How reliable can system processes be?

Brightcon

October 20, 2020

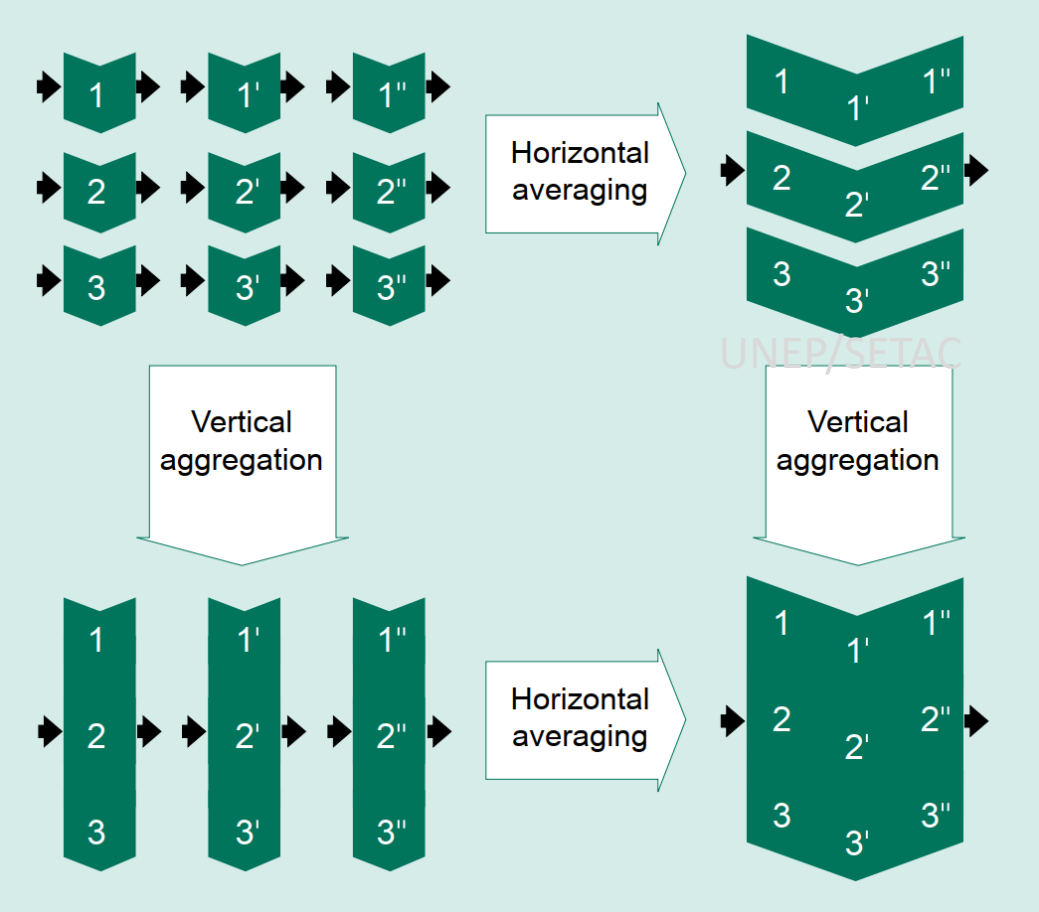
Dr. Andreas Ciroth
GreenDelta GmbH

Content

- System processes = aggregated processes
- Recent development of LCA
- The reliability of system processes
- Reliability of aggregated results in other domains; examples from the medical sector, and from finance
- A model of system process reliability
- Outlook & discussion

LCA system processes

System processes in LCA are aggregated process results



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LCA recent development

LCA recent developments, system processes

- In the past 20 years, LCA has gained attention and importance, tremendously (EU Green Deal, etc.)
- Technical infrastructure and procedures are slowly adapted
- Unit processes and system processes are both used, f(software, database, use case)..
- ..but not depending on potential reliability requirements

The reliability of system processes

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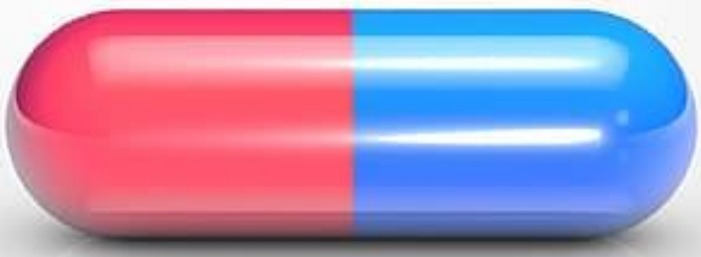

- Selling agent: This is a powerful painkiller, Ibuprofen, isobutylphenylpropionic acid
- The company claims to be reliable and is long time in business
- They describe the main composition
- Nobody outside of the providing company knows the exact recipe, since sensitive information must be protected

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Process data set: 1,3-Butadiene; oxi

gabi-documentation-2020.gabi-software.com/xml-data/processes/96cb1bbc 60%

Process data set: 1,3-Butadiene; oxidative catalytic dehydrogenation of C4; production mix, at plant; 2.4982 kg/m3, 54.09 g/mol (en)

Table of Contents: Process information - Modelling and validation - Administrative information - Inputs and Outputs

Process information

Key Data Set Information

Location	ES
Geographical representativeness description	The data set represents the country specific situation in Spain, focusing on the main technologies, the region specific characteristics and / or import statistics.
Reference year	2019
Name	Base name; Treatment, standards, routes; Mix and location types; Quantitative product or process properties 1,3-Butadiene; oxidative catalytic dehydrogenation of C4; production mix, at plant; 2.4982 kg/m3, 54.09 g/mol
Use advice for data set	The data set represents a cradle to gate inventory. It can be used to characterise the supply chain situation of the respective commodity in a representative manner. Combination with individual unit processes using this commodity enables the generation of user-specific (product) LCAs. Most commonly, Butadiene is used for the production of synthetic rubber. Another application is in the acrylic butadiene styrole (ABS) production as well as the acrylonitrile butadiene (NBR) and the styrene-butadiene production. Smaller amounts are used e.g. for nylon-intermediates (adiponitrile).
Technical purpose of product or process	More than 90% of the butadiene produced is used to make synthetic rubber. Other applications are the production of ABS and adiponitrile.
Synonyms	C4H6, CAS 106-99-0, biethylene
Classification	Class name / Hierarchy level Materials production / Organic chemicals
General comment on data set	The data set covers all relevant process steps / technologies over the supply chain of the represented cradle to gate inventory with a good overall data quality. The inventory is mainly based on industry data and is completed, where necessary, by secondary data. This dataset is based on primary data from internationally adopted production processes, connected with regional precursor chains.
	Copyright? Yes Owner of data set (contact data set) thinkstep

Quantitative reference

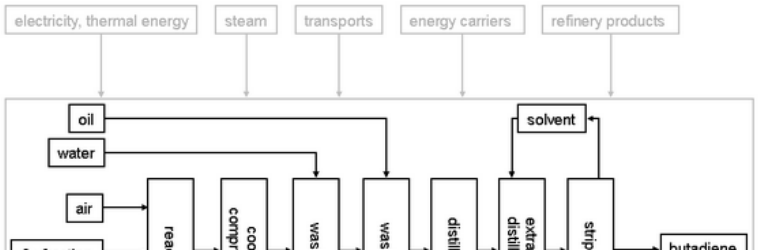
Reference flow(s)	Butadiene - 1.0 kg (Mass)

Time representativeness

Data set valid until:	2022
Time representativeness description	annual average

Geographical representativeness

Technological representativeness

Technology description including background system	Butadiene is produced by the oxidative catalytic dehydrogenation of n-butane and n-butenes. For supplying heat and keeping down partial pressure of the products at the same time, the reaction is accomplished under hot steam. Reactor's temperature is about 600 °C and pressure 1.7 atm. The product stream is cooled, compressed on 11,6 atm. Next, it is first washed with water and then with oil. Butadiene is separated by distillation from the latter. This butadiene is still very impure (about 50 %) and is up-cleaned by extractive distillation. Paraffins are by-product. The distillation is following the BASF process for extractive distillation with NMP: N-Methylpyrrolidone containing 5-10% water to increase selectivity is used as solvent. Background system: Electricity: Electricity is modelled according to the individual country-specific situations. The country-specific modelling is achieved on multiple levels. Firstly, individual energy carrier specific power plants and plants for renewable energy sources are modelled according to the current national electricity grid mix. Modelling the electricity consumption mix includes transmission / distribution losses and the own use by energy producers (own consumption of power plants and "other" own consumption e.g. due to pumped storage hydro power etc.), as well as imported electricity. Secondly, the national emission and efficiency standards of the power plants are modelled as well as the share of electricity plants and combined heat and power plants (CHP). Thirdly, the country-specific energy carrier supply (share of imports and / or domestic supply) including the country-specific energy carrier properties (e.g. element and energy content) are accounted for. Fourthly, the exploration, mining/production, processing and transport processes of the energy carrier supply chains are modelled according to the specific situation of each electricity producing country. The different production and processing techniques (emissions and efficiencies) in the different energy producing countries are considered, e.g. different crude oil production technologies or different flaring rates at the oil platforms. Thermal energy, process steam: The thermal energy and process steam supply is modelled according to the individual country-specific situation with regard to emission standards and considered energy carriers. The thermal energy and process steam are produced at heat plants. Efficiencies for thermal energy production are by definition 100% in relation to the corresponding energy carrier input. For process steam the efficiency ranges from 85%, 90% to 95%. The energy carriers used for the generation of thermal energy and process steam are modelled according to the specific import situation (see electricity above). Transports: All relevant and known transport processes are included. Ocean-going and inland ship transport as well as rail, truck and pipeline transport of bulk commodities are considered. Energy carriers: The energy carriers are modelled according to the specific supply situation (see electricity above). Refinery products: Diesel fuel, gasoline, technical gases, fuel oils, lubricants and residues such as bitumen are modelled with a parameterised country-specific refinery model. The refinery model represents the current national standard in refining techniques (e.g. emission level, internal energy consumption, etc.) as well as the individual country-specific product output spectrum, which can be quite different from country to country. The supply of crude oil is modelled, again, according to the country-specific situation with the respective properties of the resources.
Included data sets (process data set)	Electricity grid mix C4 cut (butadiene) (estimation) Process steam from natural gas 90%
Flow diagramm(s) or picture(s) (source data set)	

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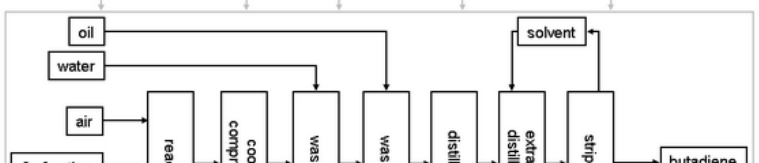

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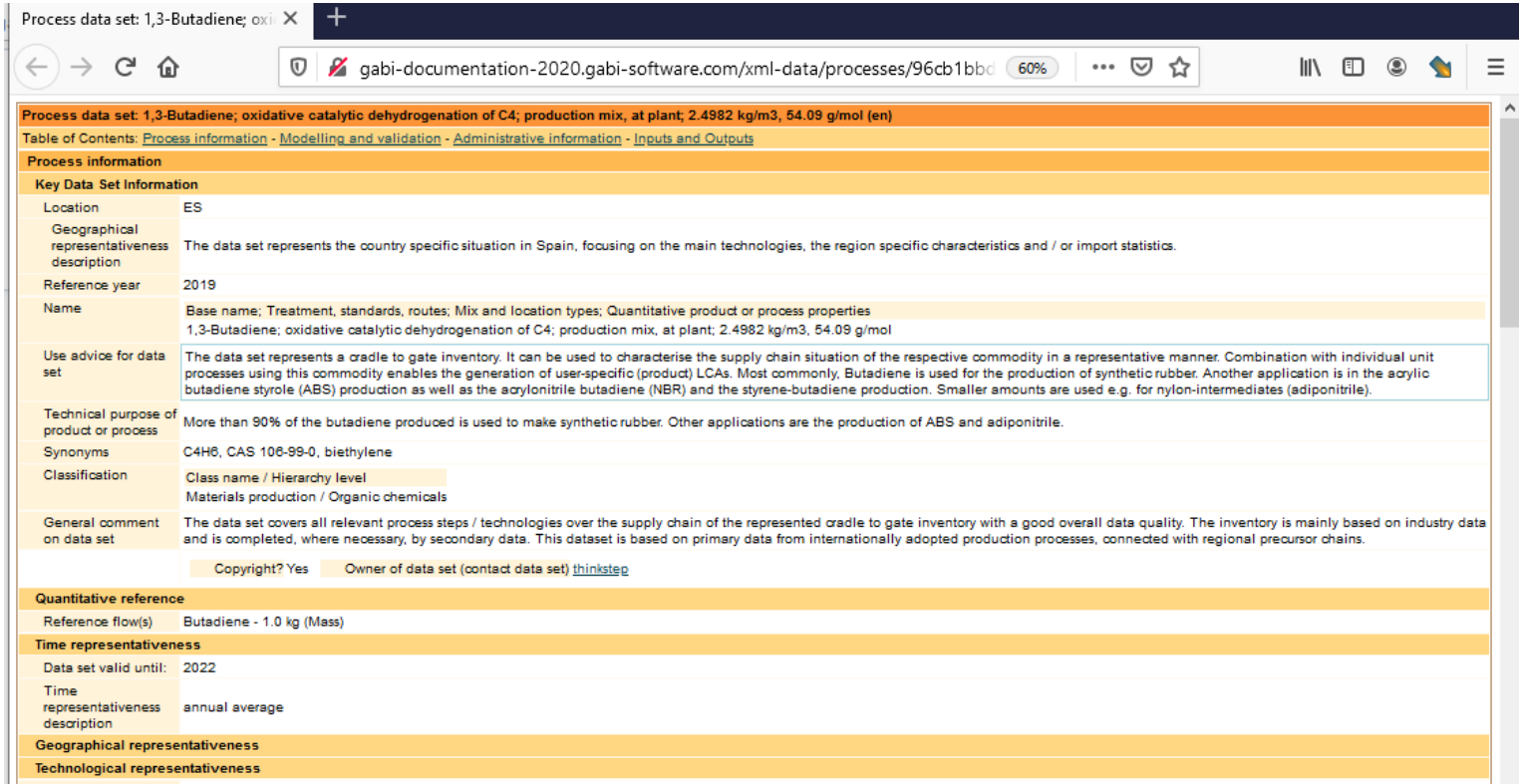
- Would you use it?



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- What seems impossible for pharmaceutical products, is common today for LCA models and datasets
- Both are surprisingly comparable though
- Difference is that
  - reliability is more important for pharmaceutical products than for LCA datasets
  - You see more easily if a medicine “does not work”

→ Let’s have a look at elements of reliability for system processes

Dimensions of reliability, system processes

1) Model access
2) Verification
3) Aggregation level of the process
4) Producer of the dataset

Dimensions of reliability, system processes

1) Model access
   a. None
   b. For verification
   c. Full, for users
2) Verification
3) Aggregation level of the process
4) Producer of the dataset

Dimensions of reliability, system processes

1) Model access
2) Verification (of the model)
   a. No verification
   b. Dependent verifier
   c. Independent verifier, not accredited
   d. Independent verifier, accredited
3) Aggregation level of the process
4) Producer of the dataset

Dimensions of reliability, system processes

1) Model access
2) Verification (of the model)
3) Aggregation level of the process
    a. Unit proces
    b. System process
    c. LCIA result, Environmental Product Declaration (EPD)
4) Producer of the dataset

Dimensions of reliability, system processes

1) Model access
2) Verification
3) Aggregation level of the process
4) Producer of the dataset
    a) Not established
    b) Established
    c) Accredited

- In the end, pharmaceutical products and LCA system processes are just aggregated systems (!)
- Difference between pharmaceutical products and LCA datasets:
  - “incorrect” medicine really needs to be prevented;
  - less worries about incorrect LCA datasets

Examples from other domains

Examples from the pharmaceutical sector: Ibuprofen

(very simplified):

- Patent describing the mechanism
- Clinical trials
- Approval, per country (took > 10 years in some)
- Produced by approved companies, in approved procedures
- Monitoring and quick response

TABLE 1.2 Summary of history and developments of the anti-inflammatory project at Boots

1953	Initial thoughts and discussions on a search for aspirin-type drug.
1955	UV erythema in guinea-pig; began preliminary investigations.
1956 (Mar.)	Report No. 848 on UV erythema technique, with recommendations for a chemical programme of work.
1958 (Aug.)	First inhibitors discovered of UV erythema: phenoxy acids.

1958 (Nov.)	RD 8402 (a phenoxy acid) made.
1960	RD 8402 in clinical trial.
1960	RD 10335, RD 10499 and ibufenac made.
1961 (Jun.)	RD 10335 active clinically, but rash in 50% of patients.
1961 (Dec.)	Ibuprofen made.
1962 (May)	Ibufenac active clinically, no rash.
1963 (Mar.)	Clinicians' meeting on ibufenac.
1964	RD 10499 in clinical trial. Active, but rash in 20% of patients.
1964 (Apr.)	Ibuprofen made product candidate.
1964 (Aug.)	Ibufenac started in clinical trials in Japan.
1966 (Feb.)	Ibuprofen shown to be active in clinical trial.
1966 (Apr.)	Ibufenac on UK market.
1967 (Nov.)	Clinicians' meeting on ibuprofen.
1968 (Jan.)	Ibufenac withdrawn UK market because of liver toxicity.
1968 (Mar.)	Ibufenac marketed by Kakenyaku Kako Co. Ltd (Kyoto and Tokyo) in Japan; superseded later by ibuprofen.
1969 (Feb.)	Brufen™ (ibuprofen) launched.
1970	First Symposium on Ibuprofen at the Royal College of Physicians, London.
1983	Approval for ibuprofen OTC in UK ((Nurofen™ launched 8 August 1983).
1984	Approval for ibuprofen OTC in USA.

Rainsford, K.D.: Ibuprofen, London 1999

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→ Model access to public (scientific publications plus patents)

→ Verification (different levels, different parties involved)

→ Aggregation: a produced pill, user has no access to details

→ Producing companies need permission
→ are "accredited"

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Examples from the financial sector

- Annual financial statements
- Published results
- Accredited verifiers
- Verifiers have access to full model (here: books of investigated company)

→ Model access to verifier

→ Verification by accredited, independent verifiers only

→ Very well established, mandatory for every capital company in Germany e.g., each year

Examples from the financial sector

- Failures: Bernie Madoff

- Established, Chair of New York Stock Exchange
- Elite investment company
- Paid very high interest rates to investors
- No insights into investment models (despite rules in principle)

→ No model access

→ No verification but trust

Turns out: Ponzi scheme, multi-billion fraud, no real investment

Examples from the financial sector

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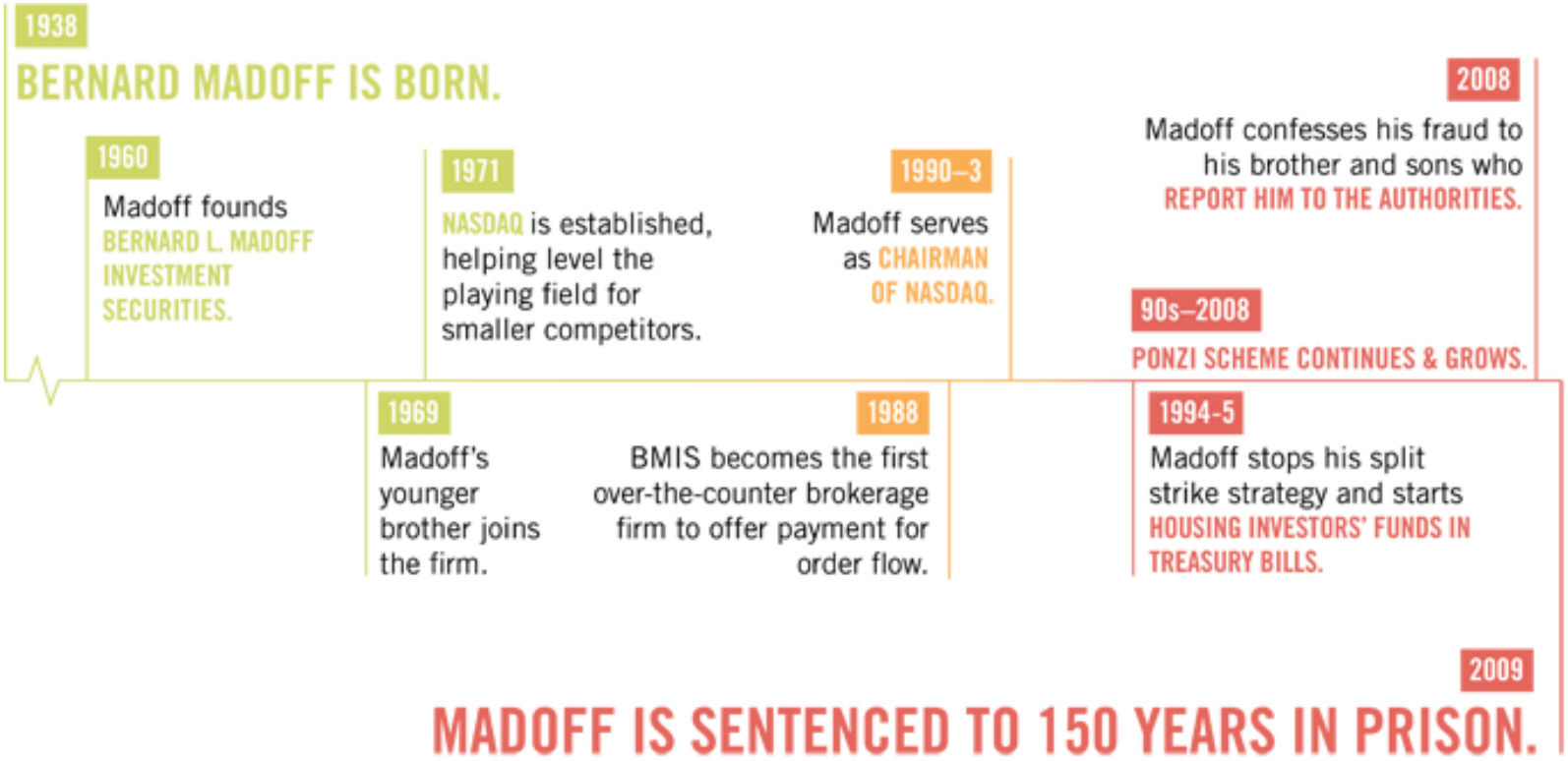

https://hbswk.hbs.edu/item/bernie-madoff-explains-himself

Examples from the financial sector

- Failures: Bernie Madoff

- **Ambition:** "In the recording, he describes his ambition, which is something that every single person at Harvard Business School—and really every person aspiring to be successful in business—can relate to," Soltes says.
- **Overconfidence:** "I built my confidence up to a level where I…felt that…there was nothing that…I couldn't attain," Madoff recalls in the recording.
- **The "slippery slope" that enables a small transgression to grow into a bigger one:** "I started to go off the tracks, and I was able to convince myself that this was, you know, a temporary situation," Madoff says.
- **Lack of self-control:** "I…probably…just didn't give it enough thought or wasn't frightened enough…to say to myself, I can't, you know, I can't do this, I can't take the risk," Madoff says.
- **Rationalization of iffy decisions:** "The piece that's most humbling in the recording is the realization of rationalization," Soltes says. "He recognizes now that it was all rationalization."

https://hbswk.hbs.edu/item/bernie-madoff-explains-himself

Examples from the financial sector

- Failures: Wirecard
- Newcomer to German DAX stock index
- Fintec (financial services)
- For years, too high revenue claimed, claimed deposits that did not exist
- Yet still, for years, annual balance accredited by E&Y

- Annual financial statements
- Published results
- Accredited verifiers
- Verifiers have access to full model (here: books of investigated company)

→ Model access to verifier
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Turns out: Company now bankrupt, political debate about lack of control

https://www.finanzen.net/aktien/wirecard-aktie

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- In other domains, stricter verification rules exist
- They do not prevent all forms of “cheating” or failures..
- ..that can occur because of
  - Carelessness
  - Greed
  - Lack of self-control
- This is something to “take home” also for LCA, if the information provided by LCA becomes more and more important

A model of system process reliability

A simple model for documenting system process reliability

- inspired by the pedigree matrix

	Model access	Verification	Producer of the dataset
1, best	For all users	Independent verifier, accredited	accredited
2			
3	Full, for verification	Independent verifier, not accredited	established
4	Just shown, for verification	Dependent verifier	
5, worst	None	No verfication	Not established

Remarks

- Aggregation level: not part of the scheme; for unit processes, access to the model is granted “automatically”
- Note that this is different from the “reliability of the source” data quality indicator
- Next steps:
  - apply for existing data sources; for EPD program operators etc., minimum thresholds can be envisaged
  - Finetune & elaborate: what does independent, accredited, established mean

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4		Dependent verifier	
5, worst	none	No verfication	Not established

Summary and outlook

Summary

- I presented a model for assessing system process reliability for LCA, ..
- ..inspired by solutions from other domains, where the "model result" has traditionally more value
- Seen from some other domains, the approach in LCA now seems somehow simple and also naïve, and not fit for an increased importance of LCA information
- The proposed model needs further refinement (specification of verification rules, for example) but is hopefully a useful start

Outlook

- The proposed model needs further refinement (specification of verification rules, for example) but is hopefully a useful start
- LCA tools needed for sharing full LCA models
  - Open source and free tools: openLCA'S JSON-LD format allows this now already
  - The European Commission's extended ILCD format eILCD has also this idea but is not able to always capture entire models, (to be) implemented in various LCA tools (openLCA since about 1 year, but previous version of the format)
- Evidently, also LCA data providers are encouraged to consider the reliability of system processes in data they provide

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sustainability consulting + software

Thank you!

Contact
Andreas Ciroth
ciroth@greendelta.com

GreenDelta GmbH
Kaiserdamm 13, 14057 Berlin
www.greendelta.com