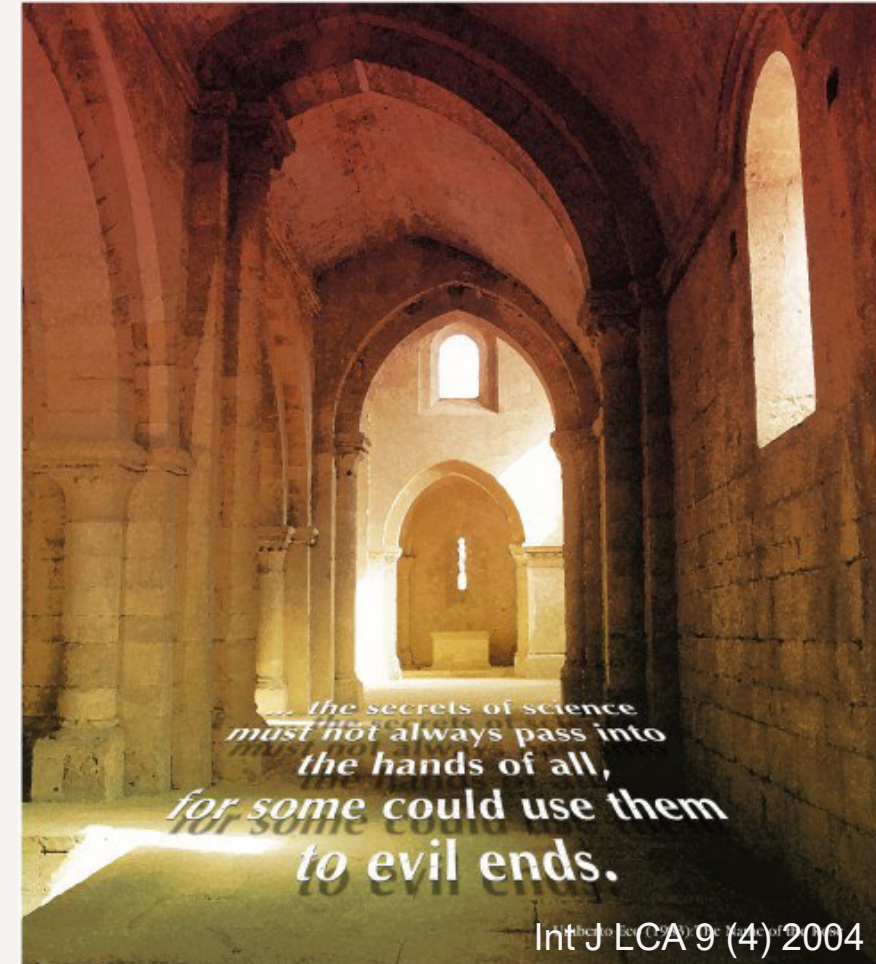


A historical perspective on the database development

Dr. Rolf Frischknecht

84. LCA Forum

Zürich, Schweiz, 21 September 2023



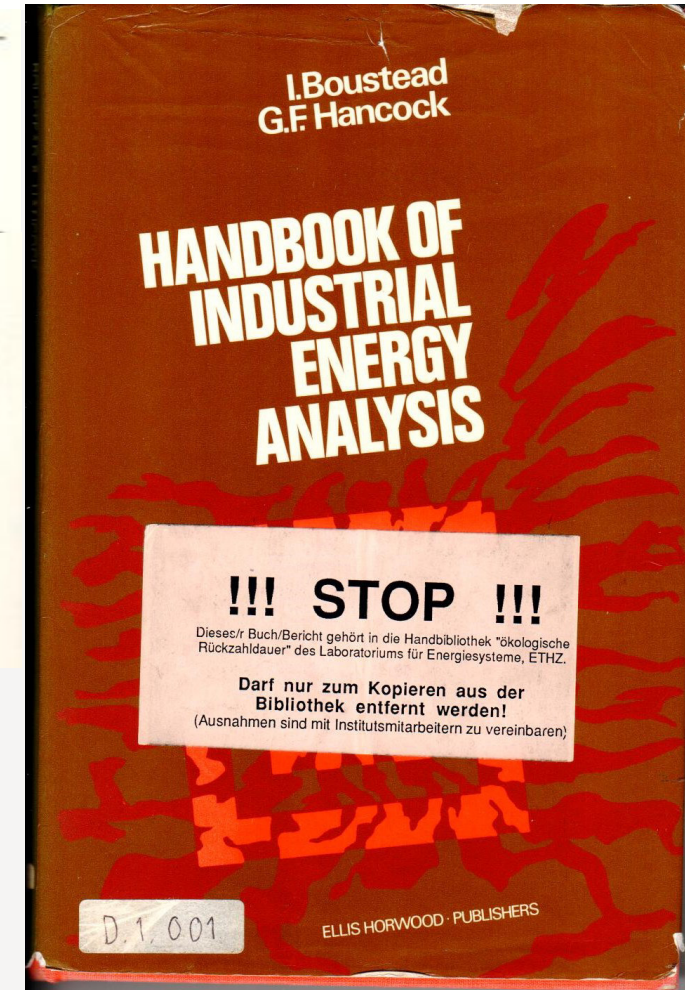
Overview

- History of LCA databases
- Frugality: Keep it simple
- Collaboration: Clear modelling rules
- Transparency: Documentation is key
- Quality: Use of brain power
- Impact: And what about the effect?



Seventies: Data compilation on cumulative energy demand of materials and chemicals

System Type	Electricity		Oil Fuels		Feedstock	Other Fuels		Feedstock	Total System Energy Requirement	Notes (see page 376 et seq.)
	Fuel production energy	Energy content of fuel	Fuel production energy	Energy content of fuel		Fuel production energy	Energy content of fuel			
CEMENT from raw materials (MJ/kg)										
<i>J</i>	*	*	*	*	*	*	*	*	4.60	(1), (40)
<i>A</i>	1.12	0.35	0.04	0.20	—	0.52	3.60	—	5.83	(6), (22), (199)
<i>F</i>	1.14	0.36	—	—	—	0.78	5.40	—	7.68	(1), (4), (54), (127), (164)
<i>H</i>	*	*	*	*	*	*	*	*	7.79	(2), (50), (195)
<i>J</i>	*	*	*	*	*	*	*	*	8.00	(2), (52), (127)
<i>A</i>	1.12	0.35	0.04	0.18	—	0.85	5.93	—	8.47	(6), (22), (200)
<i>D</i>	1.33	0.42	0.20	0.98	—	0.58	5.62	—	9.13	(1), (704), (712)
<i>F</i>	1.14	0.36	—	—	—	0.99	6.84	—	9.33	(1), (4), (54), (127), (614)
<i>H</i>	(1.14)	(0.36)	(0.04)	(0.20)	—	(0.99)	(6.84)	—	(9.57)	(1), (55), (127), (196)
<i>J</i>	11.62	3.67	0.07	0.34	—	0.36	5.38	—	21.44	(2), (59), (194)



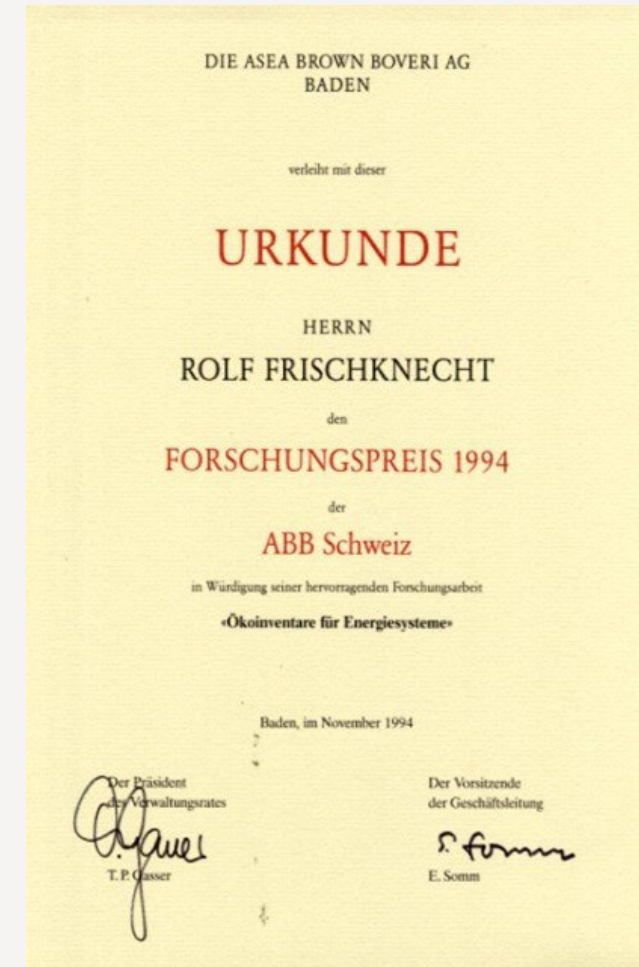
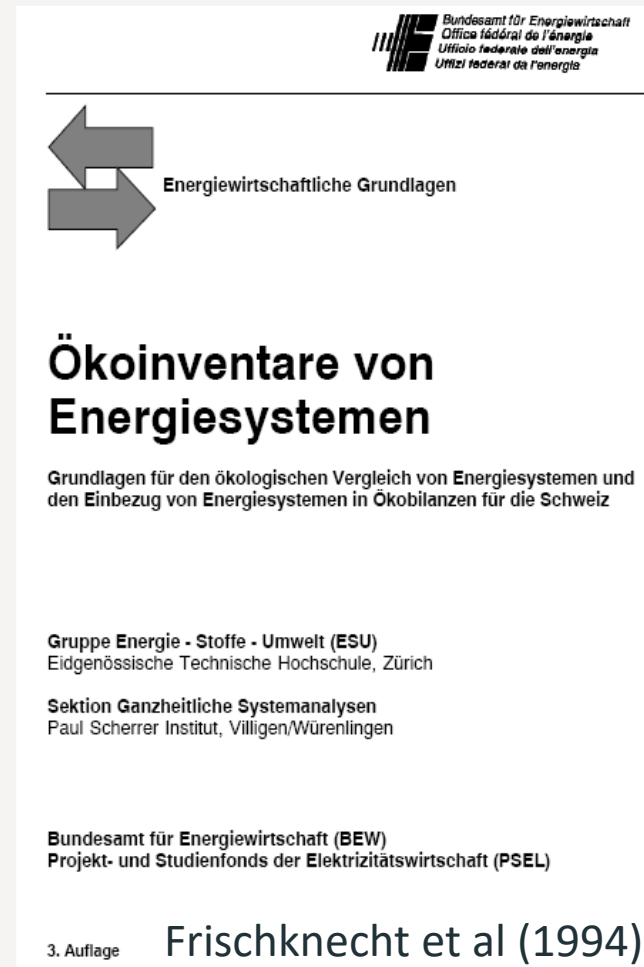
Boustead & Hancock 1979

Nineties: Cornerstone of LCA development

LCA Database Switzerland

ETH Zürich, 1994:
“Ökoinventare von
Energiesystemen”
about 500 Data sets on

- energy supply
- building materials and chemicals
- transport services
- waste management services

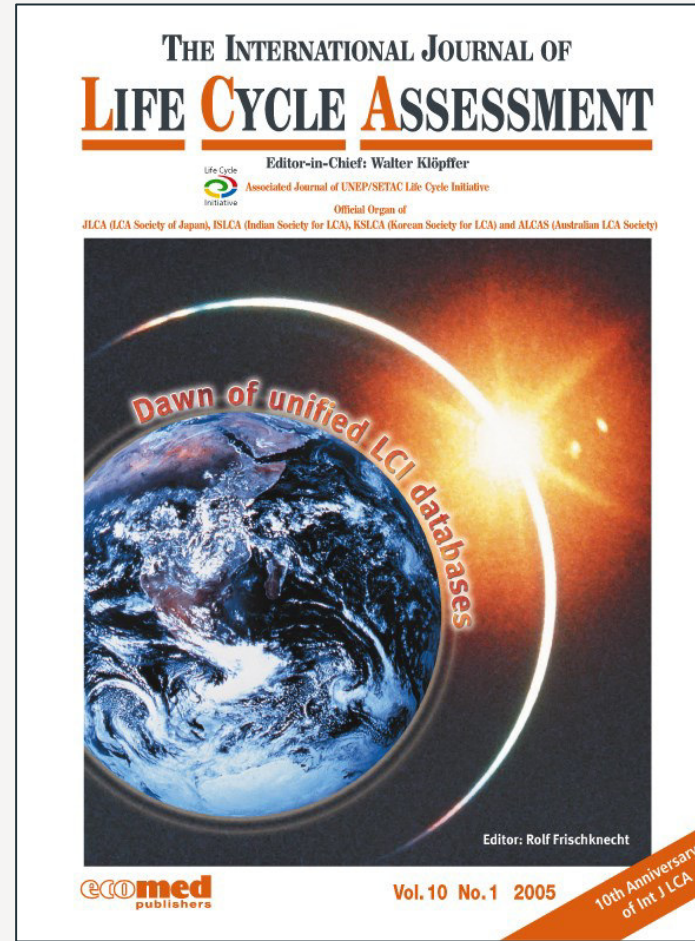


Noughties: Evolution to ecoinvent and UVEK databases



ecoinvent Centre,
KBOB/UVEK:
Online LCA database with datasets on

- energy supply
- water supply
- building materials, chemicals, packaging, textiles
- electronics
- mechanical engineering
- transport services
- waste management services
- agriculture



Frugality: Keep it simple

What do you consider the *largest* map that would be really useful?”

“About six inches to the mile.” (about 1:10'000)

“Only *six inches!*” exclaimed Mein Herr.

“We very soon got to six *yards* to the mile. (about 1:300)

Then we tried a *hundred* yards to the mile.

And then came the grandest idea of all! We actually made a map of the country, on the scale of *a mile to the mile!*”

Lewis Carroll (1893) Sylvie and Bruno Concluded

Simplify the (database) world

- Two dataset types: single output and multioutput
- Limited number of flow types (Tribute to Ernst Jandl „Wanderung“):
 - from
 - nature
 - technosphere
 - to
 - nature
 - reference product
 - allocated product
- Name of activity equals name of reference flow
- No parameterised data in database
- Market datasets (same structure like single output datasets):
 - production mix
 - supply mix

Collaboration: Good governance (1/2)

- Database protocol, with clear rules on
 - scoping
 - modelling
 - naming
- Training of dataset generators
- Regular generators' meetings
 - exchange of experience
 - discuss open issues and questions

Collaboration: Good governance (2/2)

- Dataset contents generated by humans
- Market data and technology performance data kept separate
- Data(set) generator: undivided responsibility for contents (following the database protocol)
- Extensive documentation, including references
- Third party review
- Summary on changes of database contents (from one version to the next)
- Error handling

Datasets: market mix and technology datasets

Market mixes

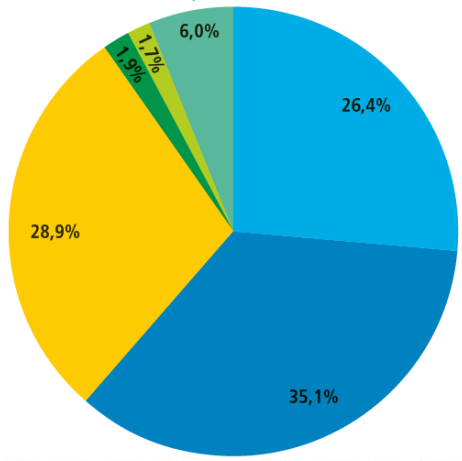


Jahr	Produktion
2009	37 136
2010	37 450
2011	33 795
2012	39 906
2013	39 572
2014	39 308
2015	39 486
2016	36 326
2017	36 666
2018	37 428
2019	40 556
2020	40 616
2021	39 500

ELEKTRIZITÄTSBILANZ DER SCHWEIZ | 11

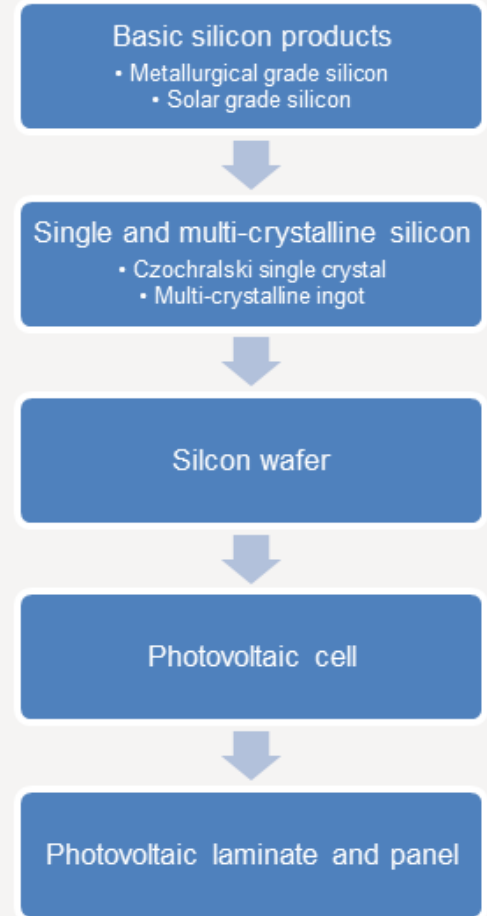
Elektroenergiebilanz der Schweiz (Kalenderjahr), in GWh (Fortsetzung)
Bilan de l'électricité (année civile), en GWh (suite)

Landeserzeugung - Production nationale	Kernkraftwerke - Centrales nucléaires	Konventionell thermische und erneuerbare Kraftwerke - Centrales thermiques classiques et renouvelables	Total	Verbrauch der Speicherpumpen (-) - Forçage d'accumulation (-)	Nettoerzeugung Production nette	Einfuhr ab 2000: physikalisch Importation des 2000: physique	Ausfuhr ab 2000: physikalisch Exportation des 2000: physique	Landesverbrauch - Consommation nationale	Verluste ¹ - Pertes	Endverbrauch ² - Consommation finale	Ausfuhrüberschuss (-) Einfuhrüberschuss (+)		
												in GWh	
73	1850	1763	34886	965	33921	33921	27896	2809	25087	-	6025		
63	1843	2181	31587	1377	30210	30210	29553	2882	26248	-	1080		
77	4650	2371	32298	1644	30654	30654	8229	30172	3031	27141	-	482	
25	5896	2424	37155	1724	35431	35431	10516	31933	3159	28774	-	3498	
63	6730	2117	37410	1541	35869	35869	9505	32638	3071	29567	-	3231	
74	7391	1629	42994	1198	41796	41796	14360	32071	3168	28903	-	9725	
72	7561	2058	36241	1344	34897	34897	9094	32982	3079	29903	-	1915	
90	7728	1885	45903	1277	44626	44626	15231	34441	3152	31289	-	10185	
10	7995	1845	42350	1361	40989	40989	13047	35595	3131	32464	-	5394	
45	11243	1963	45551	1586	43965	43965	15915	36918	3152	33766	-	7047	
42	13663	957	48162	1531	46631	46631	18128	38450	3198	35252	-	8181	
97	14462	956	51515	1395	49920	49920	19408	39408	3214	36194	-	10712	
35	14276	974	52285	1532	50753	50753	19868	39926	3195	36731	-	10827	
02	14821	996	51819	1346	50473	50473	20395	41227	3257	37970	-	9246	
72	17396	884	49152	1444	47708	47708	21001	43013	3348	39665	-	4695	
77	21281	869	54827	1364	53463	53463	15579	24277	44765	41321	-	8698	
89	21303	988	55880	1461	54419	54419	14512	23098	45833	42348	-	8586	
12	21701	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
39	21502	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
85	21543	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
75	22298	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
82	21654	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
25	22121	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
53	22029	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
56	22984	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
87	23486	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
98	23719	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
94	23971	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
95	24368	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
16	23523	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
51	24949	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
61	25293	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
13	25252	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
45	25931	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
17	25432	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
59	22020	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
57	26244	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
73	26344	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
59	26132	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455
39	26119	1048	58161	1564	56597	56597	12710	22165	47142	3551	43591	-	9455



¹ Die Verluste verstehen sich vom Kraftwerk bis zum Abnehmer bzw. bei Bahnen bis zum Fahrdraht.
² Aufteilung siehe Tabelle 21.
³ Les pertes s'entendent entre la centrale et le point de livraison et pour la traction, entre la centrale et la ligne de contact.
⁴ Répartition voir tableau 21.

Technology supply chains

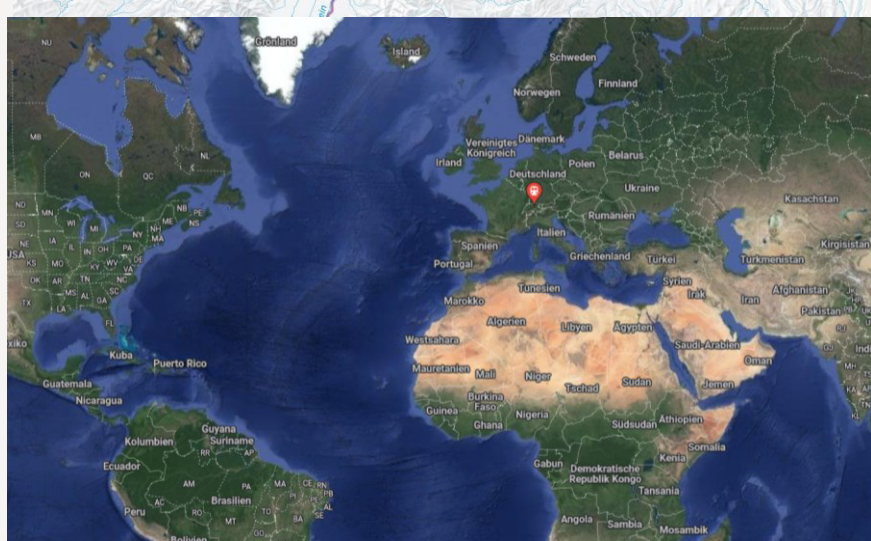


Good governance (2/2)

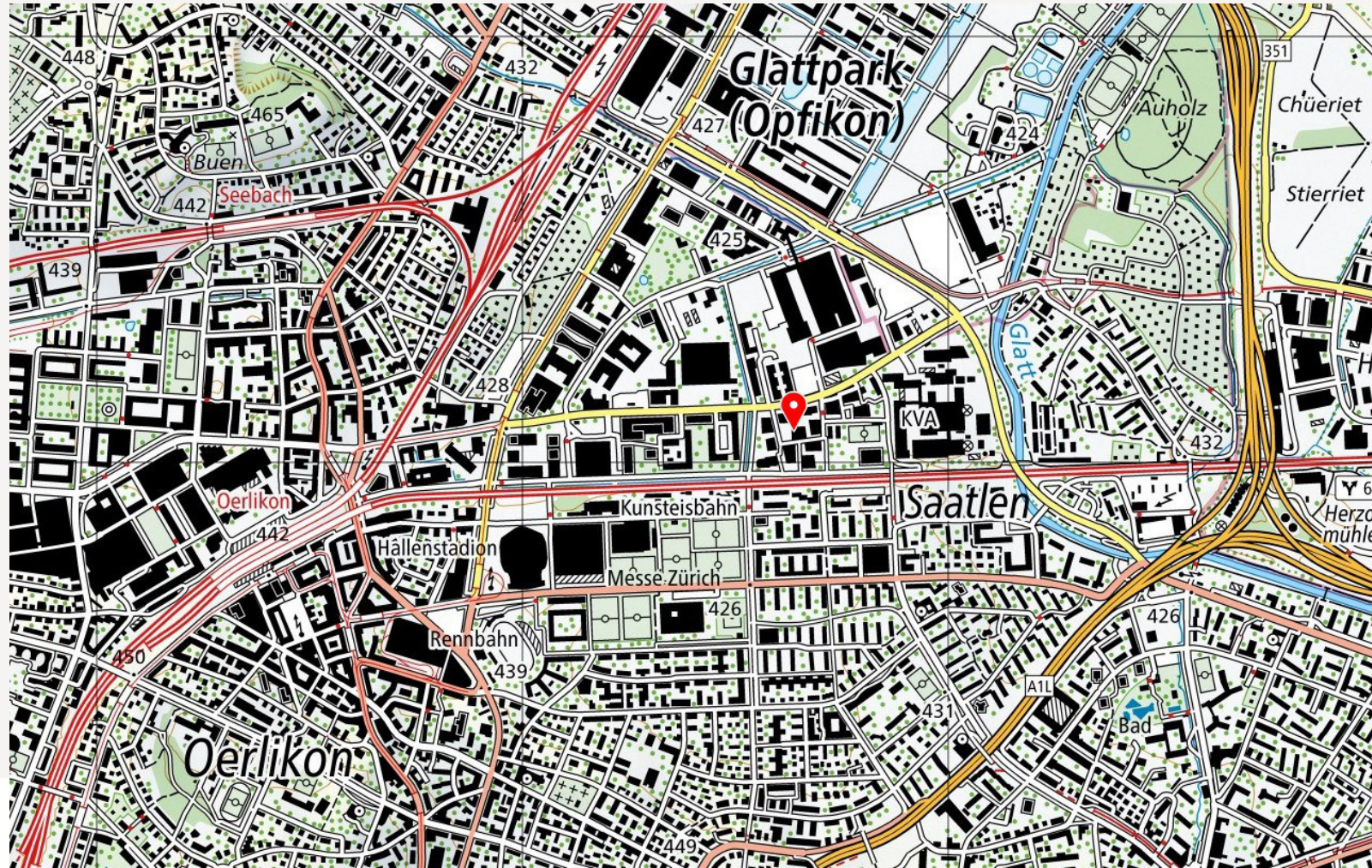
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Documentation: Guiding principles

From an overview ...



... to the details



Documentation and discussion of data selection

Jungbluth et al. (2018) Life cycle inventories of oil refinery processing and products

Tab. 7.6 Estimation for the mix of NMVOC emissions

%-by weight	%-by weight	%-by weight	%-by weight	This study
Alkanes			90	90
- Ethane	14.8	2.4	5	5
- Propane	13.7	14.5	20	20
- n Butane			15	15
- i Butane			5	5
- Butane +	55.9	68.9	-	-*)
- n Pentane			5	5
- i Pentane			20	20
- Hexane			10	10
- Heptane			5	5
- Octane +			5	5
Alkene		0.38	2.5	2.5
- Ethen	3.3	0.5	1	1
- Propene	-	-	1	1
- Propene +	8.3	0.4	-	-
- Butene	-	-	0.5	0.5
Aromatic			7.5	7.5
- Benzene	1.8	2.6	2	2
- Toluene	2.2	5.7	3	3
- Xylene	0	5.0	-	-
- o-Xylene	-	-	0.7	0.7
- p, m-Xylene	-	-	1.3	1.3
- Ethylbenzene	-	-	0.5	0.5
Total	100	100	100	100
	First refinery site (Concawe 1986)	Second refinery site (Concawe 1986)	(Veldt et al. 1992)	Own estimation in Jungbluth 2007

Referencing Two layers

... to the post of all signs



One signpost ...

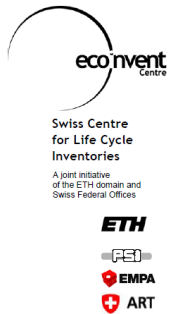


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References: Two layers

... to the full list of references

One note ...



Life Cycle Inventories of Metals

Data v2.1 (2009)

 Mischa Classen, Hans-Jörg Althaus, Silvio Blaser, Wolfram Scharnhorst
EMPA, Dübendorf

 Matthias Tuchschmid, Niels Jungbluth, Mireille Faist Emmenegger
ESU-services, Uster

6 Literature

Althaus et al. (2004) Althaus H.-J., Blaser S., Classen M. and Jungbluth N. (2004) Life Cycle Inventories of Metals. Final report ecoinvent 2000 No. 10. EMPA Dübendorf, Swiss Centre for Life Cycle Inventories, Dübendorf, CH. Online-Version under: www.ecoinvent.ch.

Alhundogan et al. (2002) Alhundogan H. S., Alhundogan S., Tümen F. and Bildik M. (2002) Arsenic adsorption from aqueous solutions by activated red mud. In: Waste Management, 22, pp. 357-363. Online-Version under: <http://www.environmental-center.com/magazine/elsevier/waste/art11.pdf>

Anonymous (2001) Local Vegetable Fibres + Industrial and Mineral Wastes for Composite Materials. Building Materials & Technology Promotion Council BMTPC of the Ministry of Urban Development and Poverty Alleviation, New Delhi. Online-Version under: <http://www.bmtpc.org/fibre.pdf>

Doka (2003) Doka G. (2003) Life Cycle Inventories of Waste Treatment Services. Final report ecoinvent 2000 No. 13. EMPA St. Gallen, Swiss Centre for Life Cycle Inventories, Dübendorf, CH. Online-Version under: <http://www.ecoinvent.ch>.

EAA (2000) Environmental Profile Report for the European Aluminium Industry. European Aluminium Association (EAA), Brussels.

Frischknecht et al. (2006) Frischknecht R., Althaus H.-J., Bauer C., Capello C., Doka G., Dones R., Faist Emmenegger M., Hirschler R., Jungbluth N., Kellenberger D., Margni M., Nemecek T. and Spielmann M. (2006) Documentation of changes implemented in ecoinvent Data v1.2 and v1.3. ecoinvent report No. 16. EMPA Dübendorf, Swiss Centre for Life Cycle Inventories, Dübendorf, CH.

Hudson et al. (1997) Hudson L. K., Mitra C. and Wefers K. (1997) Aluminium Oxide. In: Ullmann's encyclopedia of industrial chemistry (ed. Anonymous). 5th edition on CD-ROM Edition. Wiley & Sons, London.

McLaughlin et al. (1998) McLaughlin M. J., Maier N. A., Correll R. L., Smart M. K. and Grant C. D. (1998) In-situ immobilisation techniques to remediate cadmium-contaminated agricultural soils. pp. 453-460 In: Contaminated Soil '98. Proceedings of the Sixth International FZK/TNO. London. Online-Version under: <http://www.sardi.sa.gov.au/pages/horticulture/potato/insitu.htm?sectID=319&tempID=152>

Mori & Adelhardt (1998) Mori G. and Adelhardt W. (1998) Stoffmengenflüsse und Energiebedarf bei der Gewinnung ausgewählter mineralischer Rohstoffe: Teilstudie Aluminium. In: Geologisches Jahrbuch, Vol. Sonderhefte SH 2. Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover. ISBN 3-510-95824-1.

NPI (1999) NPI (1999) Emission Estimation Technique Manual for Alumina Refining. In: National Pollutant Inventory. Environment Australia. Online-Version under: http://www.npi.gov.au/handbooks/approved_handbooks/pubs/falref.pdf.

Werner (2003) Werner F. (2003) Interdependencies Between LC-modelling And The Use Of LCA In Product Design-related Decisions: With Special Emphasis On The Influence Of Cognitive Models And Values On The Modelling Of Reuse & Recycling And Other End-of-life Options. In: Diss. 14750. Eid. Technische Hochschule (ETH), Zürich.

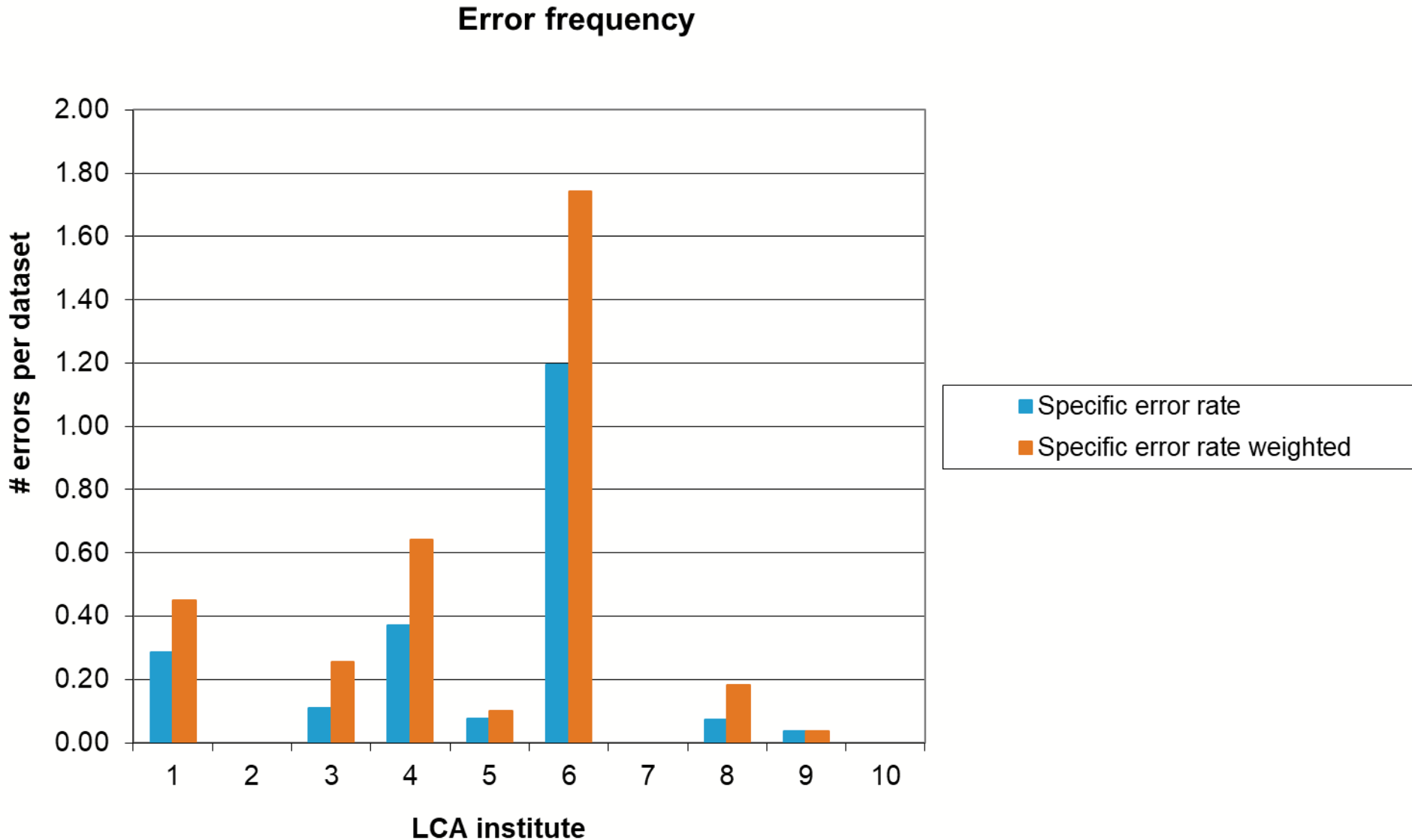
Werner & Richter (2000) Werner F. and Richter K. (2000) Economic Allocation in LCA: A Case Study About Aluminium Window Frames. In: International Journal for Life Cycle Assessment, 5(2), pp. 79-83.

Source	aluminium, primary, at plant, RER, [kg]
Number	141
Source type	4
First author	Althaus H.-J.
Additional authors	Blaser S., Classen M., Jungbluth N.
Year	2007
Title	Life Cycle Inventories of Metals
Name of editors	0
Title of anthology	Final report ecoinvent 2000
Place of publications	Dübendorf, CH
Publisher	Swiss Centre for LCI, EMPA-DU
Volume number	10
Text	CD-ROM

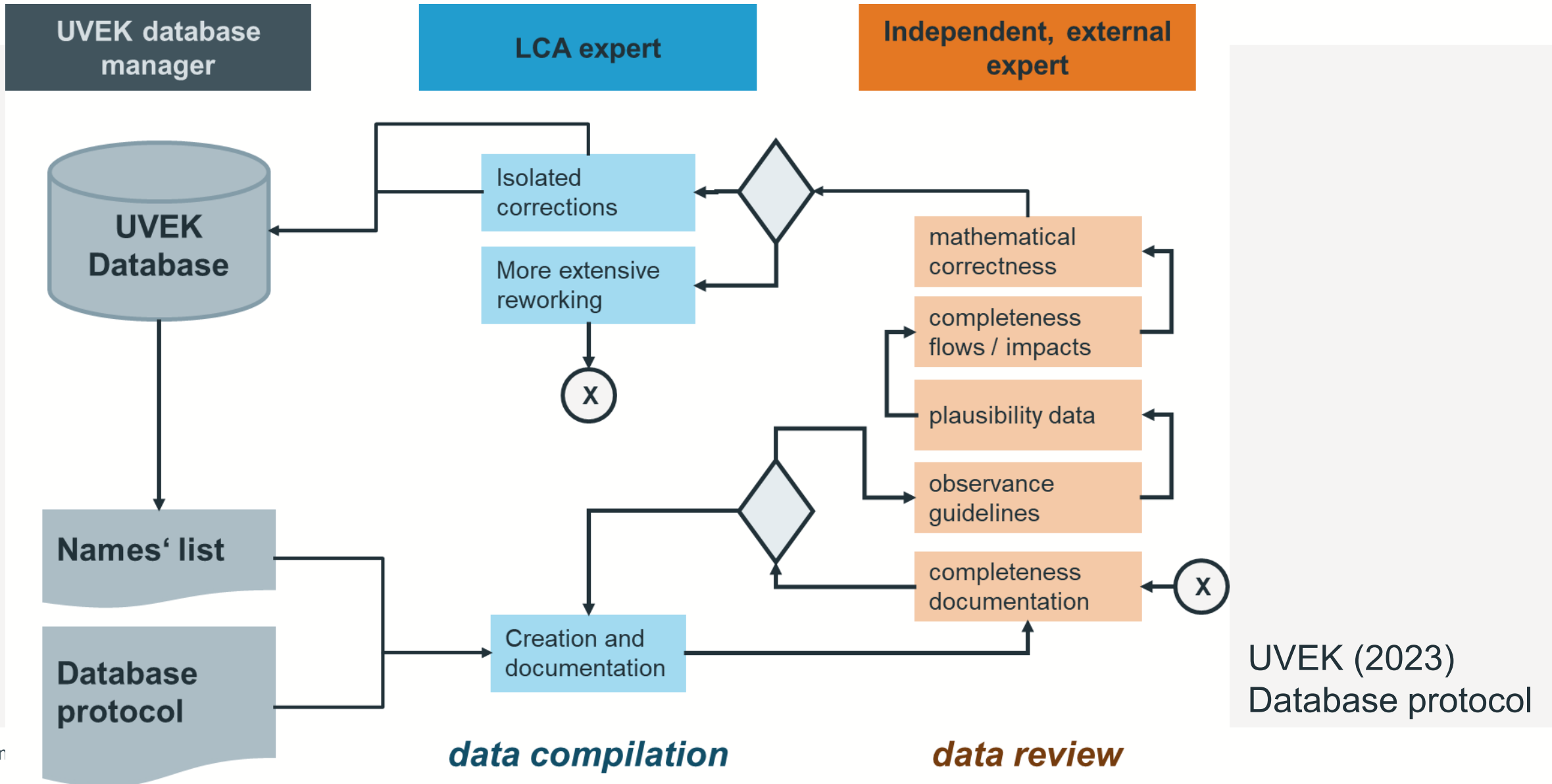
Good governance (2/2)

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Data errors: natural and reducible



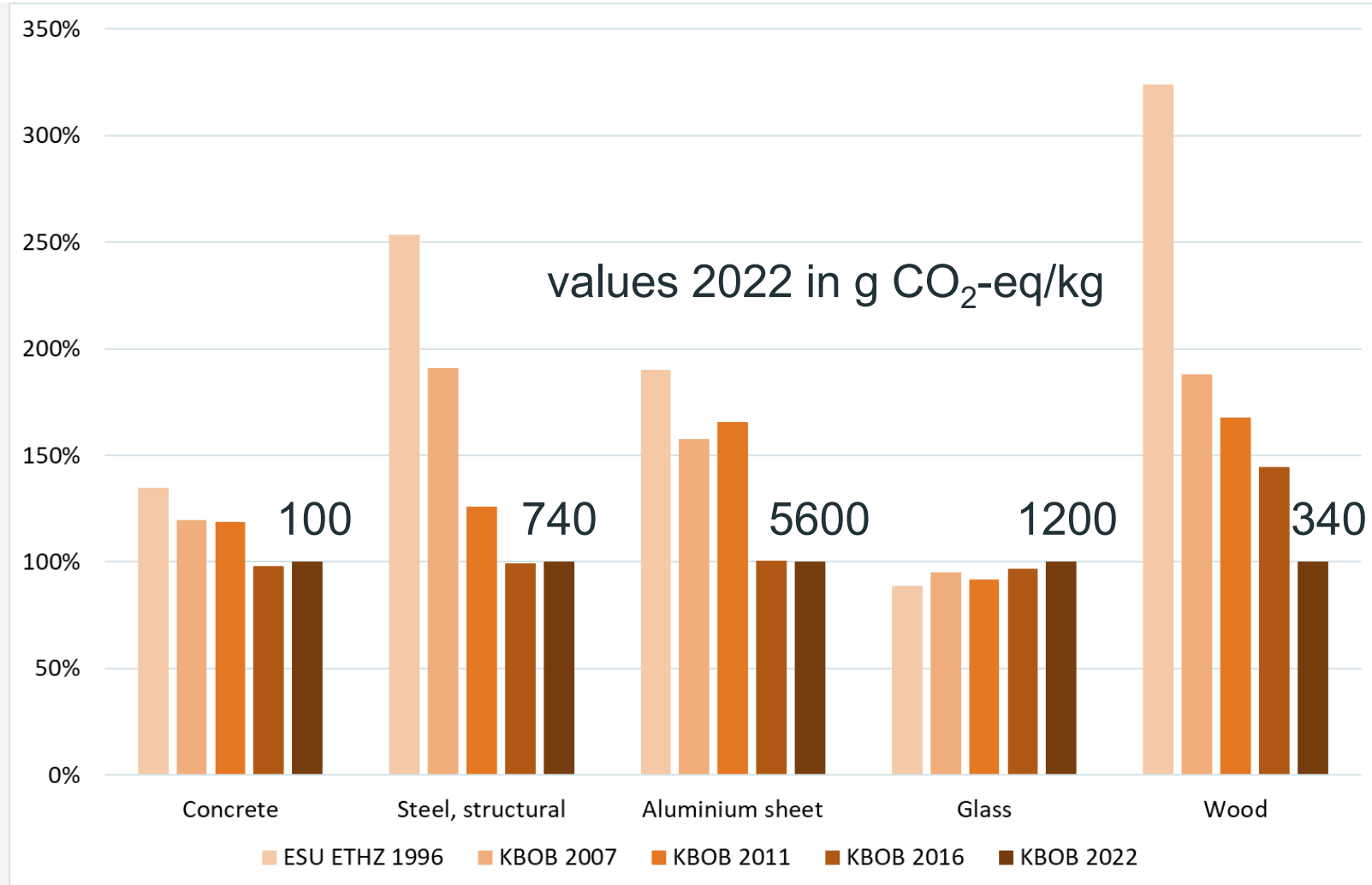
Data quality: External review





Evolution of the carbon footprint (production and end of life) of construction materials

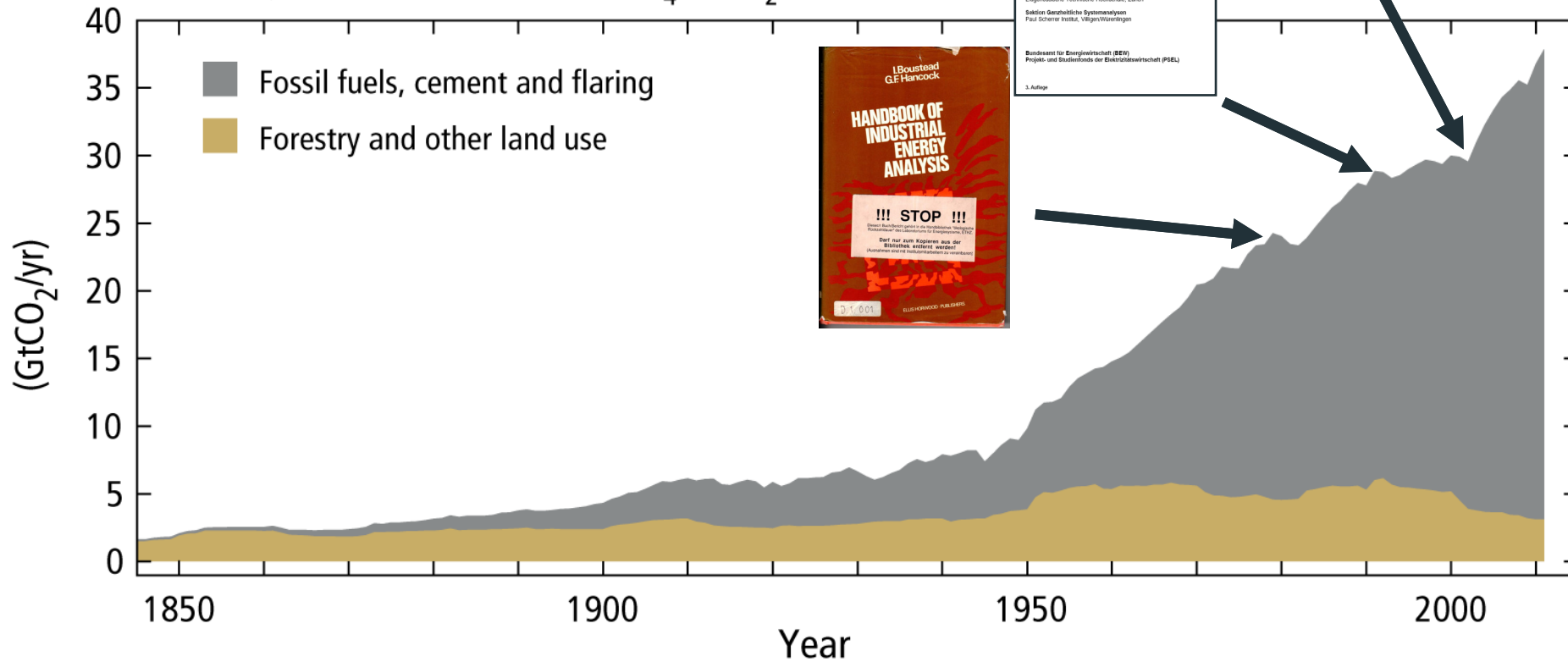
Evolution	Past
Concrete	↘
Steel	↘ ↘ ↘
Aluminium	↘ ↘
Glass	→
Wood	↘ ↘ ↘



Fossil CO₂ emissions and LCA databases

Global anthropogenic CO₂

Quantitative information of CH₄ and N₂O emission time series

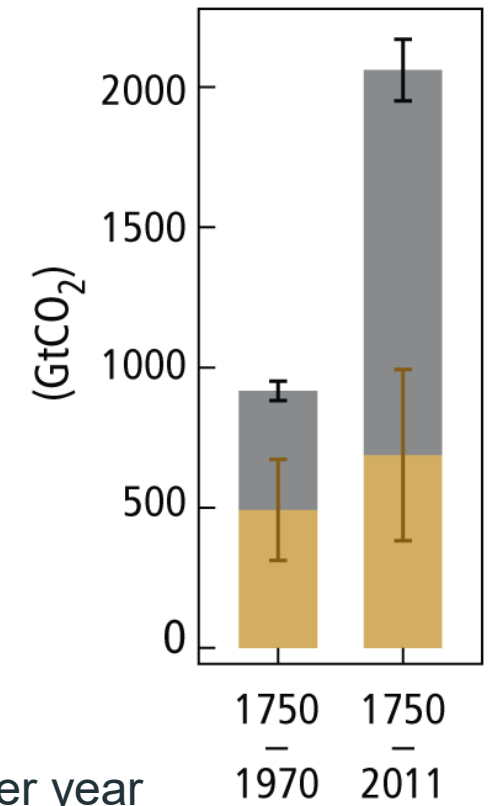


to 1970 is limited

180 years (1750-1970): 5 GtCO₂ per year
 40 years (1971-2011): 30 GtCO₂ per year

Source: IPCC (2013)

Cumulative CO₂ emissions



Lessons learned for the onward journey

- **Frugality:** Reduced complexity in database structure and dataset models
- **Collaboration:** Clear and understandable modelling rules
- **Transparency:** High quality documentation for open access databases
- **Reality check:** Brain power for contents

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not in its bookshelves and ...**

the value of knowledge is in its application

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