Construction of road sub-base (unbound) at the road site	5.34E+03	1.00E+05	1.20E+04	1.11E+07	7.22E+03	7.02E+00			2.25E+02	4.00E+03
29	Rolling of layers	6.21E+02	1.17E+04	1.39E+03	1.29E+06	8.39E+02	8.17E-01			2.61E+01	4.65E+02
30	**Construction of road base course (unbound)**	**2.01E+04**	**2.92E+05**	**4.18E+04**	**4.06E+07**	**2.17E+04**	**4.19E+01**	**1.30E+02**		**8.63E+02**	**7.67E+03**
31	Production of crushed aggregates	3.94E+03	6.16E+04	7.45E+03	7.11E+06	4.37E+03	1.91E+01	1.17E+02		1.80E+02	2.43E+03
32	Extraction of pit-run gravel/sand	2.34E+02	2.99E+03	3.69E+02	3.64E+05	2.07E+02	1.88E+00	1.32E+01		1.15E+01	1.16E+02
33	Transport of crushed aggregates	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
34	Transport of pit-run gravel/sand	6.48E+03	8.59E+04	1.37E+04	1.35E+07	6.55E+03	8.52E+00			2.73E+02	1.45E+03
35	Construction of road base course (unbound) at the road site	2.67E+03	5.01E+04	5.98E+03	5.55E+06	3.61E+03	3.51E+00			1.12E+02	2.00E+03
36	Rolling of layers	3.10E+02	5.83E+03	6.95E+02	6.45E+05	4.20E+02	4.08E-01			1.31E+01	2.33E+02
37	**Asphalt pavement, hot method**										
38	Production of hot asphalt										
39	Transport of crushed aggregates to asphalt plant										
40	Transport of bitumen to sphalt plant										
41	Transport of asphalt from asphalt plant to road construction site										
42	Paving of asphalt layers										
43	Rolling of asphalt layers										
44	**Asphalt pavement, cold method**										
45	Production of cold asphalt										
46	Transport of crushed aggregates to asphalt plant										
47	Transport of bitumen to emulsifier										
48	Transport of bitumen emulsion from emulsifier to asphalt plant										
49	Transport of asphalt from asphalt plant to road construction site										
50	Paving of asphalt layers										
51	Rolling of asphalt layers										

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**	**2.10E+04**	**2.71E+05**	**4.23E+04**	**4.24E+07**	**2.04E+04**	**2.64E+01**	**4.29E-01**		**8.43E+02**	**5.78E+03**
53	Cement stabilisation, operation of slipform paver	5.88E+02	1.10E+04	1.32E+03	1.22E+06	7.95E+02	7.74E-01			2.48E+01	4.41E+02
54	Production of cement	1.00E+03	2.00E+03	8.19E-01	8.06E+05		5.46E-02	4.29E-01		1.64E-01	1.00E+03
55	Transport of cement from production to road construction site	1.94E+04	2.58E+05	4.10E+04	4.04E+07	1.96E+04	2.56E+01			8.18E+02	4.34E+03
56	**Concrete paving, wearing course**	**9.41E+05**	**2.04E+06**	**7.44E+04**	**7.23E+08**	**4.18E+04**	**1.56E+05**	**4.29E+02**	**3.85E+04**	**1.76E+03**	**1.45E+06**
57	Production of road concrete	7.88E+05	1.66E+06	1.24E+04	6.40E+08	6.98E+03	6.13E+01	4.29E+02		3.81E+02	7.84E+05
58	Transport of crushed aggregates to concrete production	1.52E+03	2.01E+04	3.20E+03	3.15E+06	1.53E+03	1.99E+00			6.38E+01	3.38E+02
59	Transport of pit-run gravel/sand to concrete production	8.84E+02	1.17E+04	1.86E+03	1.84E+06	8.94E+02	1.16E+00			3.72E+01	1.97E+02
60	Transport of cement to concrete production	1.52E+04	2.01E+05	3.20E+04	3.15E+07	1.53E+04	1.99E+01			6.38E+02	3.38E+03
61	Transport of road concrete from production to road construction site	5.81E+02	7.71E+03	1.23E+03	1.21E+06	5.87E+02	7.65E-01			2.45E+01	1.30E+02
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)	1.25E+05	1.20E+05	2.13E+04	4.11E+07	2.75E+03	1.52E+05		2.01E+04	5.88E+02	6.58E+05
63	Exposure of aggregate on concrete carriageway	4.61E+03	1.20E+04	1.11E+03	1.25E+06	1.34E+04	3.63E-01			1.16E+01	1.44E+03
64	Sawing and sealing of joints in concrete road construction	5.78E+03	8.47E+03	1.32E+03	2.77E+06	3.30E+02	3.40E+03		1.85E+04	1.51E+01	2.22E+03
65	**Road marking**	**3.33E+01**	**4.83E+02**	**6.49E+01**	**6.93E+04**	**3.58E+01**	**2.98E-02**			**9.55E-01**	**2.27E+01**
66	**Production and assembly of wildlife fences**	**5.62E+04**	**4.10E+04**	**8.11E+03**	**1.71E+07**	**2.89E+02**	**6.86E+04**		**9.08E+03**	**2.38E+02**	**2.94E+05**
67	**Other railing and fences, amount of galvanized steel used**	**1.49E+04**	**9.83E+03**	**2.03E+03**	**4.42E+06**		**1.82E+04**		**2.42E+03**	**6.09E+01**	**7.81E+04**
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**	**4.08E+03**	**2.71E+03**	**5.45E+02**	**1.17E+06**	**7.00E+01**	**4.56E+03**	**1.39E+00**	**6.04E+02**	**1.58E+01**	**2.23E+04**
69	Galvanized steel	3.72E+03	2.46E+03	5.07E+02	1.11E+06		4.56E+03		6.04E+02	1.52E+01	1.95E+04
70	Aluminium	3.53E+02	2.52E+02	3.77E+01	6.63E+04	7.00E+01	1.77E-01	1.39E+00		5.31E-01	2.77E+03
71	**Lighting and traffic lights, use of galvanized steel and aluminium**	**7.48E+04**	**4.94E+04**	**1.02E+04**	**2.22E+07**	**7.00E+01**	**9.12E+04**	**1.39E+00**	**1.21E+04**	**3.05E+02**	**3.93E+05**
72	Galvanized steel	7.44E+04	4.91E+04	1.01E+04	2.21E+07		9.12E+04		1.21E+04	3.05E+02	3.90E+05
73	Aluminium	3.53E+02	2.52E+02	3.77E+01	6.63E+04	7.00E+01	1.77E-01	1.39E+00		5.31E-01	2.77E+03
74											
75	**Maintenance of road, total:**	**1.94E+05**	**1.76E+06**	**1.93E+05**	**2.52E+08**	**1.14E+05**	**1.83E+04**	**4.40E+01**	**9.85E+04**	**3.60E+03**	**1.53E+05**
76	**Excavation of road and sub-base with excavator**										
77	**Transport removal of excavated materials from the entire road**										
78	**Reconstruction of base course (unbound)**										
79	Production of crushed aggregates										
80	Extraction of pit-run gravel/sand										
81	Transport of crushed aggregates										
82	Transport of pit-run gravel/sand										
83	Construction of new base course (unbound) at road site										
84	Rolling of layers										
85	**Surface milling of asphalt pavement**										
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**										
87	**Asphalt pavement, hot method**										
88	Production of hot asphalt										
89	Transport of crushed aggregates to asphalt plant										
90	Transport of bitumen to asphalt plant										
91	Transport of asphalt from asphalt plant to road construction site										
92	Asphalt paving										
93	Asphalt rolling										
94	**Asphalt pavement, cold method**										
95	Production of cold asphalt										
96	Transport of crushed aggregates to asphalt plant										
97	Transport of bitumen to emulsifier										
98	Transport of bitumen emulsion from emulsifier to asphalt plant										
99	Transport of asphalt from asphalt plant to road construction site										

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	S	T	U	V	W	X	Y	Z	AA	AB
1		**Emissions to Air**									
2		**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**	**N2O**	**Particles**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving										
101	Asphalt rolling										
102	**Maintenance of concrete road**	**1.94E+05**	**1.75E+06**	**1.93E+05**	**2.52E+08**	**1.13E+05**	**1.83E+04**	**4.40E+01**	**9.85E+04**	**3.59E+03**	**1.53E+05**
103	Milling of wearing cource	3.57E+04	6.71E+05	8.00E+04	7.43E+07	4.83E+04	4.70E+01			1.50E+03	2.68E+04
104	Resealing of joints, use of EPDM-rubber	2.95E+04	2.07E+04	4.15E+03	1.21E+07		1.81E+04		9.85E+04	2.59E+01	1.09E+04
105	Road track milling for concrete filling	4.58E+04	8.61E+05	1.03E+05	9.52E+07	6.19E+04	6.03E+01			1.93E+03	3.43E+04
106	Concrete production for concrete filling	8.08E+04	1.70E+05	1.27E+03	6.57E+07	7.16E+02	6.29E+00	4.40E+01		3.91E+01	8.04E+04
107	Machine operation for concrete filling	5.34E+00	1.00E+02	1.20E+01	1.11E+04	7.22E+00	7.02E-03			2.25E-01	4.00E+00
108	Transport of crushed aggregates to concrete production	1.55E+01	2.06E+02	3.28E+01	3.23E+04	1.57E+01	2.05E-02			6.55E-01	3.47E+00
109	Transport of pit-run gravel/sand to concrete production	9.07E+00	1.20E+02	1.91E+01	1.89E+04	9.17E+00	1.19E-02			3.82E-01	2.02E+00
110	Transport of cement to concrete production	1.55E+03	2.06E+04	3.28E+03	3.23E+06	1.57E+03	2.05E+00			6.55E+01	3.47E+02
111	Transport of concrete from production site to road construction site	5.96E+02	7.91E+03	1.26E+03	1.24E+06	6.02E+02	7.84E-01			2.51E+01	1.33E+02
112	**Maintenance of road marking**	**3.33E+02**	**4.83E+03**	**6.49E+02**	**6.93E+05**	**3.58E+02**	**2.98E-01**			**9.55E+00**	**2.27E+02**
113											
114	**Operation of road, total:**	**2.02E+05**	**3.53E+05**	**4.45E+04**	**7.41E+07**	**1.54E+04**	**7.67E+02**	**5.90E+03**		**2.77E+03**	**7.73E+03**
115	**Snow clearance**	**7.07E+02**	**9.38E+03**	**1.49E+03**	**1.47E+06**	**7.15E+02**	**9.31E-01**			**2.98E+01**	**1.58E+02**
116	**Sand gritting of road in winter road maintenance**	**1.61E+02**	**2.25E+03**	**3.27E+02**	**3.20E+05**	**1.67E+02**	**4.05E-01**	**1.62E+00**		**6.98E+00**	**5.60E+01**
117	Vehicle operation, distribution truck	1.09E+02	1.44E+03	2.30E+02	2.26E+05	1.10E+02	1.43E-01			4.58E+00	2.43E+01
118	Production of sand used, crushed material	4.91E+01	7.69E+02	9.30E+01	8.88E+04	5.45E+01	2.38E-01	1.45E+00		2.25E+00	3.03E+01
119	Production of sand used, natural material	2.92E+00	3.73E+01	4.60E+00	4.55E+03	2.59E+00	2.35E-02	1.65E-01		1.43E-01	1.44E+00
120	**Salt gritting of road in winter road maintenance**	**1.56E+05**	**1.21E+05**	**1.08E+04**	**3.28E+07**	**2.20E+03**	**2.86E+00**			**9.17E+01**	**4.86E+02**
121	Vehicle operation, distribution truck	2.18E+03	2.89E+04	4.59E+03	4.53E+06	2.20E+03	2.86E+00			9.17E+01	4.86E+02
122	Production of salt used, coal based production	1.54E+05	9.24E+04	6.24E+03	2.83E+07						
123	**Sweeping**	**3.20E+02**	**6.02E+03**	**7.17E+02**	**6.65E+05**	**4.33E+02**	**4.21E-01**			**1.35E+01**	**2.40E+02**
124	**Mowing of verges**	**8.45E+02**	**1.59E+04**	**1.89E+03**	**1.76E+06**	**1.14E+03**	**1.11E+00**			**3.56E+01**	**6.33E+02**
125	**Clearance of verges**	**4.22E+02**	**7.94E+03**	**9.46E+02**	**8.78E+05**	**5.71E+02**	**5.56E-01**			**1.78E+01**	**3.16E+02**
126	**Washing of roadside posts**	**1.07E+03**	**2.01E+04**	**2.39E+03**	**2.22E+06**	**1.44E+03**	**1.40E+00**			**4.49E+01**	**8.00E+02**
127	**Washing of road signs**	**3.42E+02**	**6.42E+03**	**7.65E+02**	**7.10E+05**	**4.62E+02**	**4.50E-01**			**1.44E+01**	**2.56E+02**
128	**Erection and removal of snow posts**	**5.87E+02**	**1.10E+04**	**1.31E+03**	**1.22E+06**	**7.94E+02**	**7.72E-01**			**2.47E+01**	**4.40E+02**
129	**Digging of road trenches**	**4.03E+03**	**7.57E+04**	**9.02E+03**	**8.37E+06**	**5.45E+03**	**5.30E+00**			**1.70E+02**	**3.02E+03**
130	**Lighting and traffic lights, electric power production**	**3.59E+04**	**4.93E+04**	**1.13E+04**	**2.04E+07**		**7.51E+02**	**5.90E+03**		**2.25E+03**	**3.75E+02**
131	Lighting	2.75E+04	3.77E+04	8.61E+03	1.56E+07		5.74E+02	4.51E+03		1.72E+03	2.87E+02
132	Traffic lights	8.45E+03	1.16E+04	2.65E+03	4.79E+06		1.77E+02	1.39E+03		5.30E+02	8.83E+01
133	**Other vehicle use (complementary activities) in operation procedures**	**1.59E+03**	**2.74E+04**	**3.50E+03**	**3.31E+06**	**2.00E+03**	**2.09E+00**			**6.70E+01**	**9.56E+02**
134											
135	**Total sum:**	**2.06E+06**	**6.97E+06**	**6.48E+05**	**2.76E+09**	**3.11E+05**	**5.70E+05**	**8.72E+03**	**1.89E+05**	**1.44E+04**	**3.56E+06**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	**Construction of road, total:**	**9.28E+01**	**2.60E+04**	**3.09E+00**	**1.21E+03**		**1.56E+03**	**2.14E+03**	**6.11E+04**	**6.11E+04**
5	**Forest felling/clearence for road construction**		**3.20E+00**		**5.06E-01**		**1.07E+00**	**1.52E+00**		
6	**CO2 emission due to permanent reduction of biomass**									
7	**Excavation with excavator in the road direction**		**3.98E+02**		**6.31E+01**		**1.33E+02**	**1.89E+02**		
8	**Excavation with wheel loader in the direction of the road**		**3.60E+02**		**5.70E+01**		**1.20E+02**	**1.71E+02**		
9	**Transport of excavated materials with dumper truck in the direction of the road**		**5.28E+02**		**8.36E+01**		**1.76E+02**	**2.51E+02**		
10	**Excavation with excavator in external site for filling materials**		**3.98E+00**		**6.31E-01**		**1.33E+00**	**1.89E+00**		
11	**Excavation with wheel loader in external site for filling materials**		**3.60E+00**		**5.70E-01**		**1.20E+00**	**1.71E+00**		
12	**Transport with dumper truck of excavated materials from external site to road construction site**		**2.11E+01**		**3.34E+00**		**7.04E+00**	**1.00E+01**		
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**		**1.99E+00**		**3.15E-01**		**6.64E-01**	**9.46E-01**		
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**		**1.80E+00**		**2.85E-01**		**6.00E-01**	**8.55E-01**		
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**		**1.06E+01**		**1.67E+00**		**3.52E+00**	**5.02E+00**		
16	**Foundation reinforcement, concrete pile**		**5.69E+02**		**2.30E+02**		**1.18E+02**	**1.68E+02**	**2.59E+03**	**2.59E+03**
17	Pile-driving and materials to concrete pile		2.50E+02		1.79E+02		1.10E+01	1.57E+01	2.59E+03	2.59E+03
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production		1.82E+01		2.88E+00		6.06E+00	8.64E+00		
19	Transport of cement to concrete pile production		5.26E+01		8.33E+00		1.75E+01	2.50E+01		
20	Transport of concrete pile from production site to road construction site		2.49E+02		3.94E+01		8.30E+01	1.18E+02		
21	**Foundation reinforcement, cement/lime columns**		**3.11E+02**		**4.92E+01**		**1.04E+02**	**1.48E+02**	**2.88E+03**	**2.88E+03**
22	Foundation reinforcements work, quicklime and cement for the work		1.86E+02		2.95E+01		6.21E+01	8.84E+01	2.88E+03	2.88E+03
23	Transport of cement to road construction site		6.24E+01		9.88E+00		2.08E+01	2.96E+01		
24	Transport of quicklime to road construction site		6.24E+01		9.88E+00		2.08E+01	2.96E+01		
25	**Construction of road sub-base (unbound)**		**4.42E+02**		**7.00E+01**		**1.47E+02**	**2.10E+02**		
26	Loading of blasted rock		4.92E+01		7.79E+00		1.64E+01	2.34E+01		
27	Transport of blasted rock		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
28	Construction of road sub-base (unbound) at the road site		1.68E+02		2.67E+01		5.62E+01	8.00E+01		
29	Rolling of layers		1.96E+01		3.10E+00		6.53E+00	9.31E+00		
30	**Construction of road base course (unbound)**		**6.10E+02**		**9.66E+01**		**2.03E+02**	**2.90E+02**	**8.26E+03**	**8.26E+03**
31	Production of crushed aggregates		1.02E+02		1.61E+01		3.40E+01	4.84E+01	7.42E+03	7.42E+03
32	Extraction of pit-run gravel/sand		4.84E+00		7.67E-01		1.61E+00	2.30E+00	8.39E+02	8.39E+02
33	Transport of crushed aggregates		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
34	Transport of pit-run gravel/sand		2.05E+02		3.24E+01		6.82E+01	9.72E+01		
35	Construction of road base course (unbound) at the road site		8.42E+01		1.33E+01		2.81E+01	4.00E+01		
36	Rolling of layers		9.80E+00		1.55E+00		3.27E+00	4.65E+00		
37	**Asphalt pavement, hot method**									
38	Production of hot asphalt									
39	Transport of crushed aggregates to asphalt plant									
40	Transport of bitumen to sphalt plant									
41	Transport of asphalt from asphalt plant to road construction site									
42	Paving of asphalt layers									
43	Rolling of asphalt layers									
44	**Asphalt pavement, cold method**									
45	Production of cold asphalt									
46	Transport of crushed aggregates to asphalt plant									
47	Transport of bitumen to emulsifier									
48	Transport of bitumen emulsion from emulsifier to asphalt plant									
49	Transport of asphalt from asphalt plant to road construction site									
50	Paving of asphalt layers									
51	Rolling of asphalt layers									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
52	**Cement stabilisation of base course**		**6.32E+02**		**1.00E+02**		**2.11E+02**	**3.00E+02**	**2.73E+01**	**2.73E+01**
53	Cement stabilisation, operation of slipform paver		1.86E+01		2.94E+00		6.19E+00	8.82E+00		
54	Production of cement								2.73E+01	2.73E+01
55	Transport of cement from production to road construction site		6.14E+02		9.72E+01		2.05E+02	2.92E+02		
56	**Concrete paving, wearing course**	**9.28E+01**	**2.10E+04**	**3.09E+00**	**3.06E+02**		**3.34E+02**	**3.88E+02**	**4.71E+04**	**4.71E+04**
57	Production of road concrete		1.63E+02		2.58E+01		5.43E+01	7.74E+01	2.73E+04	2.73E+04
58	Transport of crushed aggregates to concrete production		4.79E+01		7.58E+00		1.60E+01	2.27E+01		
59	Transport of pit-run gravel/sand to concrete production		2.79E+01		4.42E+00		9.31E+00	1.33E+01		
60	Transport of cement to concrete production		4.79E+02		7.58E+01		1.60E+02	2.27E+02		
61	Transport of road concrete from production to road construction site		1.84E+01		2.91E+00		6.12E+00	8.72E+00		
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)		2.20E+02		1.35E+02		2.14E+01	3.05E+01		
63	Exposure of aggregate on concrete carriageway	9.28E+01	6.28E+02	3.09E+00	1.38E+01		6.48E+01	4.76E+00	1.99E+04	1.99E+04
64	Sawing and sealing of joints in concrete road construction		1.94E+04		4.01E+01		2.57E+00	3.66E+00		
65	**Road marking**		**1.05E+00**		**1.67E-01**		**3.51E-01**	**5.00E-01**		
66	**Production and assembly of wildlife fences**		**7.72E+01**		**5.76E+01**		**2.25E+00**	**3.20E+00**		
67	**Other railing and fences, amount of galvanized steel used**		**1.87E+01**		**1.50E+01**					
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**		**4.55E+02**		**3.76E+00**				**9.11E+01**	**9.11E+01**
69	Galvanized steel		4.68E+00		3.76E+00					
70	Aluminium		4.50E+02						9.11E+01	9.11E+01
71	**Lighting and traffic lights, use of galvanized steel and aluminium**		**5.44E+02**		**7.52E+01**				**9.11E+01**	**9.11E+01**
72	Galvanized steel		9.37E+01		7.52E+01					
73	Aluminium		4.50E+02						9.11E+01	9.11E+01
74										
75	**Maintenance of road, total:**		**1.06E+05**		**6.30E+02**		**8.90E+02**	**1.27E+03**	**2.80E+03**	**2.80E+03**
76	**Excavation of road and sub-base with excavator**									
77	**Transport removal of excavated materials from the entire road**									
78	**Reconstruction of base course (unbound)**									
79	Production of crushed aggregates									
80	Extraction of pit-run gravel/sand									
81	Transport of crushed aggregates									
82	Transport of pit-run gravel/sand									
83	Construction of new base course (unbound) at road site									
84	Rolling of layers									
85	**Surface milling of asphalt pavement**									
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**									
87	**Asphalt pavement, hot method**									
88	Production of hot asphalt									
89	Transport of crushed aggregates to asphalt plant									
90	Transport of bitumen to asphalt plant									
91	Transport of asphalt from asphalt plant to road construction site									
92	Asphalt paving									
93	Asphalt rolling									
94	**Asphalt pavement, cold method**									
95	Production of cold asphalt									
96	Transport of crushed aggregates to asphalt plant									
97	Transport of bitumen to emulsifier									
98	Transport of bitumen emulsion from emulsifier to asphalt plant									
99	Transport of asphalt from asphalt plant to road construction site									

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		**Emissions to Water**							**Waste**	
2		**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
100	Asphalt paving									
101	Asphalt rolling									
102	**Maintenance of concrete road**		**1.06E+05**		**6.28E+02**		**8.87E+02**	**1.26E+03**	**2.80E+03**	**2.80E+03**
103	Milling of wearing cource		1.13E+03		1.79E+02		3.76E+02	5.36E+02		
104	Resealing of joints, use of EPDM-rubber		1.04E+05		2.07E+02					
105	Road track milling for concrete filling		1.45E+03		2.29E+02		4.82E+02	6.87E+02		
106	Concrete production for concrete filling		1.67E+01		2.65E+00		5.57E+00	7.94E+00	2.80E+03	2.80E+03
107	Machine operation for concrete filling		1.68E-01		2.67E-02		5.62E-02	8.00E-02		
108	Transport of crushed aggregates to concrete production		4.91E-01		7.77E-02		1.64E-01	2.33E-01		
109	Transport of pit-run gravel/sand to concrete production		2.86E-01		4.53E-02		9.55E-02	1.36E-01		
110	Transport of cement to concrete production		4.91E+01		7.77E+00		1.64E+01	2.33E+01		
111	Transport of concrete from production site to road construction site		1.88E+01		2.98E+00		6.27E+00	8.94E+00		
112	**Maintenance of road marking**		**1.05E+01**		**1.67E+00**		**3.51E+00**	**5.00E+00**		
113										
114	**Operation of road, total:**		**3.86E+02**		**6.12E+01**		**1.29E+02**	**1.84E+02**	**3.75E+05**	**3.75E+05**
115	**Snow clearance**		**2.23E+01**		**3.54E+00**		**7.45E+00**	**1.06E+01**		
116	**Sand gritting of road in winter road maintenance**		**4.77E+00**		**7.55E-01**		**1.59E+00**	**2.27E+00**	**1.03E+02**	**1.03E+02**
117	Vehicle operation, distribution truck		3.44E+00		5.44E-01		1.15E+00	1.63E+00		
118	Production of sand used, crushed material		1.27E+00		2.01E-01		4.24E-01	6.04E-01	9.26E+01	9.26E+01
119	Production of sand used, natural material		6.04E-02		9.57E-03		2.01E-02	2.87E-02	1.05E+01	1.05E+01
120	**Salt gritting of road in winter road maintenance**		**6.87E+01**		**1.09E+01**		**2.29E+01**	**3.27E+01**		
121	Vehicle operation, distribution truck		6.87E+01		1.09E+01		2.29E+01	3.27E+01		
122	Production of salt used, coal based production									
123	**Sweeping**		**1.01E+01**		**1.60E+00**		**3.37E+00**	**4.80E+00**		
124	**Mowing of verges**		**2.67E+01**		**4.22E+00**		**8.89E+00**	**1.27E+01**		
125	**Clearance of verges**		**1.33E+01**		**2.11E+00**		**4.44E+00**	**6.33E+00**		
126	**Washing of roadside posts**		**3.37E+01**		**5.34E+00**		**1.12E+01**	**1.60E+01**		
127	**Washing of road signs**		**1.08E+01**		**1.71E+00**		**3.60E+00**	**5.13E+00**		
128	**Erection and removal of snow posts**		**1.85E+01**		**2.93E+00**		**6.18E+00**	**8.80E+00**		
129	**Digging of road trenches**		**1.27E+02**		**2.01E+01**		**4.24E+01**	**6.04E+01**		
130	**Lighting and traffic lights, electric power production**								**3.75E+05**	**3.75E+05**
131	Lighting								2.87E+05	2.87E+05
132	Traffic lights								8.83E+04	8.83E+04
133	**Other vehicle use (complementary activities) in operation procedures**		**5.02E+01**		**7.95E+00**		**1.67E+01**	**2.39E+01**		
134										
135	**Total sum:**	**9.28E+01**	**1.33E+05**	**3.09E+00**	**1.91E+03**		**2.58E+03**	**3.59E+03**	**4.39E+05**	**4.39E+05**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AL	AM	AN	AO	AP
1			Radioactive waste			
2		Hazardous chemical waste	Highly active	Medium and low active	Demolition waste	Radioactive exposure
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
4	**Construction of road, total:**		**8.42E+02**	**9.03E+03**	**9.03E+03**	**6.02E-05**
5	**Forest felling/clearence for road construction**					
6	**CO2 emission due to permanent reduction of biomass**					
7	**Excavation with excavator in the road direction**					
8	**Excavation with wheel loader in the direction of the road**					
9	**Transport of excavated materials with dumper truck in the direction of the road**					
10	**Excavation with excavator in external site for filling materials**					
11	**Excavation with wheel loader in external site for filling materials**					
12	**Transport with dumper truck of excavated materials from external site to road construction site**					
13	**Excavation with excavator at road constructionen site for transport to external store/landfill**					
14	**Excavation with wheel loader at road constructionen site for transport to external store/landfill**					
15	**Transport of excavated materials with dumper truck from road construction site to external store/landfill**					
16	**Foundation reinforcement, concrete pile**		**5.17E+01**	**5.54E+02**	**5.54E+02**	**3.69E-06**
17	Pile-driving and materials to concrete pile		5.17E+01	5.54E+02	5.54E+02	3.69E-06
18	Transport of crushed aggregates and pit-run gravel/sand to concrete pile production					
19	Transport of cement to concrete pile production					
20	Transport of concrete pile from production site to road construction site					
21	**Foundation reinforcement, cement/lime columns**		**7.58E+01**	**8.18E+02**	**8.18E+02**	**5.43E-06**
22	Foundation reinforcements work, quicklime and cement for the work		7.58E+01	8.18E+02	8.18E+02	5.43E-06
23	Transport of cement to road construction site					
24	Transport of quicklime to road construction site					
25	**Construction of road sub-base (unbound)**					
26	Loading of blasted rock					
27	Transport of blasted rock					
28	Construction of road sub-base (unbound) at the road site					
29	Rolling of layers					
30	**Construction of road base course (unbound)**		**1.65E+02**	**1.77E+03**	**1.77E+03**	**1.18E-05**
31	Production of crushed aggregates		1.48E+02	1.59E+03	1.59E+03	1.06E-05
32	Extraction of pit-run gravel/sand		1.68E+01	1.80E+02	1.80E+02	1.20E-06
33	Transport of crushed aggregates					
34	Transport of pit-run gravel/sand					
35	Construction of road base course (unbound) at the road site					
36	Rolling of layers					
37	**Asphalt pavement, hot method**					
38	Production of hot asphalt					
39	Transport of crushed aggregates to asphalt plant					
40	Transport of bitumen to sphalt plant					
41	Transport of asphalt from asphalt plant to road construction site					
42	Paving of asphalt layers					
43	Rolling of asphalt layers					
44	**Asphalt pavement, cold method**					
45	Production of cold asphalt					
46	Transport of crushed aggregates to asphalt plant					
47	Transport of bitumen to emulsifier					
48	Transport of bitumen emulsion from emulsifier to asphalt plant					
49	Transport of asphalt from asphalt plant to road construction site					
50	Paving of asphalt layers					
51	Rolling of asphalt layers					

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AL	AM	AN	AO	AP
1			Radioactive waste			
2		Hazardous chemical waste	Highly active	Medium and low active	Demolition waste	Radioactive exposure
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
52	**Cement stabilisation of base course**		**5.46E-01**	**5.85E+00**	**5.85E+00**	**3.90E-08**
53	Cement stabilisation, operation of slipform paver					
54	Production of cement		5.46E-01	5.85E+00	5.85E+00	3.90E-08
55	Transport of cement from production to road construction site					
56	**Concrete paving, wearing course**		**5.46E+02**	**5.84E+03**	**5.84E+03**	**3.90E-05**
57	Production of road concrete		5.46E+02	5.84E+03	5.84E+03	3.90E-05
58	Transport of crushed aggregates to concrete production					
59	Transport of pit-run gravel/sand to concrete production					
60	Transport of cement to concrete production					
61	Transport of road concrete from production to road construction site					
62	Concrete paving, operation of slipform paver and use of reinforcement bars (dowels)					
63	Exposure of aggregate on concrete carriageway					
64	Sawing and sealing of joints in concrete road construction					
65	**Road marking**					
66	**Production and assembly of wildlife fences**					
67	**Other railing and fences, amount of galvanized steel used**					
68	**Road signs, reflectors etc., use of galvanized steel and aluminium**		**1.77E+00**	**1.90E+01**	**1.90E+01**	**1.27E-07**
69	Galvanized steel					
70	Aluminium		1.77E+00	1.90E+01	1.90E+01	1.27E-07
71	**Lighting and traffic lights, use of galvanized steel and aluminium**		**1.77E+00**	**1.90E+01**	**1.90E+01**	**1.27E-07**
72	Galvanized steel					
73	Aluminium		1.77E+00	1.90E+01	1.90E+01	1.27E-07
74						
75	**Maintenance of road, total:**		**5.60E+01**	**5.99E+02**	**5.99E+02**	**4.00E-06**
76	**Excavation of road and sub-base with excavator**					
77	**Transport removal of excavated materials from the entire road**					
78	**Reconstruction of base course (unbound)**					
79	Production of crushed aggregates					
80	Extraction of pit-run gravel/sand					
81	Transport of crushed aggregates					
82	Transport of pit-run gravel/sand					
83	Construction of new base course (unbound) at road site					
84	Rolling of layers					
85	**Surface milling of asphalt pavement**					
86	**Adhesion layer application (bitumen emulsion) in maintenance of asphalt pavement**					
87	**Asphalt pavement, hot method**					
88	Production of hot asphalt					
89	Transport of crushed aggregates to asphalt plant					
90	Transport of bitumen to asphalt plant					
91	Transport of asphalt from asphalt plant to road construction site					
92	Asphalt paving					
93	Asphalt rolling					
94	**Asphalt pavement, cold method**					
95	Production of cold asphalt					
96	Transport of crushed aggregates to asphalt plant					
97	Transport of bitumen to emulsifier					
98	Transport of bitumen emulsion from emulsifier to asphalt plant					
99	Transport of asphalt from asphalt plant to road construction site					

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	AL	AM	AN	AO	AP
1			**Radioactive waste**			
2		**Hazardous chemical waste**	**Highly active**	**Medium and low active**	**Demolition waste**	**Radioactive exposure**
3	**Activity**	**g**	**cm3**	**cm3**	**cm3**	**manSv**
100	Asphalt paving					
101	Asphalt rolling					
102	**Maintenance of concrete road**		**5.60E+01**	**5.99E+02**	**5.99E+02**	**4.00E-06**
103	Milling of wearing cource					
104	Resealing of joints, use of EPDM-rubber					
105	Road track milling for concrete filling					
106	Concrete production for concrete filling		5.60E+01	5.99E+02	5.99E+02	4.00E-06
107	Machine operation for concrete filling					
108	Transport of crushed aggregates to concrete production					
109	Transport of pit-run gravel/sand to concrete production					
110	Transport of cement to concrete production					
111	Transport of concrete from production site to road construction site					
112	**Maintenance of road marking**					
113						
114	**Operation of road, total:**		**7.51E+03**	**8.04E+04**	**8.04E+04**	**5.36E-04**
115	**Snow clearance**					
116	**Sand gritting of road in winter road maintenance**		**2.06E+00**	**2.21E+01**	**2.21E+01**	**1.47E-07**
117	Vehicle operation, distribution truck					
118	Production of sand used, crushed material		1.85E+00	1.98E+01	1.98E+01	1.32E-07
119	Production of sand used, natural material		2.09E-01	2.24E+00	2.24E+00	1.50E-08
120	**Salt gritting of road in winter road maintenance**					
121	Vehicle operation, distribution truck					
122	Production of salt used, coal based production					
123	**Sweeping**					
124	**Mowing of verges**					
125	**Clearance of verges**					
126	**Washing of roadside posts**					
127	**Washing of road signs**					
128	**Erection and removal of snow posts**					
129	**Digging of road trenches**					
130	**Lighting and traffic lights, electric power production**		**7.51E+03**	**8.04E+04**	**8.04E+04**	**5.36E-04**
131	Lighting		5.74E+03	6.15E+04	6.15E+04	4.10E-04
132	Traffic lights		1.77E+03	1.89E+04	1.89E+04	1.26E-04
133	**Other vehicle use (complementary activities) in operation procedures**					
134						
135	**Total sum:**		**8.41E+03**	**9.01E+04**	**9.01E+04**	**6.00E-04**

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	A	B	C	D	E	F	G	H	I	J	K	L	M
1			**Material/Energy resources**										
2			**(Energy, electricity) *)**	**Total energy**	**Natural gas**	**Oil**	**Coal**	**Biomass fuel**	**Peat**	**Uranium**	**Hydro power**	**Bitumen**	**Pit-run gravel/sand**
3	**Activity**	**Per unit**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**MJ**	**g**	**g**
4	***Asphalt road, hot method, low emission vehicles:***												
5	Construction of a road	Road object	6.16E+05	7.66E+06	3.45E+05	4.29E+06	2.20E+06	1.74E+04	1.74E+03	6.19E+05	1.82E+05	1.48E+08	5.15E+09
6	Maintenance of a road	Road object	2.19E+05	2.87E+06	1.41E+05	2.29E+06	8.27E+03	9.30E+03	9.30E+02	3.31E+05	9.71E+04	7.80E+07	5.00E+09
7	Operation of a road	Road object	5.36E+06	1.26E+07	4.99E+04	6.97E+05	5.22E+05	2.41E+05	2.41E+04	8.58E+06	2.52E+06		6.24E+07
8	**Sum**	**Road object**	**6.20E+06**	**2.32E+07**	**5.36E+05**	**7.28E+06**	**2.73E+06**	**2.68E+05**	**2.68E+04**	**9.53E+06**	**2.80E+06**	**2.26E+08**	**1.02E+10**
9	***Asphalt road, cold method, low emission vehicles:***												
10	Construction of a road	Road object	5.11E+05	6.56E+06	2.56E+05	3.49E+06	2.20E+06	1.30E+04	1.30E+03	4.64E+05	1.36E+05	9.88E+07	5.15E+09
11	Maintenance of a road	Road object	4.02E+05	3.46E+06	5.38E+05	2.16E+06	1.42E+04	1.59E+04	1.59E+03	5.66E+05	1.66E+05	3.00E+08	5.00E+09
12	Operation of a road	Road object	5.36E+06	1.26E+07	4.99E+04	6.97E+05	5.22E+05	2.41E+05	2.41E+04	8.58E+06	2.52E+06		6.24E+07
13	**Sum**	**Road object**	**6.28E+06**	**2.27E+07**	**8.44E+05**	**6.34E+06**	**2.74E+06**	**2.70E+05**	**2.70E+04**	**9.61E+06**	**2.82E+06**	**3.99E+08**	**1.02E+10**
14	***Concrete road, low emission vehicles:***												
15	Construction of a road	Road object	8.94E+05	1.15E+07	1.41E+05	4.56E+06	5.49E+06	2.70E+04	2.70E+03	9.63E+05	2.83E+05		6.51E+09
16	Maintenance of a road	Road object	6.59E+04	2.99E+06	3.72E+02	2.56E+06	3.39E+05	1.80E+03	1.80E+02	6.39E+04	1.88E+04		1.40E+08
17	Operation of a road	Road object	5.36E+06	1.26E+07	4.99E+04	6.97E+05	5.22E+05	2.41E+05	2.41E+04	8.58E+06	2.52E+06		6.24E+07
18	**Sum**	**Road object**	**6.32E+06**	**2.71E+07**	**1.91E+05**	**7.82E+06**	**6.35E+06**	**2.70E+05**	**2.70E+04**	**9.61E+06**	**2.82E+06**		**6.72E+09**
19	***Asphalt road, hot method, standard vehicles:***												
20	Construction of a road	Road object	6.16E+05	7.66E+06	3.45E+05	4.29E+06	2.20E+06	1.74E+04	1.74E+03	6.19E+05	1.82E+05	1.48E+08	5.15E+09
21	Maintenance of a road	Road object	2.19E+05	2.87E+06	1.41E+05	2.29E+06	8.27E+03	9.30E+03	9.30E+02	3.31E+05	9.71E+04	7.80E+07	5.00E+09
22	Operation of a road	Road object	5.36E+06	1.26E+07	4.99E+04	6.97E+05	5.22E+05	2.41E+05	2.41E+04	8.58E+06	2.52E+06		6.24E+07
23	**Sum**	**Road object**	**6.20E+06**	**2.32E+07**	**5.36E+05**	**7.28E+06**	**2.73E+06**	**2.68E+05**	**2.68E+04**	**9.53E+06**	**2.80E+06**	**2.26E+08**	**1.02E+10**
24	***Asphalt road, cold method, standard vehicles:***												
25	Construction of a road	Road object	5.11E+05	6.56E+06	2.56E+05	3.49E+06	2.20E+06	1.30E+04	1.30E+03	4.64E+05	1.36E+05	9.88E+07	5.15E+09
26	Maintenance of a road	Road object	4.02E+05	3.46E+06	5.38E+05	2.16E+06	1.42E+04	1.59E+04	1.59E+03	5.66E+05	1.66E+05	3.00E+08	5.00E+09
27	Operation of a road	Road object	5.36E+06	1.26E+07	4.99E+04	6.97E+05	5.22E+05	2.41E+05	2.41E+04	8.58E+06	2.52E+06		6.24E+07
28	**Sum**	**Road object**	**6.28E+06**	**2.27E+07**	**8.44E+05**	**6.34E+06**	**2.74E+06**	**2.70E+05**	**2.70E+04**	**9.61E+06**	**2.82E+06**	**3.99E+08**	**1.02E+10**
29	***Concrete road, standard vehicles:***												
30	Construction of a road	Road object	8.94E+05	1.15E+07	1.41E+05	4.56E+06	5.49E+06	2.70E+04	2.70E+03	9.63E+05	2.83E+05		6.51E+09
31	Maintenance of a road	Road object	6.59E+04	2.99E+06	3.72E+02	2.56E+06	3.39E+05	1.80E+03	1.80E+02	6.39E+04	1.88E+04		1.40E+08
32	Operation of a road	Road object	5.36E+06	1.26E+07	4.99E+04	6.97E+05	5.22E+05	2.41E+05	2.41E+04	8.58E+06	2.52E+06		6.24E+07
33	**Sum**	**Road object**	**6.32E+06**	**2.71E+07**	**1.91E+05**	**7.82E+06**	**6.35E+06**	**2.70E+05**	**2.70E+04**	**9.61E+06**	**2.82E+06**		**6.72E+09**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1									**Emissions to Air**							
2			**Rock**	**Limestone**	**Rock salt**	**Aluminium**	**Iron**	**Zinc**	**SO2**	**NOx**	**CO**	**CO2**	**HC**	**CH4**	**VOC**	**NMVOC**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	***Asphalt road, hot method, low emission vehicles:***															
5	Construction of a road	Road object	7.47E+09	4.96E+08	2.92E+08	2.92E+08	3.36E+08	2.92E+08	8.41E+05	3.00E+06	3.46E+05	1.78E+09	1.38E+05	3.95E+05	3.22E+04	5.21E+04
6	Maintenance of a road	Road object	6.16E+09						1.30E+05	1.09E+06	1.50E+05	1.74E+08	7.32E+04	1.12E+02	1.58E+04	
7	Operation of a road	Road object	6.24E+07		2.08E+08				2.02E+05	3.53E+05	4.45E+04	7.41E+07	1.54E+04	7.67E+02	5.90E+03	
8	**Sum**	**Road object**	**1.37E+10**	**4.96E+08**	**5.00E+08**	**2.92E+08**	**3.36E+08**	**2.92E+08**	**1.17E+06**	**4.43E+06**	**5.41E+05**	**2.03E+09**	**2.26E+05**	**3.96E+05**	**5.39E+04**	**5.21E+04**
9	***Asphalt road, cold method, low emission vehicles:***															
10	Construction of a road	Road object	7.52E+09	4.96E+08	2.92E+08	2.92E+08	3.36E+08	2.92E+08	7.73E+05	2.82E+06	3.28E+05	1.71E+09	1.35E+05	3.95E+05	2.22E+04	5.21E+04
11	Maintenance of a road	Road object	1.21E+10						2.49E+05	1.29E+06	1.68E+05	1.84E+08	8.11E+04	1.30E+02	6.04E+04	
12	Operation of a road	Road object	6.24E+07		2.08E+08				2.02E+05	3.53E+05	4.45E+04	7.41E+07	1.54E+04	7.67E+02	5.90E+03	
13	**Sum**	**Road object**	**1.97E+10**	**4.96E+08**	**5.00E+08**	**2.92E+08**	**3.36E+08**	**2.92E+08**	**1.22E+06**	**4.46E+06**	**5.40E+05**	**1.97E+09**	**2.31E+05**	**3.96E+05**	**8.85E+04**	**5.21E+04**
14	***Concrete road, low emission vehicles:***															
15	Construction of a road	Road object	7.49E+09	1.71E+09	1.51E+09	1.51E+09	1.57E+09	1.51E+09	1.66E+06	4.86E+06	4.11E+05	2.44E+09	1.82E+05	5.51E+05	2.78E+03	9.07E+04
16	Maintenance of a road	Road object	2.40E+08	1.25E+08	1.25E+08	1.25E+08	1.25E+08	1.25E+08	1.94E+05	1.76E+06	1.93E+05	2.52E+08	1.14E+05	1.83E+04	4.40E+01	9.85E+04
17	Operation of a road	Road object	6.24E+07		2.08E+08				2.02E+05	3.53E+05	4.45E+04	7.41E+07	1.54E+04	7.67E+02	5.90E+03	
18	**Sum**	**Road object**	**7.79E+09**	**1.84E+09**	**1.84E+09**	**1.64E+09**	**1.70E+09**	**1.64E+09**	**2.06E+06**	**6.97E+06**	**6.48E+05**	**2.76E+09**	**3.11E+05**	**5.70E+05**	**8.72E+03**	**1.89E+05**
19	***Asphalt road, hot method, standard vehicles:***															
20	Construction of a road	Road object	7.47E+09	4.96E+08	2.92E+08	2.92E+08	3.36E+08	2.92E+08	9.10E+05	4.80E+06	5.84E+05	1.78E+09	2.46E+05	3.95E+05	3.22E+04	5.21E+04
21	Maintenance of a road	Road object	6.16E+09						1.70E+05	2.03E+06	2.86E+05	1.74E+08	1.30E+05	1.96E+02	1.58E+04	
22	Operation of a road	Road object	6.24E+07		2.08E+08				2.10E+05	5.62E+05	7.14E+04	7.41E+07	2.80E+04	7.83E+02	5.90E+03	
23	**Sum**	**Road object**	**1.37E+10**	**4.96E+08**	**5.00E+08**	**2.92E+08**	**3.36E+08**	**2.92E+08**	**1.29E+06**	**7.38E+06**	**9.42E+05**	**2.03E+09**	**4.04E+05**	**3.96E+05**	**5.39E+04**	**5.21E+04**
24	***Asphalt road, cold method, standard vehicles:***															
25	Construction of a road	Road object	7.52E+09	4.96E+08	2.92E+08	2.92E+08	3.36E+08	2.92E+08	8.41E+05	4.60E+06	5.62E+05	1.71E+09	2.43E+05	3.95E+05	2.22E+04	5.21E+04
26	Maintenance of a road	Road object	1.21E+10						2.88E+05	2.25E+06	3.00E+05	1.84E+08	1.39E+05	2.11E+02	6.04E+04	
27	Operation of a road	Road object	6.24E+07		2.08E+08				2.10E+05	5.62E+05	7.14E+04	7.41E+07	2.80E+04	7.83E+02	5.90E+03	
28	**Sum**	**Road object**	**1.97E+10**	**4.96E+08**	**5.00E+08**	**2.92E+08**	**3.36E+08**	**2.92E+08**	**1.34E+06**	**7.42E+06**	**9.34E+05**	**1.97E+09**	**4.10E+05**	**3.96E+05**	**8.85E+04**	**5.21E+04**
29	***Concrete road, standard vehicles:***															
30	Construction of a road	Road object	7.49E+09	1.71E+09	1.51E+09	1.51E+09	1.57E+09	1.51E+09	1.75E+06	7.14E+06	7.20E+05	2.44E+09	3.19E+05	5.51E+05	2.78E+03	9.07E+04
31	Maintenance of a road	Road object	2.40E+08	1.25E+08	1.25E+08	1.25E+08	1.25E+08	1.25E+08	2.48E+05	3.32E+06	3.82E+05	2.52E+08	2.08E+05	1.84E+04	4.40E+01	9.85E+04
32	Operation of a road	Road object	6.24E+07		2.08E+08				2.10E+05	5.62E+05	7.14E+04	7.41E+07	2.80E+04	7.83E+02	5.90E+03	
33	**Sum**	**Road object**	**7.79E+09**	**1.84E+09**	**1.84E+09**	**1.64E+09**	**1.70E+09**	**1.64E+09**	**2.21E+06**	**1.10E+07**	**1.17E+06**	**2.76E+09**	**5.55E+05**	**5.70E+05**	**8.72E+03**	**1.89E+05**

*) Electric power production is included in the different resources and emissions but the electricity used is here given as an additional information.

	A	B	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1					**Emissions to Water**							**Waste**	
2			**N2O**	**Particles**	**BOD**	**COD**	**Phosphorus-total**	**Nitrogen-total**	**HC**	**Oil**	**Phenol**	**Total**	**Landfillled**
3	**Activity**	**Per unit**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
4	***Asphalt road, hot method, low emission vehicles:***												
5	Construction of a road	Road object	6.06E+03	1.96E+06	2.82E+03	5.58E+04	2.96E+02	1.62E+03	2.96E+02	1.16E+03	1.65E+03	6.52E+04	2.62E+04
6	Maintenance of a road	Road object	2.76E+03	2.85E+04	1.48E+03	2.89E+04	1.56E+02	7.10E+02	1.56E+02	6.75E+02	9.61E+02	3.50E+04	1.45E+04
7	Operation of a road	Road object	2.77E+03	7.73E+03		3.86E+02		6.12E+01		1.29E+02	1.84E+02	3.75E+05	3.75E+05
8	**Sum**	**Road object**	**1.16E+04**	**1.99E+06**	**4.30E+03**	**8.50E+04**	**4.52E+02**	**2.39E+03**	**4.52E+02**	**1.96E+03**	**2.79E+03**	**4.76E+05**	**4.16E+05**
9	***Asphalt road, cold method, low emission vehicles:***												
10	Construction of a road	Road object	5.93E+03	1.95E+06	1.88E+03	3.87E+04	1.98E+02	1.36E+03	1.98E+02	1.13E+03	1.61E+03	4.54E+04	1.94E+04
11	Maintenance of a road	Road object	2.73E+03	3.18E+04	5.71E+03	1.05E+05	6.01E+02	1.82E+03	6.01E+02	6.66E+02	9.46E+02	1.04E+05	2.48E+04
12	Operation of a road	Road object	2.77E+03	7.73E+03		3.86E+02		6.12E+01		1.29E+02	1.84E+02	3.75E+05	3.75E+05
13	**Sum**	**Road object**	**1.14E+04**	**1.99E+06**	**7.58E+03**	**1.44E+05**	**7.98E+02**	**3.24E+03**	**7.98E+02**	**1.93E+03**	**2.74E+03**	**5.24E+05**	**4.20E+05**
14	***Concrete road, low emission vehicles:***												
15	Construction of a road	Road object	8.07E+03	3.40E+06	9.28E+01	2.60E+04	3.09E+00	1.21E+03		1.56E+03	2.14E+03	6.11E+04	6.11E+04
16	Maintenance of a road	Road object	3.60E+03	1.53E+05		1.06E+05		6.30E+02		8.90E+02	1.27E+03	2.80E+03	2.80E+03
17	Operation of a road	Road object	2.77E+03	7.73E+03		3.86E+02		6.12E+01		1.29E+02	1.84E+02	3.75E+05	3.75E+05
18	**Sum**	**Road object**	**1.44E+04**	**3.56E+06**	**9.28E+01**	**1.33E+05**	**3.09E+00**	**1.91E+03**		**2.58E+03**	**3.59E+03**	**4.39E+05**	**4.39E+05**
19	***Asphalt road, hot method, standard vehicles:***												
20	Construction of a road	Road object	6.06E+03	2.01E+06	2.82E+03	5.58E+04	2.96E+02	1.62E+03	2.96E+02	1.16E+03	1.65E+03	6.52E+04	2.62E+04
21	Maintenance of a road	Road object	2.76E+03	5.19E+04	1.48E+03	2.89E+04	1.56E+02	7.10E+02	1.56E+02	6.75E+02	9.61E+02	3.50E+04	1.45E+04
22	Operation of a road	Road object	2.77E+03	1.49E+04		3.86E+02		6.12E+01		1.29E+02	1.84E+02	3.75E+05	3.75E+05
23	**Sum**	**Road object**	**1.16E+04**	**2.08E+06**	**4.30E+03**	**8.50E+04**	**4.52E+02**	**2.39E+03**	**4.52E+02**	**1.96E+03**	**2.79E+03**	**4.76E+05**	**4.16E+05**
24	***Asphalt road, cold method, standard vehicles:***												
25	Construction of a road	Road object	5.93E+03	2.01E+06	1.88E+03	3.87E+04	1.98E+02	1.36E+03	1.98E+02	1.13E+03	1.61E+03	4.54E+04	1.94E+04
26	Maintenance of a road	Road object	2.73E+03	6.00E+04	5.71E+03	1.05E+05	6.01E+02	1.82E+03	6.01E+02	6.66E+02	9.46E+02	1.04E+05	2.48E+04
27	Operation of a road	Road object	2.77E+03	1.49E+04		3.86E+02		6.12E+01		1.29E+02	1.84E+02	3.75E+05	3.75E+05
28	**Sum**	**Road object**	**1.14E+04**	**2.08E+06**	**7.58E+03**	**1.44E+05**	**7.98E+02**	**3.24E+03**	**7.98E+02**	**1.93E+03**	**2.74E+03**	**5.24E+05**	**4.20E+05**
29	***Concrete road, standard vehicles:***												
30	Construction of a road	Road object	8.07E+03	3.47E+06	9.28E+01	2.60E+04	3.09E+00	1.21E+03		1.56E+03	2.14E+03	6.11E+04	6.11E+04
31	Maintenance of a road	Road object	3.60E+03	2.14E+05		1.06E+05		6.30E+02		8.90E+02	1.27E+03	2.80E+03	2.80E+03
32	Operation of a road	Road object	2.77E+03	1.49E+04		3.86E+02		6.12E+01		1.29E+02	1.84E+02	3.75E+05	3.75E+05
33	**Sum**	**Road object**	**1.44E+04**	**3.70E+06**	**9.28E+01**	**1.33E+05**	**3.09E+00**	**1.91E+03**		**2.58E+03**	**3.59E+03**	**4.39E+05**	**4.39E+05**

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