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Life Cycle Assessment of Swiss Electricity Mixes

Implemented in ecoinvent data v2.2 (2010)

Authors

Marianne Leuenberger

Rolf Frischknecht

ESU-services Ltd.

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ESU-services Ltd.
Rolf Frischknecht
Niels Jungbluth
Sybille Büsser
Marianne Leuenberger
Matthias Stucki
www.esu-services.ch

Kanzleistrasse 4
T +41 44 940 61 91
T +41 44 940 61 32
T +41 44 940 61 35
T +41 44 940 61 38
T +41 44 940 67 94
F +41 44 940 61 94

CH - 8610 Uster
frischknecht@esu-services.ch
jungbluth@esu-services.ch
buesser@esu-services.ch
leuenberger@esu-services.ch
stucki@esu-services.ch

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Title	Life Cycle Assessment of Swiss Electricity Mixes
Authors	Marianne Leuenberger, Rolf Frischknecht
	ESU-services Ltd., fair consulting in sustainability Kanzleistr. 4, CH-8610 Uster www.esu-services.ch Phone +41 44 940 61 91, Fax +41 44 940 61 94 email: frischknecht@esu-services.ch
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Summary

The Swiss consumer mix reflects the electricity mix from renewable and non-renewable sources from domestic and international production sites sold to Swiss customers. The electricity mix from certified renewable sources represents the share of electricity sold with dedicated products. The remaining electricity mix, the so called Swiss electricity mix or supply mix, represents the electricity mix sold to Swiss customers with unspecified products. The three electricity mixes described in this section represent the consumer mix according to the inquiry of the Swiss Federal Office of Energy (SFOE), the sales mix of electricity from certified renewable sources and the remaining supply mix, which corresponds to the consumer mix excluding certified electricity, named Swiss electricity mix. All statistical data refer to the electricity production and consumption in 2007.

Abbreviations and Glossary

AEE Agentur für Erneuerbare Energien (Agency for Renewable Energies)

BFE Swiss Federal Office of Energy (SFOE)

CED Cumulative Energy Demand

SF6 Sulphurhexafluoride

UCTE Union for the Co-ordination of the Transmission of Electricity

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Author: Marianne Leuenberger, Rolf Frischknecht, ESU-services, Uster
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1.1 Introduction

The Swiss electricity supply mix modelled in ecoinvent data v2.01 and v2.1 excludes the volume of certified electricity sold in dedicated electricity products and the volume of renewable electricity used by the Swiss Railways. In order to model the electricity mix at the Swiss grid more accurately, it is important to differ between the statistical supply mix and the actual supply mix, which excludes electricity sold in certified electricity products. The Swiss Federal Office of Energy SFOE published the inquiry on electricity declarations (BFE 2009). It shows the provenance of the electricity sold to Swiss customers, including certified electricity sold separately but excluding the electricity generated for and used by the Swiss Railways. The results of this inquiry corrected by the volume of separately sold certified electricity substitute the model of the Swiss supply mix in the ecoinvent data v2.01 and v2.1.

In addition, the results of the inquiry without any major further corrections are used to model the BFE consumer mix. Finally, the mix of Swiss certified electricity is modelled based on the statistics of AEE (AEE 2008). The data sets listed in Tab. 1.1 are established. All statistical data refer to electricity consumption in 2007.

Tab. 1.1: Data sets names and explanation

Electricity	Ecoinvent Name	Remarks
Certified electricity	electricity mix, certified, at grid/CH/kWh	Contains all certified electricity from renewable sources sold in 2007 in Switzerland
	electricity mix, high voltage, certified, at grid/CH/kWh	Certified electricity, includes transmission infrastructure and emissions to air
	electricity mix, medium voltage, certified, at grid/CH/kWh	Electricity from certified sources, includes losses from conversion and distribution, transmission and SF_6 emission
	electricity mix, low voltage, certified, at grid/CH/kWh	Electricity from certified sources, includes losses from conversion and distribution, transmission and SF_6 emission
Consumer mix	electricity, consumer mix, at grid/CH/kWh	Represents the Swiss supply mix including the amounts of electricity sold in certified electricity products.
	electricity, high voltage, consumer mix, at grid/CH/kWh	Consumer mix, includes transmission infrastructure and emissions to air
	electricity, medium voltage, consumer mix, at grid/CH/kWh	Consumer mix, includes losses from conversion and distribution, transmission and SF_6 emission
	electricity, low voltage, consumer mix, at grid/CH/kWh	Consumer mix, includes losses from conversion and distribution, transmission and SF_6 emission
Electricity mix	electricity mix/CH/kWh	Represents the Swiss supply mix excluding the amount of electricity sold in certified electricity products.
	electricity, high voltage, at grid/CH/kWh	Electricity mix, includes transmission infrastructure and emissions to air
	electricity, medium voltage, at grid/CH/kWh	Consumer mix, includes losses from conversion and distribution, transmission and SF_6 emission
	electricity, low voltage, at grid/CH/kWh	Consumer mix, includes losses from conversion and distribution, transmission and SF_6 emission

1.2 Characterisation of the electricity mixes

The Swiss consumer mix includes the electricity from domestic production and imported electricity, and contains electricity from different renewable and non-renewable sources. By selling some of the electricity from renewable sources in certified electricity products to subscribing clients, these electricity products are no longer part of the so called supply mix. The resulting electricity mix is named Swiss electricity mix and represents the consumer mix excluding the certified electricity (see Tab. 1.2). The following section describes the statistical basis used to model the electricity mix from renewable sources, named certified electricity, the Swiss consumer mix and the Swiss electricity mix.

1.3 Main Data Sources

The data sets are established using statistical data about the Swiss electricity consumption and the domestic electricity production provided by SFOE statistics (BFE 2008a), statistical data about certified

electricity products sold (AEE 2008), statistical data about renewable energies in Switzerland (BFE 2008b) and the results of the inquiry about electricity declarations (BFE 2009).

Further data regarding electricity transmission and distribution, as well as emissions from transformation equipment are modelled according to the ecoinvent data of the former supply mix (Frischknecht et al. 2007a).

1.4 Electricity statistics

The BFE report on electricity labelling evaluates the shares of electricity generation technologies of the Swiss supply mix (BFE 2009). These values combined with the total electricity consumption in 2007, which is 56637 GWh (BFE 2008a), form the basis for the calculation of the overall amount of electricity consumed from different sources in 2007 (see Tab. 1.2).

The data on renewable energy sources in the BFE inquiry is imprecise due to rounding. All renewable sources are listed with a share of 0.0 % or 0.1 %. In contrast, the Swiss statistics on renewable energy and the AEE report show values in GWh, which allows for a much more accurate calculation of the shares. In order to obtain more accurate values for the shares of electricity from renewable energy sources, the values are taken from Swiss statistic on renewable energy (BFE 2008b). Tab. 1.2 shows the values derived from the different statistics for the three electricity mixes.

Tab. 1.2: Statistical data used for the life cycle inventory of the Swiss consumer mix, the Swiss electricity mix and certified electricity in %, 2007

Category	Technology	Origin	Source	Consumer mix ecoinvent		Certified electricity		Electricity mix ecoinvent	
				%	GWh	%	GWh	%	GWh
renewable									
hydro		domestic		32.645%	18121.39	97.801%	4576.80	26.647%	13544.59
		import		2.458%	1364.56	0.000%	0.00	2.685%	1364.56
other									
	solar	domestic		0.049%	27.11	0.327%	15.30	0.023%	11.81
		import		0.000%	0.00	0.000%	0.00	0.000%	0.00
	wind	domestic		0.029%	16.03	0.321%	16.03	0.000%	0.00
		import		0.052%	28.80	0.615%	28.80	0.000%	0.00
	biomass	domestic	wood	0.166%	92.39	0.430%	20.14	0.142%	72.25
			biogas	0.196%	108.58	0.506%	23.66	0.167%	84.92
		import		0.000%	0.00	0.000%	0.00	0.000%	0.00
non renewable									
nuclear		domestic		29.007%	16101.84			31.678%	16101.84
		import		11.603%	6440.74			12.671%	6440.74
fossil									
	oil	domestic		0.197%	109.17			0.215%	109.17
		import		0.295%	163.75			0.322%	163.75
	natural gas	domestic		0.295%	163.75			0.322%	163.75
		import		0.885%	491.24			0.966%	491.24
	coal	domestic		0.000%	0.00			0.000%	0.00
		import		0.098%	54.58			0.107%	54.58
waste		domestic		1.967%	1091.65			2.148%	1091.65
		import		0.000%	0.00			0.000%	0.00
other	UCTE			18.388%	10206.93			20.081%	10206.93
	Pumped storage			1.671%	927.50			1.825%	927.50
Total				**100.000%**	**55510.00**	**100.000%**	**4680.73**	**100.000%**	**50829.27**

The datasets of electricity delivered at high, medium and low voltage level include manufacture of the electricity grid, the transmission losses, SF_6 and emissions. Tab. 1.3 shows the percentage of losses on the different voltage levels according to Frischknecht et al. (2007a).

Tab. 1.3: Transmission losses according to ecoinvent report No. 06_XVI (Frischknecht et al. 2007a)

Transformation to	losses
High voltage	0.98 %
Medium voltage	1.01 %
Low voltage	10.41 %

1.5 Life cycle inventory of certified electricity

The shares of the different energy sources in the certified electricity mix are calculated using the figures listed in the AEE statistics (AEE 2008). The AEE statistics provide information on the energy sources and the share of imported electricity per technology. According to the values presented in Tab. 1.2 hydropower accounts for the majority of certified electricity. All hydropower originates from Swiss hydroelectric power plants, which includes reservoir and run-off river hydropower. The same situation applies to electricity from photovoltaics. 36 percent of the wind electricity is produced in Switzerland; the remaining part is imported from European countries. The information published in the renewable energy statistics is used (BFE 2008b) to calculate the shares of electricity from biogas (54%) and wood (46%) on the total electricity produced by biomass.

Tab. 1.4: Unit process raw data of certified electricity

	Name	Location	InfrastructureProcess	Unit	electricity mix, certified	Uncertainty	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kWh			
product	electricity mix, certified	CH	0	kWh	1.00E+0			
technosphere	electricity, hydropower, at power plant	CH	0	kWh	9.78E-1	1	1.08	(1,1,2,1,1,3); According to AEE statistics 2007
	electricity, production mix photovoltaic, at plant	CH	0	kWh	3.27E-3	1	1.08	(1,1,2,1,1,3); According to AEE statistics 2007
	electricity, at wind power plant	CH	0	kWh	3.21E-3	1	1.08	(1,1,2,1,1,3); According to AEE statistics 2007
	electricity, at wind power plant	RER	0	kWh	6.15E-3	1	1.08	(1,1,2,1,1,3); According to AEE statistics 2007
	electricity, at cogen ORC 1400kWth, wood, allocation exergy	CH	0	kWh	4.30E-3	1	1.08	(1,1,2,1,1,3); According to AEE statistics 2007
	electricity, at cogen with biogas engine, allocation exergy	CH	0	kWh	5.06E-3	1	1.08	(1,1,2,1,1,3); According to AEE statistics 2007

The datasets of electricity delivered at high, medium and low voltage level include manufacture of the electricity grid, the transmission losses and SF_6 emissions. Tab. 1.3 shows the percentage of losses on the different voltage levels according to Frischknecht et al. (2007a).

Tab. 1.5: Unit process raw data of certified electricity 2007, delivered on high, medium and low voltage level

	Name	Location	InfrastructureP	Unit	electricity, high voltage, certified, at grid	electricity, medium voltage, certified, at grid	electricity, low voltage, certified, at grid	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH	CH			
	InfrastructureProcess				0	0	0			
	Unit				kWh	kWh	kWh			
product	electricity, high voltage, certified, at grid	CH	0	kWh	1					
	electricity, medium voltage, certified, at grid	CH	0	kWh		1				
	electricity, low voltage, certified, at grid	CH	0	kWh			1			
technosphere	electricity mix, certified	CH	0	kWh	1.01E+0			1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	electricity, high voltage, certified, at grid	CH	0	kWh		1.01E+0		1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	electricity, medium voltage, certified, at grid	CH	0	kWh			1.10E+0	1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	sulphur hexafluoride, liquid, at plant	RER	0	kg		3.73E-8	2.19E-9	1	1.08	(1,1,2,1,1,3); emissions set equal to Swiss consumer mix data set in ecoinvent
	transmission network, long-distance	UCTE	1	km	3.17E-10			1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss consumer mix data set in ecoinvent
	transmission network, electricity, high voltage	CH	1	km	8.44E-9			1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss consumer mix data set in ecoinvent
	transmission network, electricity, medium voltage	CH	1	km		3.24E-8		1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss consumer mix data set in ecoinvent
	distribution network, electricity, low voltage	CH	1	km			2.94E-7	1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss consumer mix data set in ecoinvent
emission soil, unspecified	Heat, waste	-	-	MJ	1.78E-3	1.65E-2	2.81E-1	1	1.32	(4,1,3,1,1,5); emissions set equal to Swiss consumer mix data set in ecoinvent
emission air, unspecified	Heat, waste	-	-	MJ	3.40E-2	2.01E-2	9.37E-2	1	1.32	(4,1,3,1,1,5); emissions set equal to Swiss consumer mix data set in ecoinvent
	Ozone	-	-	kg	4.50E-6			1	5.00	(-,-,-,-,-,-); emissions set equal to Swiss consumer mix data set in ecoinvent
	Dinitrogen monoxide	-	-	kg	5.00E-6			1	4.60	(-,-,-,-,-,-); emissions set equal to Swiss consumer mix data set in ecoinvent
	Sulfur hexafluoride	-	-	kg		3.73E-8	2.19E-9	1	1.51	(1,1,2,1,1,3); emissions set equal to Swiss consumer mix data set in ecoinvent

1.6 Life cycle inventory of the consumer mix

The BFE inquiry (BFE 2009) summarizes the electricity by rough categories, defined by energy sources and domestic or non-domestic origin. The values given in the report are adjusted using more detailed information about the shares of different types of electricity generation available from other statistics. The amount of imported electricity can be derived by subtraction of the values from domestic production statistics. The values given in the BFE inquiry represent 90 % of the electricity consumed in 2007, which is 49'200 GWh. The other statistics applied to the calculation of the electricity mixes however, refer to 100 % of the electricity production or consumption. The total electricity consumption in Switzerland is 57'432 GWh (BFE 2008a). The amount of electricity produced with pumped storage hydroelectric power plants is 927.5 GWh (see section 1.4). The amount of electricity produced by power plants of the Swiss Railways (not included in the BFE inquiry) is 1'922 GWh[1]. This results in 55'510 GWh (excluding the amount of electricity used by the Swiss Railways) and 54'582.5 GWh (excluding the amount of electricity used by the Swiss Railways and the amount of electricity produced with pumped storage hydro power) supplied to Swiss customers. 90 % of 54'582.5 GWh or 49'200 GWh are included in the SFOE inquiry on electricity declaration. This value, 54'582.5 GWh, forms the basis for the calculation of the production volumes of the different technologies. For instance, the BFE inquiry states that 33.2 % of the consumed electricity is produced in domestic hydropower plants. 33.2 % of 54'582.5 GWh are 18'121 GWh. These production volumes are then divided by the total volume of electricity supplied to Swiss customers (excluding the Swiss Railways), i.e. 55'510 GWh. The overall share of domestic hydroelectric power, for instance is calculated including the electricity from pumped storage hydroelectric power: 18'121 GWh divided by 55'510 GWh (32.6 %).

The amount of electricity from renewable sources is inaccurate due to rounding in the BFE inquiry. The values applied for the calculation of the shares are taken from the renewable energy statistics 2007 (BFE 2008b). These values are compared to the values of the AEE statistics (AEE 2008) and the values of the BFE inquiry (BFE 2009). The electricity production with biomass according to (257 GWh, BFE 2008b) is much higher as compared to the amount of biomass based electricity supplied to Swiss

[1] Personal communication, Matthias Tuchschmid, Swiss Railways, 22.10.2009

customers (55 GWh, BFE 2009). We use the figures of the Swiss renewable energy statistics assuming that about one third of the biogas electricity is used internally (not fed into the electricity grid).

93 % of electricity from hydroelectric power plants is produced in Switzerland, 7 % is assumed to be imported from France. 927.5 GWh are associated to pumped storage power plants according to BFE statistics and information taken from the ecoinvent report (Frischknecht et al. 2007a). All solar power supplied to Swiss customers is produced in Switzerland. The domestic production of wind power accounts for 36 % of the supplied volume; the majority is imported from European countries. Cogeneration plants using biomass as energy source are accounted for according to the shares presented in section 1.5. The share of biogas is adjusted by 55.9 GWh, in order to correct the inaccuracy of the BFE figures. A share of 29 % of electricity from nuclear power plants is imported. We assume import from France, as the major part of imported electricity is imported from France.

The electricity from fossil fuels is mainly imported. 40 % of the electricity from oil is generated in Switzerland, whereas 60 % is imported. Electricity from natural gas is imported (75 %) with the exception of electricity from natural gas burned in cogeneration units (25 %). The imported electricity from fossil sources is assumed to be produced in Italy (fuel oil) and Germany (natural gas and coal). These assumptions base on the figures about electricity trading with neighbouring countries in the Swiss electricity statistics (BFE 2008a). Electricity produced from waste stems from Swiss incineration plants. About 20 % of the electricity supplied to Swiss customers is of undefined origin, for which we use UCTE electricity mix.

Tab. 1.6: Unit process raw data of the Swiss consumer mix 2007

	Name	Location	InfrastructureProcess	Unit	electricity, consumer mix	Uncertainty	StandardDeviation95	% GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kWh			
product	electricity, consumer mix	CH	0	kWh	1.00E+0			
technosphere	electricity, hydropower, at power plant	CH	0	kWh	3.26E-1	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007. Pump storage excluded.
	electricity, hydropower, at power plant	FR	0	kWh	2.46E-2	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007. Assumption for imported hydropower: from France.
	electricity, hydropower, at pumped storage power plant	CH	0	kWh	1.67E-2	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and ecoinvent report
	electricity, production mix photovoltaic, at plant	CH	0	kWh	4.88E-4	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007.
	electricity, at wind power plant	CH	0	kWh	2.89E-4	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007.
	electricity, at wind power plant	RER	0	kWh	5.19E-4	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007.
	electricity, at cogen ORC 1400kWth, wood, allocation exergy	CH	0	kWh	1.66E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007. Shares of wood/biomass according to SFOE on renewable energy sources 2007.
	electricity, at cogen with biogas engine, allocation exergy	CH	0	kWh	1.96E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007. Shares of wood/biomass according to SFOE on renewable energy sources 2007.
	electricity, nuclear, at power plant	CH	0	kWh	2.90E-1	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007.
	electricity, nuclear, at power plant pressure water reactor	FR	0	kWh	1.16E-1	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007. Assumption for imported nuclear power from France.
	electricity, at cogen 200kWe diesel SCR, allocation exergy	CH	0	kWh	1.97E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007.
	electricity, oil, at power plant	IT	0	kWh	2.95E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007. Assumption: electricity imported from Italy.
	electricity, at cogen 500kWe lean burn, allocation exergy	CH	0	kWh	2.95E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007.
	electricity, natural gas, at power plant	DE	0	kWh	8.85E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007. Assumption: electricity imported from Germany.
	electricity, hard coal, at power plant	DE	0	kWh	9.83E-4	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007. Assumption: electricity imported from Germany.
	electricity from waste, at municipal waste incineration plant	CH	0	kWh	1.97E-2	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007.
	electricity, production mix UCTE	UCTE	0	kWh	1.84E-1	1	1.08	(2,1,2,2,3,3); According to SFOE statistics 2007.

The datasets of electricity delivered at high, medium and low voltage level include manufacture of the electricity grid, the transmission losses and SF_6 emissions. Tab. 1.3 shows the percentage of losses on the different voltage levels according to Frischknecht et al. (2007a).

Tab. 1.7: Unit process raw data of the Swiss consumer mix 2007, delivered on high, medium and low voltage level

	Name	Location	InfrastructureP	Unit	electricity, high voltage, consumer mix. at grid	electricity, medium voltage, consumer mix, at grid	electricity, low voltage, consumer mix, at grid	UncertaintyType	StandardDeviation95%	GeneralComment
	Location	CH	0	kWh	CH	CH	CH			
	InfrastructureProcess	0			0	0	0			
	Unit	kWh			kWh	kWh	kWh			
product	electricity, high voltage, consumer mix. at grid	CH	0	kWh	1					
	electricity, medium voltage, consumer mix, at grid	CH	0	kWh		1				
	electricity, low voltage, consumer mix, at grid	CH	0	kWh			1			
technosphere	electricity, consumer mix	CH	0	kWh	1.01E+0			1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	electricity, high voltage, consumer mix. at grid	CH	0	kWh		1.01E+0		1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	electricity, medium voltage, consumer mix, at grid	CH	0	kWh			1.10E+0	1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	sulphur hexafluoride, liquid, at plant	RER	0	kg		3.73E-8	2.19E-9	1	1.08	(1,1,2,1,1,3); emissions set equal to Swiss electricity mix data set in ecoinvent
	transmission network, long-distance	UCTE	1	km	3.17E-10			1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss electricity mix data set in ecoinvent
	transmission network, electricity, high voltage	CH	1	km	8.44E-9			1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss electricity mix data set in ecoinvent
	transmission network, electricity, medium voltage	CH	1	km		3.24E-8		1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss electricity mix data set in ecoinvent
	distribution network, electricity, low voltage	CH	1	km			2.94E-7	1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss electricity mix data set in ecoinvent
emission soil, unspecified	Heat, waste	-	-	MJ	1.78E-3	1.65E-2	2.81E-1	1	1.32	(4,1,3,1,1,5); emissions set equal to Swiss electricity mix data set in ecoinvent
emission air, unspecified	Heat, waste	-	-	MJ	3.40E-2	2.01E-2	9.37E-2	1	1.32	(4,1,3,1,1,5); emissions set equal to Swiss electricity mix data set in ecoinvent
	Ozone	-	-	kg	4.50E-6			1	5.00	(-,-,-,-,-,-); emissions set equal to Swiss consumer mix data set in ecoinvent
	Dinitrogen monoxide	-	-	kg	5.00E-6			1	4.60	(-,-,-,-,-,-); emissions set equal to Swiss consumer mix data set in ecoinvent
	Sulfur hexafluoride	-	-	kg		3.73E-8	2.19E-9	1	1.51	(1,1,2,1,1,3); emissions set equal to Swiss consumer mix data set in ecoinvent

1.7 Life cycle inventory of Swiss electricity mix

The Swiss electricity mix (supply mix) represents the consumer mix, excluding the shares of electricity sold with certified electricity products. The shares are calculated by subtracting the total amounts of certified electricity from the total amounts of the consumer mix (see Tab. 1.2).

Tab. 1.8: Unit process raw data of the Swiss electricity mix

	Name Location InfrastructureProcess Unit	Location	InfrastructureProcess	Unit	electricity mix CH 0 kWh	Uncertainty	StandardDeviation95%	GeneralComment
product	electricity mix	CH	0	kWh	1.00E+0			
technosphere	electricity, hydropower, at power plant	CH	0	kWh	2.66E-1	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007. Without pumped storage (1893 GWh)
	electricity, hydropower, at power plant	FR	0	kWh	2.68E-2	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007. Assumption: all imported hydropower from France.
	electricity, hydropower, at pumped storage power plant	CH	0	kWh	1.82E-2	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007
	electricity, production mix photovoltaic, at plant	CH	0	kWh	2.32E-4	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and ecoinvent report
	electricity, at cogen ORC 1400kWth, wood, allocation exergy	CH	0	kWh	1.42E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007. Shares wood/biogas calculated from SFOE statistics on renewable energy.
	electricity, at cogen with biogas engine, allocation exergy	CH	0	kWh	1.67E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007. Shares wood/biogas calculated from SFOE statistics on renewable energy.
	electricity, nuclear, at power plant	CH	0	kWh	3.17E-1	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007and AEE statistics 2007.
	electricity, nuclear, at power plant pressure water reactor	FR	0	kWh	1.27E-1	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007. Assumption: all imported nuclear power from France.
	electricity, at cogen 200kWe diesel SCR, allocation exergy	CH	0	kWh	2.15E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007.
	electricity, oil, at power plant	IT	0	kWh	3.22E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007. Assumption: electricity imported from Italy.
	electricity, at cogen 500kWe lean burn, allocation exergy	CH	0	kWh	3.22E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007.
	electricity, natural gas, at power plant	DE	0	kWh	9.66E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007. Assumption: electricity imported from Germany.
	electricity, hard coal, at power plant	DE	0	kWh	1.07E-3	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007. Assumption: electricity imported from Germany.
	electricity from waste, at municipal waste incineration plant	CH	0	kWh	2.15E-2	1	1.08	(1,1,2,1,1,3); According to SFOE statistics 2007 and AEE statistics 2007.
	electricity, production mix UCTE	UCTE	0	kWh	2.01E-1	1	1.08	(2,1,2,2,3,3); According to SFOE statistics 2007and AEE statistics 2007. Assumption for electricity of unspecified origin.

The datasets of electricity delivered at high, medium and low voltage level include manufacture of the electricity grid, the transmission losses and SF_6 emissions. Tab. 1.3 shows the percentage of losses on the different voltage levels according to Frischknecht et al. (2007a).

Tab. 1.9: Unit process raw data of the Swiss electricity mix 2007, delivered on high, medium and low voltage level

	Name Location InfrastructureProcess Unit	Location	InfrastructureP	Unit	electricity, high voltage, at grid CH 0 kWh	electricity, medium voltage, at grid CH 0 kWh	electricity, low voltage, at grid CH 0 kWh	UncertaintyType	StandardDeviation95%	GeneralComment
product	electricity, high voltage, at grid	CH	0	kWh	1					
	electricity, medium voltage, at grid	CH	0	kWh		1				
	electricity, low voltage, at grid	CH	0	kWh			1			
technosphere	electricity mix	CH	0	kWh	1.01E+0			1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	electricity, high voltage, at grid	CH	0	kWh		1.01E+0		1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	electricity, medium voltage, at grid	CH	0	kWh			1.10E+0	1	1.24	(3,1,1,1,3,1); specific losses of network estimated based on values published in ecoinvent report
	sulphur hexafluoride, liquid, at plant	RER	0	kg		3.73E-8	2.19E-9	1	1.08	(1,1,2,1,1,3); emissions set equal to Swiss consumer mix data set in ecoinvent
	transmission network, long-distance	UCTE	1	km	3.17E-10			1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss consumer mix data set in ecoinvent
	transmission network, electricity, high voltage	CH	1	km	8.44E-9			1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss consumer mix data set in ecoinvent
	transmission network, electricity, medium voltage	CH	1	km		3.24E-8		1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss consumer mix data set in ecoinvent
	distribution network, electricity, low voltage	CH	1	km			2.94E-7	1	3.16	(3,1,4,5,3,5); infrastructure set equal to Swiss consumer mix data set in ecoinvent
emission soil, unspecified	Heat, waste	-	-	MJ	1.78E-3	1.65E-2	2.81E-1	1	1.32	(4,1,3,1,1,5); emissions set equal to Swiss consumer mix data set in ecoinvent
emission air, unspecified	Heat, waste	-	-	MJ	3.40E-2	2.01E-2	9.37E-2	1	1.32	(4,1,3,1,1,5); emissions set equal to Swiss consumer mix data set in ecoinvent
	Ozone	-	-	kg	4.50E-6			1	5.00	(-,-,-,-,-,-); emissions set equal to Swiss consumer mix data set in ecoinvent
	Dinitrogen monoxide	-	-	kg	5.00E-6			1	4.60	(-,-,-,-,-,-); emissions set equal to Swiss consumer mix data set in ecoinvent
	Sulfur hexafluoride	-	-	kg		3.73E-8	2.19E-9	1	1.51	(1,1,2,1,1,3); emissions set equal to Swiss consumer mix data set in ecoinvent

1.8 Cumulative results and interpretation

1.8.1 Introduction

Selected LCI results and values for the cumulative energy demand are presented and discussed in this chapter. Please note that only a small part of the about 1'000 elementary flows is presented here. The selection of the elementary flows shown in the tables is not based on their environmental relevance. It rather allows showing by examples the contributions of the different life cycle phases, or specific inputs from the technosphere to the selected elementary flows. Please refer to the ecoinvent database for the complete LCIs (ecoinvent Centre 2009).

The shown selection is not suited for a life cycle assessment of the analysed processes and products. Please use the data downloaded from the database for your own calculations, also because of possible minor deviations between the presented results and the database due to corrections and changes in background data used as inputs in the dataset of interest.

The ecoinvent database also contains life cycle impact assessment results. Assumptions and interpretations were necessary to match current LCIA methods with the ecoinvent inventory results. They are described in Frischknecht et al. (2007b). It is strongly advised to read the respective chapters of the implementation report before applying LCIA results.

1.8.2 Results

The selected results presented in Tab. 1.10 show the characteristics of the three electricity mixes. The certified electricity contains only electricity from renewable sources, which leads to higher values for the cumulative renewable energy demand (3.85 MJ-eq./kWh). On the other hand, the Swiss electricity and the consumer mix have higher shares of nuclear and fossil fuel based energy, which can be seen in the results for the non-renewable energy demand of 7.91 MJ-eq. and 7.64 MJ-eq. respectively. The carbon dioxide emissions confirm these results. While the electricity from certified sources emits 4.4 grams of fossil CO_2, the Swiss electricity mix accounts for 105 grams of CO_2. The highest CO_2 emission can be found with the consumer electricity mix (108g CO_2/kWh), as the electricity from certified sources is excluded from the mix.

Tab. 1.10: Selected LCI results of Swiss electricity mix, certified electricity and consumer mix, at the busbar

	Name		electricity mix	electricity, consumer mix	electricity mix, certified
	Location		CH	CH	CH
	InfrastructureProcess		0	0	0
	Unit	Unit	kWh	kWh	kWh
CED	Non renewable, fossil	MJ eq	1.34E+0	1.43E+0	4.76E-2
CED	Non-renewable, nuclear	MJ eq	6.57E+0	6.21E+0	1.45E-2
CED	Non-renewable, biomass	MJ eq	7.19E-7	7.83E-7	1.13E-7
CED	Renewable, biomass	MJ eq	3.97E-2	6.13E-2	8.85E-2
CED	Renewable, wind, solar, geothe	MJ eq	2.10E-2	2.00E-2	4.89E-2
CED	Renewable, water	MJ eq	1.36E+0	1.45E+0	3.71E+0
NMVOC	air	kg	3.04E-5	3.00E-5	3.82E-6
Carbon dioxide, fossil	air	kg	1.05E-1	1.08E-1	4.40E-3
Sulphur dioxide	air	kg	1.73E-4	3.50E-4	7.01E-6
Nitrogen oxides	air	kg	1.59E-4	2.00E-4	2.42E-5
Particulates, <2.5 um	air	kg	1.64E-5	2.97E-5	1.24E-5
Land occupation	resource	m2a	3.75E-3	4.14E-3	5.32E-3
BOD	water	kg	4.28E-5	5.84E-5	5.74E-6
Cadmium	soil	kg	6.46E-11	1.02E-10	1.53E-10

1.8.3 Data quality

The values provided by the statistics allow for a quite accurate modelling of the different electricity mixes. However, main uncertainty arises from the representation of non verifiable electricity (ca. 20 % of the total mix). In addition, the percentage of hydropower or nuclear power produced abroad is known, but the statistic does not specify the countries from which the hydropower is imported. The origin of the electricity can be important, e.g. in the case of electricity from photovoltaics. Further minor uncertainties can be identified with the shares of electricity from renewable sources in the consumer mix and the Swiss electricity mix due to rounded values in the statistic. These uncertainties are addressed by using more detailed information on renewable energy from the BFE report (BFE 2008b).

1.9 References

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Appendices: EcoSpold Meta Information

Tab. A. 1: Metainformation of the datasets representing „consumer mix"

ReferenceFunction	Name	electricity, consumer mix	electricity, high voltage, consumer mix. at grid	electricity, medium voltage, consumer mix, at grid	electricity, low voltage, consumer mix, at grid
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	kWh	kWh	kWh	kWh
	IncludedProcesses	This data set includes the electricity from domestic production and imported electricity. Certified electricity products are included in the calculation.	This data set includes the transmission network infrastructure and emissions from transmission.	This data set includes the transmission network infrastructure and emissions from transmission at medium voltage. SF6 and losses accounted for.	This data set includes the transmission network infrastructure and emissions from transmission at low voltage.SF6 and losses accounted for.
	Amount	1	1	1	1
	LocalName	Strom, Verbrauchermix	Strom, Hochspannung, Verbrauchermix, ab Netz	Strom, Mittelspannung, Verbrauchermix, ab Netz	Strom, Niederspannung, Verbrauchermix, ab Netz
	Synonyms				
	GeneralComment	This data set represents the production of the electricity in the Swiss supply mix, including electricity from certified sources. Shares are calculated from SFOE and AEE statistics 2007. Electricity consumption for pumped storage added to statistical values according to ecoinvent report.	This data set represents the Swiss supply mix, including electricity from certified sources. Electricity at high voltage.	This data set represents the Swiss supply mix, including electricity from certified sources. Electricity at medium voltage.	This data set represents the Swiss supply mix, including electricity from certified sources. Electricity at low voltage.
	InfrastructureIncluded	1	1	1	1
	Category	electricity	electricity	electricity	electricity
	SubCategory	supply mix	supply mix	supply mix	supply mix
	LocalCategory	Elektrizität	Elektrizität	Elektrizität	Elektrizität
TimePeriod	StartDate	2004	2004	2004	2004
	EndDate	2007	2007	2007	2007
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText	Time period of statistics used.	Time period of statistics used.	Time of publications.	Time of publications.
Geography	Text	Data valid for Supply mix with certified electricity.	Data valid for Supply mix with certified electricity.	Data valid for Supply mix with certified electricity.	Data valid for Supply mix with certified electricity.
Technology	Text				
Representativeness	Percent	100	100	100	100
	ProductionVolume	55.5 TWh	55.5 TWh	55.5 TWh	55.5 TWh
	SamplingProcedure	national statistics SFOE and AEE 2007	national statistics SFOE and AEE 2007	national statistics SFOE and AEE 2007	national statistics SFOE and AEE 2007
	Extrapolations	none	none	none	none
	UncertaintyAdjustments	none	none	none	none

Tab. A. 2: Metainformation of the datasets representing the certified electricity

ReferenceFunction	Name	electricity mix, certified	electricity, high voltage, certified, at grid	electricity, medium voltage, certified, at grid	electricity, low voltage, certified, at grid
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	kWh	kWh	kWh	kWh
	IncludedProcesses	This data set includes the electricity from certified sources. Domestic production and imports are accounted for.	This data set includes the transmission network infrastructure and emissions from transmission.	This data set includes the transmission network infrastructure and emissions from transmission at medium voltage. SF6 and losses accounted for.	This data set includes the transmission network infrastructure and emissions from transmission at low voltage. SF6 and losses accounted for.
	Amount	1	1	1	1
	LocalName	Strom, zertifizierter	Strom, Hochspannung,	Strom, Mittelspannung,	Strom, Niederspannung,
	Synonyms				
	GeneralComment	This data set represents the production of the electricity mix from renewable sources, which are sold in certified products. Shares are calculated from AEE statistics 2007.	This data set represents the electricity mix from certified sources. Electricity at high voltage.	This data set represents the electricity mix from certified sources. Electricity at medium voltage.	This data set represents the electricity mix from certified sources. Electricity at low voltage.
	InfrastructureIncluded	1	1	1	1
	Category	electricity	electricity	electricity	electricity
	SubCategory	supply mix	supply mix	supply mix	supply mix
	LocalCategory	Elektrizität	Elektrizität	Elektrizität	Elektrizität
TimePeriod	StartDate	2004	2004	2004	2004
	EndDate	2007	2007	2007	2007
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText	Time period of statistics used.	Time period of statistics used.	Time period of statistics used.	Time period of statistics used.
Geography	Text	Data valid for Electricity from certified sources	Data valid for Electricity from certified sources	Data valid for Electricity from certified sources	Data valid for Electricity from certified sources
Technology	Text				
Representativeness	Percent	100	100	100	100
	ProductionVolume	4.7 TWh	4.7 TWh	4.7 TWh	4.7 TWh
	SamplingProcedure	national statistics AEE 2007	national statistics AEE 2007	national statistics AEE 2007	national statistics AEE 2007
	Extrapolations	none	none	none	none
	UncertaintyAdjustments	none	none	none	none

Tab. A. 3: Metainformation of the datasets representing the Swiss electricity mix

ReferenceFunction	Name	electricity mix	electricity, high voltage, at grid	electricity, medium voltage, at grid	electricity, low voltage, at grid
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	kWh	kWh	kWh	kWh
	IncludedProcesses	This data set includes the electricity from domestic production and imported electricity without the shares of electricity sold as certified electricity.	This data set includes the transmission network infrastructure and emissions from transmission.	This data set includes the transmission network infrastructure and emissions from transmission at medium voltage. SF6 and losses accounted for.	This data set includes the transmission network infrastructure and emissions from transmission at low voltage. SF6 and losses accounted for.
	Amount	1	1	1	1
	LocalName	Strommix	Strom, Hochspannung, ab Netz	Strom, Mittelspannung, ab Netz	Strom, Niederspannung, ab Netz
	Synonyms				
	GeneralComment	This data set represents the electricity production for the virtual supply mix. Electricity products from certified sources are excluded. Shares are calculated from SFOE and AEE statistics 2007. Electricity consumption for pumped storage added to statistical values according to ecoinvent report.	This data set represents the Swiss supply mix, excluding electricity from certified sources. Electricity at high voltage.	This data set represents the Swiss supply mix, excluding electricity from certified sources. Electricity at medium voltage.	This data set represents the Swiss supply mix, excluding electricity from certified sources. Electricity at low voltage.
	InfrastructureIncluded	1	1	1	1
	Category	electricity	electricity	electricity	electricity
	SubCategory	supply mix	supply mix	supply mix	supply mix
	LocalCategory	Elektrizität	Elektrizität	Elektrizität	Elektrizität
TimePeriod	StartDate	2004	2004	2004	2004
	EndDate	2007	2007	2007	2007
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText	Time period of statistics used.	Time period of statistics used.	Time period of statistics used.	Time period of statistics used.
Geography	Text	Data valid for Supply mix without certified electricity	Data valid for Supply mix without certified electricity	Data valid for Supply mix without certified electricity	Data valid for Supply mix without certified electricity
Technology	Text				
Representativeness	Percent	100	100	100	100
	ProductionVolume	50.8 TWh	50.8 TWh	50.8 TWh	50.8 TWh
	SamplingProcedure	national statistics SFOE and AEE 2007	national statistics SFOE and AEE 2007	national statistics SFOE and AEE 2007	national statistics SFOE and AEE 2007
	Extrapolations	none	none	none	none
	UncertaintyAdjustments	none	none	none	none