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sustainability consulting + software

Life Cycle Sustainability Assessment of photovoltaic panels using soca

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PSILCA database – Agenda

1. Background and motivation
2. Objectives and approach
3. Methods
4. Results
5. Conclusion

1 Background and motivation

Background and Motivation

"Ensure access to affordable, reliable, *sustainable* and modern energy for all"

(Goal 7 of the UN Sustainable Development Goals (SDG) 2016)

- Sustainable energy "transforms lives, economies and the planet"

→ Covers three dimensions of sustainability

- On EU level: research on life-cycle approach for evaluating the sustainability performance of energy technologies

Background and Motivation

Challenges:

- Only a few case studies for LCSA exist so far, different approaches
- No agreed method or standards– how to combine life cycle tools?

  → Only some LC stages were considered
- Because hugh amounts of data are required
- So far no comprehensive database allowing efficient calculation of environmental, social and economic impacts of product life cycles simultaneously

2 Objectives and approach

Objectives and approach

- Aim: contribute to research of Life Cycle Sustainability Assessment (LCSA) by providing a tool

- Develop database containing environmental and social inventory information and costs for different product life cycles
- Test database´s usability and reliability for LCSA in a case study

3 Methods

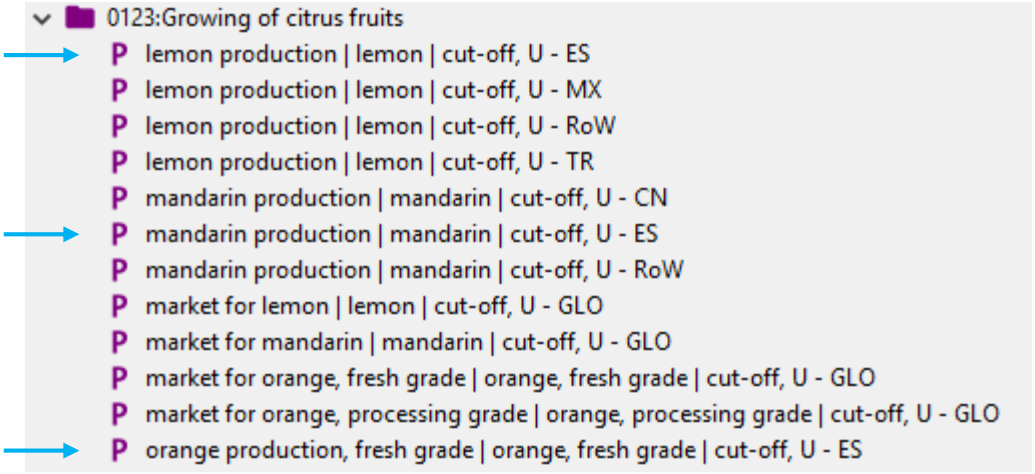
Methods: Development of database

- Develop add-on containing social inventory information for ecoinvent v.3.3
- Ecological inventory data and costs are based on ecoinvent v.3.3
- Social inventory data based on PSILCA

Database: Mapping

- Assigning of risk-assessed indicators from PSILCA *country-specific-sectors* to ecoinvent *categories*

PSILCA “Spain: Products of agriculture” → *ecoinvent “Spain: Growing of citrus fruits”*



Screenshot from openLCA

- Exception: market processes and activities for administration and database modelling

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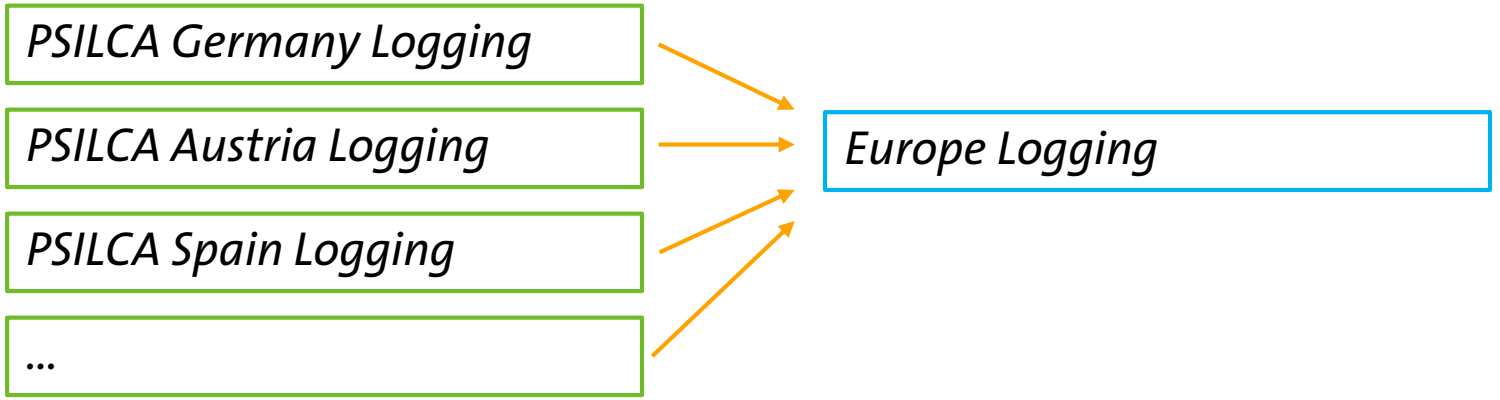
Database: Mapping

- Ecoinvent processes of trans-national (or global) regions get an average of same/similar sectors of all related countries in PSILCA



- Ecoinvent processes of “Rest-of-World” regions get an average of similar/same sectors of all countries in PSILCA not covered individually for these activities

Database: Activity variable

- Worker hours
- Calculated out of working time per USD sector output (from PSILCA) multiplied by cost of ecoinvent product
- Average of PSILCA working times assumed for global and regional processes

Outputs

Flow	Category	Amount	Unit	Costs/Revenues
barley grain, feed, organic	011:Growing of non-perennial crops/0111:Gro...	1.00000	kg	0.15900 EUR
Children in employment, total; no risk	Workers/Child labour	0.00185	h	
Human rights issues faced by indigenous people; not appli...	Local Community/Respect of indigenous rights	0.00185	h	
Living wage, per month; high risk	Workers/Fair Salary	0.00185	h	
Minimum wage, per month; very high risk	Workers/Fair Salary	0.00185	h	
Presence of indigenous population; no risk	Local Community/Respect of indigenous rights	0.00185	h	
Rate of fatal accidents at workplace; low risk	Workers/Health and Safety (Workers)	0.00185	h	
Sector average wage, per month; very low risk	Workers/Fair Salary	0.00185	h	
Water	Emission to air/unspecified	0.05040	kg	

Screenshot from openLCA

Database: Activity variable

- For ecoinvent activities without costs, parameters were defined

Outputs

Flow	Category	Amount	Unit
Sulfur dioxide	Emission to air/high population density	0.00088	kg
Calcium	Emission to air/high population density	2.37770E-6	kg
NMVOC, non-methane volatile organic compounds, unspecifie...	Emission to air/high population density	2.28130E-6	kg
Molybdenum	Emission to water/ground water, long-term	1.11560E-7	kg
Copper, ion	Emission to water/surface water	9.71220E-6	kg
Chromium	Emission to soil/agricultural	4.30130E-6	kg
Zinc, ion	Emission to water/surface water	3.38050E-5	kg
Lead	Emission to water/surface water	9.48660E-7	kg
Cyanide	Emission to air/high population density	5.99520E-7	kg
Rate of fatal accidents at workplace; medium risk	Workers/Health and Safety (Workers)	1*WH_m3	h
Presence of indigenous population; no risk	Local Community/Respect of indigenous rights	1*WH_m3	h
Human rights issues faced by indigenous people; not applicable	Local Community/Respect of indigenous rights	1*WH_m3	h
Minimum wage, per month; very high risk	Workers/Fair Salary	1*WH_m3	h
Living wage, per month; high risk	Workers/Fair Salary	1*WH_m3	h
Sector average wage, per month; very low risk	Workers/Fair Salary	1*WH_m3	h
Children in employment, total; no risk	Workers/Child labour	1*WH_m3	h

Screenshot from openLCA

Database: Data quality

- Data quality assessment is basically transferred from PSILCA original data
- regarding geographical and technical conformance assessment, mapping and data attribution procedures were taken into consideration

Forced Labour						
Goods produced by forced labour		No data	5.19122E-4			
Frequency of forced labour	1.5 [‰]	Very low risk	5.19122E-4	(2;4;3;3;2)		ILO 2012: Forced Labour
Trafficking in persons	1 [Tier]	Very low risk	5.19122E-4	(2;1;1;1;4)		U.S. Department of State 2014: Trafficking in Persons
Fair Salary						
Living wage, per month	883.913486 [USD]	High risk	5.19122E-4	(2;2;4;2;2)	Mean over differe...	WageIndicator 2014: Living wage
Minimum wage, per month	1400 [USD]	Very low risk	5.19122E-4	(2;3;1;1;2)	Data scope: count...	WageIndicator 2014: Minimum wage
Sector average wage, per month	6759.4144 [USD]	Very low risk	5.19122E-4	(2;2;2;1;2)	Risk level referrin...	ILOstat 2014

Screenshot from openLCA

Application: Case study

- LCSA of electricity production with photovoltaic panels

1. Produce 1kWh electricity, low voltage with solar energy in Germany (DE), India (IN) and Mexico (MX)

2. To compare: produce electricity with 1 photovoltaic panel in DE, IN, MX

“electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | electricity, low voltage”

- Calculate three dimensions of LCSA
- From cradle-to-gate

Application: Impact assessment

- ReCiPe 2008, midpoint (H)
- Rudimentary method for social impacts
- Value added approach by Moreau and Weidema (2015)

Impact assessment method: Social Impacts Weighting method

Impact factors

Impact category: Gender wage gap

Flow	Category	Flow property	Factor	Unit	Uncertainty
Gender wage gap; high risk	Workers/Discrimination	Duration	10.0	GW med risk hours/h	none
Gender wage gap; low risk	Workers/Discrimination	Duration	0.1	GW med risk hours/h	none
Gender wage gap; medium risk	Workers/Discrimination	Duration	1.0	GW med risk hours/h	none
Gender wage gap; no data	Workers/Discrimination	Duration	0.1	GW med risk hours/h	none
Gender wage gap; no risk	Workers/Discrimination	Duration	0.0	GW med risk hours/h	none
Gender wage gap; very high risk	Workers/Discrimination	Duration	100.0	GW med risk hours/h	none
Gender wage gap; very low risk	Workers/Discrimination	Duration	0.01	GW med risk hours/h	none

Screenshot from openLCA

4 Results

Soca database

- S-LCA add-on for ecoinvent v3.3
- Complements environmental and cost data by social risk information:

Workers, Local communities, Value chain actors, Society

↓

17 sub-categories

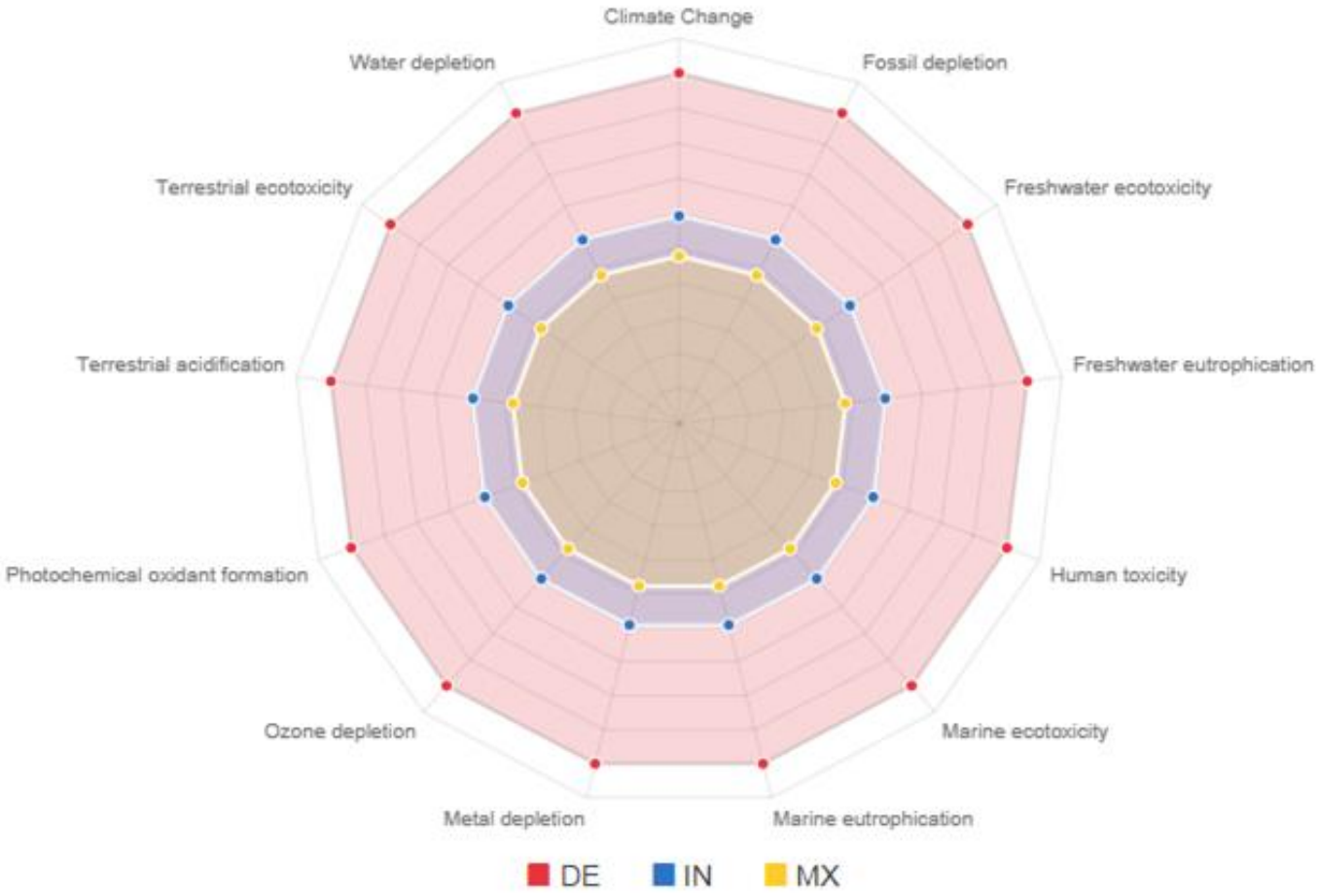
↓

53 indicators

- “Social aspects”: raw values, data quality, sources...

Case study:

Relative environmental impact comparison, 1 kWh electricity



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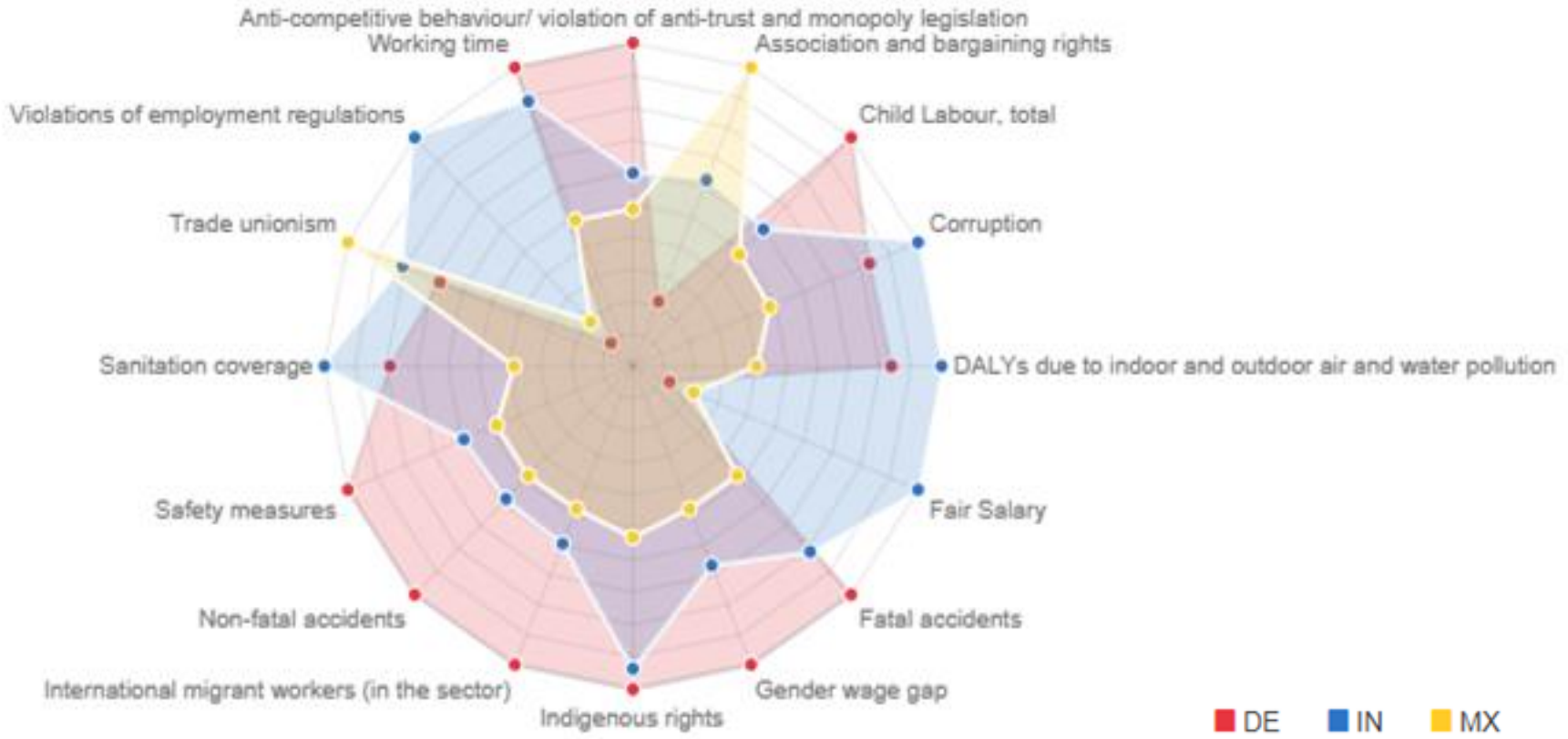
Case study:
Relative social impact comparison, 1 kWh electricity



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Case study:
LCC, 1 kWh electricity

- Total added value = **0.12 USD** for all options

→ Due to global average prices for most of the activities

Case study:
Relative social impact comparison, 1 photovoltaic panel

- Environmental impacts are the same for all scenarios

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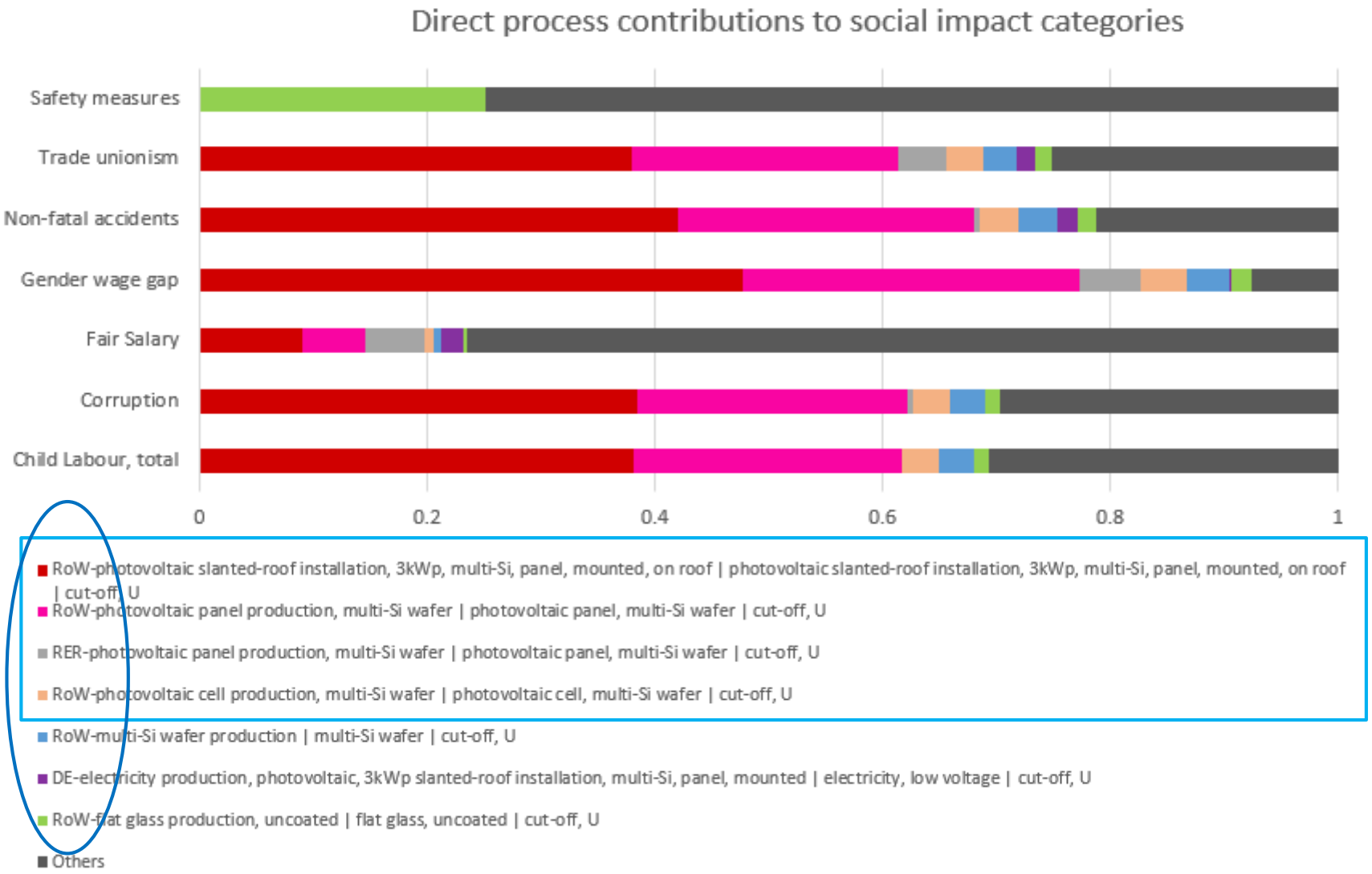
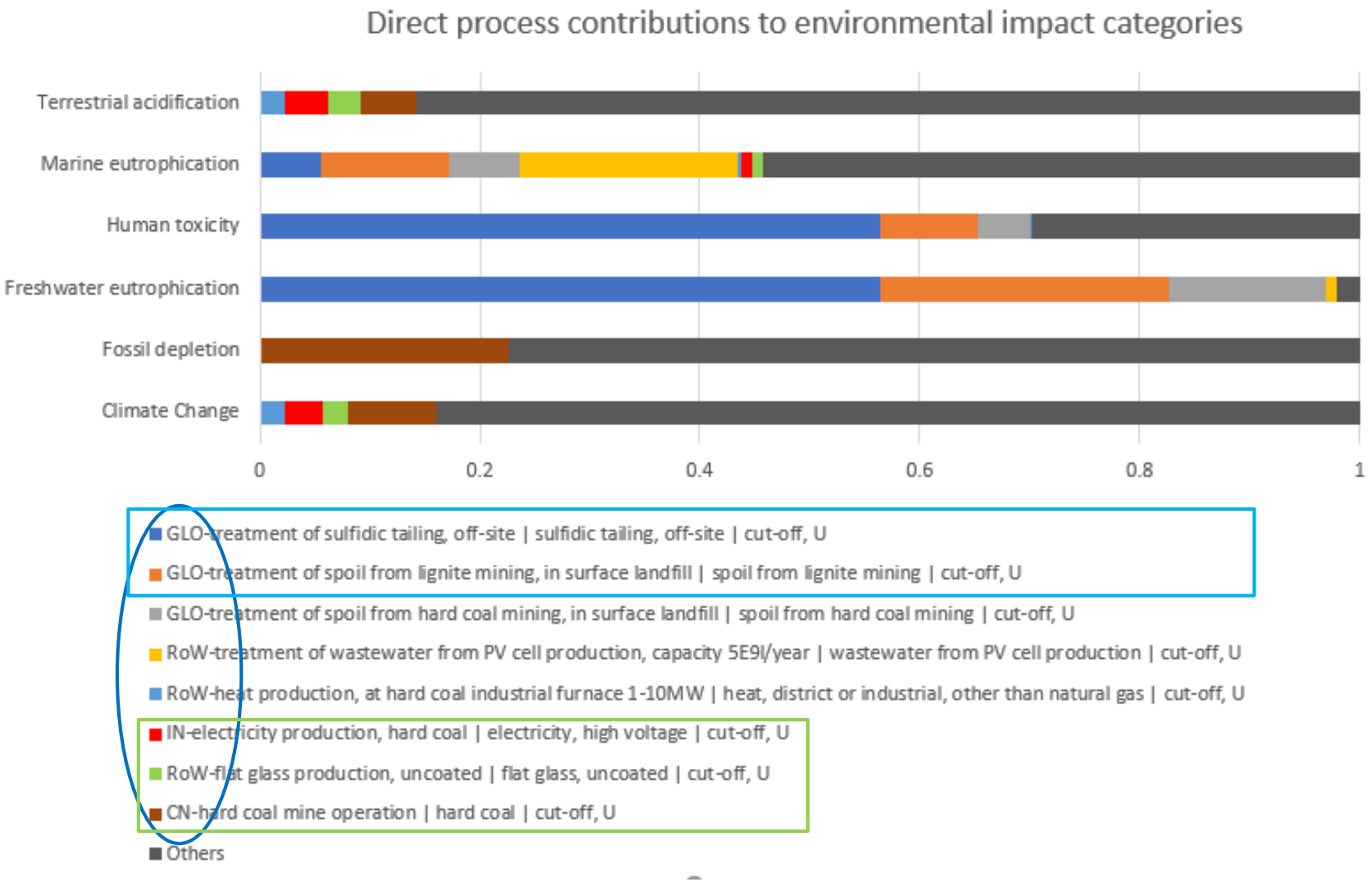
Case study: Contributions, S-LCA, DE (1 kWh)



Case study: Contributions, LCA DE (1 kWh)



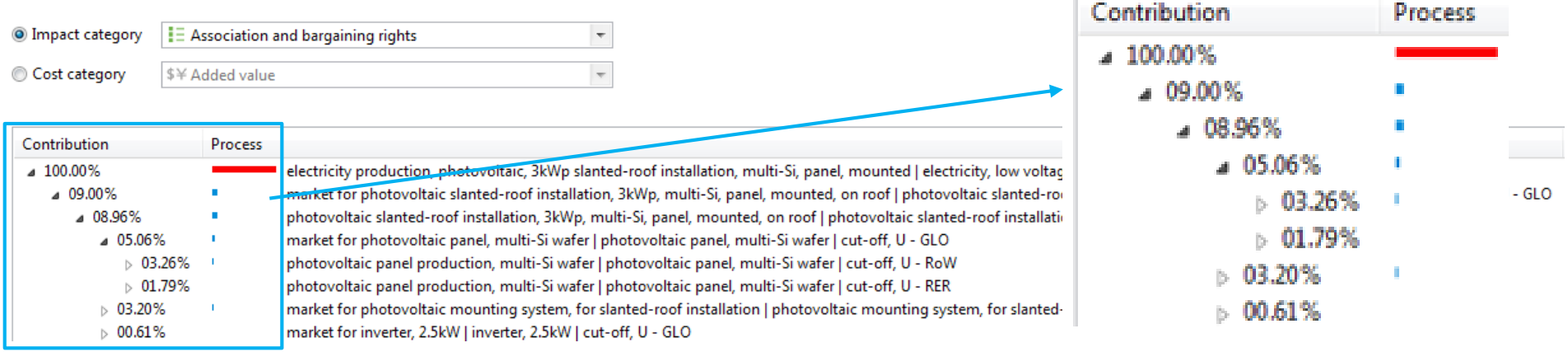
Case study: Contributions, DE (1 kWh) LCC

Process	Product	Amount	Unit	Added value
photovoltaic panel production, multi-Si wafer | photovoltaic panel, multi-Si wafer | cut-off, U - RoW	photovoltaic panel, multi-Si wafer	0.00022	m2	0.09 USD
photovoltaic panel production, multi-Si wafer | photovoltaic panel, multi-Si wafer | cut-off, U - RER	photovoltaic panel, multi-Si wafer	0.00012	m2	0.05 USD
flat glass production, uncoated | flat glass, uncoated | cut-off, U - RoW	flat glass, uncoated	0.00319	kg	0.01 USD
transmission network construction, electricity, high voltage | transmission network, electricity, high voltage | cut-off, U - RoW	transmission network, electricity,...	4.48262E-7	m	0.00 USD
flat glass production, uncoated | flat glass, uncoated | cut-off, U - RER	flat glass, uncoated	0.00066	kg	0.00 USD
electricity production, hydro, run-of-river | electricity, high voltage | cut-off, U - RoW	electricity, high voltage	0.08685	MJ	0.00 USD
aluminium ingot, primary, to aluminium, wrought alloy market | aluminium, wrought alloy | cut-off, U - GLO	aluminium, wrought alloy	0.00100	kg	-0.00 USD
electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | electricity, low voltage | cut-o...	electricity, low voltage	3.60000	MJ	-0.07 USD

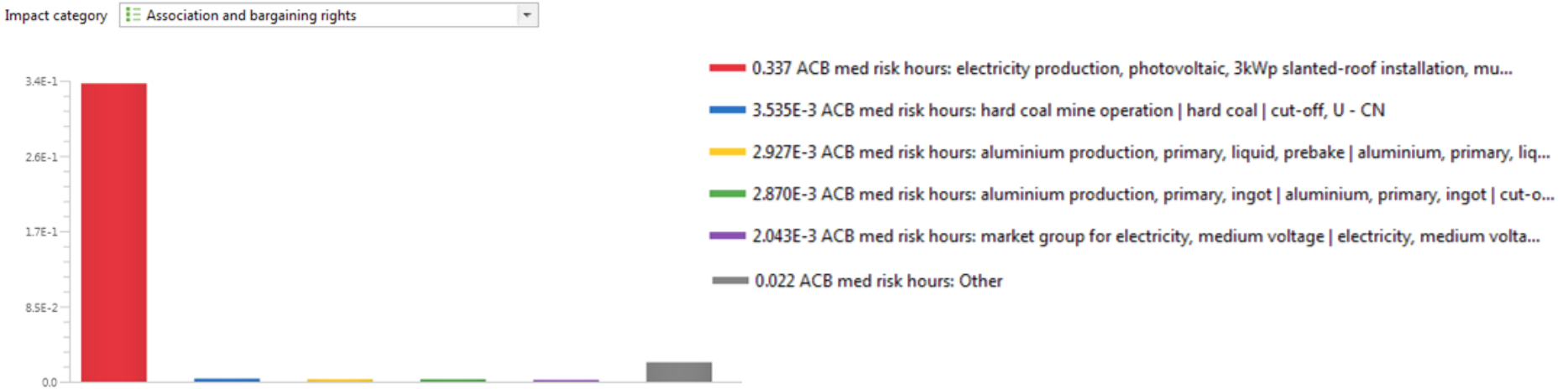
Screenshot from openLCA

Case study: Contributions, MX (1 kWh)

Contribution tree



Top 5 direct contributions



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Case study: Contributions, DE (1 kWh) LCC

DE

Process	Product	Amount	Unit	Added value
photovoltaic panel production, multi-Si wafer | photovoltaic panel, multi-Si wafer | cut-off, U - RoW	photovoltaic panel, multi-Si wafer	0.00022	m2	0.09 USD
photovoltaic panel production, multi-Si wafer | photovoltaic panel, multi-Si wafer | cut-off, U - RER	photovoltaic panel, multi-Si wafer	0.00012	m2	0.05 USD
flat glass production, uncoated | flat glass, uncoated | cut-off, U - RoW	flat glass, uncoated	0.00319	kg	0.01 USD
transmission network construction, electricity, high voltage | transmission network, electricity, high voltage | cut-off, U - RoW	transmission network, electricity,...	4.48262E-7	m	0.00 USD
flat glass production, uncoated | flat glass, uncoated | cut-off, U - RER	flat glass, uncoated	0.00066	kg	0.00 USD
electricity production, hydro, run-of-river | electricity, high voltage | cut-off, U - RoW	electricity, high voltage	0.08685	MJ	0.00 USD
aluminium ingot, primary, to aluminium, wrought alloy market | aluminium, wrought alloy | cut-off, U - GLO	aluminium, wrought alloy	0.00100	kg	-0.00 USD
electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | electricity, low voltage | cut-o...	electricity, low voltage	3.60000	MJ	-0.07 USD

IN

Process	Product	Amount	Unit	Added value
photovoltaic panel production, multi-Si wafer | photovoltaic panel, multi-Si wafer | cut-off, U - RoW	photovoltaic panel, multi-...	0.00013	m2	0.06 USD
photovoltaic panel production, multi-Si wafer | photovoltaic panel, multi-Si wafer | cut-off, U - RER	photovoltaic panel, multi-...	7.22803E-5	m2	0.03 USD
flat glass production, uncoated | flat glass, uncoated | cut-off, U - RoW	flat glass, uncoated	0.00189	kg	0.01 USD
electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | electricity, low voltage | cut-off, U - IN	electricity, low voltage	3.60000	MJ	0.01 USD
transmission network construction, electricity, high voltage | transmission network, electricity, high voltage | cut-off, U - RoW	transmission network, elec...	2.65403E-7	m	0.00 USD
flat glass production, uncoated | flat glass, uncoated | cut-off, U - RER	flat glass, uncoated	0.00039	kg	0.00 USD
electricity production, hydro, run-of-river | electricity, high voltage | cut-off, U - RoW	electricity, high voltage	0.05142	MJ	0.00 USD

5 Conclusions

Conclusions:

Soca is first database allowing complete LCSA

+ fast, efficient calculation of social and environmental impacts and costs for several life cycle stages

+ three sustainability dimensions can be evaluated for the same product system simultaneously

+ clear visualizations and comparisons of results showing different environmental, social and cost hotspots

Conclusions:

- Mapping from input/output database to LCA database

→ Average social risks for all activities of same category

- Global and RoW processes with average social and environmental risks are very dominant as contributions
- Prices are global averages for many activities → not only distorts overall costs but also worker hours (hence social impacts)

→ Environmental and social inventory data, and especially costs should be much more country- and process-specific

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Thank you!

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