a new LCA database

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Topics

- Need
- Approach
- Status
- How you can get involved

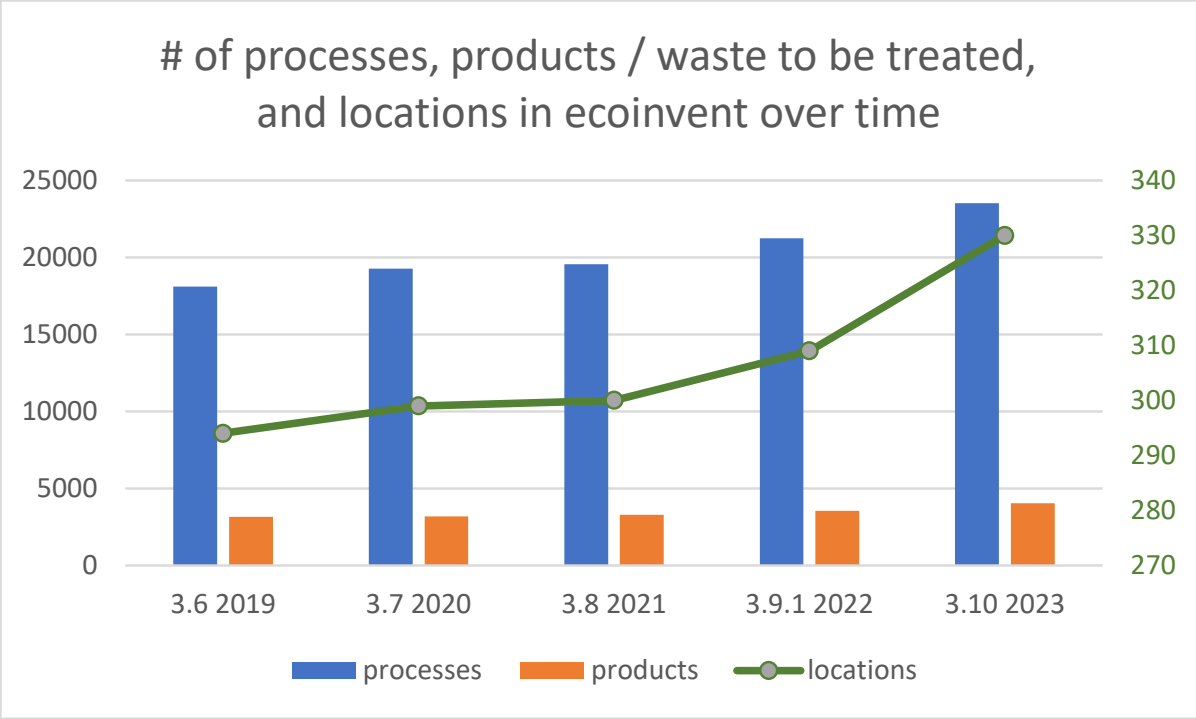
Need

The need for a new database

- ..comes from two sides:
  - A, demand for LCA data is increasing and LCA data need to be available for a multitude of products
  - B, current databases struggle to keep up, with updates of own data, and with inclusion of new data

The need for a new database

B, current databases struggle to keep up, with updates of own data, and with inclusion of new data



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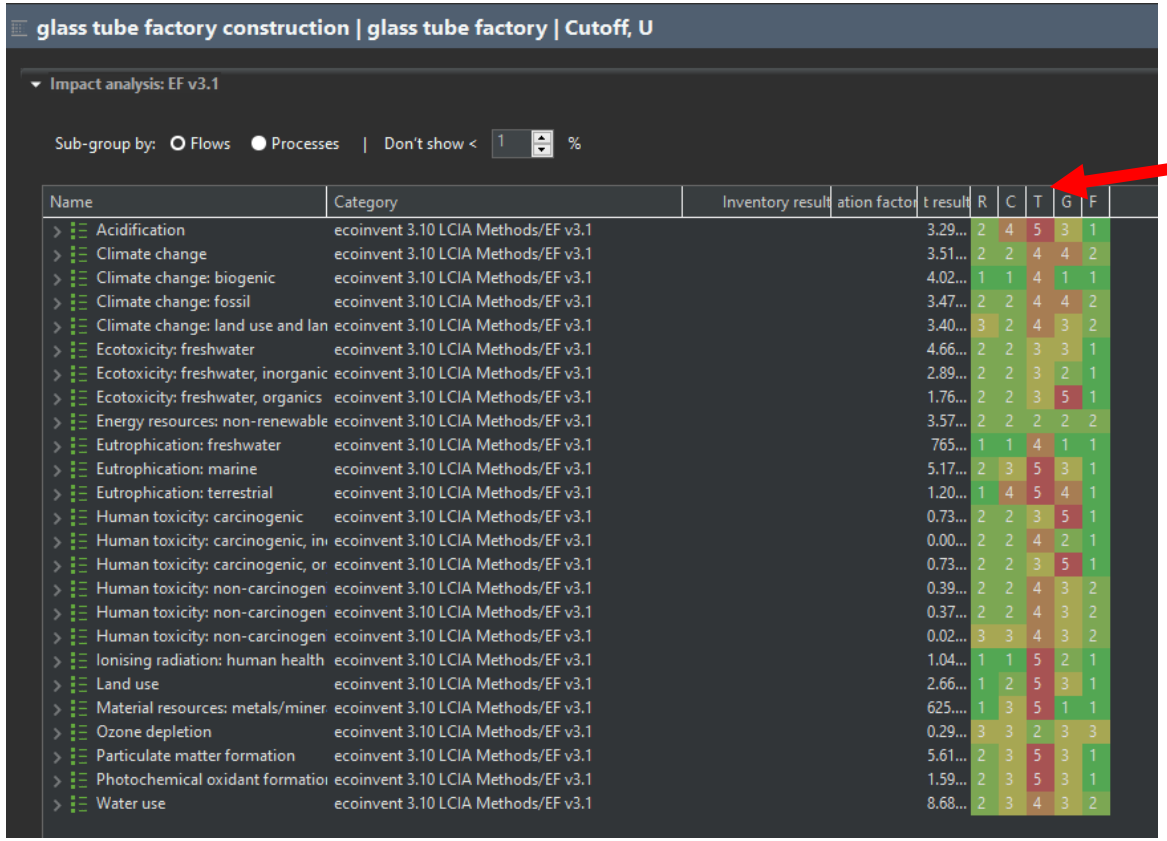
The need for a new database

B, current databases struggle to keep up, with updates of own data, and with inclusion of new data

ecoinvent version and year	processes	products	locations
3.6 2019	18121	3146	294
3.7 2020	19271	3185	299
3.8 2021	19565	3292	300
3.9.1 2022	21238	3550	309
3.10 2023	23523	4031	330

The need for a new database

B, current databases struggle to keep up, with updates of own data, and with inclusion of new data



Name	Category	Inventory result	ation factor	t result	R	C	T	G	F
Acidification	ecoinvent 3.10 LCIA Methods/EF v3.1			3.29...	2	4	5	3	1
Climate change	ecoinvent 3.10 LCIA Methods/EF v3.1			3.51...	2	2	4	4	2
Climate change: biogenic	ecoinvent 3.10 LCIA Methods/EF v3.1			4.02...	1	1	4	1	1
Climate change: fossil	ecoinvent 3.10 LCIA Methods/EF v3.1			3.47...	2	2	4	4	2
Climate change: land use and lan	ecoinvent 3.10 LCIA Methods/EF v3.1			3.40...	3	2	4	3	2
Ecotoxicity: freshwater	ecoinvent 3.10 LCIA Methods/EF v3.1			4.66...	2	2	3	3	1
Ecotoxicity: freshwater, inorganic	ecoinvent 3.10 LCIA Methods/EF v3.1			2.89...	2	2	3	2	1
Ecotoxicity: freshwater, organics	ecoinvent 3.10 LCIA Methods/EF v3.1			1.76...	2	2	3	5	1
Energy resources: non-renewable	ecoinvent 3.10 LCIA Methods/EF v3.1			3.57...	2	2	2	2	2
Eutrophication: freshwater	ecoinvent 3.10 LCIA Methods/EF v3.1			765...	1	1	4	1	1
Eutrophication: marine	ecoinvent 3.10 LCIA Methods/EF v3.1			5.17...	2	3	5	3	1
Eutrophication: terrestrial	ecoinvent 3.10 LCIA Methods/EF v3.1			1.20...	1	4	5	4	1
Human toxicity: carcinogenic	ecoinvent 3.10 LCIA Methods/EF v3.1			0.73...	2	2	3	5	1
Human toxicity: carcinogenic, in	ecoinvent 3.10 LCIA Methods/EF v3.1			0.00...	2	2	4	2	1
Human toxicity: carcinogenic, or	ecoinvent 3.10 LCIA Methods/EF v3.1			0.73...	2	2	3	5	1
Human toxicity: non-carcinogen	ecoinvent 3.10 LCIA Methods/EF v3.1			0.39...	2	2	4	3	2
Human toxicity: non-carcinogen	ecoinvent 3.10 LCIA Methods/EF v3.1			0.37...	2	2	4	3	2
Human toxicity: non-carcinogen	ecoinvent 3.10 LCIA Methods/EF v3.1			0.02...	3	3	4	3	2
Ionising radiation: human health	ecoinvent 3.10 LCIA Methods/EF v3.1			1.04...	1	1	5	2	1
Land use	ecoinvent 3.10 LCIA Methods/EF v3.1			2.66...	1	2	5	3	1
Material resources: metals/miner	ecoinvent 3.10 LCIA Methods/EF v3.1			625....	1	3	5	1	1
Ozone depletion	ecoinvent 3.10 LCIA Methods/EF v3.1			0.29...	3	3	2	3	3
Particulate matter formation	ecoinvent 3.10 LCIA Methods/EF v3.1			5.61...	2	3	5	3	1
Photochemical oxidant formatio	ecoinvent 3.10 LCIA Methods/EF v3.1			1.59...	2	3	5	3	1
Water use	ecoinvent 3.10 LCIA Methods/EF v3.1			8.68...	2	3	4	3	2

T: time as data quality indicator, ecoinvent 3.10 calculation.
5 = worst assessment, data is outdated

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The need for a new database

Plus, technical flaws in existing database creation

Table of content

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Approach

Approach: how to develop a new LCA database?

Starting considerations

1. There is quite a lot of data related to inputs and outputs and other LCA-relevant aspects for process datasets available – outside the LCA domain
2. There is of course also an increasing amount of LCA information and knowledge available
3. GreenDelta project LCA data machine -> logic for information assessment
4. AI directly (ask AI to create process datasets) somewhat pointless but AI can support

Approach: how to develop a new LCA database?

Towards the technical solution

1. Combine top-down and bottom up
2. Model “atoms”, truly smallest information units, for important elements
3. Important elements are processes, flows, locations
4. Initial database should not be in one of the existing reference systems (nomenclature and format) - ILCD, EcoSpold, etc., but be agnostic, and be possible to be exported in these
5. Create process data sets and iteratively refine them
6. Where existing, use good, detailed models (transport, waste treatment)

Approach: how to develop a new LCA database?

Start

1. Combined Nomenclature, European Commission
2. Postulate datasets based on common knowledge
3. Refine datasets from open source information (PRTR, Wikipedia, UN Food database, satellite images, ..)...
4. Using reasoning and graph databases and models
5. Calculate data quality
6. ..until satisfactory

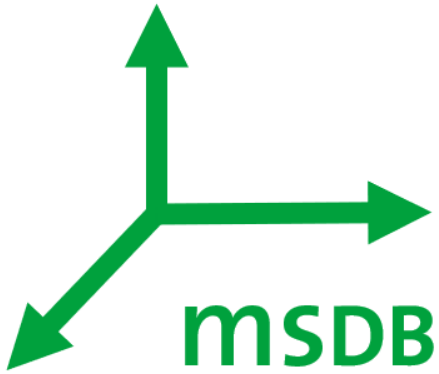
Dimensions are flows, processes, locations.

Approach: how to develop a new LCA database?

Dimensions are flows, processes, locations.

This creates a massive sustainability database with traceable quality.

We call it the msdb.



Status

Combined nomenclature

- https://taxation-customs.ec.europa.eu/customs-4/calculation-customs-duties/customs-tariff/combined-nomenclature_en

2024, from https://tulli.fi/en/statistics/combined-nomenclature-cn

~ 16,000 categories

These are categories for products

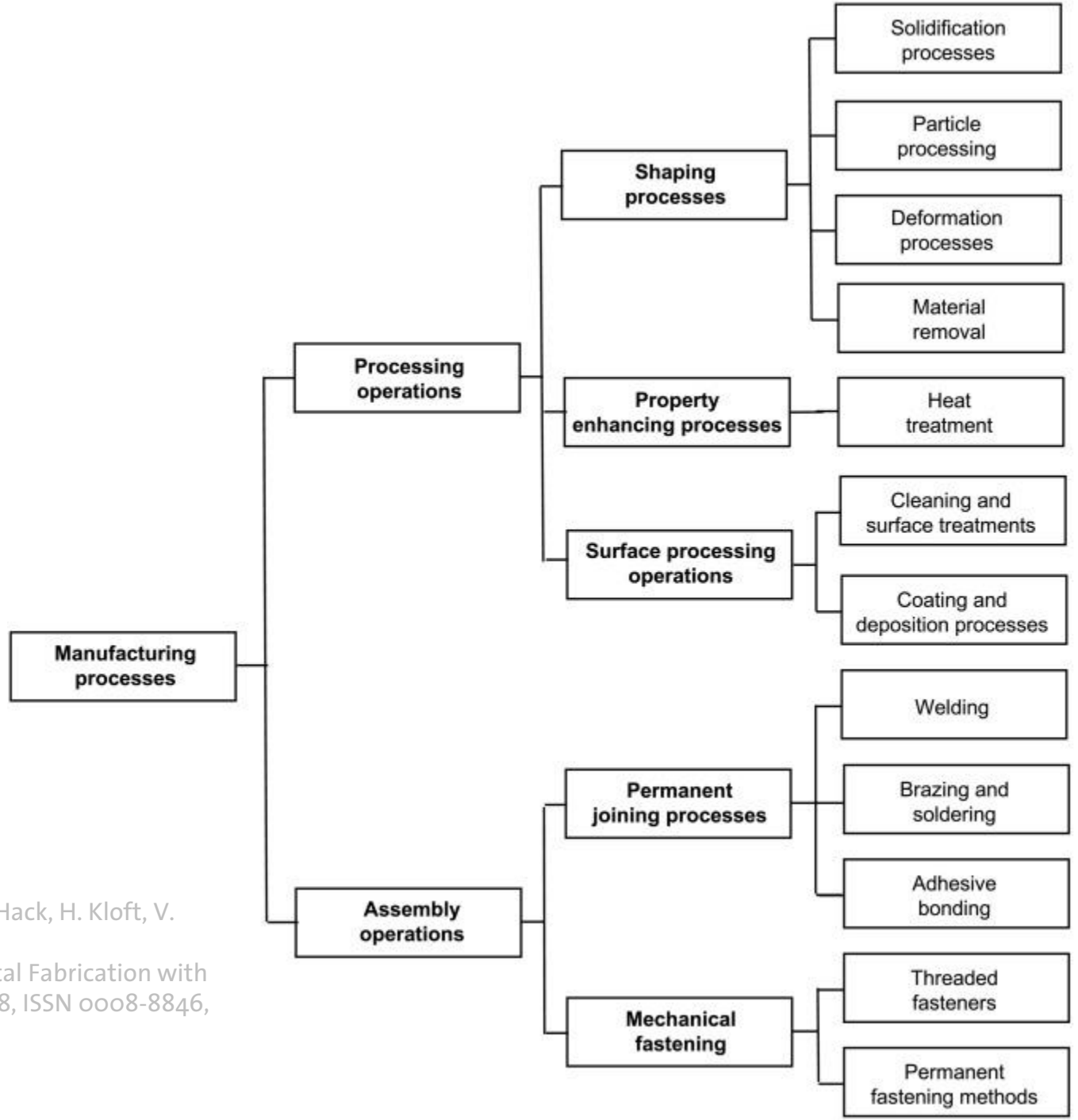
cn_code	en
01	LIVE ANIMALS
0101	Live horses, asses, mules and hinnies
010121	Pure-bred breeding horses
01012100	Pure-bred breeding horses
010129	Live horses (excl. pure-bred for breeding)
01012910	Horses for slaughter
01012990	Live horses (excl. for slaughter, pure-bred for breeding)
010130	Live asses
01013000	Live asses
010190	Live mules and hinnies
01019000	Live mules and hinnies
0102	Live bovine animals
010221	Pure-bred cattle for breeding
01022110	Pure-bred breeding heifers "female bovines that have never calved"
01022130	Pure-bred breeding cows (excl. heifers)
01022190	Pure-bred cattle for breeding (excl. heifers and cows)
010229	Live cattle (excl. pure-bred for breeding)
01022905	Live cattle of the sub-genus Bibos or Poephagus (excl. pure-bred for breeding)
01022910	Live cattle of a weight <= 80 kg (excl. pure-bred for breeding)
01022921	Cattle of a weight > 80 kg but <= 160 kg, for slaughter
01022929	Live cattle of a weight > 80 kg but <= 160 kg (excl. for slaughter, pure-bred for breeding)
01022941	Cattle of a weight > 160 kg but <= 300 kg, for slaughter
01022949	Live cattle of a weight > 160 kg but <= 300 kg (excl. for slaughter, pure-bred for breeding)
01022951	Heifers "female bovines that have never calved" of a weight > 300 kg, for slaughter
01022959	Live heifers "female bovines that have never calved" of a weight > 300 kg (excl. for slaughter and pure-bred for breed
01022961	Cows of a weight > 300 kg, for slaughter (excl. heifers)
01022969	Live cows of a weight > 300 kg (excl. for slaughter and pure-bred for breeding and heifers)
01022991	Cattle of a weight > 300 kg, for slaughter (excl. heifers and cows)
01022999	Live cattle of a weight > 300 kg (excl. for slaughter, pure-bred for breeding and heifers and cows)
010231	Pure-bred buffalo for breeding
01023100	Pure-bred buffalo for breeding
010239	Live buffalo (excl. pure-bred for breeding)
01023910	Live domestic buffalo (excl. pure-bred for breeding)
01023990	Live buffalo (excl. domestic species and pure-bred for breeding)
010290	Live bovine animals (excl. cattle and buffalo)
01029020	Bovine pure-bred breeding animals (excl. cattle and buffalo)
01029091	Live domestic bovine animals (excl. cattle and buffalo and pure-bred for breeding)
01029099	Live bovine animals (excl. cattle, buffalo, pure-bred for breeding and domestic species)
0103	Live swine
010310	Pure-bred breeding swine
01031000	Pure-bred breeding swine
010391	Live pure-bred swine, weighing < 50 kg (excl. pure-bred for breeding)
01039110	Domestic swine, weighing < 50 kg (excl. pure-bred for breeding)
01039190	Live non-domestic swine, weighing < 50 kg
010392	Live pure-bred swine, weighing >= 50 kg (excl. pure-bred for breeding)
01039211	Live domestic sows, having farrowed at least once, weighing >= 160 kg (excl. pure-bred for breeding)
01039219	Live domestic swine, weighing >= 50 kg (excl. sows having farrowed at least once and weighing >= 160 kg, and those
01039290	Live non-domestic swine, weighing >= 50 kg
0104	Live sheep and goats
010410	Live sheep
01041010	Pure-bred sheep for breeding
01041030	Live lambs "sheep up to a year old" (excl. purebred breeding animals)
01041080	Live sheep (excl. lambs and pure-bred breeding animals)
010420	Live goats
01042010	Pure-bred breeding goats
01042090	Live goats (excl. pure-bred for breeding)
0105	Live poultry, "fowls of the species Gallus domesticus, ducks, geese, turkeys and guinea fowls"
010511	Live fowls of the species Gallus domesticus, weighing <= 185 g (excl. turkeys and guinea fowls)
01051111	Grandparent and parent female chicks of fowls of the species Gallus domesticus laying stocks of a weight of <= 185
01051119	Grandparent and parent female chicks fowls of the species Gallus domesticus of a weight of <= 185 g (excl. laying st
01051191	Laying stock "fowls of the species Gallus domesticus" of a weight of <= 185 g (excl. grandparent and parent female c
01051199	Live fowls of the species Gallus domesticus of a weight of <= 185 g (excl. grandparent and parent female chicks and
010512	Live domestic turkeys, weighing <= 185 g

Combined nomenclature

These are categories for products

Processes?

- More messy; not one clean taxonomy.
- Many different proposals for different sectors, industries
- Often very ‘high level’ and not detailed.



R.A. Buswell, W.R. Leal da Silva, F.P. Bos, H.R. Schipper, D. Lowke, N. Hack, H. Kloft, V. Mechtcherine, T. Wangler, N. Roussel,
A process classification framework for defining and describing Digital Fabrication with Concrete, Cement and Concrete Research, Volume 134, 2020, 106068, ISSN 0008-8846, https://doi.org/10.1016/j.cemconres.2020.106068.

Processes?

-> Structure for the database as own development, based on the life cycle of products and public information

Processes?

- **Own definition: Archetypes of processes, with segments that add nuances/flavours, completed with information from LCA and Wikipedia etc..**

Archetypes:
Animal husbandry
Energy conversion
Freight transport
Generation / extraction of fuel
Generation of materials, agriculture
Generation of materials, other
Incineration
Material conversion
Mixing of goods or materials
Operation of means of transport
Person transport
Storing of goods or materials
Transport, electricity
Transport, pipelines
Waste treatment

Processes?

- **Own definition: Archetypes of processes, with segments that add nuances/flavours, completed with information from LCA and Wikipedia etc..**

Flavours:
cleaning
compressing
cooling
drying
filtering
sorting
wetting
machine operation
…

Example for a top-down “postulation” of a process dataset content, per archetype

6.14. Betrieb Transportmittel - Erzeugungseinheit

Definition:

Betrieb von Transportmittel zum Transport von Gütern. Das Transportmittel bewegt sich.

Beispiel: LKW 3,5t Euro 4 innerstädtisch. Frachtflugzeug Boeing 747 interkontinental.

Inputs:

- Transportmittel (Infrastruktur)
- Treibstoff
- Hilfsstoffe, Wartung

Outputs:

- Betrieb Transportmittel als Dienstleistung
- Wahrscheinlich Emissionen Verbrennung
- Wahrscheinlich andere Emissionen aus Betrieb (Reifenabrieb, Bremsabrieb)
- Evtl. verbrauchte, verlorene Hilfsstoffe (Ölverlust, …)
- Evtl. Abwärme

Prozessparameter:

- Evtl. Auslastung ρ, $\rho \leq 1$
- Evtl. Katalysator, Emissionsklasse
- Evtl. Betriebsweise Transportmittel (bei LKW: Autobahn, innerstädtisch, …; bei Flugzeug Langstreckenflug, Kurstreckenflug)
- Evtl. Transportverlust (verlorenes Gut, verdorbenes Gut, Eintrocknen, …)

Beziehungen innerhalb des Prozesses:

- C-Gehalt Brennstoff = CO2-Gehalt Abgas * VDV
- (weitere, die NOx und andere Emissionen beschreiben, auch H2O, in Abhängigkeit der Verbrennung, des Motortyps…)

Sonstiges:

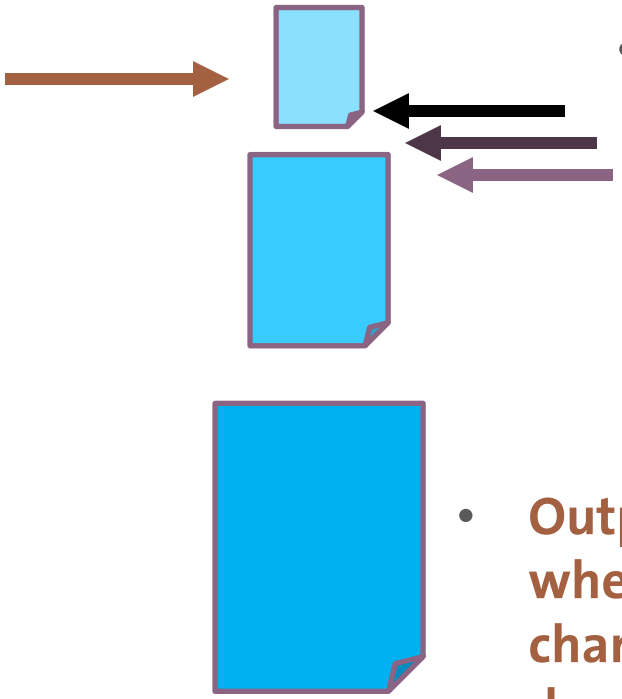
- -

Locations, finally

- ..are countries plus groups and sets typically addressed in LCA: Europe, North America Region, etc.
- Can be easily extended
- Different region has as consequence:
  - Different product providers (electricity grid, e.g.)
  - For some processes, different process settings, and not all processes can take place everywhere (growing wine in Scotland)

Overall approach then

- Start with a task to make a dataset (process, product, location), from postulate



- Challenge and refine with information from various sources, on various aspects

- Output is a dataset where the “procedural changes” are documented, with an indication of quality

How selection of better data and information is done

- **Two aspects:**

  a, Shannon entropy (~conditional probability: how likely is a certain information)

$$H(p|q) = -\sum_{i=1}^{n} p_i * log_2 \frac{p_i}{q_i}$$

  b, data quality

One example process: Soldering for surface mounted devices

- **Quantitative reference: 1m2 soldered area**
- **Inputs:**

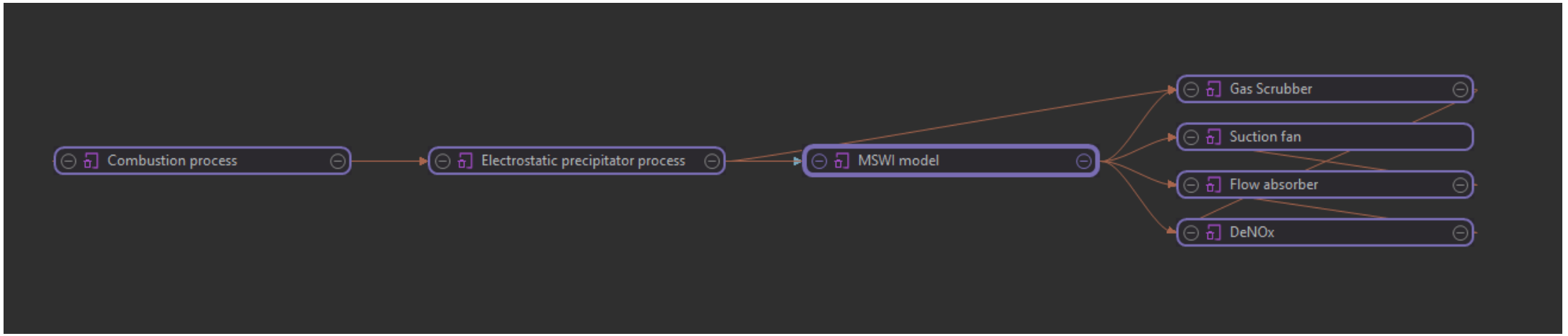
FLOWNAME	FLOWID	AMOUNT	AMOUNT_REL	AMOUNT_QU	UNIT
solder, lead free		0.25			kg
PCB		1.05			m2
electronic components		0.1			kg
electricity		6.25			kWh
machinery		1.00E-10			piece
building		1.00E-15			piece
N2		0.75			kg
flux		0.25			kg

- **Outputs:**

FLOWNAME	FLOWID	AMOUNT	AMOUNT_REL	AMOUNT_QU	UNIT	FLOWTYPE
soldered area		1			m2	PRODUCT
electronic waste		0.15			kg	
Nox	to air	0.15			kg	
2-Propanol	to air	0.05			kg	
production waste, hazardous		0.05			kg	WASTE
production waste, non hazardous		0.1			kg	WASTE

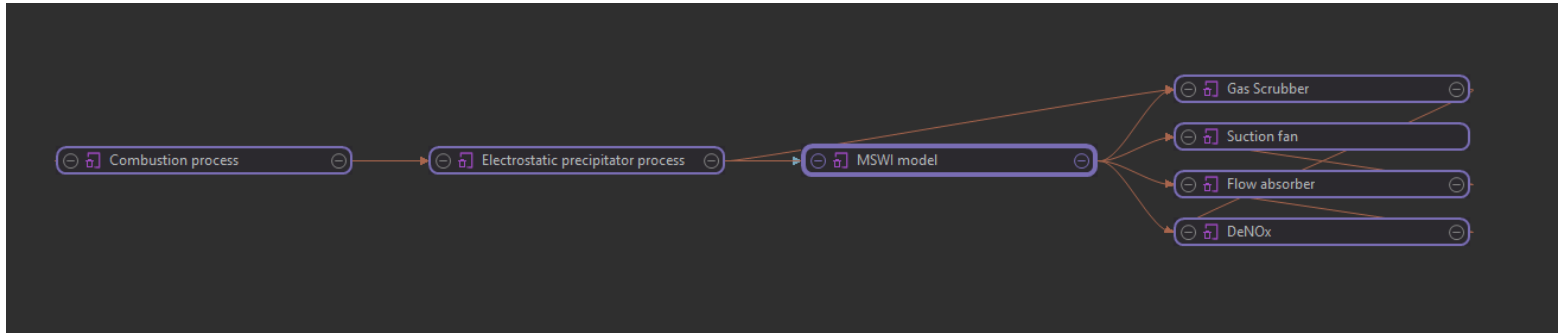
Some important processes modelled in full, so far

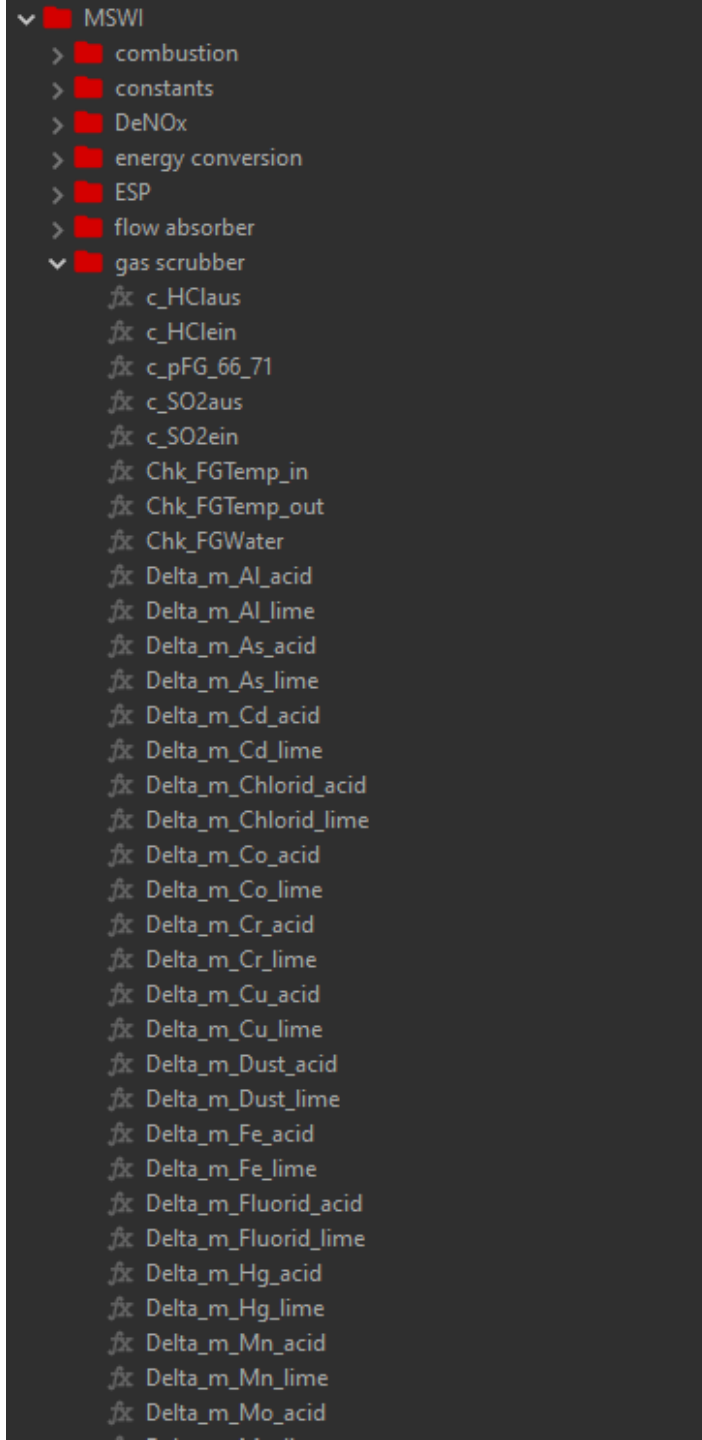
- Transportation (EU Commission transport models, COPERT etc., refined and extended) -> fuel consumption and emissions per payload e.g., very recent and verified
- Waste water treatment, depending on waste water composition (TU Vienna etc. models)
- Municipal solid waste incineration, per waste composition (model from GreenDelta), heavily parameterised



Some important processes modelled explicitly so far

- **Municipal solid waste incineration, per waste composition (model from GreenDelta), heavily parameterised**





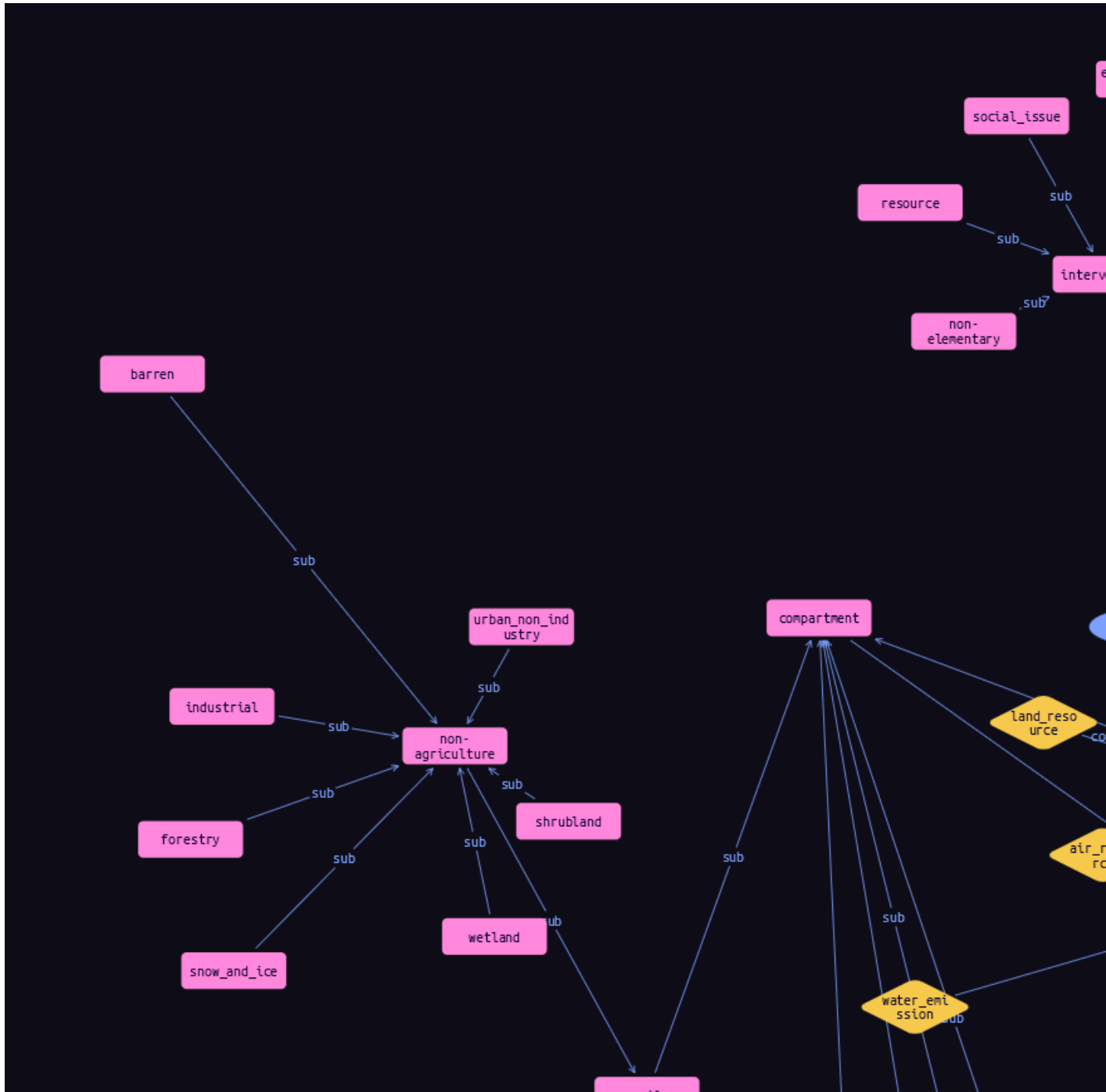
On “atomistic modelling”: e.g. elementary flows:

- intervention
- compartment
- flow

As three independent entities that can be combined as needed

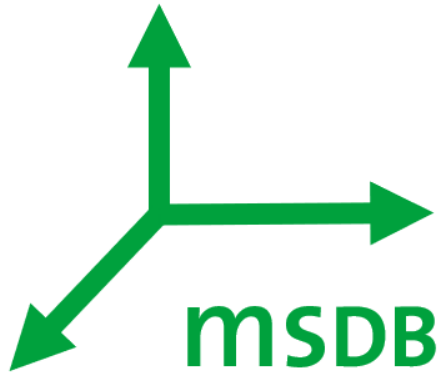
➔ Model becomes more flexible and powerful

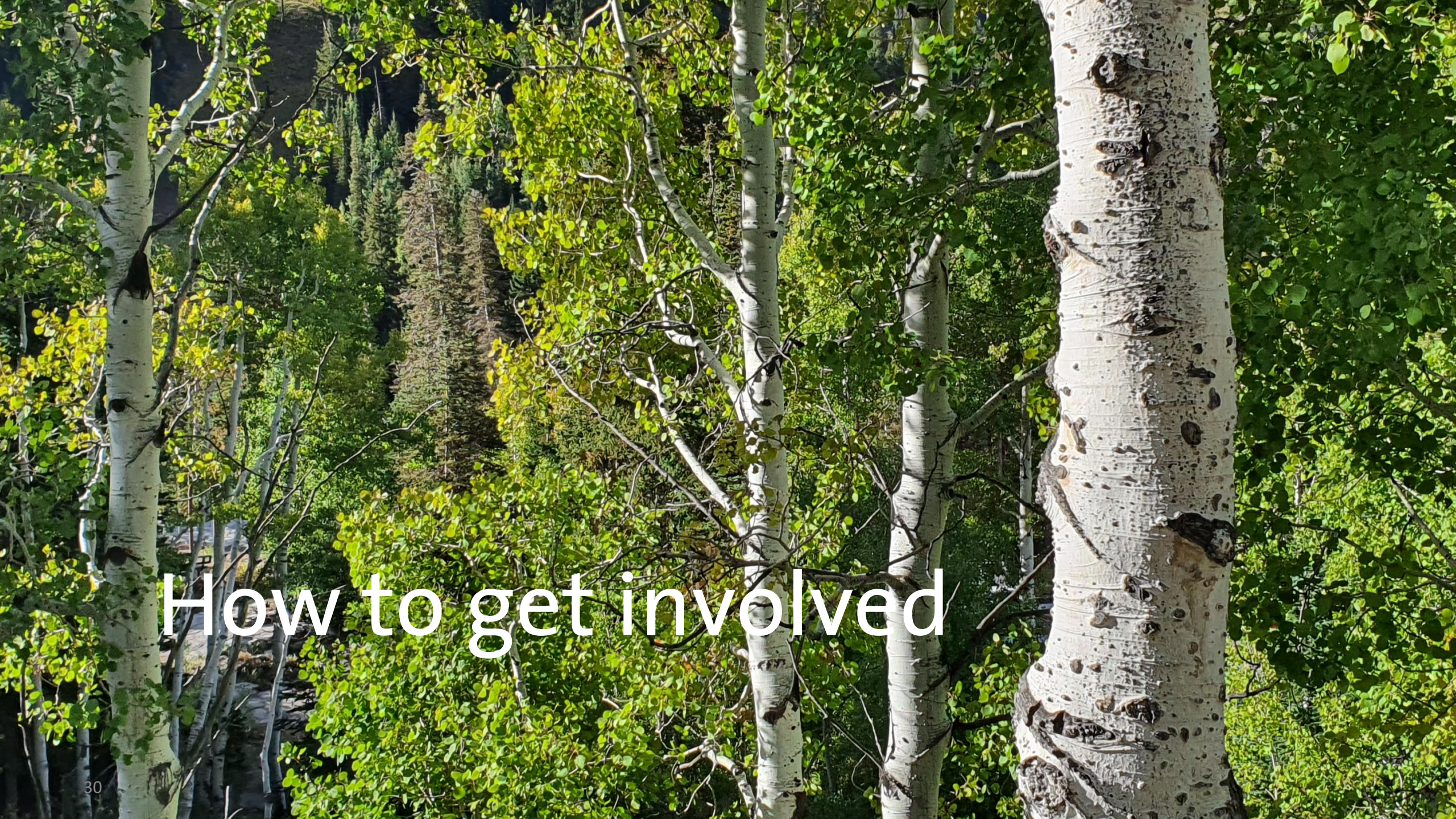
(screenshot from overall model, excerpt, TypeDB)



Overall:

- A massive database with about 500,000 datasets to come, triplets of product, process, location.
- The database is based on a system that is able to create datasets for any database, on the spot
- It can integrate, and gets better, with inclusion of more, specific information sources.
- It will be able to produce datasets in line with several reference systems (e.g., different flow reference systems, inclusion of infrastructure or not, ...)
- This is of course not easy, but needed.





How to get involved

How to get involved

- If you have access to good, useful, .. data that is not bound to a protected license, then please contact us (no system processes but could be details for processes, efficiencies, ...)
- Otherwise: we plan to release a first version ~ end of this year, and will have a first external reviewer round then; contact us also then (but: we planned this already some years ago and were then distracted and did not proceed).

Thank you!

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