SimaPro
Database Manual

The BUWAL 250 library

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Written by: PRé Consultants

Renilde Spriensma

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Support: phone +31 33 4555022
fax +31 33 4555024
e-mail support@pre.nl
web site www.pre.nl

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1 The BUWAL 250 library

1.1 Introduction

This chapter summarises the information from the BUWAL 250 report (second edition) in the following system descriptions:

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- Pulp and cellulose
- Graphic paper
- Cardboard
- Packaging paper
- Liners and fluting for corrugated cardboard
- Corrugated cardboard
- Aluminium
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- Municipal landfill
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- Electricity generation
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The information in this chapter can also be found in the system descriptions that are mentioned in each of the BUWAL250 process records. The report “Oekoinventare für Verpackungen”, Schriftenreihe Umwelt Nr. 250, part 1+2, second edition, (German language) can be ordered from BUWAL, Dokumentationsdienst, CH 3003 Bern, Switzerland. English and French translations are available. Online ordering is possible via http://www.buwal.ch/publikat/oekobila.htm.

1.1.1 System description format

The system descriptions in this chapter are described following the recommendations of the SPOLD format. Three levels can be distinguished:

1. General BUWAL methodology that is relevant for all materials and processes.
2. Methodology in relation to groups of materials, for example plastics.
3. Methodology which is relevant to one specific process of a material, that is the process record itself.

A system description is made up of the following elements:

1. **Description**
   General description of the model
2. **Sub-systems**
   The unit processes which are taken up by the system, including the total contribution to the total process
3. **Cut-off rules**
   The exclusion of certain emissions or elements out of the system, or the method used to determine the cut-off point including its justification.
4. **Allocation rules**
   Each individual process record must have the allocation specified using a list of co-products and allocations rules.

5. **Energy model**
   Relevant information on the energy conversion processes and its efficiency. This refers to unit processes.
6. **Transport model**
   Relevant information on transport processes including the method of transport, the distance and the load. This refers to unit processes.
7. **Waste model**
   Waste processing system plus relevant proportions and the used allocation rules.
8. **Other assumptions**
   Any other assumptions of relevance to the system description.
9. **Other information.**
   All other information that is considered relevant.

1.2 System descriptions

1.2.1 System description BUWAL 250 (general principles)

Description:
The inventory table includes emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the materials. The system description is based on the Swiss consumption of packaging materials and the imports and exports of materials, the origin of raw materials and the use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of input materials.

2. Cut-off rules:
Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the packaging materials after the consumption phase. For most other processes, except for a very few processing processes, they could not be registered as there were no emissions to soil reported.

In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.

In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory either.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.

The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
When production is situated in one specific country, the electricity model for this country is used. In other cases the UCPTE model for 1993, with an overall efficiency of 31% is used.

Source	% in UCPTE model
Electricity from Coal	17.4
Electricity from Lignite	7.8
Electricity from Oil	10.7
Electricity from Gas	7.4
Electricity from Nuclear power	40.3
Electricity from Hydro power	16.4

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste that can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste, which is not specified as inert, is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste that is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities, which stay at the production site.

For the waste treatment of packaging materials after the consumption phase, specific models are given for incineration and disposal under Swiss conditions.

1.2.2 System description Plastics

Description:
The system description plastics describes the production of basic polymer materials for packaging purposes and is based on the "Ecoprofiles of the European plastics industry" developed by Boustead Consulting for the Association of Plastics Manufacturers in Europe (APME 1992-1995). The inventory table includes emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the polymer materials. The system description is based on the Swiss consumption of packaging materials and the imports and

exports of materials, the origin of raw materials and use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of input materials (see specific process records for details):

- NaCl
- Chlorine (Cl_2)
- NaOH
- Naphtha (inventory for refinery products in Northern and Central European countries, 15% North sea oil, 85% overseas)
- Ethylene
- Propylene
- Benzene
- Styrene
- Polybutadiene

2. Cut-off rules:
In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.

In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory.

Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products which are explicitly mentioned form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.
The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
Production of electricity for polymerisation processes is according to APME data, which depend on the site of the factories. For more details consult the APME reports on plastics production ("Ecoprofiles of the European plastics industry" developed by Boustead Consulting for the Association of Plastics Manufacturers in Europe (APME 1992-1995)

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

All polymerisation factories are situated outside Switzerland. The transports of the plastics are not included in the inventories. The table below is only for information. For transports over land a combination of 20% train and 80% truck is assumed.

tkm/t	PE*	LDPE	HDPE	PP	EPS	GPPS HIPS	PS*	PVC	PVDC	PET
Truck	465	430	513	525	471	454	460	383	330	603
Train	116	107	128	131	118	114	115	96	83	151
Ship	628	651	596	2	2686	5	983	78	-	744

*) All grades

6. Waste model:

Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste, which can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste that is not specified as inert is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste, which is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities, which stay at the production site.

APME	BUWAL 250
Mineral waste	Mineral waste (mining)
Industrial waste	30% combustion 70% controlled landfill
Slags and ash	controlled landfill
Regulated chemicals	controlled landfill
Toxic chemicals	controlled landfill

8. Other information:

Modifications to the original data from APME:

- HHV for oil and natural gas are slightly lower than the HHV used by ETHZ in the energy conversions.
- Some intermediate products are used as fuel and a correction to the inputs for the amounts of fuel and feedstock has been made. Thus the data are adjusted to account for feedstock used as fuel. This correction causes higher carbon dioxide emissions for all polymers.

1.2.3 System description Glass

Description:
The system description glass describes the production of packaging glass (bottles and jars) from raw materials and recycling glass in Switzerland (1994). Different coloured used glass is collected separately, resulting in a very high share of recycled glass in the final product. The energy-use of the melting furnace is lower when more recycling glass is used, resulting in substantial energy savings.

Type	Effective share of secondary glass %	Maximal share of secondary glass %
Brown	61	70-80
Green	99	100
White	55	70-80

The inventory tables include emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the bottles and jars as well as collection, transport and processing of secondary glass.
The system description is based on the Swiss consumption of packaging materials and the imports and exports of materials, the origin of raw materials and use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of input materials (see unit processes for details):

- $NaSO_4$
- Soda
- NaOH
- Ammonia
- Processing of secondary glass: sorting, grinding and sifting (see unit process).

2. Cut-off rules:
In general the production process is traced back to the raw material resources. In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory.

Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.

The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
Oil (S, EU) is used for the direct heating of the melting furnace (see unit process). Theoretical energy-use for the melting of raw materials is 2250-3000 MJ/t glass. Production of electricity is according to the Swiss electricity model, with an efficiency of 36.8%.

Source	% in Swiss model
Electricity from Coal	4.7
Electricity from Lignite	1.4
Electricity from Oil	2.5
Electricity from Gas	1.2
Electricity from Nuclear power	50
Electricity from Hydro power	40.1
Other	0.1

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland. Transports from the consumer to the collection container are not included.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

Transport of secondary glass:

- Train, 50% load, 120 km
- Truck (16t), 30% load, 20 km

Transport of raw materials and chemicals is listed below:

Material	Truck (28t) km (50% load)	Train km (45% load)	Rhine ship km (70% load)
Quartz		80	980
Feldspar		550	
Dolomite		350	
Limestone	110		
NaSO4	200		
Soda		300	
NaOH	20		
Ammonia	150		
Additives	100	200	

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste, which can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste, which is not specified as inert is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste, which is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities, which stay at the production site.

1.2.4 System description Mechanical wood pulp and cellulose

Description:
The system description pulp includes the mechanical production of mechanical wood pulp and the chemical production of sulphite and sulphate cellulose from soft and hard wood in Switzerland, Germany, Canada and Sweden, including the bleaching process.

Wood pulp and cellulose are used for the production of packaging paper, printing paper, paperboard and corrugated board. For pulp production from new wood the cultivation of the wood (only Sweden), the forest maintenance, felling and sawing are included. For production of pulp from remnants from sawmills, only transport from the mill to the pulp factory is included, since in this process secondary materials from another process are used.
The inventory table includes emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the pulp. The system description is based on the Swiss consumption of packaging materials and the imports and exports of materials, the origin of raw materials and use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of wood (excluding the actual growing).
Production of input materials (see specific processes for details):

- Cl_2
- O_2
- $NaClO_3$
- $NaSO_4$
- NaOH
- $CaCO_3$
- CaO
- HCl
- Soda
- Sulphur (S)
- SO_2
- H_2SO_4
- H_2O_2

2. Cut-off rules:
Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources. Accordingly the uptake of solar energy and carbon dioxide by the trees during their growth is not included either.
Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.
In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.
In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another

production process, no emissions from recycling processes of these materials are included in the inventory.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.
The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
Production of electricity for pulp production is according to the country specific electricity models listed in the table below.

Electricity Source	Switzerland %	Canada %	Germany %	Sweden %
Coal	4.7	20.1	28.9	0.9
Lignite	1.4		18.8	0.0
Oil	2.5	2.9	1.2	5.9
Gas	1.2	1.3	4.5	0.1
Nuclear power	50	17.5	39.3	39.5
Hydro power	40.1	58.2	6.3	53.6
Other	0.1		1.0	0.0
Overall efficiency	36.8	unknown	28.6	41.6

For the production processes of the chemicals the UCPTE model for 1993 is used for pulp produced in Europe, the Nordel model is used for production in Scandinavian countries and the Canadian model for pulp production situated in Canada.

Source	% in Nordel model	% in UCPTE model
Electricity from Coal	11.8	17.4
Electricity from Lignite	0	7.8
Electricity from Oil	5.3	10.7
Electricity from Gas	1.5	7.4
Electricity from Nuclear power	21.8	40.3
Electricity from Hydro power	59.2	16.4
Other sources	0.4	0
Overall efficiency	44.7	31.0

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

The transports for chemicals, new wood and remnants from sawmills in the pulp and cellulose producing countries are listed in the table below. The data presented are average values based on information from the companies and estimates. The assumed average load for trucks is 50%, for ships 70%.

Producing country	Transport chemicals	Distance
Sweden	truck (40t) train ship	100 km 50 km 30 km
Canada	truck (40t) train	200 km 50 km
Switzerland	train	200 km
Germany	train	200 km

Producing country	Transport wood	Distance
Sweden/Canada	truck (40t) train	76 km 20 km
Switzerland/Germany	truck (28t) train	40 km 30 km

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste that can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste, which is not specified as inert is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste, which is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities, which stay at the production site.

1.2.5 System description Graphic papers

Description:
Production of graphic papers from sulphate cellulose, sulphite cellulose, mechanical wood pulp, thermomechanical wood pulp or recycling paper pulp for the printing industry based on data from Swiss factories (1993/1994).

The inventory table includes emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the materials. The system description is based on the Swiss production of printing papers. Therefore the imports and

exports of materials, the origin of raw materials and use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of input materials:

- Sulphate cellulose
- Sulphite cellulose
- Mechanical wood pulp
- Wood production
- Sorting of recycling paper
- Auxiliary materials for paper and pulp production process

Production of thermomechanical wood pulp (TMP) and de-inked paper pulp in the production of newsprint are part of an integrated process. No inventory tables are available for these two processes, but the input data are listed in table 18.40 of the BUWAL 250 report.

2. Cut-off rules:
Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.

In the output, production waste is mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.

The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
All printing paper production is situated in Switzerland. This means that the Swiss electricity model with an overall efficiency of 36.8 % is used in the paper production processes. Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

Source	% in Swiss model
Electricity from Coal	4.7
Electricity from Lignite	1.4
Electricity from Oil	2.5
Electricity from Gas	1.2
Electricity from Nuclear power	50.0
Electricity from Hydro power	40.1
Other	0.1

For the production processes of the chemicals the UCPTE model for 1993 is used for pulp produced in Europe, the Nordel model is used for production in Scandinavian countries and the Canadian model for pulp production situated in Canada.

Source	% in Nordel model	% in Canadian model	% in UCPTE model
Electricity from Coal	11.8	20.1	17.4
Electricity from Lignite	0	0	7.8
Electricity from Oil	5.3	2.9	10.7
Electricity from Gas	1.5	1.3	7.4
Electricity from Nuclear power	21.8	17.5	40.3
Electricity from Hydro power	59.2	58.2	16.4
Other sources	0.4	0	0
Overall efficiency	44.7	Unknown	31.0

5. Transport model:
The data for the transport models originate from ESU-ETH models (1994) for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

Transport distances for input materials of the paper production are based on company data and listed below.

Input materials	Transport	Load
Cellulose Sweden	2000 km sea ship 800 km inland vessel 150 km train	70 % 70 %
Cellulose Switzerland	150 km train	
Cellulose Canada	6000 km sea ship 800 km inland vessel 300 km train	70 % 70 %
Rest wood Switzerland	40 km truck (28t) 50 km train	50 %
Mechanical wood pulp	50 km train	
Recycling paper	60 km truck (28t) 100 km train	70 %
Fillers (kaolin, chalk etc.)	200 km ship 800 km train	70 %
Starch	500 km train	
Auxiliary materials	200 km truck (28t) 400 km train	50 %

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste that can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste that is not specified as inert is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste that is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities, which stay at the production site.

1.2.6 System description Cardboard

Description:
Integrated and non-integrated production of different kinds of cardboard (92 % dry matter) in different countries in Europe in 1993/1994. Cardboard contains several different layers of fibres, which can be made from new fibres or recycled fibres, depending on the required quality of the materials. New fibres can be cellulose, wood pulp or combinations of these materials. A special coating is applied when the cardboard needs to be printed on.

The inventory table includes emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the materials. The system description is based on the Swiss consumption of packaging materials and the imports and exports of materials, the origin of raw materials and use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of input materials (for details see unit processes) for the non-integrated cardboard production:

- All types of cellulose (sulphate or sulphite, bleached or non-bleached)
- Wood pulp
- Recycling paper
- Auxiliary materials: aluminium sulphate, $CaCO_3$, kaolin, starch, synthetic latex.

The production of cellulose cardboard and the production of liquid packaging board in Sweden are both integrated processes. This means that these products are directly produced from wood in one integrated process. Production processes of input materials:

- Wood (mixed wood)
- O_2
- $NaClO_3$
- NaOH
- CaO
- SO_2
- H_2SO_4
- H_2O_2
- Starch
- Kaolin
- Synthetic latex

2. Cut-off rules:
Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the

effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.
In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory either.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.
The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
When production is situated in one specific country, the electricity model for this country is used. In other cases the UCPTE model for 1993 with an overall efficiency of 31% is used. For production of Grey Cardboard the Swiss electricity model (36.8 % efficiency) is used and for the integrated processes of the Cellulose Cardboard and the Liquid Packaging Board, the Swedish electricity model (41.0 % efficiency) is used.

Electricity Source	Switzerland %	Sweden %	UCPTE %
Coal	4.7	0.9	17.4
Lignite	1.4	0.0	7.8
Oil	2.5	5.9	10.7
Gas	1.2	0.1	7.4
Nuclear power	50	39.5	40.3
Hydro power	40.1	53.6	16.4
Other	0.1	0.0	0.0
Overall efficiency	36.8	41.6	28.6

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.
For the production processes of the chemicals the UCPTE model for 1993 is used for pulp produced in Europe, the Nordel model is used for production in Scandinavian countries and the Canadian model for pulp production situated in Canada.

Source	% in Nordel model	% in Canadian model
Electricity from Coal	11.8	20.1
Electricity from Lignite	0	0
Electricity from Oil	5.3	2.9
Electricity from Gas	1.5	1.3
Electricity from Nuclear power	21.8	17.5
Electricity from Hydro power	59.2	58.2
Other sources	0.4	0
Overall efficiency	44.7	Unknown

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

Input materials for the non-integrated production	Transport	Load
Cellulose Sweden	2000 km sea ship 800 km inland vessel 150 km train	70 % 70 %
Cellulose Switzerland and Germany	150 km train	
Cellulose Canada	6000 km sea ship 800 km inland vessel 300 km train	70 % 70 %
Wood pulp	400 km train 400 km ship	 70 %
Used paper	100 km truck (28t/40t) 100 km train 100 km ship	70 % 70 %
Auxiliary materials	200 km truck (28t) 400 km train	50 %

Input materials for the integrated production of cellulose board are listed in the table below.

Input materials Cellulose Cardboard	Transport	Load
Wood	105 km truck (40t)	50 %
Wood import	500 km ship	70 %
CaO	220 km truck (40t)	70 %
NaOH	1000 km ship 200 km train	70 %
$NaClO_3$	200 km truck (40t)	70 %
H_2SO_4	150 km truck (40t)	50 %
SO_2	550 km truck (28t)	50 %
H_2O_2	200 km truck (28t)	50 %
O_2	100 km truck (28t)	50 %
Pigments	150 km truck (40t)	50 %
Binding agents	130 km truck (40t)	50 %

Input materials for production of Liquid Packaging Board	Transport	Load
Wood	80 km truck (40t) 20 km train	50 %
CaO	150 km truck (40t)	50 %
$NaClO_3$	1060 km train	
H_2SO_4	15 km truck (40t) 900 km ship	50 % 70 %
SO_2	650 km train (28t)	
O_2	22 km truck (28t)	50 %
NaOH	15 km truck (40t) 1260 km ship	50 % 70 %
Other auxiliaries	200 km truck (40t) 200 km train	50 %

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste that can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste, which is not specified as inert, is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste that is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities that stay at the production site.

1.2.7 System description Packaging paper

Description:
Integrated and non-integrated production of extra strong packaging paper in Switzerland, Sweden and Austria. For the non-integrated production mainly sulphate cellulose is used which is mixed with recycling paper, sulphite cellulose only for the production of Swisskraft.
The inventory table includes emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the paper itself. The system description is based on the Swiss consumption of packaging materials and the import and export of materials, the origin of raw materials and use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of input materials (for details see unit processes) for the non-integrated packaging paper production:

- All types of cellulose (mainly sulphate pulp, bleached or non-bleached)
- Recycling paper (Swisskraft only)
- Auxiliary materials: aluminium sulphate, $CaCO_3$, kaolin, starch, synthetic latex.

The production of bag paper in Austria and in Sweden is an integrated process. This means that these products are directly produced from wood in one integrated process. Production processes of input materials:

- Wood
- $NaSO_4$
- NaOH
- $CaCO_3$
- CaO
- H_2SO_4
- Starch
- Kaolin
- Synthetic latex
- Aluminiumsulphate

2. Cut-off rules:
Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.

In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory either.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.

The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:

When production is situated in one specific country, the electricity model for this country is used. Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

Electricity source	Switzerland %	Sweden %	Austria %
Coal	4.7	0.9	7.1
Lignite	1.4	0.0	8.8
Oil	2.5	5.9	2.8
Gas	1.2	0.1	9.9
Nuclear power	50	39.5	6.3
Hydro power	40.1	53.6	65.0
Other	0.1	0.0	0.1
Overall efficiency	36.8	41.6	48.1

For the production processes of the chemicals the UCPTE model for 1993 is used for pulp produced in Europe, the Nordel model is used for production in Scandinavian countries and the Canadian model for pulp production situated in Canada.

Source	% in Nordel model	% in UCPTE model	% in Canadian model
Electricity from Coal	11.8	17.4	20.1
Electricity from Lignite	0	7.8	0
Electricity from Oil	5.3	10.7	2.9
Electricity from Gas	1.5	7.4	1.3
Electricity from Nuclear power	21.8	40.3	17.5
Electricity from Hydro power	59.2	16.4	58.2
Other sources	0.4	0.0	0
Overall efficiency	44.7	28.6	unknown

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

Transport distances are based on company information.

Input materials for the non-integrated production in Switzerland	Transport	Load
Cellulose Sweden	2000 km sea ship 800 km inland vessel 150 km train	70 % 70 %
Cellulose Switzerland	150 km train	
Cellulose Canada	6000 km sea ship 800 km inland vessel 300 km train	70 % 70 %
Used paper	60 km truck (28t) 100 km train	70 %
Auxiliary materials	200 km truck (28t) 400 km train	50 %

The transports for chemicals, new wood and remnants from sawmills for the integrated production of bag paper are listed in the table below. The data presented are average values based on information from the companies and estimates. The assumed average load for trucks is 50%, for ships 70%.

Producing country	Transport chemicals	Distance
Sweden	truck (40t) train ship	100 km 50 km 30 km
Austria	train	200 km

Producing country	Transport wood	Distance
Sweden	truck (40t) train	76 km 20 km
Austria	truck (28t) train	40 km 30 km

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste that can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste that is not specified as inert is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste, which is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities, which stay at the production site.

1.2.8 System description Liners and fluting for corrugated cardboard

Description:
For the production of corrugated cardboard two types of semi-manufactures are needed; the liner (facing) and the corrugated medium (fluting). Fluting and Wellenstoff form corrugated layers, Kraftliner, Schrenz and Testliner form the liners. Depending on the required quality of the corrugated cardboard, the semi-manufactures are produced mainly from new fibres (Fluting, Kraftliner) or from secondary paper (Wellenstoff, Testliner and Schrenz).

The inventory table includes emissions from raw material production, energy production, production of new and secondary fibres from wood, paper and auxiliary materials, transports and the production process of the liners and fluting. The system description is based on the Swiss consumption of packaging materials and the import and export of materials, the origin of raw materials and use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of input materials:

- Starch
- Wood, wood chips
- NaOH
- Sulphur
- H_2SO_4
- Soda
- $CaCO_3$
- CaO
- Kaolin
- $Al_2(SO_4)_3$
- $NaClO_3$
- O_2
- H_2O_2
- SO_2
- Secondary paper and packaging waste collection

2. Cut-off rules:
Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.

In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory either.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.

The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
When production is situated in one specific country, the electricity model for this country is used. Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

Electricity Source	Switzerland %	Sweden %	Austria %
Coal	4.7	0.9	7.1
Lignite	1.4	0.0	8.8
Oil	2.5	5.9	2.8
Gas	1.2	0.1	9.9
Nuclear power	50	39.5	6.3
Hydro power	40.1	53.6	65.0
Other	0.1	0.0	0.1
Overall efficiency	36.8	41.6	48.1

For the production processes of the chemicals the UCPTE model for 1993 is used for pulp produced in Europe, the Nordel model is used for production in Scandinavian countries and the Canadian model for pulp production situated in Canada.

Source	% in Nordel model	% in UCPTE model	% in Canadian model
Electricity from Coal	11.8	17.4	20.1
Electricity from Lignite	0	7.8	0
Electricity from Oil	5.3	10.7	2.9
Electricity from Gas	1.5	7.4	1.3
Electricity from Nuclear power	21.8	40.3	17.5
Electricity from Hydro power	59.2	16.4	58.2
Other sources	0.4	0.0	0
Overall efficiency	44.7	28.6	unknown

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

Transports for Testliner, Schrenz and Wellenstoff (production in Switzerland):

Materials	Proportion	Transport	Load
Secondary paper	30% 20% 50%	120 km truck 28t 100 km train 160 km truck 28t	80% - 50%
Starch	100%	400 km train 400 km truck 28t	- 50%
Various	100%	200 km truck 28t	50%

Transports for Fluting (production in Sweden):

Materials	Transport	Load
Wood	50 km truck 40t 75 km train	50% -
Imported wood	600 km ship	70%
Wood chips	200 km truck 40t	50%
NaOH	30 km truck 40t	50%
Sulphur	200 km truck 40t	50%
H_2SO_4	400 km train	50%

Transports for Kraftliner (production in Austria):

Materials	Transport	Load
Wood	400 km train	-
Wood chips	80 km truck 28t	50%
Packaging waste	100 km train	-
CaO	80 km train	-
Sulphur	800 km train	-
Soda	100 km train	-
Auxiliary materials	150 km truck 28t	50%

Transports for Kraftliner (production in Sweden):

Materials	Transport	Load
Wood	80 km truck 40t 20 km train	50% -
Wood chips	100 km truck 40t	50%
Waste from corrugated cardboard	500 km ship 200 km train	70% -
Auxiliary materials	100 km truck 40t 50 km train 30 km ship	50% - 70%

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste that can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste that is not specified as inert is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste that is put in a landfill.
4. Mineral waste: stones and rubble from mining activities that stay at the production site.

1.2.9 System description Corrugated cardboard

Description:
Corrugated cardboard is produced from two kinds of semi-manufactures, the liner and the corrugated medium. Corrugated cardboard can consist of several layers of liners and corrugated layers.

Corrugated cardboard category	Composition
Secondary fibres 1	67% Testliner, 33% Wellenstoff
Secondary fibres 2	67% Schrenz, 33% Wellenstoff
New fibres	67% Kraftliner Brown (Austria), 33% Fluting
Mixed fibres 1	34% Kraftliner Brown (Sweden), 33% Wellenstoff, 33% Testliner
Mixed fibres 2	34% Kraftliner White top (Sweden), 33% Wellenstoff, 33% Testliner
Mixed fibres, double corrugated	20% Kraftliner Brown (Sweden) 20% Schrenz, 40% Wellenstoff, 20% Testliner

The inventory table includes emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the materials. The system description is based on the Swiss consumption of packaging materials and the imports and exports of materials, the origin of raw materials and use of energy and electricity are therefore primarily determined by the Swiss situation.

1. Sub-systems:
Production of input materials:

- Fluting (corrugated medium, mainly new fibres)
- Wellenstoff (corrugated medium, recycled fibres)
- Kraftliner (liner, mainly new fibres, 3 types)
- Schrenz (liner, mainly recycled fibres)
- Testliner (liner, mainly recycled fibres)
- Starch
- NaOH

2. Cut-off rules:
Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.

In the output, production waste and re-usable waste are listed. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory either.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list. The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
As production is situated in Switzerland the Swiss electricity model is used (overall efficiency of 36.8%).

Source	Switzerland %
Electricity from Coal	4.7
Electricity from Lignite	1.4
Electricity from Oil	2.5
Electricity from Gas	1.2
Electricity from Nuclear power	50
Electricity from Hydro power	40.1
Other	0.1

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

For the production processes of the chemicals the UCPTE model for 1993 is used for pulp produced in Europe, the Nordel model is used for production in Scandinavian countries and the Canadian model for pulp production situated in Canada.

Source	% in Nordel model	% in UCPTE model	% in Canadian model
Electricity from Coal	11.8	17.4	20.1
Electricity from Lignite	0	7.8	0
Electricity from Oil	5.3	10.7	2.9
Electricity from Gas	1.5	7.4	1.3
Electricity from Nuclear power	21.8	40.3	17.5
Electricity from Hydro power	59.2	16.4	58.2
Other sources	0.4	0.0	0
Overall efficiency	44.7	28.6	unknown

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

Transports included in the inventory are based on production of the cardboard in Switzerland. Transports from semi-manufactures and auxiliary materials to the production site are given in the tables below.

Semi-manufacture	Train (km)	Ship (70% load) (km)
Fluting (Sweden)	1000	500
Kraftliner brown (Austria)	600	0
Kraftliner brown (Sweden)	1000	500
Kraftliner white top (Sweden)	1000	500
Schrenz (Switzerland)	50	0
Testliner (Switzerland)	50	0
Wellenstoff (Switzerland)	50	0

Material	Transport	Load
Starch	400 km train 400 km truck 28t	- 50%
NaOH	200 km truck 28t	50%
Borax	1500 km ship 500 km train 30 km truck 28t	50% - 50%

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste that can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste that is not specified as inert is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste that is put in a landfill.
4. Mineral waste: stones and rubble from mining activities, which stay at the production site.

1.2.10 System description Aluminium

Description:
Average European production of alumina (Al_2O_3) from bauxite with the Bayer process and production of aluminium in Hall Héroult electrolysis process with pre-baked anodes, which represents 80% of Western European production. The system is based on the data from the European Aluminium Association (EEA, reference year 1993) which are representative for an European average. However, the inventories of new aluminium (and mixes of new and recycled aluminium) are representative for Switzerland. Switzerland imports 60% Aluminium from Europe and 40% from Canada and Iceland. For this 40% the used electricity mix is an average of these countries. Therefore the inventories have to be used with caution for other countries in Europe if the import is very different.

The inventory table includes emissions from mining processes and other material production (bauxite, AlF_3, NaOH) energy production, production of semi-manufactures (anodes) and auxiliary materials, transports and the production process of the materials.

1. Sub-systems:
Production of input materials:

- Bauxite
- Limestone
- NaOH
- Cokes
- AlF_3
- Rolling
- Casting

For details see specific processes.

2. Cut-off rules:
In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.

With the use of secondary aluminium the collection of used aluminium from final consumers is not included in the recycling of old scrap.

Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory either.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total

inventory input list. In the inventory the co-production of Cl_2 with NaOH has been accounted for in the allocations.
Output of re-usable waste is not allocated to, since it functions as a raw material in another product system.

4. Energy model:
For electrolysis of primary aluminium a specific electricity model is calculated, representing combined models of average electricity use for aluminium production in Europe (60%) and in Canada (40%). Since for electricity production in Canada 100% hydropower is assumed, in the calculated, weighted model 66.3 % of the electricity is produced by hydropower. In all other cases the UCPTE model for 1993, with an overall efficiency of 31% is used.

Source	% in electrolysis process	% in UCPTE model
Electricity from Coal	13.6	17.4
Electricity from Lignite	0	7.8
Electricity from Oil	2.1	10.7
Electricity from Gas	3.2	7.4
Electricity from Nuclear power	14.8	40.3
Electricity from Hydro power	66.3	16.4

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

Transports of the most important raw materials included in the inventory are based on data from EEA and ESU-ETHZ (1994). Distances are weighted (loading included).

Material	Transport	Distance
Bauxite	overseas ship	7917
Limestone and $CaCO_3$	inland ship	500
NaOH	inland ship and truck	500
Alumina (AlO_3)	overseas ship	4587
	train	68
Cokes	overseas ship	1000
Pitch	inland ship and truck	250
Aluminium fluoride	train and truck	300
Aluminium (internal)	elevator, truck, tractor	Energy use data
Primary aluminium	inland ship	300
	train	100
Aluminium overseas (50% Canada, 50% Island)	overseas ship	4650

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste, which can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste, which is not specified as inert, is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste, which is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities, which stay at the production site.

1.2.11 System description Steel and tin plate

Description:
The system includes production of ECCS steel plate (electrolytic chrome coated steel), tin-plated steel and de-tinning and re-melting of scrap. In the first processes raw iron is produced from ores and scrap in a blast furnace converted in a oxygen converter and cast into blocks. A sheet is formed through hot rolling (1.7-3 mm). This sheet is than covered by a chromate layer 0.4 g/kg) to form ECCS sheet, alternatively it is covered with a tin layer (3.9 g/kg steel) and a very thin chromate layer (0.02) to form tin plate.

The inventory table includes emissions from raw material production, energy production, production of semi-manufactures and auxiliary materials, transports and the production process of the materials. The system description is based on the production of packaging steel in Germany, which is imported into Switzerland.

1. Sub-systems:
Production of input materials:

- mining of limestone, tin and iron ores
- production of auxiliary materials

2. Cut-off rules:
Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

Emissions to soil are only included in connection with waste processing of the final products, the packaging materials, after the consumption phase. For most other processes they could not be registered, as there were no emissions to soil reported.

In general the production process is traced back to the raw material resources as far as possible. For some inputs, mainly chemicals and complex auxiliary materials, which are used in the production processes in smaller amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small. These input materials are listed as "not traced back" in the inventory tables.

In the output, production waste and re-usable waste are mentioned. Since the amount of production waste is small, and the composition is unknown, no emissions from the processing of this waste are included in the inventory. For the re-usable wastes, which function as raw materials in another production process, no emissions from recycling processes of these materials are included in the inventory either.

3. Co-products and allocations:
In general the environmental impacts of multiple output processes have been allocated on a mass basis. In the output of the system co-products, which are explicitly mentioned, form an exception to this rule because these co-products leave the whole system defined and are not allocated to. In the inventory table these are listed as solids without emissions. Co-products (intermediate products), which have been balanced in single process steps, are allocated to and these are not mentioned in the total inventory input list.

The output of re-usable waste has not been allocated any emissions, since it functions as a raw material in another product system.

4. Energy model:
When production is situated in one specific country, the electricity model for this country is used. In other cases the UCPTE model for 1993, with an overall efficiency of 31% is used. Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

Source	% in UCPTE model
Electricity from Coal	17.4
Electricity from Lignite	7.8
Electricity from Oil	10.7
Electricity from Gas	7.4
Electricity from Nuclear power	40.3
Electricity from Hydro power	16.4

5. Transport model:
The data for the transport models originate from ESU-ETH (1994) models for Europe and are listed in the table below. Transports of from semi-manufactures from one production site to the other are included in the inventories. Not included are the transports of final products to consumers in Switzerland.

Transport	Unit	Load [%]	Fuel oil (S,E) [kg]	Diesel [kg]	Petrol [kg]	Electricity [kWh]
Sea ship	tkm	60	0.022			
Inland ship	tkm	70		0.011		
Passenger car	km	-		0.012	0.051	
Delivery van <3.5t	tkm	50		0.0263	0.111	
Truck 16t	tkm	50		0.0635		
Truck 28t	tkm	50		0.0423		
Truck 40t	tkm	50		0.0259		
Train electric	tkm	-		0.0011		0.058
Train combined	tkm	-		0.0033		0.042

Average transport for raw materials for production of ECCS sheet and tin plate are calculated from the average distance between the different production sites. Transports included in the inventory are based on the fact that the consumption of the final products is situated in Switzerland.

Raw materials	Transport	Loading
Iron ore from Australia	1000 km train 200 km truck 40t 21000 km freighter	 50% 60%
Iron ore from Canada	1000 km train 200 km truck 40t 8500 km cargo freighter	 50% 60%
Iron ore from Brazil	1000 km train 200 km truck 40t 10000 km freighter	 50% 60%
Coal from Germany	30 km train	
Tin (transport means are assumed)	500 km train 1000 km truck 40t 10000 km freighter	 50% 50%
Limestone, auxiliary materials (assumption)	800 km train 300 km truck 40 t	 50%
Scrap (average)	500 km train 200 km truck	 50%

6. Waste model:
Production waste, originating from the production processes, is listed with its amount in the inventory without further processing. Production waste is grouped into 4 categories:

1. Combustible waste: waste that can be burnt in an incinerator together with municipal waste. Mostly organic waste and waste from paper production are placed in this category, when no alternative was explicitly mentioned.
2. Non inert waste: waste that is not specified as inert is placed in this category. This waste is deposited in a special landfill with drainage water monitoring.
3. Inert waste: inert waste that is put in a landfill.
4. Mineral waste: Stones and rubble from mining activities, which stay at the production site.

1.2.12 System description Municipal landfill

Description:
The system is based on a landfill with mixed municipal waste (household, construction and surplus sludge from wastewater treatment) with a relatively high amount of organic materials during the controlled phase (150 years). The controlled phase lasts until concentrations of harmful compounds in the drainage water are below the required standards and treatment of the water is no longer necessary.

The design and treatment methods are based on present technology (1995) and include energy recovery through biogas collection and combustion (methane).

The system includes collection (76% municipal collection, 24% direct delivery) wastewater treatment during the controlled phase, sludge incineration and sludge treatment by means of landfarming. Due to these processes, emissions to water, soil and air occur. Inventory tables are constructed for emissions from 13 different packaging materials by means of transfer coefficients, which are based on the composition and degradability of the materials.

Starting point of the calculations for the inventory is the average composition of municipal waste. Transfer coefficients are calculated product specific and are based on the composition of the materials. All degradable waste is assumed to be completely degraded during the controlled phase. The degradable mass % of the materials is 100% for paper and board and 5% for plastics.

The inventory table includes emissions from raw material production, energy production, production of auxiliary materials, transports and the emissions from the waste processing. The system description is based on the Swiss consumption and disposal of packaging materials, therefore all processes are primarily determined by the Swiss situation.

1. Sub-systems:
The system description includes:

- Collection of waste: 76% municipal collection, 24% direct delivery.
- Waste water treatment: 400 mm rainfall per m2, 20 m depth, 20 litre per tonne waste per year.
- Sludge incineration: 51% of the total sludge production, municipal waste incineration (see system description municipal waste incineration).
- Sludge treatment by means of landfarming: 49% of the total sludge production.
- Production of biogas: 200 m3 per tonne waste (47% methane, 37% carbon dioxide, 13% nitrogen), 47% is directly emitted into the air, 53% is combusted (see also co-products).

All data are aggregated thus most unit processes are not available. The use of auxiliary materials in the landfill is presented in the table below.

Auxiliary materials for landfill	Allocation	Used for
Diesel for landfill machinery	1.09 kg/t waste	Landfill maintenance
Electricity (Swiss model, middle voltage)	1.35 kWh/t waste	Gas pumps
Oil (Europe low sulphur) for heating	0.038 kg/t waste	Company buildings
Electricity (Swiss model, low voltage)	0.15 kWh/t waste	Company buildings

2. Cut-off rules:
The system only includes the post-consumer waste and neglects production waste, since the composition of the production waste is unknown. This means that the emission inventories represent the lower limit.

Contrary to the original data from BUWAL 250, only the emissions occurring during the controlled phase are included in the library by PRé. The system disregards emissions occurring after the controlled phase, since the emission concentrations after this period have decreased to levels that are considered harmless. The use of the total emission potential from BUWAL 250 seems unrealistic since concentrations will not decrease below background values.[See also JO Sundqvist, Workshop on LCA and treatment of solid waste, Sweden, 1995]

In general the processes are traced back to the raw material resources as far as possible. For some inputs, mainly chemicals (waste water treatment) or complex auxiliary materials, which are used in relatively small amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small.

Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

3. Co-products and allocations:
Energy production from biogas combustion is regarded as a co-product without emissions. The use of methane produced by the landfill is 31% of the total gas production for production of electricity and heat. The final efficiency is only 11% of the total energy content of the gas produced. The energy production is deducted in the energy use of the total system and is product specific allocated, depending on degradability of the materials.

The energy production from the MWI (only sludge incineration) is deducted in the energy use of the total process and is allocated product specific, depending on the water content and combustibility of the materials.

4. Energy model:
For electricity production the Swiss model is used. When production of auxiliary materials (chemicals) is not situated in one specific country, the UCPTE model for 1993, with an overall efficiency of 31% is used.

Source	% in Swiss model	% in UCPTE model
Electricity from Coal	4.7	17.4
Electricity from Lignite	1.4	7.8
Electricity from Oil	2.5	10.7
Electricity from Gas	1.2	7.4
Electricity from Nuclear power	50	40.3
Electricity from Hydro power	40.1	16.4
Other	0.1	0

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

5. Transport model:
Transports of waste, collected by the municipality (76%), are based on a stop-and-go cycle with an average distance of 10 kilometres per tonne mixed municipal waste and a diesel consumption of 4 litres per ton waste. Direct delivery of company waste (24%) is carried out by a 16 tonne truck (see transport process). Transports included in the inventory are based on the fact that the consumption of the final products is situated in Switzerland.

6. Waste model:
Excess sludge is burnt in an incinerator (see incineration of municipal waste 1995).

8. Other information:
A waste scenario "Landfill B250" has been created to be able to use the landfill B250 waste treatments in life cycles. In this scenario the landfill waste treatments for plastics (PET, PE, PP, PS, PVC, PVDC) , glass, aluminium, tin plate, ECCS steel, paper, cardboard and newsprint are used. Other plastics that are not specified as above are treated as PE. All *other* materials that cannot be found in the waste fractions specified in this scenario (for which there are no BUWAL waste treatment data) are treated as unspecified waste, that means that no emissions are allocated to these materials.

Please note that BUWAL does not take "avoided emissions" into account. This waste scenario is not peer reviewed by EMPA.

1.2.13 System description Municipal waste incineration (1995)

Please note: This system is based on a calculation performed by PRé on the original data from BUWAL 250. The modification is carried out in order to allow users of the library to use the incineration scenario for 1995. PRé also created extra scenarios in which avoid product allocation is taken into account.

Description:
The system is based on incineration of mixed municipal waste (household, construction and surplus sludge from wastewater treatment) with present technology (1995) and 1.3% illegal combustion. The inventories are derived from the IST scenario, which reflects the present (1995) situation of waste treatment in Switzerland with 22% disposal in landfills, 77% incineration in an Municipal Waste Incinerator (MWI) and 1% illegal burning of waste. The inventories are calculated by excluding the disposal in landfills (22%) and calculating 100% incineration. Because it was not possible to isolate the data for illegal burning, the data include 1.3% illegal burning.

The data include waste collection (76% municipal collection, 24% direct delivery), combustion, treatment and disposal of inorganic waste (dust from electrostatic filter and ashes from the kettle) and MWI slags in landfills and treatment of drainage water during the controlled phase. The controlled phase lasts until concentrations of harmful compounds in the drainage water are below the required

standards and treatment of the water is no longer necessary. The controlled phase of the landfill for inorganic waste is 40 and for slags 75 years.

Inventories are made for emissions to water, soil and air from 13 different packaging materials based on the composition, dry matter content and water content. The illegal combustion causes relatively high and direct soil and air emissions.

Starting point of the calculations for the inventory is the average composition of municipal waste. Transfer coefficients for substances migrating from the waste to air water and soil are calculated product specific and are based on the composition of the materials.

The inventory table includes emissions from raw material production, energy production, production of auxiliary materials, transports and the emissions from the waste processing of the materials. The system description is based on the Swiss consumption and disposal of packaging materials, therefore all processes are primarily determined by the Swiss situation.

1. Sub-systems:
The system description includes:

- Collection of waste (transport): 76% municipal collection, 24% direct delivery.
- Waste combustion in an municipal waste incinerator (technology 1995).
- Flue gas treatment: electrostatic filters (elimination of particles) and successively for part of the waste there is acid and alkaline treatment (elimination of HCl, HF, SO_2 and heavy metals) followed by denitrification (deNO_x).
- Waste water treatment: waste water from washing filter dust and kettle ashes and waste water from flue gas treatment is neutralised with limestone and purified by using flocculants.
- Filter dust, kettle ashes and slags are washed separately. The filter dust and kettle ashes (together called fly ashes) are immobilised in cement together with the sludge from the water treatment. For 40% of the produced slags there is recovery of steel and iron by means of magnetic separation.
- Disposal of solid waste: Immobilised inorganic waste and slags are placed in separate landfills.

Auxiliary materials for MWI and landfills	**Allocation**	**Used for**
Process water	980 kg/t waste	MWI
Ammonia	1.1 kg/t waste	MWI, flue gas treatment
Natural gas	19 MJ/t	MWI, deNO_x
Diesel for landfill machinery	0.63 kg/t slags	Landfill maintenance
Oil (Europe low sulphur) for heating	0.038 kg/t slags	Company buildings
Electricity (Swiss model, low voltage)	0.15 kWh/t slags	Company buildings
Cement	215 kg/t waste	Fly ashes
Limestone	85 kg/t waste	neutralising washing water

All data are aggregated thus most unit processes are not available. The use of auxiliary materials in the landfill is presented in the table.

2. Cut-off rules:
The system only includes the post-consumer waste and neglects production waste, since the composition of the production waste is unknown. this means that the emission inventories represent the lower limit.

Contrary to the original data from BUWAL 250, only the emissions occurring during the controlled phase are included in the library by PRé. The system disregards emissions occurring after the controlled phase, since the emission concentrations after this period have decreased to levels that are considered harmless. The use of the total emission potential from BUWAL 250 seems unrealistic since concentrations will not decrease below background values.[See also J.O. Sundqvist, Workshop on LCA and treatment of solid waste, Sweden, 1995]

In general the processes are traced back to the raw material resources as far as possible. For some inputs, mainly chemicals or complex auxiliary materials, which are used in relatively small amounts, not enough data were available to trace the production of these materials back to the raw material

resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small.

Biogenous carbon dioxide emissions are not included in the inventory table, since these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

3. Co-products and allocations:
The energy production from the MWI is deducted in the energy use of the total process and is allocated product specific, depending on the water content and combustibility of the materials.

4. Energy model:
For electricity production the Swiss model is used. When production of auxiliary materials (chemicals) is not situated in one specific country, the UCPTE model for 1993, with an overall efficiency of 31% is used.

Source	% in Swiss model	% in UCPTE model
Electricity from Coal	4.7	17.4
Electricity from Lignite	1.4	7.8
Electricity from Oil	2.5	10.7
Electricity from Gas	1.2	7.4
Electricity from Nuclear power	50	40.3
Electricity from Hydro power	40.1	16.4
Other	0.1	0

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

5. Transport model:
Transports of waste, collected by the municipality (76%), are based on a stop and go cycle with an average distance of 10 kilometres per tonne mixed municipal waste and a diesel consumption of 4 litres per ton waste. A 16 tonne truck (see unit process) carries out direct delivery of company waste (24%). Transports for slags are 40 tkm and for the residue from flue gas treatment 50 tkm. Transports included in the inventory are based on the Swiss situation.

6. Waste model:
Immobilised inorganic waste and slags are placed in controlled separate landfills.

8. Other information:
A waste scenario "Incineration B250" has been created to be able to use the incineration B250 waste treatments in life cycles. In this scenario the incineration waste treatments for plastics (PET, PE, PP, PS, PVC, PVDC), glass, aluminium, tin plate, ECCS steel, paper, cardboard and newsprint are used. Other plastics that are not specified as above are treated as PE. All *other* materials that cannot be found in the waste fractions specified in this scenario (for which there are no BUWAL waste treatment data) are treated as unspecified waste, that means that no emissions are allocated to these materials. Please note that BUWAL does not take "avoided emissions" into account. This waste scenario is not peer reviewed by EMPA.

1.2.14 System description Municipal waste incineration (2000)

Description:
The system is based on incineration of mixed municipal waste (household, construction and surplus sludge from wastewater treatment) in the year 2000.

The inventories are derived from the future scenario (SOLL Szenario), which reflects the future situation of waste treatment in Switzerland with 100% incineration in a modern Municipal Waste Incinerator (MWI). The main difference with the incineration in 1995 is the design of the incinerator. The incinerator of the year 2000 has a more advanced flue gas treatment and mainly catalytic deNO_x treatment. The main differences are demonstrated in the table below.

Installed flue gas treatment in Switzerland in 1995	Technology 1995 (IST Scenario)	Technology 2000 (SOLL Scenario)*
Advanced flue gas treatment (acid and alkaline treatment)		
- Without Advanced treatment:	4%	0%
- With advanced treatment:	96%	100%
Removal of nitrogen oxides:		
- Without deNO$_x$	60%	20%
- Conventional deNO$_x$	17%	15%
- Catalytic deNO$_x$	23%	65%

* Estimate

The data include waste collection (76% municipal collection, 24% direct delivery), combustion, treatment and disposal of inorganic waste (dust from electrostatic filter and ashes from the kettle) and MWI slags in landfills and treatment of drainage water during the controlled phase. The controlled phase of the landfill for inorganic waste is 40 and for slags 75 years.

Inventories are made for emissions to water and air from 13 different packaging materials based on the composition, dry matter content and water content.

Starting point of the calculations for the inventory is the average composition of municipal waste. Transfer coefficients for substances migrating from the waste to air and water are calculated product specific and are based on the composition of the materials.

The inventory table includes emissions from raw material production, energy production, production of auxiliary materials, transports and the emissions from the waste processing of the materials. The system description is based on the Swiss consumption and disposal of packaging materials, therefore all processes are primarily determined by the Swiss situation.

1. Sub-systems:
The system description includes:

- Collection of waste: 76% municipal collection, 24% direct delivery.
- Waste combustion in a municipal waste incinerator (technology 2000).
- Flue gas treatment: electrostatic filters (elimination of particles) and successively acid and alkaline treatment (elimination of HCl, HF, SO2 and heavy metals) followed by denitrification (deNO$_x$).
- Waste water treatment: waste water from washing filter dust and kettle ashes and waste water from flue gas treatment is neutralised with limestone and purified by using flocculants.
- Filter dust, kettle ashes and slags are washed separately. The filter dust and kettle ashes (together called fly ashes) are immobilised in cement together with the sludge from the water treatment. For 40% of the produced slags there is recovery of steel and iron by means of magnetic separation.
- Disposal of solid waste: Immobilised inorganic waste and slags are placed in separate landfills.

All data are aggregated thus most unit processes are not available. The use of auxiliary materials in the landfill is presented in the table.

Auxiliary materials for MWI and landfills	Allocation	Used for
Process water	980 kg/t waste	MWI
Ammonia	1.1 kg/t waste	MWI, flue gas treatment
Natural gas	19 MJ/t	MWI, deNO$_x$
Diesel for landfill machinery	0.63 kg/t slags	Landfill maintenance
Oil (Europe low sulphur) for heating	0.038 kg/t slags	Company buildings
Electricity (Swiss model, low voltage)	0.15 kWh/t slags	Company buildings
Cement	215 kg/t waste	Fly ashes
Limestone	85 kg/t waste	neutralising washing water

2. Cut-off rules:
The system only includes the post-consumer waste and neglects production waste, since the composition of the production waste is unknown. This means that the emission inventories represent the lower limit.

Contrary to the original data from BUWAL 250, only the emissions occurring during the controlled phase are included in the library by PRé. The system disregards emissions occurring after the controlled phase, since the emission concentrations after this period have decreased to levels that are considered harmless. The use of the total emission potential from BUWAL 250 seems unrealistic since concentrations will not decrease below background values.[See also J.O. Sundqvist, Workshop on LCA and treatment of solid waste, Sweden, 1995]

In general the processes are traced back to the raw material resources as far as possible. For some inputs, mainly chemicals or complex auxiliary materials, which are used in relatively small amounts, not enough data were available to trace the production of these materials back to the raw material resources. Since these materials are only used in small amounts, the effect of the omission in the final results will be small.
Biogenous carbon dioxide emissions are not included in the inventory, these are assumed to be part of the sustainable use of the biogenous, renewable, resources.

3. Co-products and allocations:
The energy production from the MWI is deducted in the energy use of the total process and is allocated product specific, depending on the water content and combustibility of the materials.

4. Energy model:
For electricity production the Swiss model is used. When production of auxiliary materials (chemicals) is not situated in one specific country, the UCPTE model for 1993, with an overall efficiency of 31% is used.

Source	% in Swiss model	% in UCPTE model
Electricity from Coal	4.7	17.4
Electricity from Lignite	1.4	7.8
Electricity from Oil	2.5	10.7
Electricity from Gas	1.2	7.4
Electricity from Nuclear power	50	40.3
Electricity from Hydro power	40.1	16.4
Other	0.1	0

Processes for electricity generation and production of thermal energy from different fuels, derived from ESU-ETH (1994/1995) can be found in the energy section of the library.

5. Transport model:
Transports of waste, collected by the municipality (76%), are based on a stop and go cycle with an average distance of 10 kilometres per tonne mixed municipal waste and a diesel consumption of 4 litres per ton waste. Direct delivery of company waste (24%) is carried out by a 16 tonne truck (see unit process). Transports for slags are 40 tkm and for the residue from flue gas treatment 50 tkm. Transports included in the inventory are based on the Swiss situation.

6. Waste model:
Immobilised inorganic waste and slags are placed in controlled separate landfills.

8. Other information:
A waste scenario "Incineration 2000 B250" has been created to be able to use the incineration 2000 B250 waste treatments in life cycles. In this scenario the incineration 2000 waste treatments for plastics (PET, PE, PP, PS, PVC, PVDC) , glass, aluminium, tin plate, ECCS steel, paper, cardboard and newsprint are used. Other plastics that are not specified as above are treated as PE. All *other* materials that cannot be found in the waste fractions specified in this scenario (for which there are no BUWAL

waste treatment data) are treated as unspecified waste, that means that no emissions are allocated to these materials. Please note that BUWAL does not take "avoided emissions" into account.
This waste scenario is not peer reviewed by EMPA.

1.2.15 System description Swiss waste treatment 1995

Description:
Waste treatment of post consumer packaging materials in Switzerland (1995). This model is based on the present treatment of municipal waste in Switzerland and represents a combination of waste treatment methods, 22% disposal in a landfill, 77% incineration and 1 % illegal combustion. The treatment methods landfill and incineration are described in detail in the corresponding system descriptions (see sections 2.12 and 2.13). No waste scenario for these treatments has been made.

1.2.16 System description Electricity generation

Description:
Original data are taken from ESU-ETHZ (1994/1995) and modified by BUWAL. The system includes the generation of electricity from different primary energy sources based on Higher Heating Values and medium voltage.

Source	Total efficiency (%) (including grid losses)
Gas	34.2
Coal	28.5
Hydropower	76.5
Oil	27.1
Lignite	24.8
Nuclear power	27.2

Sub-systems
The system includes the production of primary energy resources and the processing and transport of the primary sources. For more details see ESU ETHZ (1994/1995).

Cut off rules
The environmental impacts from infrastructure and capital goods, which were included in the original data of ESU-ETHZ, are excluded in the BUWAL 250 inventories.

1.2.17 System description Thermal energy production

Description:
Production of thermal energy from different energy sources based on Higher Heating Values. Original data are taken from ESU-ETHZ (1994/1995) and modified by BUWAL/EMPA to exclude capital goods.

Source	Total efficiency (%) (including grid losses)
Gas	34.2
Coal	28.5
Hydropower	76.5
Oil	27.1
Lignite	24.8
Nuclear power	27.2

Sub-systems
The system includes the production of primary energy resources and the processing and transport of the primary sources. For more details see ESU ETHZ (1994/1995).

Cut off rules

The environmental impacts from infrastructure and capital goods, which were included in the original data of ESU-ETHZ, are excluded in the BUWAL 250 inventories.