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生命週期評估
전 과정 평가
வாழ்க்கை வட்டப் பகுப்பாய்வு
ارزیابی چرخه عمر
Evaluarea Ciclului de Viață
Posuzování Životního Cyklu
Bizi zikloaren analisi
Olelusringi hindamine
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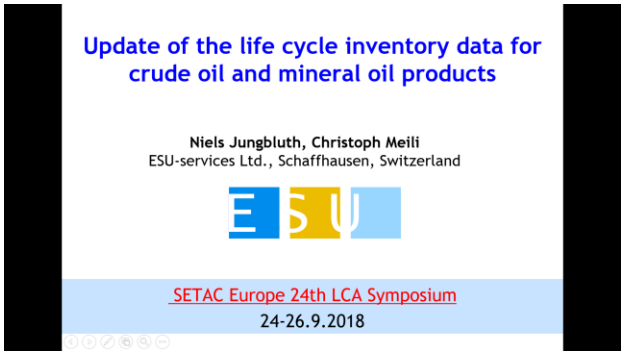

Update of the life cycle inventory data for crude oil and mineral oil products

Niels Jungbluth, Christoph Meili
ESU-services Ltd., Schaffhausen, Switzerland

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Who are we?

Dr Niels Jungbluth

Over 20 years of experience in life cycle assessment

Founded 1998 as an ETHZ spin-off

Christoph Meili

Clients from industry, NGOs, administration, universities

Own LCA database with more than 6'000 datasets

Update 2018

LCI OF MINERAL OIL PRODUCTS

Introduction – Goal and Scope

- Last update of ecoinvent data in 2007 (reference year 2000) with many data still from 1994-96
- The goal was to update the LCI data for mineral oil products from a Swiss perspective for the reference year 2016
- Focus on updates of most relevant data points
- Quality check with GWP, CED and ecological scarcity (UBP2013)

Starting point - Major developments

- New countries are now important for crude oil supplies to Switzerland and Europe
- Close-down of one out of two Swiss refineries lead to increased imports of products to CH
- Blending with biofuels for automotive fuels
- Developments for heating technologies

Deliverables: 5 English reports (250 pages) and XML data in EcoSpold v1

- Crude oil extraction in 8 countries
- Long distance transport to refineries
- Refinery processing in CH/RER
- Storage and distribution of mineral oil products
- Heating with light and heavy fuel oil in CH/RER
- 144 XML datasets for unit processes linked to ecoinvent v2.2 data (KBOB 2016) and published on www.lc-inventories.ch

New & updated Datasets

Imports of crude oil from	cumulated to Switzerland	availability of dataset in	Onshore & Offshore?	combined oil&gas?
Russia	25.4%	ecoinvent v1.0	Onshore only	No
Nigeria	13.6%	ecoinvent v1.0	Yes	Yes
Kazakhstan	9.6%	KBOB v2.2	Yes	No
Norway	8.8%	ecoinvent v1.0	Offshore only	Yes
Iraq	7.2%	new	Onshore only	Yes
Mexico	6.4%	new	Yes	Yes
Saudi-Arabia	5.8%	new	Yes	Yes
USA	4.6%	ecoinvent v3	Onshore only	Yes
Azerbaijan	3.2%	KBOB v2.2+	Offshore only	No
Libya	2.3%	ecoinvent v1.0	Onshore only	No
Algeria	2.1%	ecoinvent v1.0	Onshore only	No
Egypt	0.9%	-	-	-
Other countries	10.2%			
Source	Erdöl-Vereinigung 2016 & statista.com			

new
updated

Updates: oil extraction

- New supply situation to Switzerland and Europe considered
- Data are available on different levels and show a high variation
- Focus on direct energy uses and emissions including drilling, venting and flaring (high variability and thus uncertain!)
- Reduction of ozone depleting substances
- Use and disposal of water

Methane emissions due to flaring and venting

- More reliable data for flaring from satellite measurements (Worldbank 2016)
- For venting, besides emissions from technical leaks now data from broken rock formations are also taken into account (Höglung-Isaksson 2012).
- Values for venting up to 100 times higher than in the last analysis!

Results: oil extraction

- Still large differences between different countries
- Changes on venting and flaring dominate the results
- US venting assessment still under discussion

technology	reference value	primary energy factor, total	primary energy factor,fossil	primary energy factor, nuklear	primary energy factor, renewable	CO2 equivalents	eco-points	CO2 equivalents	CO2-eq direct (IOGP2015)	Range EU study	EROEI (this study)	EROEI (direct model)	EROEI (in literature)
		MJ-eq	MJ-eq	MJ-eq	MJ-eq	kg CO2-eq	eco-points 2013	gCO2/MJ	gCO2/MJ	gCO2/MJ	-		-
production onshore /RU	kg OE	52.4	51.9	0.41	0.15	0.55	1'471	12.8	2.3	3-7.5	8	17	24
production /NG	kg OE	49.2	49.2	0.02	0.01	0.52	576	12.1	4.9	10-22	14	14	17
production offshore /KZ	kg OE	49.7	49.7	0.02	0.02	0.40	1'064	9.4	2.3	3-7.5	12	25	23
production onshore /KZ	kg OE	51.0	50.8	0.15	0.08	0.48	1'398	11.2	2.3	3-7.5	9	19	23
production /KZ	kg OE	50.7	50.5	0.12	0.06	0.47	1'318	10.8	2.3	3-7.5	10	20	23
production offshore /NO	kg OE	48.1	48.0	0.02	0.03	0.40	700	9.2	1.3	2.5-4	21	22	22
production /IQ	kg OE	50.4	50.3	0.10	0.04	0.64	799	14.9	1.3	3-10	10	11	11
production offshore /MX	kg OE	48.3	48.3	0.02	0.02	0.43	1'229	10.0	3.0	3-10	18		20
production onshore /MX	kg OE	49.7	49.4	0.16	0.09	0.51	880	11.9	3.0	3-10	13		20
production /MX	kg OE	48.7	48.6	0.06	0.04	0.45	1'141	10.5	3.0	3-10	17	20	20
production offshore /SA	kg OE	47.1	47.1	0.02	0.02	0.32	1'144	7.3	1.3	1-5	36		49
production onshore /SA	kg OE	47.4	47.3	0.10	0.04	0.33	649	7.7	1.3	1-5	31		49
production /SA	kg OE	47.4	47.2	0.08	0.03	0.33	759	7.6	1.3	1-5	32	49	49
production offshore /US	kg OE	51.6	51.5	0.09	0.02	1.33	1'322	30.7	6.3	3-17	8		8
production onshore /US	kg OE	54.5	54.1	0.27	0.14	1.51	1'606	34.9	6.3	3-17	6		8
production /US	kg OE	54.0	53.6	0.24	0.12	1.48	1'554	34.2	6.3	3-17	6	7	8
production offshore /GB	kg OE	48.2	48.1	0.02	0.02	0.15	821	3.4		3-4	20		
production offshore /NL	kg OE	46.6	46.5	0.03	0.02	0.06	655	1.3		2-4	64		
production onshore /NL	kg OE	46.3	46.2	0.02	0.01	0.04	189	0.8		2-4	102		
production onshore RAF	kg OE	50.0	49.5	0.32	0.11	0.38	546	8.8			12		
production onshore RME	kg OE	47.3	47.2	0.02	0.03	0.14	378	3.1			33		

Updates: long distance transports

- Transport from oil field to refinery
- New origins added
- New model for average European refinery instead of just considering EU refineries supplying to CH
- One dataset for modelling average supply to refinery (easier to handle updates)

Results: long distance transports

- Crude oil at production is the most dominant contributor for most indicators
- Differences are mainly due to differences in crude oil extraction
- Second most important are distances for transports by oceanic tanker and pipeline
- Direct emissions, energy uses, and infra-structure are of minor importance

Updates: Refineries

- Petrol and diesel modelled with low-sulphur (10 ppm) only
- Update of product properties, e.g. carbon and energy content (must be considered for datasets using products!)
- Update for internal energy use and emissions
- Change of allocation for crude input (energy content instead of mass)

Results: oil refinery

Refinery products	reference value	primary energy factor, total	primary energy factor,fossil	primary energy factor, nuklear	primary energy factor, renewable	CO2 equivalents	eco-points	primary energy factor,fossil	CO2 equivalents
		MJ-eq	MJ-eq	MJ-eq	MJ-eq	kg CO2-eq	eco-points 2013	MJ-eq/MJ	kg CO2-eq/MJ
benzene/CH	kg	56.6	55.5	0.84	0.24	0.90	1'549	1.37	22.2
bitumen/RER	kg	51.7	50.9	0.67	0.22	0.70	1'338	1.25	17.3
diesel/CH	kg	55.0	54.2	0.56	0.17	0.94	1'518	1.26	21.8
diesel/RER	kg	55.7	54.9	0.61	0.20	0.82	1'476	1.28	19.1
heavy fuel oil/CH	kg	51.7	50.9	0.59	0.18	0.83	1'401	1.24	20.1
heavy fuel oil/RER	kg	52.1	51.3	0.62	0.20	0.70	1'345	1.25	17.1
kerosene/CH	kg	54.9	54.2	0.52	0.16	0.92	1'510	1.26	21.4
kerosene/RER	kg	55.6	54.8	0.59	0.20	0.80	1'461	1.27	18.5
light fuel oil/CH	kg	54.6	53.9	0.55	0.17	0.92	1'502	1.26	21.4
light fuel oil/RER	kg	55.3	54.5	0.61	0.20	0.80	1'456	1.27	18.7
naphtha/CH	kg	56.6	55.5	0.84	0.24	0.90	1'549	1.23	20.0
naphtha/RER	kg	57.2	56.1	0.82	0.26	0.77	1'495	1.25	17.2
petrol/CH	kg	55.1	54.0	0.84	0.24	0.95	1'549	1.27	22.3
petrol/RER	kg	56.2	55.1	0.83	0.26	0.87	1'529	1.29	20.4
petroleum coke/RER	kg	40.4	39.7	0.58	0.18	0.55	1'046	1.25	17.2
propane/ butane/CH	kg	59.7	58.6	0.86	0.25	1.04	1'673	1.27	22.7
propane/ butane/RER	kg	60.9	59.7	0.89	0.28	0.96	1'653	1.30	20.8
refinery gas/CH	kg	61.7	60.8	0.67	0.20	1.02	1'693	1.25	21.0
refinery gas/RER	kg	62.4	61.4	0.72	0.24	0.88	1'635	1.26	18.1

Interpretation

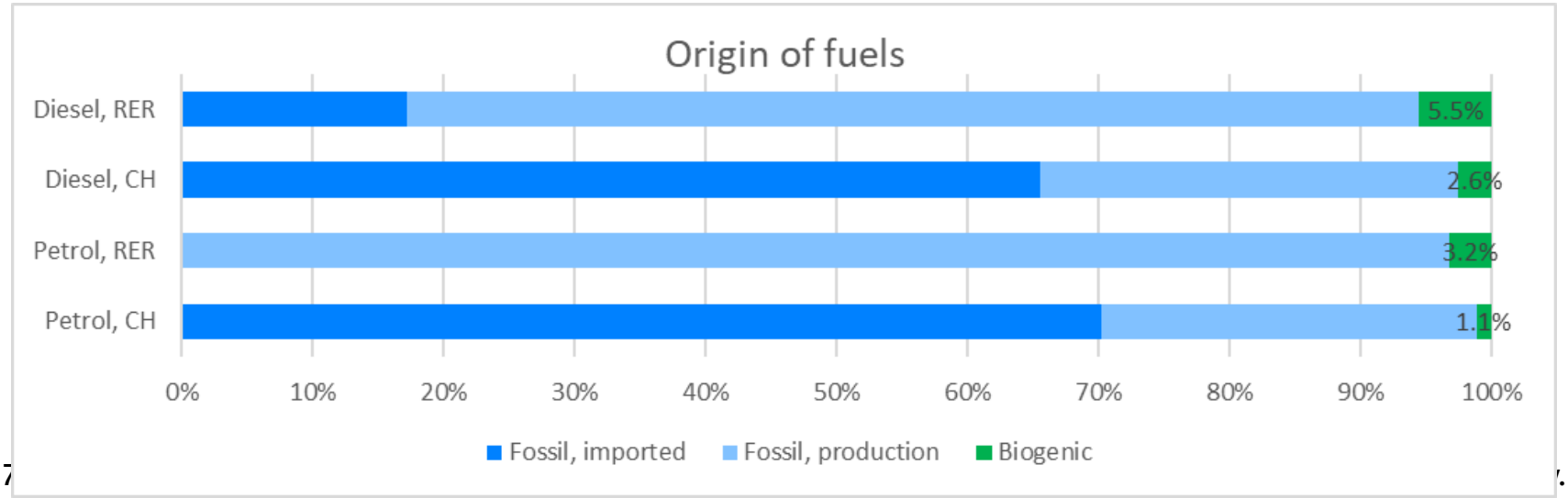
- Increase of eco-points for CH products and a decrease for EU products due to harmonization of assumptions
- Increase of the GWP for all products due to new data for venting emissions during crude oil extraction
- No clear trend for the fossil energy demand. Changes due to allocation factors
- European products have slightly higher energy demand than products of the Swiss refinery. This is mainly due to the higher internal energy use

Updates: storage and distribution of oil products

- Share of biofuels in transportation fuels modelled at this stage
- Update of fugitive emissions
- Update on transport distances
- No investigation of specific products like E10/85 as not relevant anymore

Blending with biofuels

- Share of import and domestic biofuels considered
- Biomass feedstocks considered
- Assumption all fuels are blended (average supply of petrol and diesel) and no set a side for “green” fuels sold separately
- Credit for biogenic carbon content to correct the inventories which use these fuel inputs



Results: storage and distribution

- Most changes explained by changes until refinery and due to oil extraction
- Biofuels used for blending are very relevant for eco-points and renewable energy → Higher eco-points for European fuels with agricultural biomass

Refinery products	reference value	primary energy factor, total	primary energy factor,fossil	primary energy factor, nuklear	primary energy factor, renewable	CO2 equivalents	eco-points	primary energy factor,fossil	Lower heating value
		MJ-eq	MJ-eq	MJ-eq	MJ-eq	kg CO2-eq	eco-points 2013	MJ-eq/MJ	MJ-eq/kg
diesel/CH	kg	55.1	54.1	0.77	0.24	0.81	1'520	1.26	43.0
diesel/RER	kg	57.3	53.8	1.00	2.34	0.79	1'802	1.25	43.0
heavy fuel oil/CH	kg	52.6	51.3	1.02	0.28	0.83	1'436	1.25	41.2
heavy fuel oil/RER	kg	53.3	52.1	0.88	0.28	0.76	1'421	1.26	41.2
kerosene/CH	kg	56.6	55.2	1.06	0.32	0.84	1'530	1.28	43.2
kerosene/RER	kg	56.5	55.3	0.84	0.27	0.85	1'517	1.28	43.2
light fuel oil/CH	kg	56.2	54.8	1.05	0.31	0.88	1'539	1.28	42.9
light fuel oil/RER	kg	56.4	55.3	0.86	0.28	0.86	1'532	1.29	42.9
naphtha/CH	kg	58.1	56.5	1.29	0.37	0.85	1'580	1.26	45.0
naphtha/RER	kg	58.3	56.9	1.08	0.34	0.83	1'572	1.26	45.0
petrol/CH	kg	57.3	54.9	1.30	1.07	0.90	1'619	1.29	42.6
petrol/RER	kg	57.8	54.8	1.13	1.85	0.86	1'760	1.29	42.6

Updates: Heating with light fuel oil

- Update of key air emissions and efficiencies with new data
- Renaming of main datasets to “average” in order to reflect today average technology
- Better explanation of efficiency and temperature levels
- Keep differences between “burned in” and “heat, at” to allow change of working conditions

Results: oil heatings

- Lower eco-points for heavy fuel oil burned in industrial furnace due to lowered air emission factors and reduced emissions in the production
- Increase in GWP due to higher venting rates found for crude oil extraction

technology	reference value	primary energy factor, total		eco-points		CO2 equivalents	
		MJ-eq		eco-points		kg CO2-equivalents	
light fuel oil, 10kW, non-modulating	MJ	1.34	1.37	71.5	78.4	0.090	0.096
light fuel oil, 10kW condensing, non-modulating	MJ	1.34	1.37	71.7	78.5	0.090	0.096
light fuel oil, 100kW, non-modulating	MJ	1.31	1.33	69.6	76.2	0.090	0.095
light fuel oil, 100kW condensing, non-modulating	MJ	1.31	1.33	69.8	76.3	0.090	0.095
light fuel oil, 1MW, CH	MJ	1.30	1.32	73.5	72.0	0.089	0.094
light fuel oil, 1MW, RER	MJ	1.30	1.33	75.7	72.0	0.090	0.094
heavy fuel oil, 1MW, CH	MJ	1.32	1.29	81.7	83.7	0.093	0.098
heavy fuel oil, 1MW, RER	MJ	1.36	1.30	106.1	84.2	0.093	0.096
Source		KBOB v2.2: 2016	This study	KBOB v2.2: 2016	This study	KBOB v2.2: 2016	This study

CHALLENGES FOR UPDATES IN 2016 - COMPARED TO 1994-2003

First version in 1996

- Estimates often based on bottom-up approaches
- Data available from measurements done e.g. at universities
- Comprehensive inventory of pollutants, e.g. detailed emission profiles for single NMVOC

Updates 2000-2003

- More data are available in environmental reports of single companies
- Focus on energy use and main pollutants
- No newer data for many pollutants reported in the first version
- Different data sources had to be combined for an estimate

Updates in 2018

- Most information available in the internet
- Data available from European statistics, large measurement campaigns or associations
- More information found for European situation and less for Africa, Russia or Middle East
- Reports of global oil companies cannot be assigned to single countries nor single stages, often only relative changes are shown → Not suitable for LCI work anymore
- Focus in literature on main air pollutants like CO, NO_X, SOx, NMOVC
- No current information found for specific pollutants (heavy metals, single NMVOC) reported in former versions

Thank you very much for your attention!

Validation of data by ZHAW is underway
Data and reports should be available soon on
www.lc-inventories.ch

Contact:

jungbluth@esu-services.ch

meili@esu-services.ch

Website:

http://www.esu-services.ch

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In case of any questions, please contact:

Dr. Niels Jungbluth, CEO - Chief Executive Officer
ESU-services Ltd. - fair consulting in sustainability
Vorstadt 14
CH-8200 Schaffhausen
www.esu-services.ch
tel +41 44 940 61 32
jungbluth@esu-services.ch