



Schweizer Zentrum für Ökoinventare
packaging

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Special LCA Discussion Forum, December 5, 2003
EPF Lausanne

Session „Packaging“

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Timetable

part ONE - Paper / Board	20'
part TWO - Packaging glass	10'
part TRE - Plastics	15'
part FOUR - Diskussion	30'



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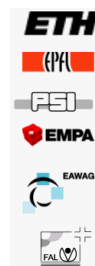
Content

- What ?
 - system boundaries
 - included types
- How ?
 - used data sources
 - procedure
 - (- common points)
- Example (raw data - cumulated data - results)
- Conclusion / Outlook



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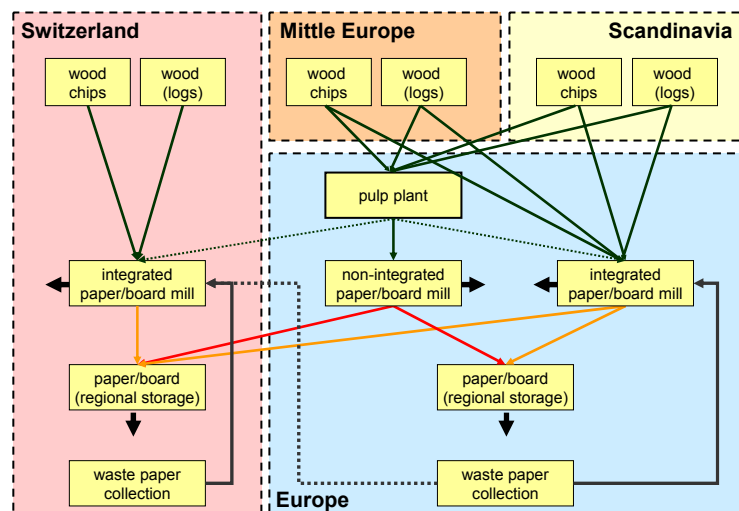
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part ONE

Paper / Board

System boundaries



Included types

Market pulp	Chemical pulp	Sulfate pulp
		Sulfite pulp
	Mechanical pulp	Chemi-thermomechanical pulp (CTMP)
		Thermomechanical pulp (TMP)
		Stone ground wood pulp (SGW)
Paper	Mechanical pulp dominated graphical paper grades	Newsprintpaper
		SC paper
		LWC paper
	Chemical pulp dominated graphical paper grades	Uncoated fine paper
		Coated fine paper
	Graphical recycling paper grades	Recyclingpaper with Deinking
		Recyclingpaper without Deinking
	Packaging paper grades	Unbleached packaging paper
		Bleached packaging paper
Board	Cartonboard	Solid Bleached Board
		Solid Unbleached Board
		Folding Boxboard
		Whitelined Chipboard
	Containerboard (Case Material)	Corrugated Base Paper
		Corrugated Board

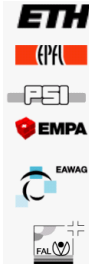
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Used data sources

	Characteristics	Advantages	Disadvantages
Buwal 250	Former Swiss Life Cycle Inventory study covering packaging and graphical paper	- Swiss situation	- age of the data (most of the data are from 1993/1994)
CER	Environmental reports, established by single mills and/or the entire group	- publicly accessible	- data format not standardized and therefore data reported different within the CER from different companies
FEFCO	Life Cycle Inventory data from the European corrugated board producers	- "real" average values, based on more than 50% of the respective producers	- covers only the sector of corrugated board
KCL EcoData	Commercial database from the Finnish research organisation KCL containing datasets on unit process level for a variety of different pulp, paper and board types	- datasets established from specialists, representing a typical situation - very detailed database (containing several different datasets for the same)	- copyright protected – and therefore only averages of several datasets usable
Questionnaire	Questionnaire, sent out to the main producers of paper within Switzerland	- data from present processes used within the sector	- not filled in from all of the asked companies - limited on Swiss producers
UBA	German LCA study about graphical paper in Germany	- datasets for the German production	- not all datasets are published on a unit process level

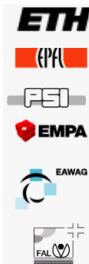
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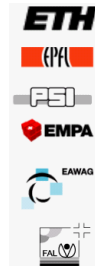
Infrastructure



- 1 general dataset of a „paper machine“ - based on information from one producer plus own assumptions
- Specific datasets for „integrated paper/board mill“, „non-integrated paper/board mill“, „pulp plant“
 - Land use & number of paper machines: average of various mills in CH, D, SE, FIN
 - Other infrastructure parts based on own assumptions

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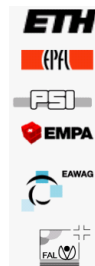
Waste



- Each specific type of waste is represented by a respective specific dataset that defines composition of the waste as well as the disposal way
 - Example „Disposal of Deinking sludge“:
 - 100% internally burned
 - > Disposal = 0.44 kg ash / kg sludge goes to landfill
- Data source: literature (reference books, EU-IPPC-report)

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Case study

- Lightweight coated paper (LWC-paper)

LWC paper is used for magazines, catalogues and advertising material in long printing runs where excellent printing quality and image reproduction is required.

LWC paper is essentially a thin paper made from ground spruce pulpwood, reinforced with a small proportion of kraft pulp to add strength. The resulting paper is then covered with coating in which the most important constituent is fine-grained clay. The result is a printing paper with extremely good printing properties, particularly with regard to image reproduction.

Homepage of SCA (www.publicationpapers.sca.com)

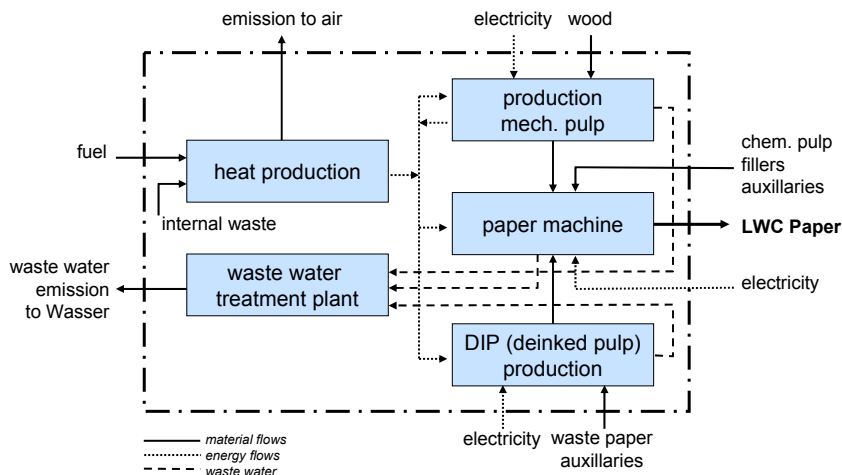


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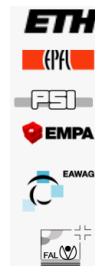


System boundaries of LWC paper



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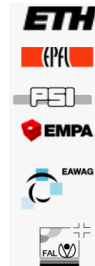
Data sources of LWC Paper

- Filled in questionnaire from one European LWC producer
- CER of various European producers (in Germany, but also in Scandinavia)
- Finnish LCA Datenbank EcoData of KCL
- German LCA study about graphical paper
- European IPPC BAT documentation about the paper and board industry



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Establishing the input data

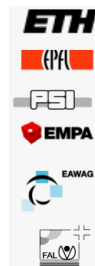
1. Bring together the information from various sources

all amounts in g	KCL EcoData	CER	Company	UBA Nord	BRD	IPPC
softwood	810.0	848.9	-	-	-	-
moisture (%)	0	140	-	-	-	-
wood, thinnings	-	361.2	221.0	884.0	moisture different	-
moisture (%)	-	140	54	15	-	-
Chips from saw mill	220.5	18.4	625.4	18.3	899.8	361.0
moisture (%)	0	10	54	15	15	0
Purchased pulp	-	217.9	666.2	273.0	286.0	259.0
Type of pulp	-	sulfate	sulfate	sulfate	sulfate	sulfate
Waste paper for DIP	-	24.5	258.7	-	17.2	-
Purchased DIP	24.4	15.3	-	-	-	-



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Establishing the input data

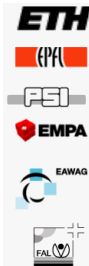


1. Bring together the information from various sources

all amounts in g	KCL EcoData	CER	Company	UBA Nord	BRD	IPPC
softwood	810.0	848.9	-	-	-	-
moisture (%)	0	140	-	-	-	-
wood, thinnings	-	361.2	221.0	884.0	-	-
moisture (%)	-	140	54	15	-	-
Chips from saw mill	220.5	18.4	625.4	18.3	899.8	361.0
moisture (%)	0	10	54	15	15	0
Purchased pulp	-	217.9	696.2	273.0	286.0	259.0
Type of pulp	-	sulfate	sulfate	sulfate	sulfate	sulfate
Waste paper for DIP	-	24.4	258.7	-	17.2	-
Purchased DIP	-	24.4	15.3	-	-	-

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2. Re-calculate the data at a constant moisture content

all amounts in g	KCL	CER	Company	UBA		IPPC
	EcoData			Nord	BRD	
softwood	810.0	353.7	-	-	-	-
wood, thinnings	-	150.5	143.5	768.7	-	-
wood chips	220	17	406	16	782	361
purchased pulp ¹	24.4	252.8	873.2	273.0	299.7	259.0
Total Input	1054.9	773.7	1422.8	1057.6	1082.2	620.0

¹ Where a waste paper input is reported, a yield of 80% is assumed for the DIP production



Establishing the input data

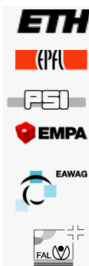


1. Bring together the information from various sources

all amounts in g	KCL EcoData	CER	Company	UBA Nord	BRD	IPPC
softwood	810.0	848.9	-	-	-	-
moisture (%)	0	140	-	-	-	-
wood, thinnings	-	361.2	221.0	884.0	-	-
moisture (%)	-	140	54	15	-	-
Chips from saw mill	220.5	18.4	625.4	18.3	899.8	361.0
moisture (%)	0	10	54	15	15	0
Purchased pulp	-	217.9	696.2	273.0	286.0	259.0
Type of pulp	-	sulfate	sulfate	sulfate	sulfate	sulfate
Waste paper for DIP	-	24.4	258.7	-	17.2	-
Purchased DIP	-	24.4	15.3	-	-	-

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2. Re-calculate the data at a constant moisture content

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softwood	810.0	353.7	-	-	-	-
wood, thinnings	-	150.5	143.5	768.7	-	-
wood chips	220	17	406	16	782	361
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Total Input	1054.9	773.7	1422.8	1057.6	1082.2	620.0

¹ Where a waste paper input is reported, a yield of 80% is assumed for the DIP production

3. Input data



all amounts in g	This study
softwood	1210.1
moisture (%)	140
wood, thinnings	-
moisture (%)	-
Chips from saw mill	28.5
moisture (%)	70
Purchased pulp	217.9
Type of pulp	sulfate
Waste paper for DIP	43.5
Purchased DIP	-



Input data

	Name	Location	Unit	paper, wood-containing, LWC, at plant
	Location	Unit	RER	kg
Inputs	resource, in water	Water, cooling, unspecified natural origin	m3	2.40E-02
	wood	Water, unspecified natural origin	m3	2.07E-02
		chips, Scandinavian softwood (plant-debarked), u=70%, at plant	NORDEL	m3
		industrial residue wood, softwood, forest-debarked, u=70%, at plant	RER	m3
		industrial wood, Scandinavian softwood, under bark, u=140%, at forest road	NORDEL	m3
		industrial wood, softwood, under bark, u=140%, at forest road	RER	m3
	pulp	sulphate pulp, average, at regional storage	RER	kg
	waste paper	waste paper, mixed, from public collection, for further treatment	RER	kg
		waste paper, sorted, for further treatment	RER	kg
		potato starch, at plant	DE	kg
Inputs		kaolin, at plant	RER	kg
		kaolin, at plant	RER	kg
		aluminium sulphate, powder, at plant	RER	kg
		bentonite, at processing	DE	kg
		limestone, milled, loose, at plant	CH	kg
		chlorine, liquid, production mix, at plant	RER	kg
		hydrogen peroxide, 50% in H2O, at plant	RER	kg
		sodium chlorate, powder, at plant	RER	kg
		sodium dithionite, anhydrous, at plant	RER	kg
		sodium hydroxide, 50% in H2O, production mix, at plant	RER	kg
Inputs		sulphur dioxide, liquid, at plant	RER	kg
		sulphuric acid, liquid, at plant	RER	kg
		latex, at plant	RER	kg
		urea, as N, at regional storehouse	RER	kg
		carboxymethyl cellulose, powder, at plant	RER	kg
		chemicals inorganic, at plant	GLO	kg
		chemicals organic, at plant	GLO	kg
		electricity, medium voltage, production NORDEL, at grid	NORDEL	kWh
		electricity, medium voltage, production UCTE, at grid	UCTE	kWh
		electricity, medium voltage, at grid	GB	kWh
Inputs		hard coal, burned in industrial furnace 1-10MW	RER	MJ
		lignite briquette, burned in stove 5-15kW	RER	MJ
		natural gas, burned in industrial furnace >100kW	RER	MJ
		heavy fuel oil, burned in industrial furnace 1MW, non-modulating	RER	MJ
		wood chips, from industry, softwood, burned in furnace 300kW	CH	MJ
	infrastructure	integrated paper mill	RER	unit
	transports	transport, long distance	RER	km
		transport, freight, rail	RER	km
		disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	kg
		disposal, ash from paper prod. sludge, 0% water, to residual material landfill	CH	kg
Outputs		disposal, sludge from pulp and paper production, 25% water, to sanitary landfill	CH	kg
		disposal, wood ash mixture, pure, 0% water, to sanitary landfill	CH	kg
		disposal, hazardous waste, 0% water, to underground deposit	DE	kg
		product	RER	kg
		paper, wood-containing, LWC, at plant	RER	kg
	air emission	Heat, waste	MJ	5.76E+00
		AOX, Adsorbable Organic Halogen as Cl	kg	1.60E-06
		BOD5, Biological Oxygen Demand	kg	1.10E-04
		COD, Chemical Oxygen Demand	kg	2.20E-03
		Nitrogen	kg	4.30E-05
Outputs		Phosphorus	kg	7.60E-06
		Suspended solids, unspecified	kg	3.40E-04
		paper, recycling, with deinking, at plant	RER	kg
		paper, wood-containing, LWC, at plant	RER	kg
		paper, wood-containing, supercalendred (SC), at plant	RER	kg
		paper, woodfree, coated, at integrated mill	RER	kg
		paper, woodfree, coated, at integrated mill	RER	kg
		paper, woodfree, coated, at integrated mill	RER	kg
		paper, woodfree, coated, at integrated mill	RER	kg
		paper, woodfree, coated, at integrated mill	RER	kg

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Cumulated data (LCI)

	Name	Location	Unit	paper, recycling, with deinking, at plant	paper, wood-containing, LWC, at plant	paper, wood-containing, supercalendred (SC), at plant	paper, woodfree, coated, at integrated mill
	Location	Unit	RER	RER	RER	RER	RER
	Infrastructure	Unit	kg	kg	kg	kg	kg
LCIA results			0	0	0	0	0
LCI results							
resource	Land occupation	total	m2a	6.2E-1	4.5E+0	5.4E+0	4.1E+0
	Carbon dioxide, fossil	total	kg	1.4E+0	1.2E+0	9.6E-1	1.1E+0
	NM VOC	total	kg	6.1E-4	9.2E-4	7.5E-4	1.1E-3
	Nitrogen oxides	total	kg	2.5E-3	4.3E-3	3.6E-3	4.6E-3
	Sulphur dioxide	total	kg	2.9E-3	4.3E-3	3.5E-3	3.7E-3
	Particulates, < 2.5 um	total	kg	3.2E-4	6.9E-4	6.6E-4	1.2E-3
	BOD	total	kg	2.2E-3	1.9E-3	2.2E-3	2.9E-3
	Cadmium	total	kg	6.5E-9	9.0E-9	7.9E-9	3.8E-9

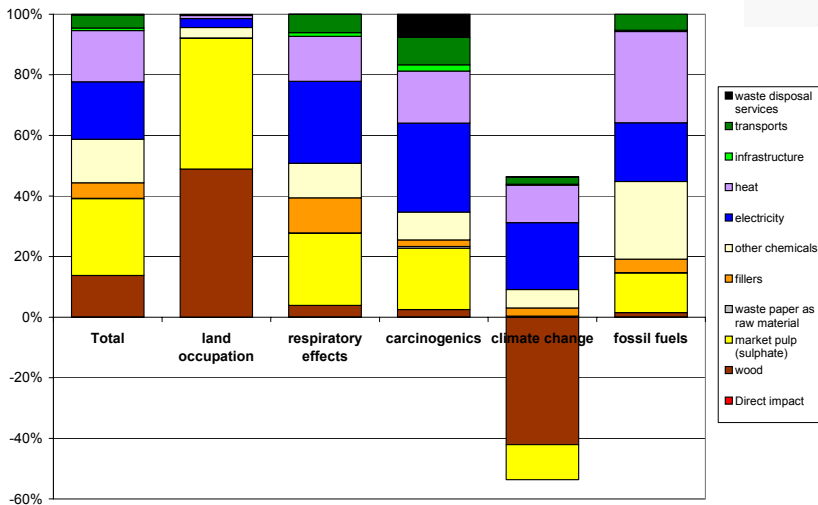
- LWC
- CED fossil quite equal to recycling paper and woodfree paper
 - air emissions in same order of magnitude like for other paper types
 - water emission is higher for woodfree paper

Folie 18

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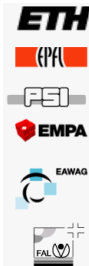
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Cumulated data (LCIA) / II



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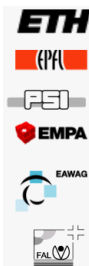
Conclusion / Outlook

- Average datasets of most **important types of paper / board for European situation in year 2000** are included into the database ecoinvent.
- **Representativeness** of different datasets **not equal** - some datasets are based on only few informations.
(-> Quality indicators)
- **Collaboration with** the European paper / board **industry** as an option to achieve better datasets in a future update



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Folie 20

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part TWO

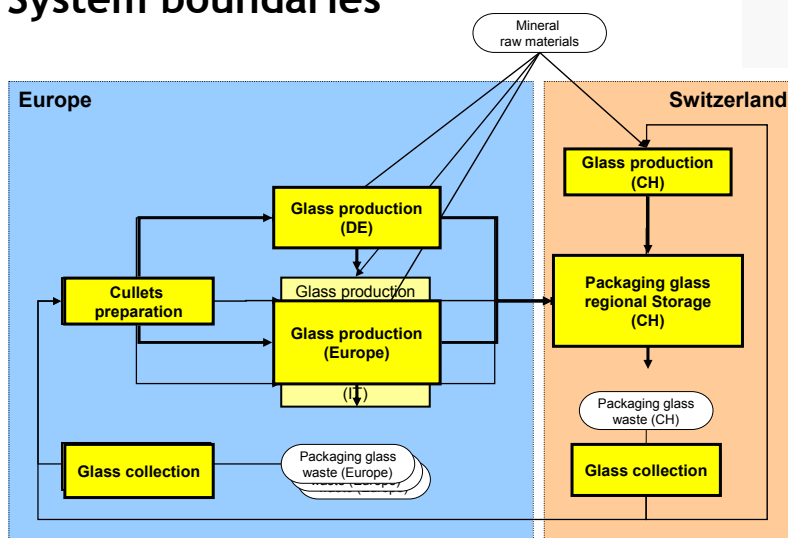
Packaging Glass

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System boundaries



Folie 22

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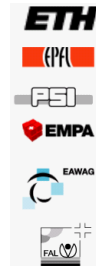
Data sources



	Characteristics	Advantages	Disadvantages
EUROPEAN Data	Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Glass Manufacturing Industry	Present European conditions;	only one average dataset available (no distinction between different colors); degree of details not always sufficient
GERMAN Data	German packaging glass data, collected for a national packaging study	average data for Germany, distinguishing the different types of colors;	Age of data (1996);
SWISS Data	company data; measured data from one specific production site	representative data for the present technology used for the production of packaging glass	confidential data; only aggregated form can be published (although data on a unit process level available)

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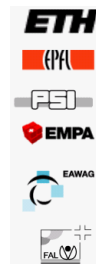
Example - green German glass



- Data from a German packaging study, covering 67% of German glass bottle production
- Data represent a mix of the different technologies used
- Included production steps:
preparation of the glass melt, melting furnace, feeder, container forming machine (press and blow or blow and blow), cooling furnace and finally packaging

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Input data

	Name		Location	Unit	packaging glass, green, at plant
	Location	Unit			
INPUTS	Resources	Water, unspecified natural origin		m3	2.12E-04
	Energy	heavy fuel oil, at regional storage	RER	kg	2.24E-02
		diesel, at regional storage	RER	kg	1.77E-03
		natural gas, high pressure, at consumer	RER	MJ	2.50E+00
		electricity, medium voltage, at grid	DE	kWh	1.59E-01
	Raw materials	glass, cullets, sorted, at sorting plant	RER	kg	8.48E-01
		silica sand, at plant	CH	kg	9.87E-02
		soda, powder, at plant	RER	kg	3.05E-02
		limestone, milled, loose, at plant	CH	kg	1.99E-02
	Auxiliaries	dolomite, at plant	RER	kg	1.44E-02
		lidsap, at plant	RER	kg	1.62E-02
		graphite, at plant	RER	kg	1.25E-06
		chemicals inorganic, at plant	GLO	kg	1.14E-03
	Packagings	lubricating oil, at plant	RER	kg	2.39E-05
		EUR-flat pallet	RER	unit	7.16E-04
OUTPUTS	Packagings	polyethylene, HDPE, granulate, at plant	RER	kg	1.17E-02
		solid unbleached board, SUB, at plant	RER	kg	1.70E-02
	Infrastructure	glass production site	RER	unit	1.25E-10
	Transports	transport, lorry 16t	RER	tkm	1.47E-04
		transport, lorry 32t	RER	tkm	1.31E-01
	Waste	disposal: municipal solid waste, 22.9% water, to municipal incineration	CH	kg	2.50E-03
		disposal: municipal solid waste, 22.9% water, to sanitary landfill	CH	kg	2.50E-03
	Output	packaging glass, green, at plant	DE	kg	1.00E+00
	Air emission	Heat, waste	MJ	4.40E+00	
		Carbon monoxide, fossil	kg	9.50E-01	
		Carbon dioxide, fossil	kg	2.57E-01	
		Nitrogen oxides	kg	8.41E-04	
		Sulfur dioxide	kg	7.03E-04	
		Particulates, > 10 um	kg	7.78E-06	
		Particulates, > 2.5 um, and < 10um	kg	7.10E-07	
		Particulates, < 2.5 um	kg	1.74E-06	
		Hydrogen chloride	kg	1.60E-05	
		Hydrogen fluoride	kg	4.94E-06	
		Ammonia	kg	3.55E-08	
		Oxinitrogen monoxide	kg	5.88E-07	
		Methane, fossil	kg	1.21E-07	
		Benzene	kg	9.59E-08	
		Cobalt	kg	1.00E-16	
		Formaldehyde	kg	4.00E-07	
		Benzo(a)pyrene	kg	1.37E-11	
		NM/OC, non-methane volatile organic compounds, unspecified origin	kg	4.42E-06	
		Hydrocarbons, aliphatic, alkanes, unspecified	kg	1.19E-05	
		Cadmium	kg	1.91E-08	
		Arsenic	kg	1.91E-08	
		Cobalt	kg	1.91E-08	
		Nickel	kg	1.91E-08	
		Selenium	kg	2.08E-06	
		Antimony	kg	1.91E-08	
		Lead	kg	2.19E-07	
		Chromium	kg	1.91E-08	
		Copper	kg	1.91E-08	
		Manganese	kg	1.91E-08	

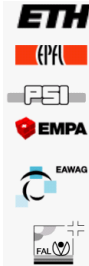
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Cumulated data (LCI)

	Name		Unit	packaging glass, green, at plant	packaging glass, green, at plant	packaging glass, green, at plant
	Location	Unit				
LCIA results	Infrastructure			DE	RER	CH
				kg	kg	kg
				0	0	0
	cumulative energy demand	non-renewable energy resources, fossil	MJ-Eq	7.9E+0	1.3E+1	8.6E+0
	cumulative energy demand	non-renewable energy resources, nuclear	MJ-Eq	9.4E-1	1.7E+0	5.1E-1
LCI results	resource	renewable energy resources, water	MJ-Eq	1.4E-1	2.9E-1	8.5E-1
	air	renewable energy resources, wind, solar, geothermal	MJ-Eq	4.8E-2	4.2E-2	1.6E-2
	air	renewable energy resources, biomass	MJ-Eq	1.2E+0	1.3E+0	6.8E-1
	air	Land occupation	m2a	2.3E-1	2.6E-1	1.3E-1
LCI results	air	Carbon dioxide, fossil	kg	5.2E-1	8.1E-1	4.8E-1
	air	NM/OC	kg	3.5E-4	4.9E-4	3.0E-4
	air	Nitrogen oxides	kg	1.9E-3	3.6E-3	2.6E-3
	air	Sulphur dioxide	kg	1.3E-3	4.9E-3	8.7E-4
	air	Particulates, < 2.5 um	kg	1.4E-4	4.5E-4	1.6E-4
	water	BOD	kg	7.7E-4	1.7E-3	4.4E-4
	soil	Cadmium	kg	7.9E-10	1.7E-8	6.7E-10

- • German and Swiss data are very similar
- European data show higher values than the German / Swiss production (e.g. for CO2, NOx, BOD, etc.)

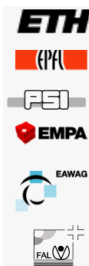
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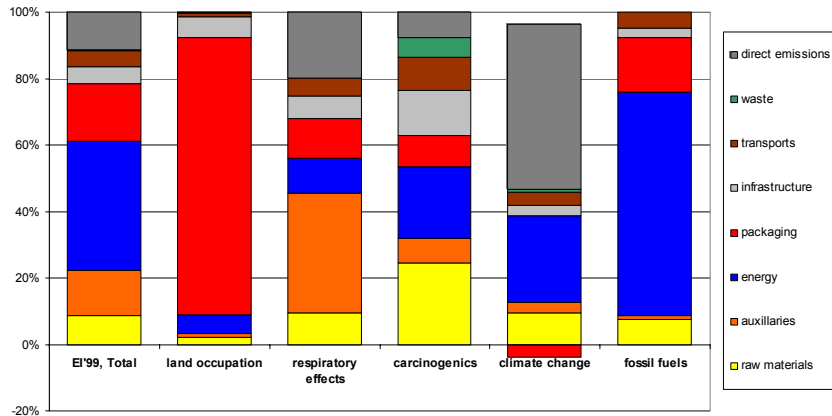


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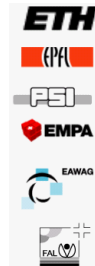


Cumulated data (LCIA) / II



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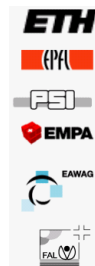
Conclusion

- Average datasets of most **important types of packaging glass for Swiss / European situation in year 2000** are included into the database ecoinvent.
- **Representativeness** of different datasets **not equal** - some datasets are based on only few informations.
(-> Quality indicators)
- Missing are specific datasets for two out of the three Swiss trading partners (France, Italy)



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part TRE

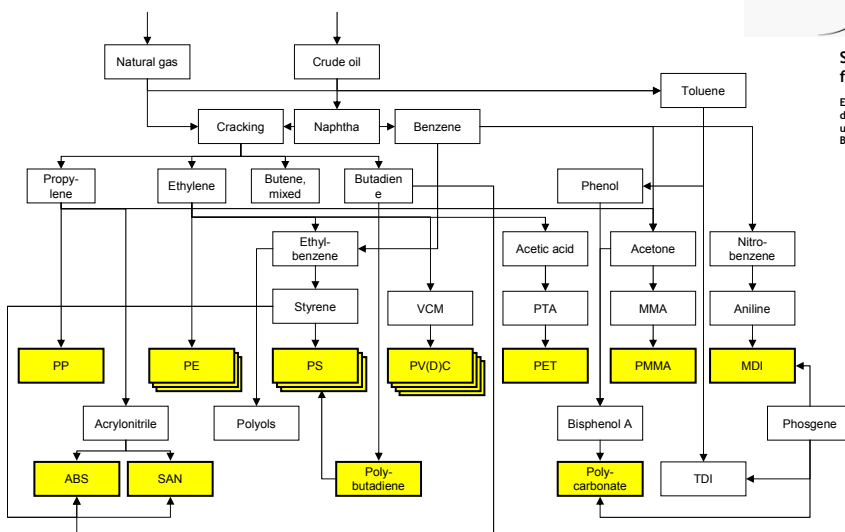
PLASTICS

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System boundaries



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Used data sources



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	Characteristics	Advantages	Disadvantages
APME (others than PET- report)	Ecoprofiles of the European Plastics Industry - collected and calculated by a independent consultant	European condition; degree of producers covered in general between good and very good (depending on the respective dataset)	only cumulated data ! Age of the data (majority of data from 1st half of the 90s)
APME's PET - report	Ecoprofiles of the European Plastics Industry - collected and calculated by a independent consultant	European condition; covering 10 European sites, year 1999/2000 unit process level	Energy consumption only in a unspecified form mentioned; infrastructure and transports missing
Ullmann's	standard reference book for technical processes of the chemical industry	free accessible process and technique widely described	contains most of the time no quantitative information

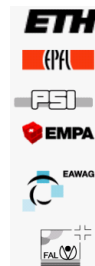


Case studies



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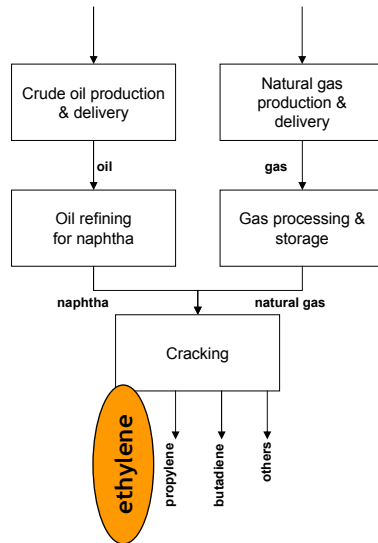
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- **Ethylene, average, at plant (RER)**
example of a process, based on APME's cumulated European
average LCI data.
-> *represents all „Boustead processes“ (plastics as well as
chemicals !)*
- **PET, amorphous, at plant (RER)**
example of a process, based on average European unit process
data (from APME's database)
-> *represents the unit processes*



Ethylene, average, at plant (RER)



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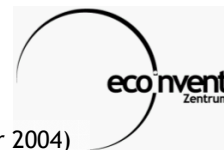
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Assumptions / basis

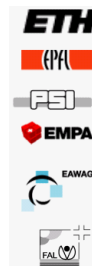
1.) 2.) Assumptions & Proceeding for integration (Hischier 2004)

Datei	Bearbeiten	Ansicht	Einfügen	Format	Extras	Daten	Fenster	2	Frage hier eingeben
Boustead									
1	Boustead	Ecoinvent database	Remarks / Calculation procedure						
2	1 mg Crude oil	10 ⁶ kg Oil, crude, in ground	-						
3	1 mg Gas / condensate	1.25 * 10 ⁶ Nm ³ Gas, natural, in ground	Based on a density of 0.0006 kg/L for natural gas, as described in Frischknecht et al. 2003						
4	1 mg Coal	10 ⁶ kg Coal, hard, unspecified, in ground	-						
5	1 mg Metallurgical coal	10 ⁶ kg Coal, hard, unspecified, in ground	Metallurgical coal = coking coal and pulverized coal consumed in making steel (Definition US-EIA)						
6	1 mg Lignite	10 ⁶ kg Coal, brown, in ground	-						
7	1 mg Peat	10 ⁶ kg Peat, in ground	-						
8	1 mg Wood	1.52 * 10 ⁶ m ³ Wood, unspecified, standing	Based on the density of 658 kg/m ³ for logs (CH, unspecified, 1a dried), as described in Frischknecht et al. 2003						
9	1 mg Biomass	2.37 * 10 ⁶ MJ Energy, gross calorific value, in biomass	Based on the heating value (H _u = 23.7 MJ/kg) from agricultural bio gas, as described in Frischknecht et al. 2003						
10	1 MJ Hydro	1 MJ Energy, potential, stock, in barrage water	As the efficiency of 80% for electricity production from water is already included into the amount in Boustead (Boustead 1999: 52), the respective amount can be transferred directly to Ecoinvent.						
11	1 MJ Nuclear	2.75 * 10 ⁶ kg Uranium, 90% in oxides, 10% in crude ore, in ground	In Boustead, an efficiency of 35% for electricity production is already included. In Frischknecht et al. 1996, it is calculated that 1 T _{th} of a UCTE-Nuclear Power Plant needs 7.85 kg uranium. Due to the fact that both mentioned sources represent the situation around 1995, these values are used for the calculation of the conversion factor.						
12									



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Input data - part of inputs

	Name		Location	Unit	ethylene, average at plant RER
	Location	Unit			
Input	Aluminium, 24% in bauxite, 11% in crude ore, in ground	kg	1.33E-04		
	Anhydrite, in ground	kg	6.83E-06		
	Baryte, 15% in crude ore, in ground	kg	5.59E-08		
	Calcite, in ground	kg	1.39E-03		
	Chromium, 25.5 in chromite, 11.6% in crude ore, in ground	kg	8.23E-11		
	Clay, bentonite, in ground	kg	6.85E-05		
	Clay, unspecified, in ground	kg	1.69E-05		
	Coal, brown, in ground	kg	7.05E-04		
	Coal, hard, unspecified, in ground	kg	1.79E-02		
	Dolomite, in ground	kg	2.85E-06		
	Zinc 5%, Lead 5%, in sulfide, in ground	kg	7.16E-08		
	Uranium, in ground	kg	8.42E-07		
	sylvite, 25 % in sylvinite, in ground	kg	2.64E-06		
	Sulfur, in ground	kg	7.06E-05		
	Sodium chloride, in ground	kg	9.81E-04		
	Shale, in ground	kg	1.93E-05		
	Sand, unspecified, in ground	kg	6.93E-05		
	Rutile, in ground	kg	9.30E-28		
	Phosphorus, 18% in apatite, 12% in crude ore, in ground	kg	5.11E-08		
	Olivine, in ground	kg	2.15E-06		
	Oil, crude, in ground	kg	7.50E-01		
	Nickel, 1.98% in silicates, 1.04% in crude ore, in ground	kg	1.89E-11		
	Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground	kg	2.96E-07		
	Iron, 46% in ore, 25% in crude ore, in ground	kg	3.14E-04		
	Gravel, in ground	kg	8.47E-07		
	Granite, in ground	kg	4.19E-09		
	Gas, natural, in ground	Nm3	7.98E-01		
	Fluorspar, 92%, in ground	kg	3.03E-07		
	Feldspar, in ground	kg	1.12E-33		
resource, biotic	Peat, in ground	kg	3.50E-05		
	Wood, unspecified, standing	m3	1.77E-09		
resource, in water	Energy, gross calorific value, in biomass	MJ	7.83E-03		
	Water, cooling, unspecified natural origin	m3	6.16E-02		
	Water, river	m3	3.70E-06		
	Water, salt, ocean	m3	2.49E-04		
	Water, unspecified natural origin	m3	1.60E-03		
waste service	Water, sink, in ground	m3	1.59E-08		
	Energy, potential, stock, in barrage water	MJ	1.90E-01		
	disposal, facilities, chemical production	REER	kg	4.14E-05	
	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	kg	9.48E-04	
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	kg	1.06E-05	
	disposal, wood untreated, 20% water, to municipal incineration	CH	kg	1.16E-08	
	disposal, hard coal mining waste tailings, in surface backfill	GLO	kg	5.25E-03	
	disposal, average incineration residue, 0% water, to residual material landfill	CH	kg	1.17E-03	
	disposal, hazardous waste, 0% water, to underground deposit	DE	kg	7.86E-04	

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Input data - part of outputs

	Name		Location	Unit	ethylene, average at plant RER
	Location	Unit			
Product	ethylene, average at plant	REER	kg	1.00E+00	
	Acetylene, unspecified	kg	1.00E-09		
	Ammonia	kg	7.09E-10		
	Carbon dioxide, biogenic	kg	1.77E-04		
	Carbon dioxide, fossil	kg	1.16E+00		
	Carbon dioxide	m3	5.59E-08		
	Carbon monoxide, biogenic	kg	1.33E-07		
	Carbon monoxide, fossil	kg	8.84E-04		
	Chlorine	kg	1.42E-07		
	Chlorine	CH	kg	9.48E-04	
	Dinitrogen monoxide	kg	1.15E-07		
	Ethane, 1,2-dichloro-	kg	5.16E-14		
	Ethane, chloro-	kg	2.74E-14		
	Fluorine	kg	8.97E-11		
	Halogenated hydrocarbons, chlorinated	MJ	2.54E-09		
	Heat, waste	MJ	1.93E+01		
	Hydrocarbons, aliphatic, alkanes, cyclic	kg	5.20E-34		
	Hydrocarbons, aromatic	kg	1.32E-05		
	Hydrogen	kg	2.66E-05		
	Hydrogen chloride	kg	9.28E-08		
	Hydrogen fluoride	kg	2.87E-07		
	Hydrogen sulfide	kg	5.20E-06		
	Lead	kg	7.32E-11		
	Mercury	kg	1.91E-07		
	Methane, biogenic	kg	6.03E-07		
	Methane, fossil	kg	4.07E-03		
	Nitrogen oxides	kg	6.35E-03		
	NM/OC, non-methane volatile organic compounds, unspecified origin	kg	1.69E-03		
	Particulates, < 2.5 um	kg	1.70E-04		
	Particulates, > 10 um	kg	2.17E-04		
	Particulates, > 2.5 um and < 10um	kg	2.90E-04		
	Sulfate	kg	3.96E-13		
Output	Sulfur dioxide	kg	5.16E-06		
	Acetylene, unspecified	kg	4.40E-05		
	Aluminium	kg	4.03E-07		
	Ammonium, ion	kg	3.36E-06		
	Ammonia	kg	1.78E-10		
	BOD, Biological Oxygen Demand	kg	2.46E-06		
	Calcium, ion	kg	8.20E-07		
	Carbonate	kg	6.86E-05		
	Chloride	kg	1.34E-04		
	Chlorinated solvents, unspecified	kg	5.14E-10		
	Chlorine	kg	9.74E-10		
	Chromium VI	kg	5.15E-11		
	CO, Chemical Oxygen Demand	kg	1.22E-04		
	Copper, ion	kg	2.56E-08		
	Cyanide	kg	5.63E-08		
	Ethane, 1,2-dichloro-	kg	8.35E-17		
	Ethane, chloro-	kg	1.21E-30		
	Fluoride	kg	3.27E-09		
	Hydrocarbons, unspecified	kg	9.16E-05		
	Iron, ion	kg	4.09E-09		
	Lead	kg	1.74E-08		
	Magnesium	kg	1.13E-08		
	Mercury	kg	2.21E-08		
	Nickel, ion	kg	1.21E-06		
	Nitrate	kg	2.20E-08		
	Nitrogen	kg	1.16E-04		
	Oil, unspecified	kg	1.59E-05		
	Phosphorus	kg	1.05E-07		
	Potassium, ion	kg	7.81E-08		
	Sodium, ion	kg	1.47E-04		
	Solved solids	kg	1.78E-04		
	Sulfate	kg	1.05E-04		
	Sulfide	kg	7.95E-07		
	Suspended solids, unspecified	kg	1.93E-04		
	Zinc, ion	kg	7.35E-09		

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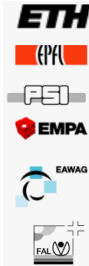
EMPA

Cumulated data (LCI)

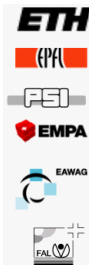
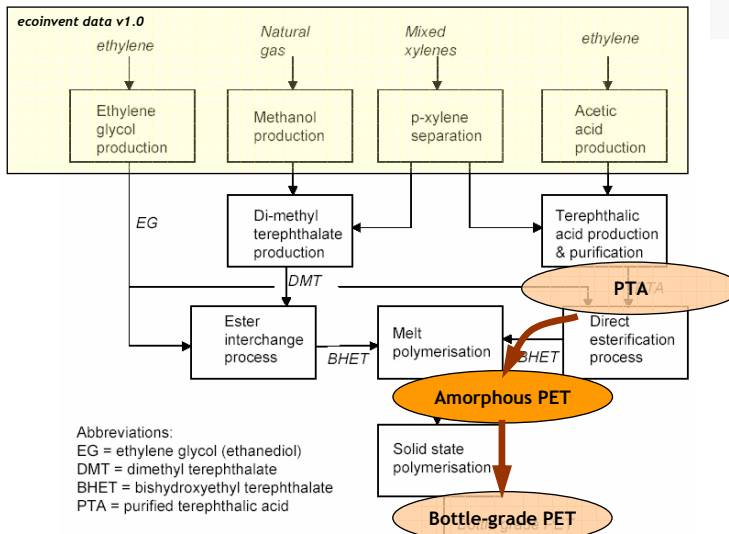
				ethylene, average, at plant	ethylene, pipeline system, at plant	propylene, at plant	styrene, at plant	vinyl chloride, at plant
Name				RER	RER	RER	RER	RER
Location								
Unit				kg	kg	kg	kg	kg
Infrastructure			Unit	0	0	0	0	0
LCIA results								
	cumulative energy demand	non-renewable energy resources, fossil	MJ-Eq	6.7E+1	7.0E+1	6.8E+1	8.7E+1	4.3E+1
	cumulative energy demand	non-renewable energy resources, nuclear	MJ-Eq	4.7E-1	3.0E-1	4.6E-1	1.2E+0	7.5E+0
	cumulative energy demand	renewable energy resources, water	MJ-Eq	1.9E-1	2.3E-2	1.1E-1	7.3E-2	9.7E-1
	cumulative energy demand	renewable energy resources, wind, solar, geothermal	MJ-Eq	7.9E-6	6.4E-6	8.2E-6	1.2E-5	5.5E-5
	cumulative energy demand	renewable energy resources, biomass	MJ-Eq	8.2E-3	3.1E-3	7.9E-3	1.7E-2	1.9E-1
LCI results								
resource	Land occupation	total	m2a	1.1E-4	5.6E-5	1.1E-4	9.8E-5	4.9E-4
air	Carbon dioxide, fossil	total	kg	1.2E+0	1.2E+0	1.2E+0	2.4E+0	1.5E+0
air	NMVOG	total	kg	1.7E-3	1.2E-3	1.5E-3	2.5E-3	2.0E-3
air	Nitrogen oxides	total	kg	6.4E-3	5.9E-3	5.9E-3	9.2E-3	6.9E-3
air	Sulphur dioxide	total	kg	5.2E-3	4.7E-3	4.7E-3	6.8E-3	7.5E-3
air	Particulates, < 2.5 um	total	kg	1.7E-4	1.7E-4	1.7E-4	2.8E-4	6.3E-4
water	BOD	total	kg	8.4E-5	7.7E-5	7.7E-5	1.7E-4	7.2E-4
soil	Cadmium	total	kg	3.9E-13	2.9E-13	3.3E-13	5.5E-13	2.6E-12

The input data (for comparison reasons) :

Air emission	amount
Carbon dioxide, fossil	kg 1.16E+00
Nitrogen oxides	kg 6.35E-03
Sulfur dioxide	kg 5.16E-03
Particulates, < 2.5 µm	kg 1.70E-04



PET, amorphous, at plant (RER)



Assumptions / basics

1. Data from APME report

Dito (4.)

INPUTS		per kg PET	OUTPUTS		per kg PET
Materials			amorphous PET	g	1000
PTA	g	874.59	Emission to air		
ethylene glycol	g	334.28	dust	mg	1
compressed air	m3	2.53	organics	mg	90
nitrogen	g	29.78	Emission to water		
Energy			COD	mg	1018
thermal fuels	MJ	1.63 MJ	BOD	mg	160
Electricity	MJ	0.07 MJ	suspended solids	mg	1
water			organics	mg	439
process water	g	163	hydrocarbons	mg	60
cooling water	g	6400	Waste		
Chemical plant		4e-10 unit	waste plastics	g	2.31
Transport, lorry		0.124 tkm	hazardous chemicals	g	0.09
...			inert chemicals	g	0.4
			incinerated waste	g	0.88

2. assumptions:

- Fuel-Mix according to cumulated data
- electricity mix = UCTE-Mix

3. Additional data:

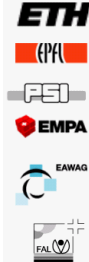
- Transports: standard distances (QR)
- infrastructure: chemical plant

4. „Translation“ according to Standard list for Boustead-Data (Hischer 2004)

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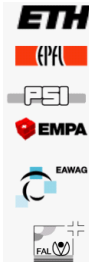
Input data PET (amorphous)

	Name	Location	Unit	polyethylene terephthalate, granulate, amorphous, at plant
	Location InfrastructureProcess Unit			RER 0 kg
Input	resource, in water	Water, cooling, unspecified natural origin	m3	6.40E-03
	materials	purified terephthalic acid, at plant	RER kg	8.75E-01
		nitrogen, liquid, at plant	RER kg	2.98E-02
		ethylene glycol, at plant	RER kg	3.34E-01
	energy	electricity, medium voltage, production UCTE, at grid	UCTE kWh	1.94E-01
		heat, natural gas, at industrial furnace >100kW	RER MJ	6.65E-01
		heat, at hard coal industrial furnace 1-10MW	RER MJ	3.06E-01
		heat, heavy fuel oil, at industrial furnace 1MW	RER MJ	4.94E-01
		heat, light fuel oil, at industrial furnace 1MW	RER MJ	1.65E-01
		steam, for chemical processes, at plant	RER kg	9.40E-01
	transports & infrastructure	transport, lorry 32t	RER tkm	1.24E-01
		transport, freight, rail	RER tkm	7.43E-01
		chemical plant, organics	RER unit	4.00E-10
Output	waste services	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH kg	8.80E-04
		disposal, plastics, mixture, 15.3% water, to municipal incineration	CH kg	2.31E-03
		disposal, average incineration residue, 0% water, to residual material landfill	CH kg	4.00E-04
		disposal, hazardous waste, 0% water, to underground deposit	DE kg	9.00E-05
	Product	polyethylene terephthalate, granulate, amorphous, at plant	RER kg	1.00E+00
	emission to air, high population density	Heat, waste	MJ	7.00E-01
		NH ₃ /VOC, non-methane volatile organic compounds, unspecified origin	kg	9.00E-05
		Particulates, < 2.5 um	kg	2.50E-07
		Particulates, > 10 um	kg	3.20E-07
	emission to water, river	Particulates, > 2.5 um, and < 10um	kg	4.30E-07
		BOD ₅ , Biological Oxygen Demand	kg	1.60E-04
		COD, Chemical Oxygen Demand	kg	1.02E-03
		Hydrocarbons, unspecified	kg	4.99E-04
		Suspended solids, unspecified	kg	1.00E-06
		DOC, Dissolved Organic Carbon	kg	2.62E-04
		TOC, Total Organic Carbon	kg	2.62E-04

ecovent
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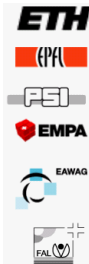
Cumulated data (LCI)



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			Name		purified terephthalic acid, at plant	polyethylene terephthalate, granulate, amorphous, at plant	polyethylene terephthalate, granulate, bottle grade, at plant
			Location Unit Infrastructure	Unit	RER kg 0	RER kg 0	RER kg 0
LCIA results							
cumulative energy demand		non-renewable energy resources, fossil	MJ-Eq	5.7E+1	7.4E+1	7.6E+1	
cumulative energy demand		non-renewable energy resources, nuclear	MJ-Eq	3.4E+0	6.1E+0	7.2E+0	
cumulative energy demand		renewable energy resources, water	MJ-Eq	5.0E-1	9.6E-1	1.1E+0	
cumulative energy demand		renewable energy resources, wind, solar, geothermal	MJ-Eq	8.1E-2	1.5E-1	1.8E-1	
cumulative energy demand		renewable energy resources, biomass	MJ-Eq	7.3E-2	1.5E-1	1.8E-1	
LCI results							
resource	Land occupation	total	m2a	1.6E-2	3.2E-2	4.1E-2	
air	Carbon dioxide, fossil	total	kg	1.5E+0	2.3E+0	2.4E+0	
air	NMVOG	total	kg	2.9E-3	3.4E-3	3.4E-3	
air	Nitrogen oxides	total	kg	4.4E-3	6.4E-3	6.9E-3	
air	Sulphur dioxide	total	kg	4.3E-3	6.7E-3	7.3E-3	
air	Particulates, < 2.5 um	total	kg	2.9E-4	4.9E-4	5.5E-4	
water	BOD	total	kg	2.6E-3	3.5E-3	4.5E-3	
soil	Cadmium	total	kg	7.1E-10	1.7E-9	2.2E-9	



Folie 41

Präsentation Roland Hischier

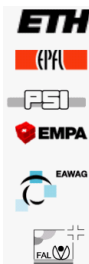
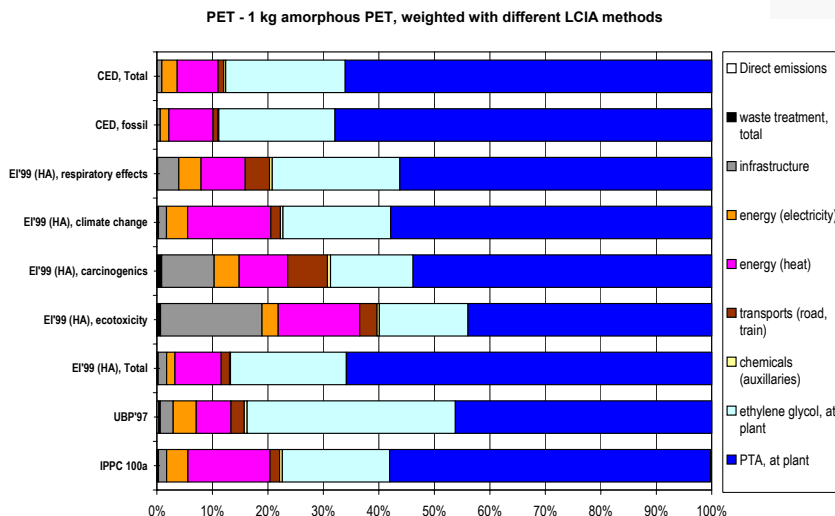


Cumulated data (LCIA)



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Folie 42

Präsentation Roland Hischier



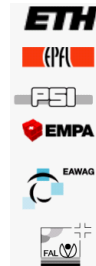
Conclusion & Outlook

- A **big amount** of various plastics will be included into the database ecoinvent data v1.01
- **Majority of plastics** are **not on a unit process level** available - there is only a cumulated dataset of the substance (APME data) and this means:
 - Data can NOT be harmonised with rest of the database (e.g. different electricity mix included / no infrastructure /)
 - An analysis concerning the amount of the result being from single areas (e.g. energy, transport, raw materials) is not possible
- BUT, APME shows itself that **opposite possible** (-> PET !)



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