Life Cycle Inventory of E85, LPG supply in Switzerland and Biogasmix 2008

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Abbreviations

CH	Switzerland
DE	Germany
E85	mixture of 85 vol% petrol and 15 vol% ethanol
GLO	Global
LCI	Life Cycle Inventory
LPG	Liquefied petroleum gas
RER	Europe
SE	Sweden
UCTE	Union for the Co-ordination of Transmission of Electricity

1 Introduction

This report shows the life cycle inventories of the following fuels:

- Supply of E85, mixture of 85 vol% petrol and 15 vol% ethanol, to Switzerland
- Liquefied petroleum gas, at service station
- Update of biogas production mix

The inventories are supposed to be used in the ecoinvent database and are thus established according to the ecoinvent guidelines (ecoinvent Centre 2009). The functional unit is 1 kg of product.

2 LCI of E85 supply in Switzerland

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Summary

This chapter describes the provision of E85 at service stations in Switzerland. Since 2008 ethanol is imported from Scandinavia, thus, Swedish ethanol production is modelled based on already existing ecoinvent datasets.

2.1 Introduction

Until 2008, the only producer and supplier of bioethanol in Switzerland was Borregaard Schweiz AG in Riedholz. The production of bioethanol was derived from the production of paper pulp from wood cellulose[1].

Since Borregaard closed the plant in Switzerland in 2008, ethanol supply is secured by contracts with Scandinavian bioethanol producers. Part of the Scandinavian bioethanol is produced by a process almost identical to the one Borregaard Schweiz employed and derives also from wood waste[1] (Schaller 2009).

2.2 System Characterisation

The system includes the production of ethanol from wood in Sweden, its conversion to ethanol, 99.7% in water, transport to Switzerland by train[2], distribution to service station and mixing with petrol. The mixing is conducted at the service station. Losses of refuelling are included.

The functional unit is 1 kg of product.

[1] Biofuels platform: http://www.biofuels-platform.ch/en/infos/ch-bioethanol.php - note3, December 2009, partner of the platform are the Swiss Federal Office of Energy, SwissEnergy, Laboratory of Energy Systems of EPFL, CRDE (Conférence Romande des Délégués à l'Energie) and others.

[2] Personal communication with Pierre Schaller, Alcosuisse, November 2009

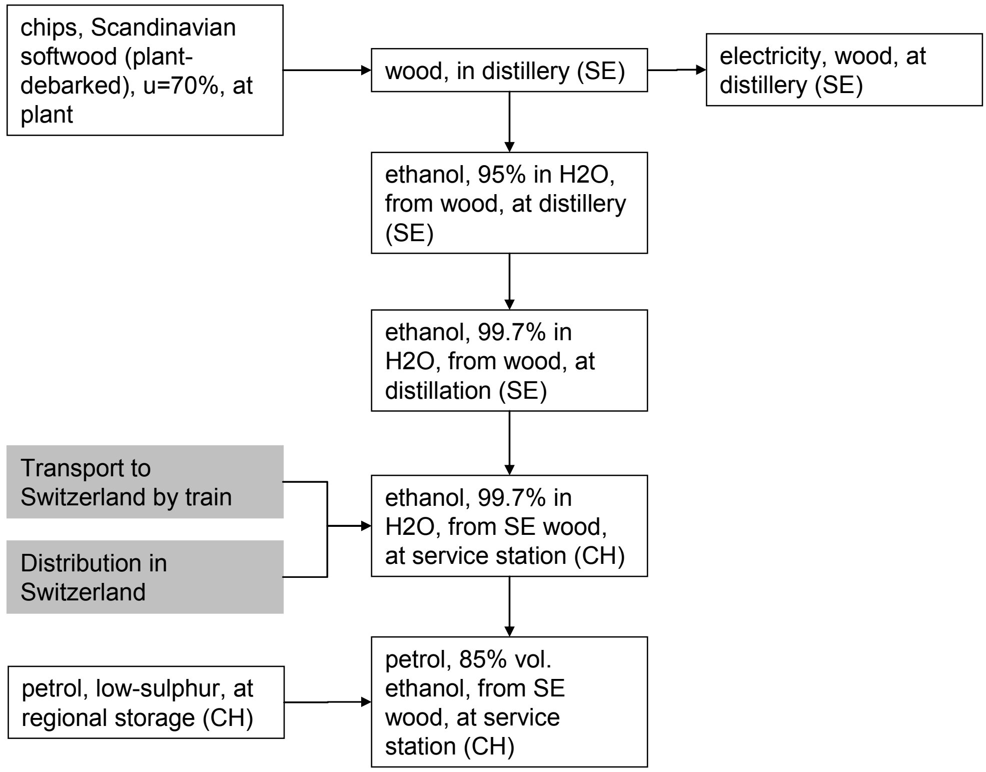

Fig. 2.1: Petrol, 85%vol. ethanol from Swedish wood at service station in Switzerland; system definition and boundaries

2.3 Wood, in distillery (SE)

The description of the production process as well as LCI data are adapted from the existing ecoinvent process "wood, in distillery, CH" with the two outputs "ethanol, 95% in H20, from wood, at distillery, CH" and "electricity, wood, at distillery, CH" (Jungbluth et al. 2007). This is a valid assumption because the Swiss biofuels-platform[1] stated that the production process as well as the use of raw materials in the Swedish production are similar to the former Swiss production. However, the wood input is changed to wood chips from Scandinavian plant-debarked softwood ("chips, Scandinavian softwood (plant-debarked), u=70%, at plant, NORDEL"). As a consequence emissions are adapted as described in (Jungbluth et al. 2007) for the process "wood, in distillery, CH" and transport means as well as water supply are changed to European conditions.

Compared to hardwood chips (u=80%) Scandinavian softwood chips (u=70%) have other characteristics. They are summarized in Tab. 2.1 together with the recalculation of the used amount of wood.

Tab. 2.1: Summary of characteristics and calculation of Scandinavian softwood chips input in ethanol production.

	Unit	Value	Remark/Source
u (moisture content)		70%	
x (water content)		41%	calculated
Dry matter content		59%	calculated
Weight softwood (u=70%), wood	kg/m^3	451	59% of total weight
Weight softwood (u=70%), water	kg/m^3	314	Calculated, 41% of total weight
Weight softwood (u=70%), total	kg/m^3	765	Value according to Tab. 4.7 in Frischknecht et al. (2007),
Total volume per t softwood (u=70%)	m^3/t	1.31	calculated

Economic allocation factors between ethanol and electricity are calculated to be 99.68% for ethanol and 0.32% for electricity (Jungbluth et al. 2007).

Tab. 2.2: Unit process raw data and uncertainty information of the multi-output process "wood, in distillery, SE" with the outputs "ethanol 95% in H2O, from wood, at distillery, SE" and" electricity, wood, at distillery, SE"

	Name	Location	InfrastructureProcess	Unit	wood, in distillery	UncertaintyType	StandardDeviation95%	GeneralComment	ethanol, 95% in H2O, from wood, at distillery	electricity, wood, at distillery
	Location				SE				SE	SE
	InfrastructureProcess				0				0	0
	Unit				kg				kg	kg
Outputs	ethanol, 95% in H2O, from wood, at distillery	SE	0	kg	1.44E-1				100	
Outputs	electricity, wood, at distillery	SE	0	kg	6.49E-3					100
technosphere	chips, Scandinavian softwood (plant-debarked), u=70%, at plant	NORDEL	0	m3	1.31E-3	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	tap water, at user	RER	0	kg	1.16E+0	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	sulphuric acid, liquid, at plant	RER	0	kg	1.19E-2	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	ammonium sulphate, as N, at regional storehouse	RER	0	kg	1.71E-4	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	diammonium phosphate, as N, at regional storehouse	RER	0	kg	2.41E-4	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	quicklime, in pieces, loose, at plant	CH	0	kg	4.64E-3	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	ammonia, liquid, at regional storehouse	CH	0	kg	9.52E-3	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	maize starch, at plant	DE	0	kg	3.81E-3	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	magnesium sulphate, at plant	RER	0	kg	7.85E-5	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	calcium chloride, CaCl2, at regional storage	CH	0	kg	1.73E-4	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	chemicals organic, at plant	GLO	0	kg	3.45E-5	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	transport, freight, rail	RER	0	tkm	1.92E-2	1	2.05	(2,3,1,2,1,5,BU:2); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	transport, lorry >16t, fleet average	RER	0	tkm	6.66E-2	1	2.05	(2,3,1,2,1,5,BU:2); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	transport, tractor and trailer	CH	0	tkm	5.00E-3	1	2.05	(2,3,1,2,1,5,BU:2); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	ethanol fermentation plant	CH	1	unit	5.96E-11	1	3.05	(2,3,1,2,1,5,BU:3); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	disposal, gypsum, 19.4% water, to inert material landfill	CH	0	kg	1.57E-2	1	1.22	(2,3,1,2,1,5,BU:1.05); etha+ project Alcosuisse, SSCF technology from NREL	9.97E+1	3.20E-1
	chlorine, liquid, production mix, at plant	RER	0	kg	8.88E-7	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	sodium chloride, powder, at plant	RER	0	kg	1.11E-5	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	lubricating oil, at plant	RER	0	kg	8.88E-6	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	8.88E-6	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	disposal, wood ash mixture, pure, 0% water, to landfarming	CH	0	kg	3.57E-4	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	8.88E-6	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	3.57E-4	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	disposal, wood ash mixture, pure, 0% water, to sanitary landfill	CH	0	kg	7.18E-4	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	2.13E-6	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	water, decarbonised, at plant	RER	0	kg	2.13E-3	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	urea, as N, at regional storehouse	RER	0	kg	7.26E-5	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	cogen unit 6400kWth, wood burning, building	CH	1	unit	6.55E-10	1	3.10	(4,4,2,1,1,5,BU:3); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	cogen unit 6400kWth, wood burning, common components for heat+electricity	CH	1	unit	2.62E-9	1	3.10	(4,4,2,1,1,5,BU:3); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	cogen unit 6400kWth, wood burning, components for electricity only	CH	1	unit	2.62E-9	1	3.10	(4,4,2,1,1,5,BU:3); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
air, high population	Heat, waste			MJ	2.91E+0	1	1.14	(2,4,1,3,1,3,BU:1.05); calculation from electricity consumption and energy balance	9.97E+1	3.20E-1
	Acetaldehyde			kg	1.65E-7	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Ammonia			kg	4.60E-5	1	1.39	(4,4,2,1,1,5,BU:1.2); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Arsenic			kg	2.71E-9	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Benzene			kg	2.67E-6	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Benzene, ethyl-			kg	8.80E-8	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Benzene, hexachloro-			kg	2.11E-14	1	3.10	(4,4,2,1,1,5,BU:3); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Benzo(a)pyrene			kg	1.47E-9	1	3.10	(4,4,2,1,1,5,BU:3); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Bromine			kg	1.62E-7	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Cadmium			kg	1.90E-9	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Calcium			kg	1.58E-5	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Carbon monoxide, biogenic			kg	2.05E-5	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Chlorine			kg	4.87E-7	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Chromium			kg	1.07E-8	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Chromium VI			kg	1.08E-10	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Copper			kg	5.96E-8	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Dinitrogen monoxide			kg	5.96E-5	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin			kg	9.09E-14	1	3.10	(4,4,2,1,1,5,BU:3); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Fluorine			kg	1.35E-7	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Formaldehyde			kg	3.81E-7	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Hydrocarbons, aliphatic, alkanes, unspecified			kg	2.67E-6	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Hydrocarbons, aliphatic, unsaturated			kg	9.09E-6	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Lead			kg	6.74E-8	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Magnesium			kg	9.77E-7	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Manganese			kg	4.63E-7	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Mercury			kg	8.12E-10	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Methane, biogenic			kg	1.27E-6	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	m-Xylene			kg	3.52E-7	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Nickel			kg	1.62E-8	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Nitrogen oxides			kg	1.19E-4	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	NMVOC, non-methane volatile organic compounds, unspecified origin			kg	1.79E-6	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	PAH, polycyclic aromatic hydrocarbons			kg	3.23E-8	1	3.10	(4,4,2,1,1,5,BU:3); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Particulates, < 2.5 um			kg	1.47E-5	1	3.10	(4,4,2,1,1,5,BU:3); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Phenol, pentachloro-			kg	2.38E-11	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Phosphorus			kg	8.12E-7	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Potassium			kg	6.34E-5	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Sodium			kg	3.52E-6	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Sulfur dioxide			kg	6.74E-6	1	1.32	(4,4,2,1,1,5,BU:1.05); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Toluene			kg	8.80E-7	1	1.63	(4,4,2,1,1,5,BU:1.5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Zinc			kg	8.12E-7	1	5.12	(4,4,2,1,1,5,BU:5); adapted from the dataset 'wood chips, in cogen 6400kWth, wood, emission control', according to actual water, carbon and energy content of the fuel (unconverted solids, mainly lignin)	9.97E+1	3.20E-1
	Carbon dioxide, biogenic			kg	7.43E-1	1	1.05	(1,1,1,1,1,1,BU:1.05); to close carbon cycle	9.97E+1	3.20E-1

2.4 Ethanol, 99.7% in H20, from wood, at distillation (SE)

The modelling of the conversion of hydrated ethanol 95% to anhydrous ethanol 99.7% is based on the dataset "ethanol, 99.7% in H20, from biomass, at distillation (RER)". On a wet basis the ratio of hydrated to anhydrous ethanol is 1.05 kg (0.997/0.95). However, on a dry matter basis the 1 kg ethanol 95% is used to produce 1 kg ethanol, 99.7%. A more detailed description of this process is shown in Jungbluth (2007).

Included in this dataset are input of ethanol, energy consumption, treatment of liquid effluents and infrastructure (Jungbluth et al. 2007).

Unit process raw data are shown in Tab. 2.3.

Tab. 2.3: Unit process raw data of the process "ethanol, 99.7% in H2O, from wood, at distillation" for Swedish conditions.

Explanations	Name	Location	Infrastructure-Process	Unit	ethanol, 99.7% in H2O, from wood, at distillation	uncertaintyType	StandardDeviation95%	GeneralComment
	Location				SE			
	InfrastructureProcess				0			
	Unit				kg			
Output	ethanol, 99.7% in H2O, from wood, at distillation	SE	0	kg	1.00E+0			
technosphere	ethanol, 95% in H2O, from wood, at distillery	SE	0	kg	1.00E+0	1	1.05	(1,1,1,1,1,1); Product, calculation
	electricity, medium voltage, at grid	SE	0	kWh	9.15E-3	1	2.05	(1,2,1,1,1,5); etha+ project Alcosuisse, industrial data
	heat, natural gas, at industrial furnace >100kW	RER	0	MJ	1.02E+0	1	1.21	(1,2,1,1,1,5); etha+ project Alcosuisse, industrial data
	ethanol fermentation plant	CH	1	unit	5.30E-11	1	2.05	(1,2,1,1,1,5); etha+ project Alcosuisse, industrial data
	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	4.96E-5	1	2.05	(1,2,1,1,1,5); etha+ project Alcosuisse, industrial data
air, high population density	Heat, waste			MJ	3.29E-2	1	1.14	(2,4,1,3,1,3); Calculated from the electricity input

2.5 Ethanol, 99.7% in H20, from SE wood, at service station (CH)

To provide ethanol at the service station it first needs to be imported from Scandinavia to Switzerland where it is distributed to the service stations.

According to Alcosuisse[3] ethanol is transported from Scandinavia to Switzerland by train. Thus, a distance of 2400 km is included until the Swiss border. Within Switzerland ecoinvent standard distances (Frischknecht et al. 2007) of 100 km by train and 150 km by lorry are considered.

For reasons of consistency with other datasets relating to the distribution of fuels (gasoline, diesel, other biofuels (Jungbluth 2004; 2007), the distribution part is based on the existing dataset "petrol, unleaded, at regional storage" (Jungbluth 2004; 2007). A loss of 0.0005 kg/kg ethanol at service station is taken into account as well.

[3] Personal communication with Pierre Schaller, Alcosuisse, November 2009

Tab. 2.4: Unit process raw data of the process “ethanol, 99.7% in H2O, from Swedish wood, at service station”.

Explanations	Name	Location	Category	Sub-Category	Infrastructure-Process	Unit	ethanol, 99.7% in H2O, from Swedish wood, at service station	uncertaintyType	StandardDeviation95%	GeneralComment
	Location						CH			
	InfrastructureProcess						0			
	Unit						kg			
Output	ethanol, 99.7% in H2O, from Swedish wood, at service station	CH	-	-	0	kg	1.00E+0			
technosphere	ethanol, 99.7% in H2O, from wood, at distillation	SE	-	-	0	kg	1.00E+0	1	1.05	(1,1,1,1,1,1); Product plus losses
	electricity, low voltage, at grid	CH			0	kWh	6.70E-3	1	1.25	(2,4,1,3,3,3); Estimation according fuel distribution
	light fuel oil, burned in boiler 100kW, non-modulating	CH			0	MJ	6.21E-4	1	1.25	(2,4,1,3,3,3); Estimation according fuel distribution
	tap water, at user	CH			0	kg	6.89E-4	1	1.25	(2,4,1,3,3,3); Data for fuel distribution
	transport, freight, rail	RER	-	-	0	tkm	2.40E+0	1	2.10	(4,5,na,na,na,na); Sweden to Swiss border 2400 km
	transport, lorry >28t, fleet average	CH	-	-	0	tkm	1.50E-1	1	2.10	(4,5,na,na,na,na); standard distances
	transport, freight, rail	CH	-	-	0	tkm	1.00E-1	1	2.10	(4,5,na,na,na,na); standard distances
	regional distribution, oil products	RER			1	p	2.60E-10	1	3.09	(4,5,na,na,na,na); Estimation
	treatment, sewage, to wastewater treatment, class 2	CH			0	m3	6.89E-7	1	1.25	(2,4,1,3,3,3); Estimation according fuel distribution
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH			0	m3	7.50E-5	1	1.25	(2,4,1,3,3,3); Estimation according fuel distribution
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH			0	kg	6.27E-6	1	1.25	(2,4,1,3,3,3); Estimation according fuel distribution
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH			0	kg	1.68E-4	1	1.25	(2,4,1,3,3,3); Estimation according fuel distribution
air, high population density	Ethanol		air	high population density		kg	5.00E-4	1	1.58	(3,na,1,3,3,na); Estimation
	Heat, waste		air	high population density		MJ	2.41E-2	1	1.14	(2,4,1,3,1,3); Calculated from the electricity input

2.6 Petrol, 85% vol. ethanol, from Swedish wood, at service station (CH)

According to Jungbluth (2007) the two components ethanol 99.7% and petrol are mixed at the service station. Tab. 2.5 gives an overview of the characteristics of E85 and Tab. 2.5 summarizes the inventory.

Tab. 2.5: Characteristics of petrol, 85% vol. ethanol, from Swedish wood

	Unit	Value
Density E85	kg/l	0.783
Net calorific value	MJ/kg	30.17

Tab. 2.6: Unit process raw data of the process “petrol, 85% vol. ethanol, from Swedish wood, at service station”.

Explanations	Name	Location	Category	Sub-Category	Infrastructure-Process	Unit	petrol, 85% vol. ethanol, from Swedish wood, at service station	uncertaintyType	StandardDeviation95%	GeneralComment
	Location						CH			
	InfrastructureProcess						0			
	Unit						kg			
Output	petrol, 85% vol. ethanol, from Swedish wood, at service station	CH	-	-	0	kg	1.00E+0			
Technosphere	petrol, low-sulphur, at regional storage	CH			0	kg	1.44E-1	1	1.21	(1,2,1,1,1,5); Calculations, according to the incorporation rate of ethanol and the respective densities of ethanol (0.783 kg/l) and gasoline (0.75 kg/l)
	ethanol, 99.7% in H2O, from Swedish wood, at service station	CH	-	-	0	kg	8.56E-1	1	1.21	(1,2,1,1,1,5); Calculations, according to the assumed ethanol mix

2.7 Data Quality Considerations

The simplified approach with a pedigree matrix is applied. Inventories are mainly based on existing ecoinvent datasets.

2.8 Cumulative Results and Interpretation

Results can be downloaded from the database (www.ecoinvent.org)

3 Liquefied Petroleum Gas

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Review: Roland Hischier, Empa, St. Gallen

Acknowledgement

The authors would like to thank to a Western European LPG company for providing data on LPG distribution.

Summary

This chapter describes the provision of LPG at service stations in Switzerland. The liquefied petroleum gas consists of 50% butane and 50% propane. Data on distribution are based on company data, thus, data quality is considered to be good.

3.1 Introduction

The term liquefied petroleum gas (LPG, GPL, LP gas, autogas) describes hydrocarbon mixtures in which the main components are propane, butane, isobutane, propene, and butenes. It is extracted at natural gas extraction or produced as by-product in refineries (Thompson & Robertson 2005).
LPG can be used for different purposes, e.g. in the petrochemical industry, in the transport sector for fuel or in the household for barbecue or as heating fuel.

This inventory describes the use of LPG in the transportation sector. LPG is a knockproof motor fuel and stored liquid at a pressure between 5 and 10 bar. Characteristics are shown in the following Tab. 3.1.

Tab. 3.1: Characteristics of LPG

	Unit	Value
Relation propane/butane[4]	-	50% / 50%
Density	kg/l	0.592
Net calorific value	MJ/kg	46.14
CO_2 emissions burning LPG	kg/kg	3.0195

For the determination of the CO_2-emissions a C-content of 82.3% in the mixture is calculated. The carbon fixed in CO-emissions is not yet subtracted.

3.2 System Characterisation

The system includes the production of propane/butane in Swiss and European refineries (Jungbluth 2007), its distribution within Switzerland and the fuelling process at the service station. The functional unit is 1 kg LPG refuelled at the service station.

[4] Data from a Western European LPG company

3.3 Origin and Use of LPG

Swiss trade statistics of LPG are provided by BFE[5]. Most important trade partners for import and export in 2008 were Germany, Serbia, Italy and Croatia. Only about 3% of total LPG consumption is used in the transportation sector. The mixture of LPG distributed in Switzerland derives from European refineries (about 20%) and Swiss Refineries (about 80%). In the modelling the average of the years 1999 until 2008 is used.

3.4 Liquefied petroleum gas, at service station in Switzerland

3.4.1 Production of LPG

Inventories for LPG production at the refinery are already established and described (Jungbluth 2004; 2007). The names of these datasets are “propane/butane, at refinery, CH” and “propane/butane, at refinery, RER”.

3.4.2 Distribution of LPG

To estimate transportation expenditures from European refineries to Switzerland standard distances as defined in Frischknecht (2004) are used, i.e. 100 km by lorry >16t and 600 km by train.

Data for the distribution of LPG within Switzerland are provided by a Western European LPG company. A summary of the provided data is shown in Tab. 3.2. No losses occur during storage of LPG. Overall losses from loading of lorries until refueling of the car amount to 0.033%. These losses are released to air (50% propane/50% butane). Treatment of waste water and solid waste treatment are assumed to be the same as for the distribution of oil products (Jungbluth 2007).

Tab. 3.2: LPG distribution data

	Amount	Unit
Evaporation losses at loading	0.25	kg/t
Transport distance storage to service station (including return trip)	168	km
Fuel consumption lorry	0.35	l/km
Losses unloading at service station	0.05	kg
Average LPG load per time for service station	2000	kg
Energy consumption service station	0.00278	kWh/kg
Losses at refuelling car	0.0015	kg
Average fuel volume per refuel time	50	l

3.4.3 LCI of LPG, at service station

Unit process raw data of LPG fuelled at service station in Switzerland are shown in Tab. 3.3.

[5] Personal communication with Jasmin Gülden, Energie und Kommunikation UVEK, Bundesamt für Energie BFE, Sektion Analysen und Perspektiven, 16.12.2009

Tab. 3.3: Unit process raw data and uncertainty information of the process "liquefied petroleum gas, at service station".

	Name	Location	InfrastructureProcess	Unit	liquefied petroleum gas, at service station	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
product	liquefied petroleum gas, at service station	CH	0	kg	1			
technosphere	propane/ butane, at refinery	CH	0	kg	8.025E-01	1	1.05	(1,1,1,1,1,1); Product plus losses at loading, unloading and refuelling, trade mix according to BFE (2009)
	propane/ butane, at refinery	RER	0	kg	1.979E-01	1	1.05	(1,1,1,1,1,1); Product plus losses at loading, unloading and refuelling, trade mix according to BFE (2009)
	transport, lorry >16t, fleet average	RER	0	tkm	1.979E-02	1	2.09	(4,5,na,na,na,na); LPG Transport from European refineries to Switzerland
	transport, freight, rail	RER	0	tkm	1.187E-01	1	2.09	(4,5,na,na,na,na); LPG Transport from European refineries to Switzerland
	transport, lorry 20-28t, fleet average	CH	0	tkm	8.401E-02	1	2.00	(1,1,1,1,1,1); Distribution in Switzerland, 168 km including return trip
	electricity, low voltage, at grid	CH	0	kWh	2.780E-03	1	1.05	(1,1,1,1,1,1); at the filling station
	regional distribution, oil products	RER	1	unit	2.780E-10	1	3.02	(2,4,1,3,1,3); according to distribution of oil
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	6.890E-07	1	1.14	(2,4,1,3,1,3); according to distribution of oil
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH	0	m3	7.500E-05	1	1.14	(2,4,1,3,1,3); according to distribution of oil
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	6.270E-06	1	1.14	(2,4,1,3,1,3); according to distribution of oil
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg	1.680E-04	1	1.14	(2,4,1,3,1,3); according to distribution of oil
emission air, high population density	Heat, waste	-	-	MJ	1.001E-02	1	1.05	(1,1,1,1,1,1); due to electricity consumption
	Propane	-	-	kg	1.648E-04	1	1.50	(1,1,1,1,1,1); losses, mix LGP 50% butane and 50% propane
	Butane	-	-	kg	1.648E-04	1	1.50	(1,1,1,1,1,1); losses, mix LGP 50% butane and 50% propane

3.5 Data Quality Considerations

The simplified approach with a pedigree matrix is applied.

3.6 Cumulative Results and Interpretation

Results can be downloaded from the database (www.ecoinvent.org)

4 Biogas Mix 2008

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Review: Roland Hischier, Empa, St. Gallen

4.1 Introduction

In this update the biogas mix fed into the natural gas network (according to Jungbluth et al. 2007) is adapted to the Swiss situation in 2008.

The Swiss statistics about renewable energy shows data on biogas input in the natural gas network and service stations (BFE 2009). Important data are summarized in Tab. 4.1. Share of biogas from biowaste in the biogas mix is thus 48% and share of biogas from sewage sludge 52%.

Tab. 4.1: Biogas fed into the natural gas network in 2008

Biogas input in natural gas network and direct sale at service stations	14.3	GWh
Sewage gas input in natural gas network	15.5	GWh
Total	29.8	GWh

Tab. 4.2: Unit process raw data and uncertainty information of the process "biogas, production mix, at storage, CH"

	Name	Location	InfrastructureProc	Unit	biogas, production mix, at storage	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				Nm3			
product	biogas, production mix, at storage	CH	0	Nm3	1			
technosphere	biogas, from biowaste, at storage	CH	0	Nm3	4.80E-1	1	1.05	(1,1,1,1,1,1); based on statistics
	biogas, from sewage sludge, at storage	CH	0	Nm3	5.20E-1	1	1.05	(1,1,1,1,1,1); based on statistics

4.2 Data Quality Considerations

The simplified approach with a pedigree matrix is applied.

4.3 Cumulative Results and Interpretation

Results can be downloaded from the database (www.ecoinvent.org)

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