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Allocation applied on co-production processes in large LCI process network databases

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Overview

- Background
- Case study and problem setting
- Allocation in ecoinvent
- Example MG silicon purification
- Theses and questions

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Background

- Multi-output processes are common in background databases
- In ecoinvent data v1.0 about 4% of all datasets are multi-output processes
- All co-products need to be considered in a background database
- Background databases should include information of multi-output processes BEFORE allocation (Heijungs 1997)
- 100% rule needs to be respected (ISO 14041)

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Case study: MG silicon purification

- LCI data of photovoltaic power plants
- MG silicon purification is especially important within the product system of photovoltaic electricity
- Three products:
  EG silicon, offgrade silicon, and silicon tetrachloride

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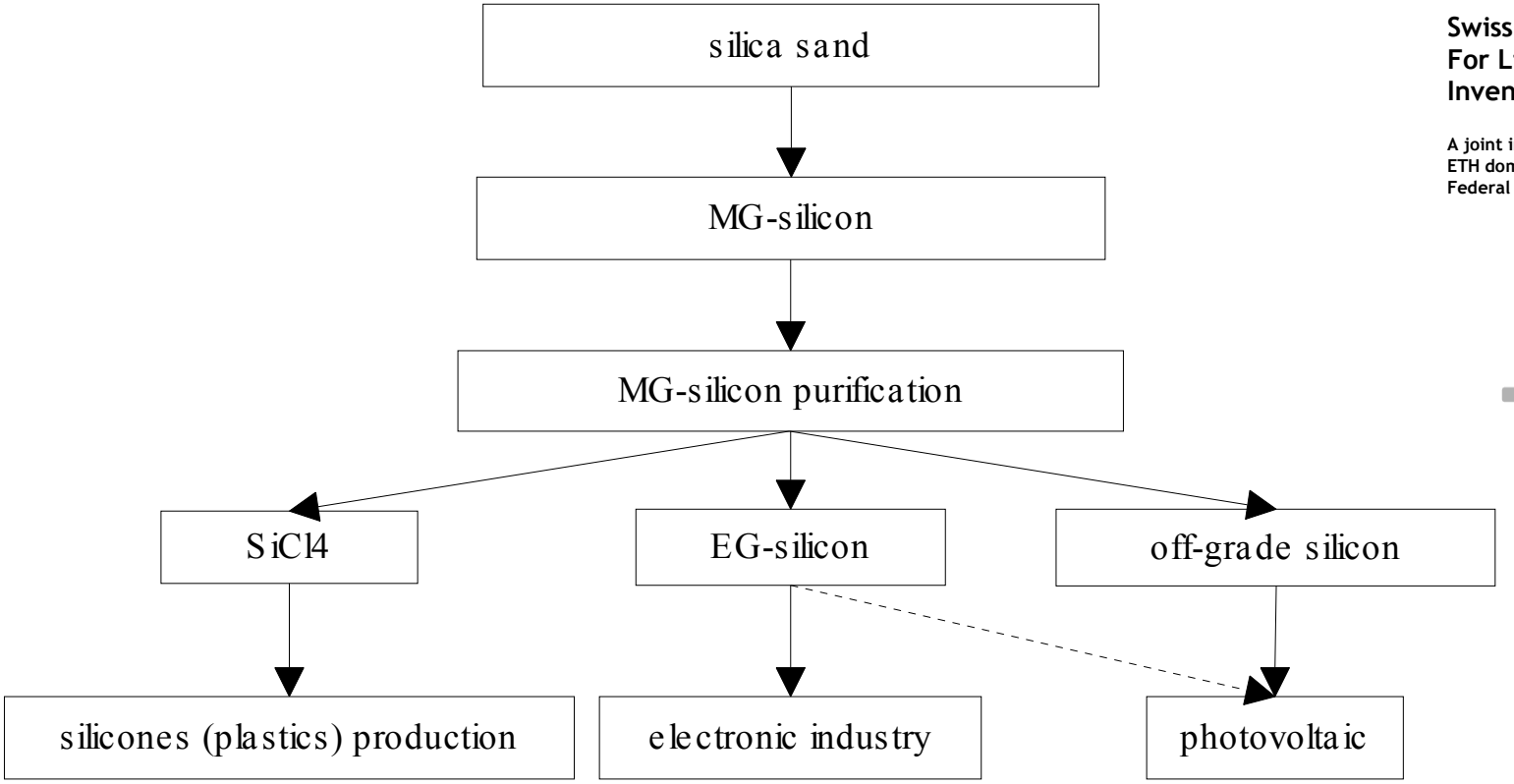
MG-silicon purification



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Problem setting

- LCA study on PV electricity:
  all burdens attributed to purified silicon, 20% Si lost
- LCA study on vacuum insulation:
  partial attribution of burdens to silicon tetrachloride

⇒ Adding up the results of the two studies:
sum of burdens per kg MG-Si input higher than 100%

⇒ inconsistent modelling

- How can 100% rule be fulfilled and controlled?
- How can flexibility be maintained?

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Allocation in ecoinvent

- Multi-output processes are stored in the database – BEFORE allocation
- Input- and output-specific allocation factors, i.e.
  individual allocation factor allowed per pollutant and input
- Allocation executed after import of dataset into database
  -> calculation of allocated unit processes
  -> matrix becomes invertible
- NO System expansion,
  NO credits
- Cut-off applied for outputs without economic value and wastes for recycling

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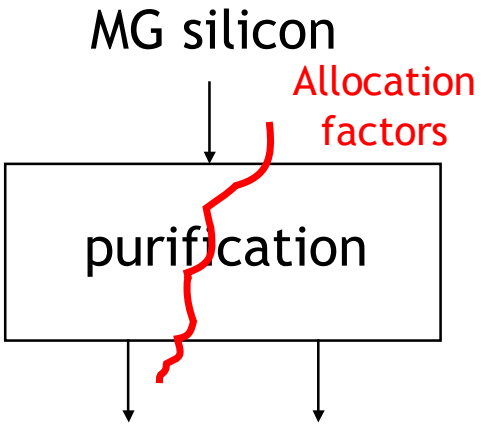
Allocation

Multi-output process:



Derived unit processes:

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Multi-output process raw data BEFORE allocation

Multi-output process inputs/outputs before allocation

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	Name Location Unit	Location	Unit	MG-Si in purif. kg	EG-Si kg	Off-grade Si kg	$SiCl_4$ kg	Allocation criteria
allocated products	silicon, electronic grade, at plant	DE	kg	6.76E-1	100	0	0	
	silicon, electronic grade, off-grade, at plant	DE	kg	8.44E-2	0	100	0	
	silicon tetrachloride, at plant	DE	kg	1.20E+0	0	0	100	
technosphere	MG-silicon, at plant	NO	kg	1.00E+0	71.1	8.9	20.0	Material balance
	polyethylene, HDPE, granulate, at plant	RER	kg	6.37E-4	72.0	2.4	25.6	Revenue all products
	hydrochloric acid, 30% in H_2O, at plant	RER	kg	2.00E+0	48.4	1.6	50.0	Stoechometric calculation
	natural gas, burned in boiler condensing modulating >100kW	RER	MJ	1.22E+2	96.8	3.2	-	Revenue purified silicon
	electricity, natural gas, at combined cycle plant, best	RER	kWh	8.66E+1	96.8	3.2	-	Revenue purified silicon
	electricity, hydropower, at run-of-river power plant	RER	kWh	2.74E+1	96.8	3.2	-	Revenue purified silicon
	price	GLO	€	70.36	75.00	20.00	15.00	
	revenue	GLO	€	70.36	50.67	1.69	18.00	

Allocation factors (in %)

Unit process raw data
AFTER allocation

derived unit process inputs/outputs

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	Name	Location	Unit	MG-silicon, to purification	silicon, electronic grade, at plant	silicon, electronic grade, off-grade, at plant	silicon tetrachloride, at plant	
	Unit	0	0	kg	kg	kg	kg	
allocated products	silicon, electronic grade, at plant	DE	kg		1	0	0	
	silicon, electronic grade, off-grade, at plant	DE	kg		0	1	0	
	silicon tetrachloride, at plant	DE	kg		0	0	1	
technosphere	MG-silicon, at plant	NO	kg		1.1	1.1	0.2	Material balance
	polyethylene, HDPE, granulate, at plant	RER	kg		6.79E-4	1.81E-4	1.36E-4	Revenue all products
	hydrochloric acid, 30% in H2O, at plant	RER	kg		1.4	0.4	0.8	Stoechometric calculation
	natural gas, burned in boiler condensing modulating >100kW	RER	MJ		174.2	46.5	-	Revenue purified silicon
	electricity, natural gas, at combined cycle plant, best	RER	kWh		124.1	33.1	-	Revenue purified silicon
	electricity, hydropower, at run-of-river power plant	RER	kWh		39.2	10.5	-	Revenue purified silicon

ecoinvent and avoided burdens

- ecoinvent is able to model system expansion by
  - defining one reference flow (one of the co-products), and
  - introducing negative outputs for the other co-products
- Identification of displaced processes: see, e.g., Ekvall 1999, Weidema 2001
- No allocation factors needed,
  although questionable whether all avoided burdens shall be attributed to the co-product output of interest (reference flow)
- If performed for all co-products of one multi-output process: 100% rule not necessarily fulfilled.

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Main characteristics of allocation in ecoinvent

- Input and output flow data of an MO-process are stored and available in ecoinvent before allocation
- Allocation factors can be chosen per individual input/output
- Sum of allocated burden always equals 100% of total burdens otherwise dataset import denied!
- Unit processes for co-products are derived when importing dataset into ecoinvent database
- Derived unit process data are used for (matrix) calculation of cumulative LCI results

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Advantages and drawback

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Advantages:

- Fully transparent reporting of allocation factors
- 100% rule is obeyed (otherwise dataset cannot be imported)
- LCIs of all co-products are fully consistent
- If necessary, allocation factors may easily be changed

Drawback:

- Cumulative LCI results of the non-allocated multi-output process are NOT available

Theses and questions for session A

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Theses:

- Allocation (and avoiding it by system expansion) on a product/service level involves (subjective) value choices
- Rather than trying to keep LCI free from value choices, they should be accepted and addressed pro-actively.
- Approaches should be developed that help to incorporate value choices in LCI

Questions:

- Can cultural theory (used in eco-indicator 99) play a role?
- Are there other approaches available from social sciences, like, e.g., position-oriented tactics and strategies?