Assessing supply disruption impacts along the supply chain within Life Cycle Sustainability Assessment – the SPOTTER approach applied to the Swiss Economy –

88th Discussion Forum on LCA “Frontiers in Life Cycle Sustainability Assessment – How can Life Cycle Thinking embrace the Triple Bottom Line?”

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ZHAW Wädenswil

Switzerland

Marcus Berr[1,2], Roland Hischier[1], Patrick Wäger[1]

[1]Empa, Swiss Federal Laboratories for Materials Science and Technology, St. Gallen, Switzerland

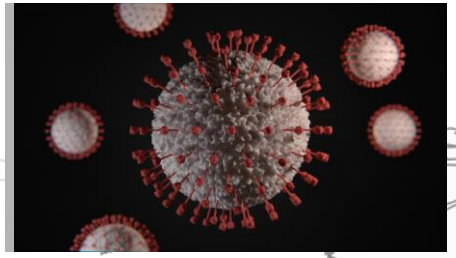
[2]myclimate Foundation, Zurich, Switzerland

Agenda

- Introduction
- SPOTTER Approach
- Results & Discussion
- Conclusion & Outlook

Introduction

Supply disruptions may occur at each supply chain stage



Resource extraction

Mineral

Raw material processing

Raw material

Intermediate product manufacturing

Supply disruption events

Intermediate product

Final product manufacturing

Final product

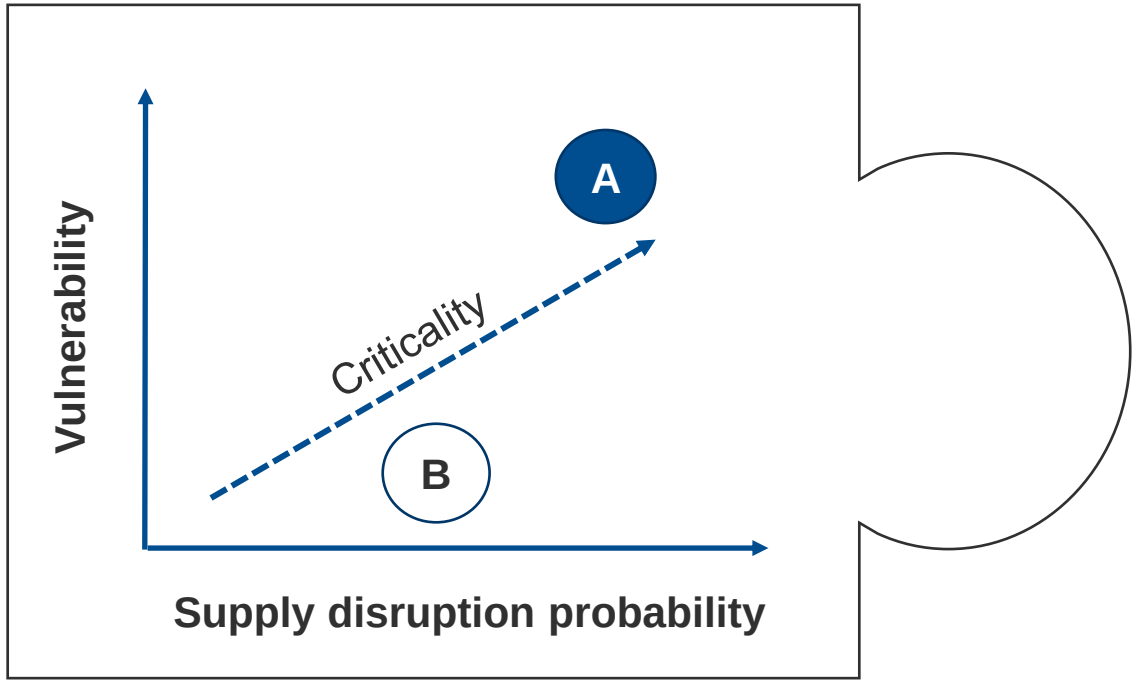
Product use

Resource

Mobility
Energy
ICT

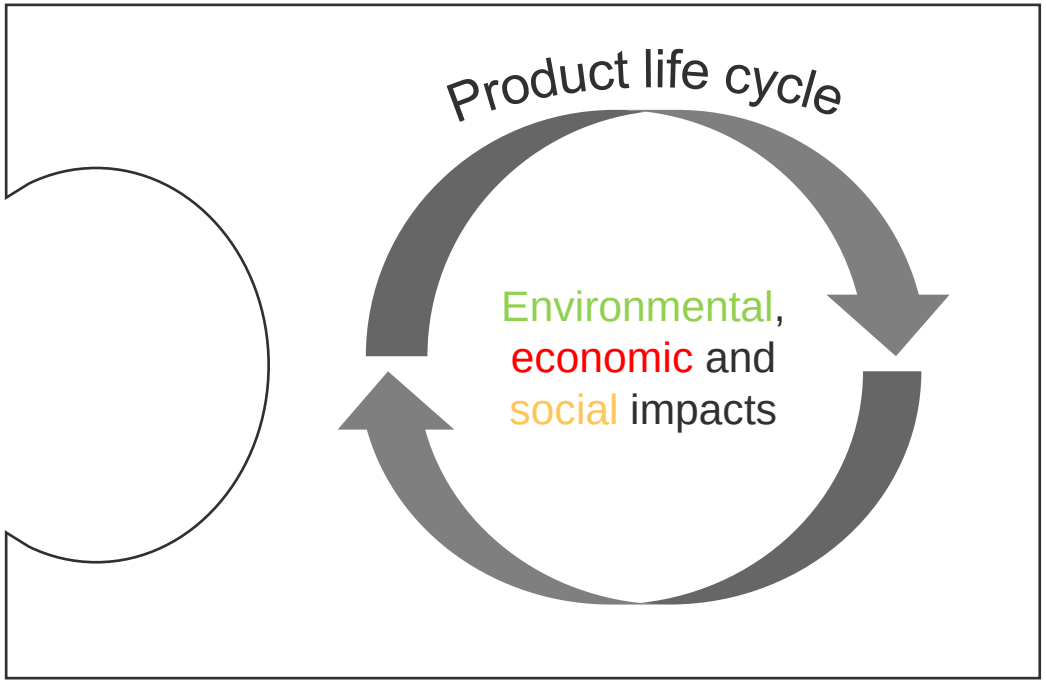
Methods/tools to assess supply disruption impacts

Criticality Assessment



(NRC 2008)

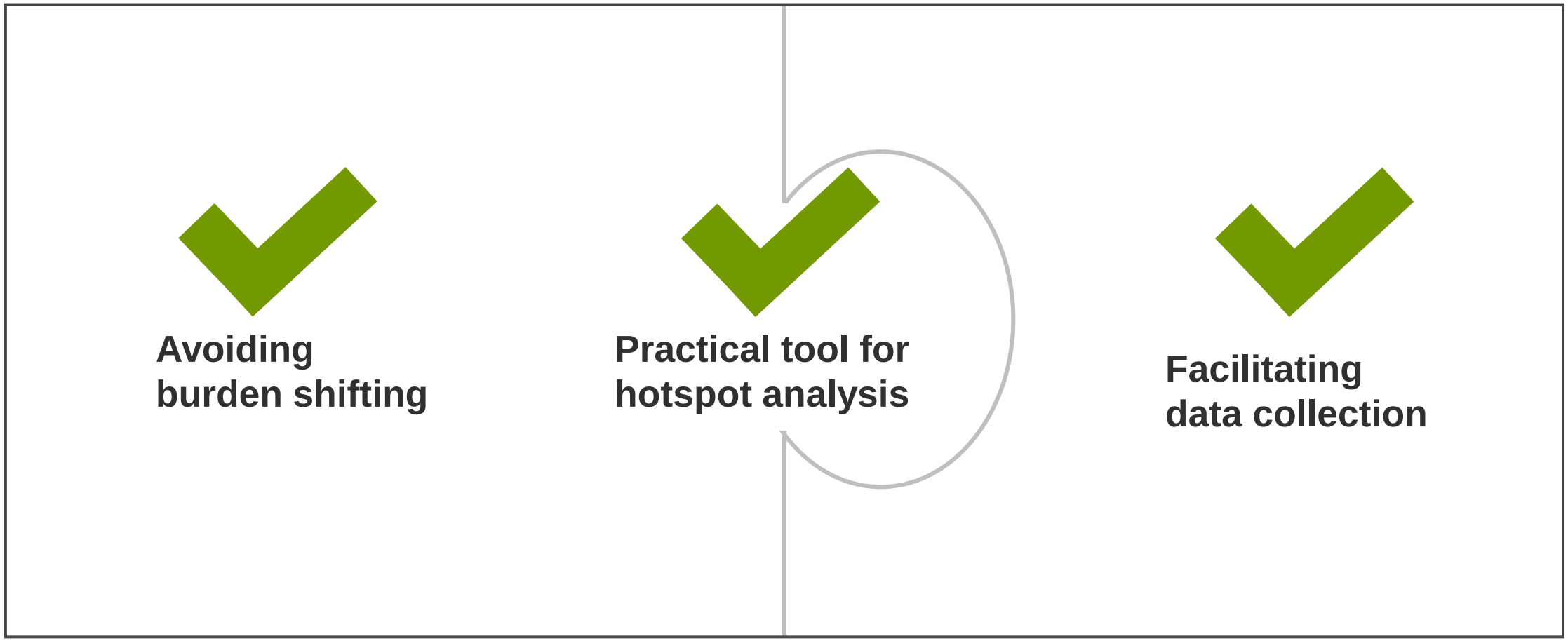
Life Cycle Sustainability Assessment (LCSA)



(UNEP/SETAC Life Cycle Initiative 2011)

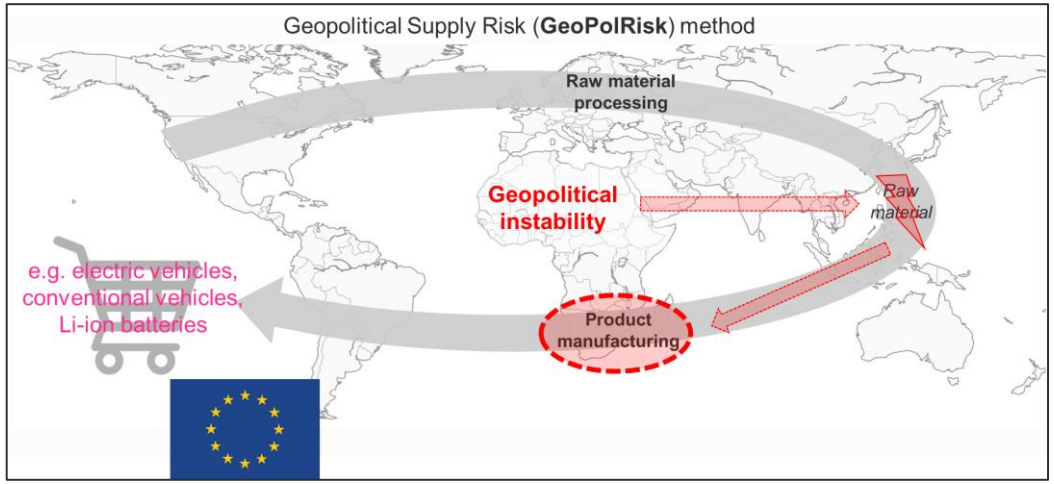
Benefits of an integrated assessment

Criticality assessment integrated into the LCSA framework



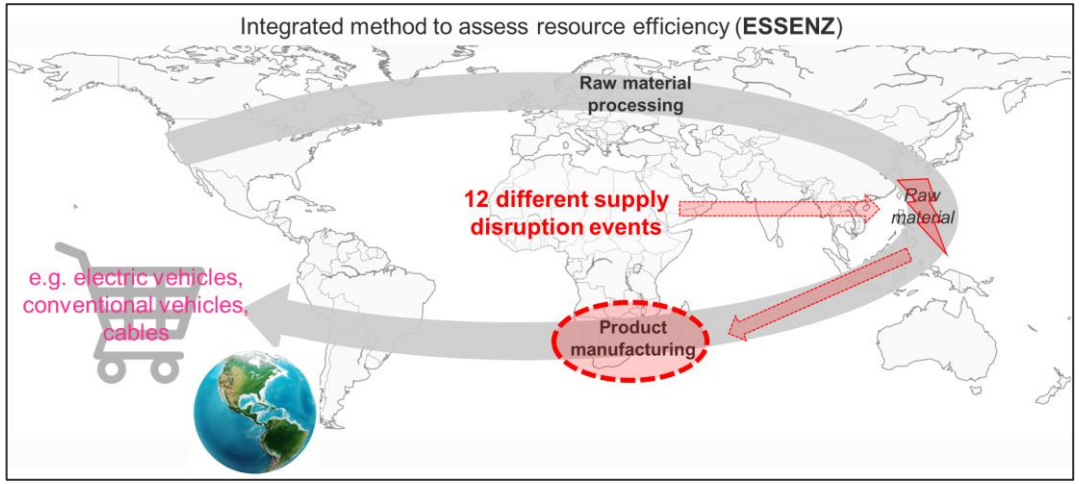
(Cimprich et al. 2019; Sonnemann et al. 2015)

Suitable approaches are still missing!



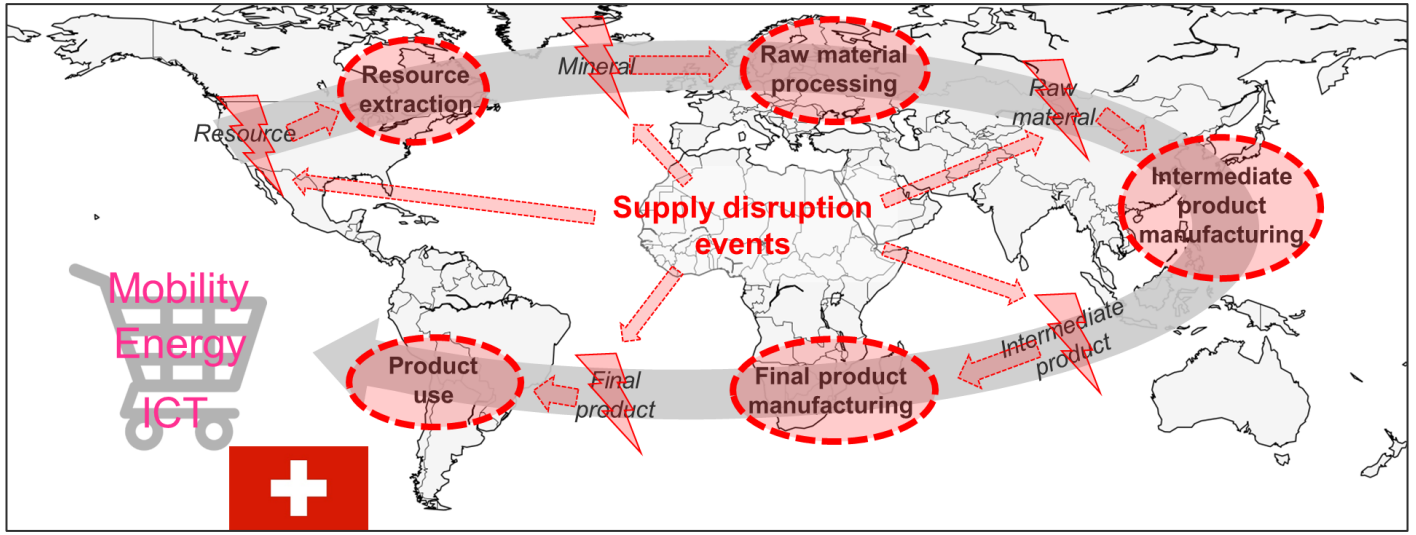
(Cimprich et al. 2017, 2018; Santillan et al. 2020)

OR



(Bach et al. 2016; Sun et al. 2021)

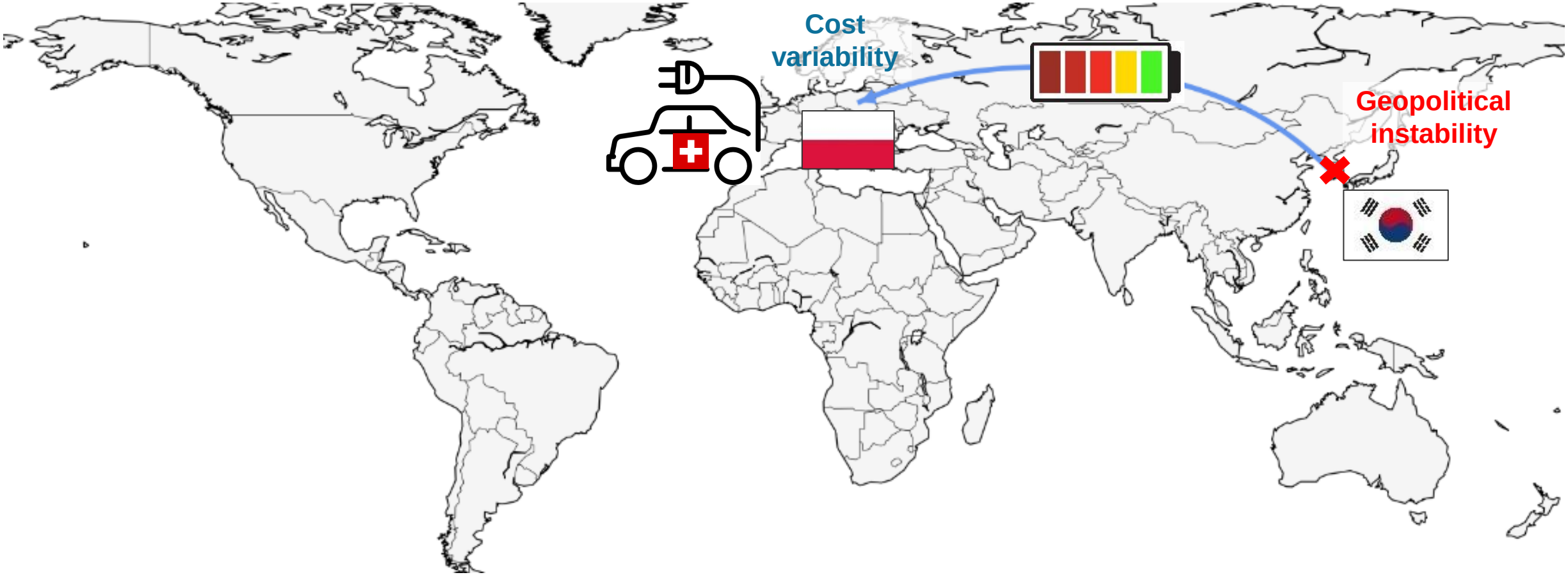
…are not suitable for…



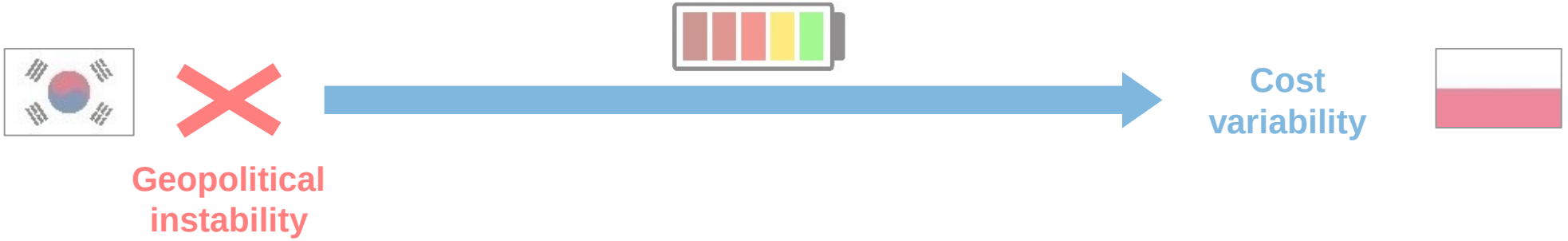
SPOTTER Approach

(«A**s**sessing potential su**p**ply disrupti**o**n impacts along **t**he supply chain in the shor**t**- and m**e**dium-term within the LCSA f**r**amework»)

Example of potential disruption in battery supply chain



Impact score calculation follows the principles of LCSA

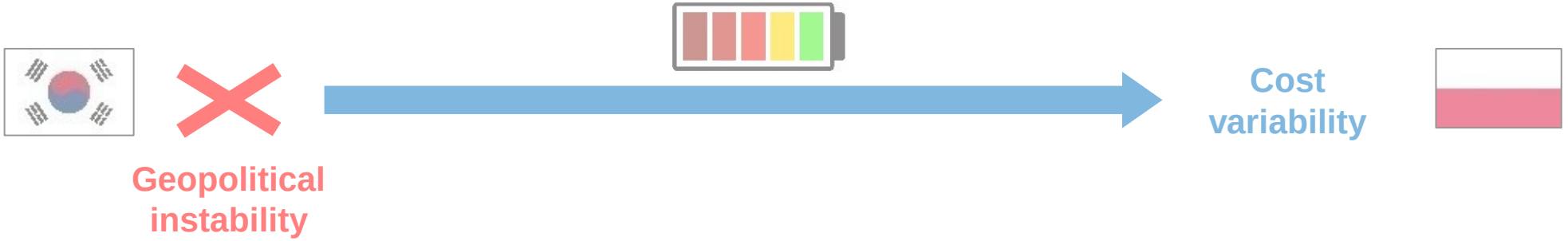


$$Impact\ score = m * CF$$

Inventory flow amount

Characterization factor

Impact score calculation follows the principles of LCSA

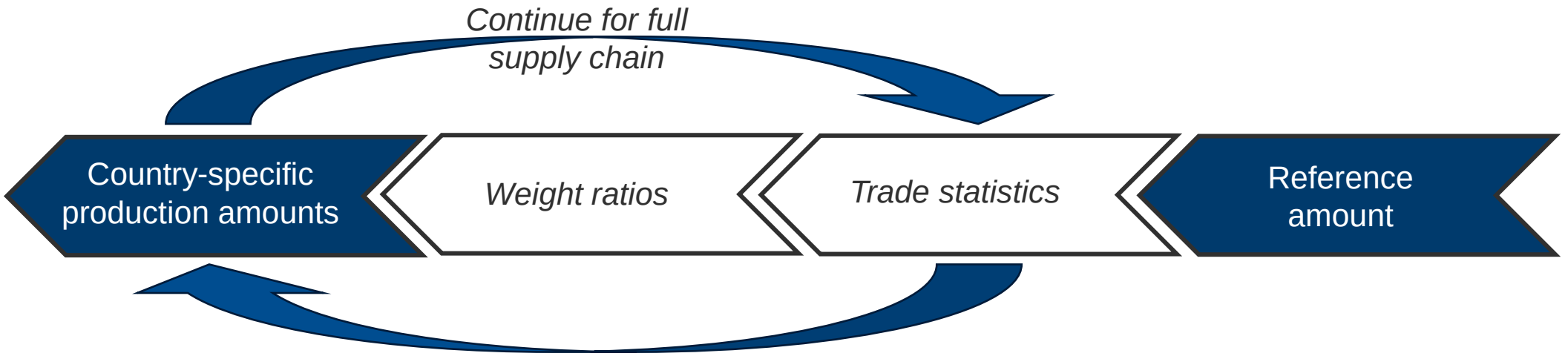


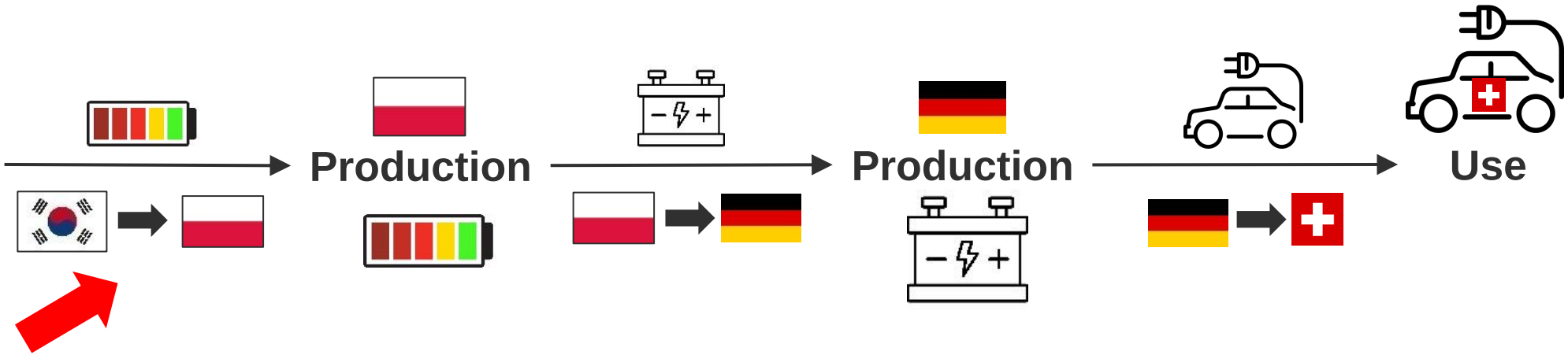
$$Impact\ score = \boldsymbol{m} * CF$$

Inventory flow amount

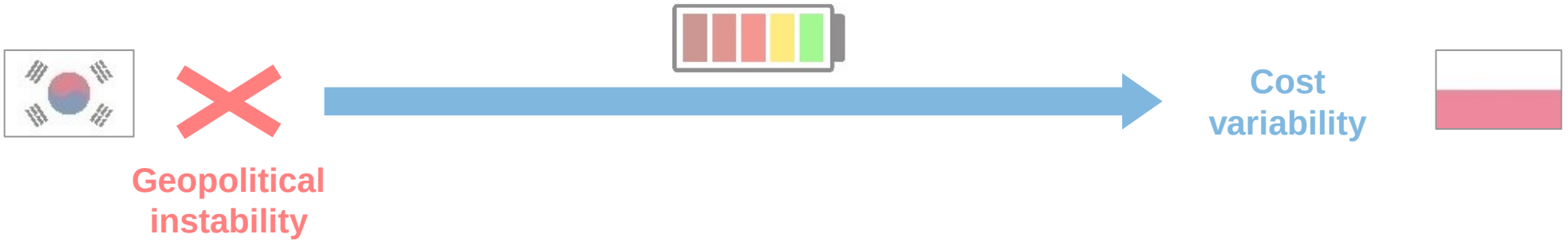
Characterization factor

Inventory flows are determined upstream the supply chain





Impact score calculation follows the principles of LCSA



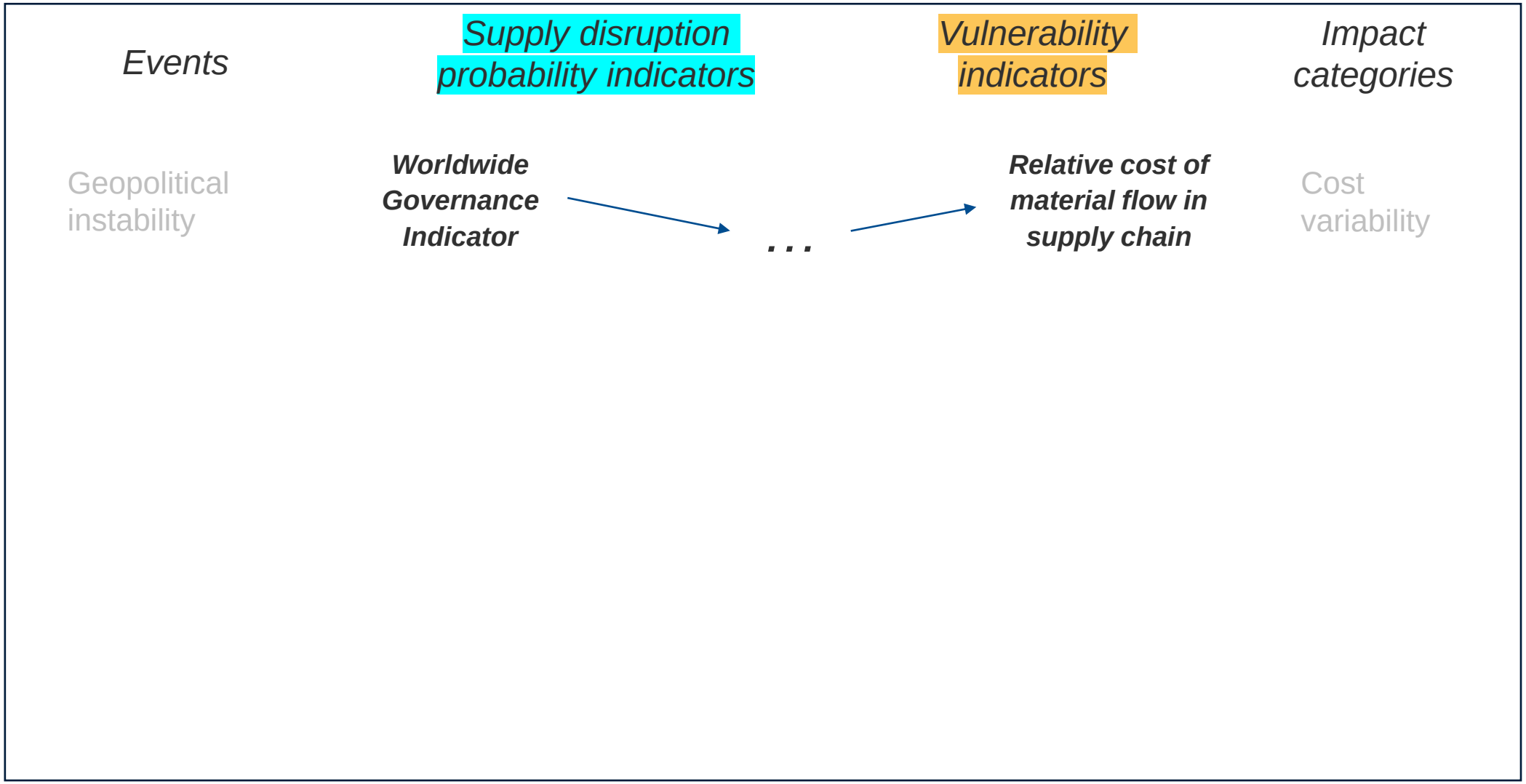
$$Impact\ score = m * \boldsymbol{CF}$$

Inventory flow amount

Characterization factor

$$CF = Supply\ disruption\ probability * Vulnerability$$

Considered elements with SPOTTER

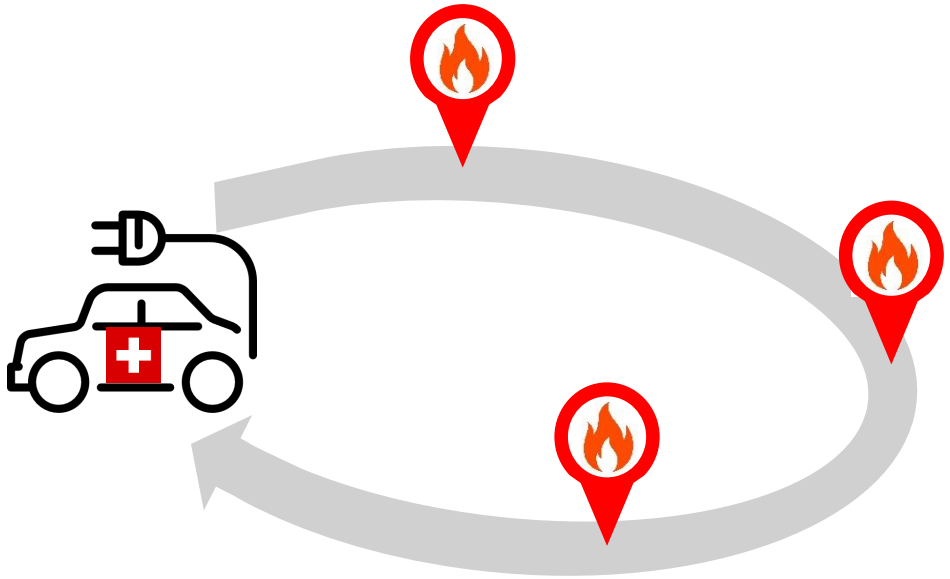


Considered elements with SPOTTER

	Events	*Supply disruption probability indicators*	*Vulnerability indicators*	*Impact categories*
Short-term (<5 years)	• Geopolitical instability • Child labor restrictions • Trade barriers • Price volatility • Limited recyclability • Depletion of economic resources	By the combination of indicators, impacts of **short-term events** and **medium-term events** are analyzed within **two seperate impact categories**.		• Cost variability • Limited availability
Medium-term (5-15 years)	• Demand growth • Co-product dependency • Primary raw material reliance • Depletion of ultimate resource	→ Details described by Berr et al. (2022)		

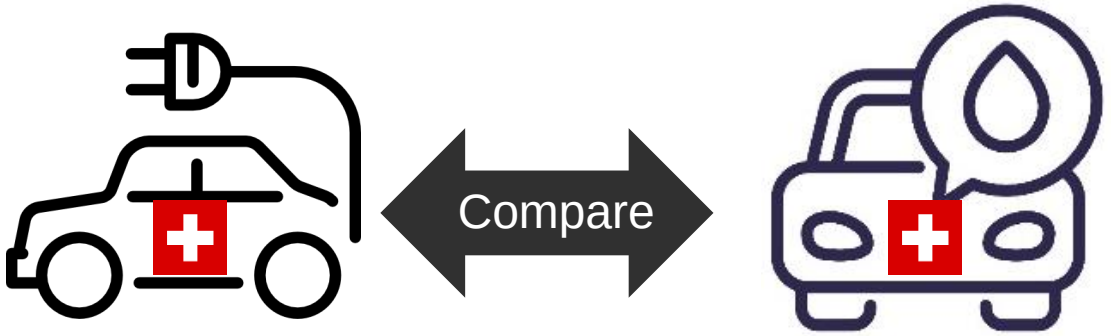
Two possible types of analysis with SPOTTER

Hotspot analysis



$$Impact\ score > 1\%\ of\ Impact\ score_{total}$$

Impact comparison



$$Impact\ score_{total} = \sum m * CF$$

Results & Discussion

Hotspots for the Swiss economy (short-term)*

$$Impact\ score > 1\%\ of\ Impact\ score_{total}$$

Examples of hotspots (based on data from the year 2020)

*mobility, energy and ICT sectors

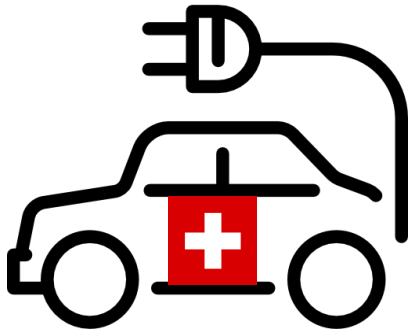
Suitable risk mitigation measures could be…

- **Implement circular economy strategies**
- **Conclude long-term contracts***
- **Build-up stockpiles***

*to be communicated to trade partners

Comparing the impacts of BEVs with impacts of ICEVs…

$$Impact\ score_{total} = \sum m * CF$$



$Impact\ score_{BEV,total}$

Materials/products

?

Fuel

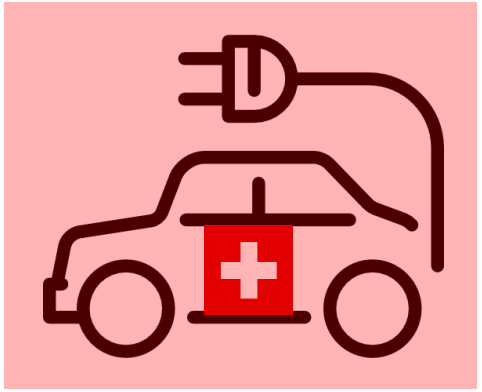
?

$Impact\ score_{ICEV,total}$

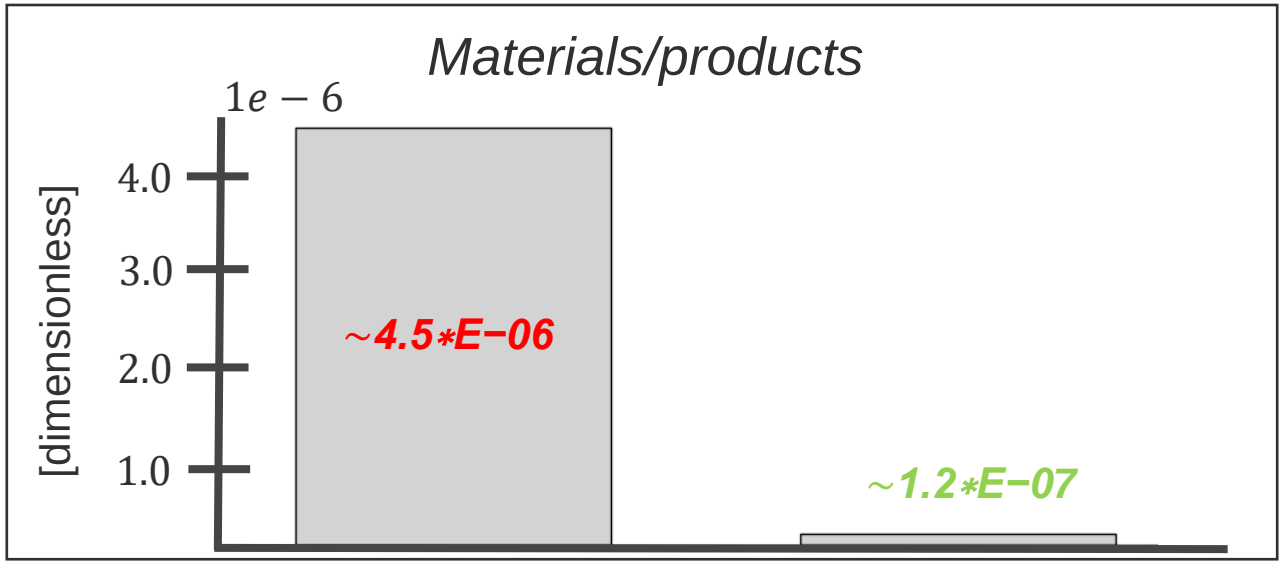
BEV: Battery electric vehicle

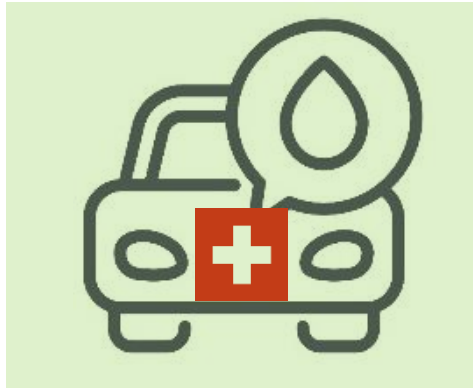
$ICEV$: Conventional vehicle

…higher risks are identified for materials/products supply…



$Impact\ score_{BEV,total}$



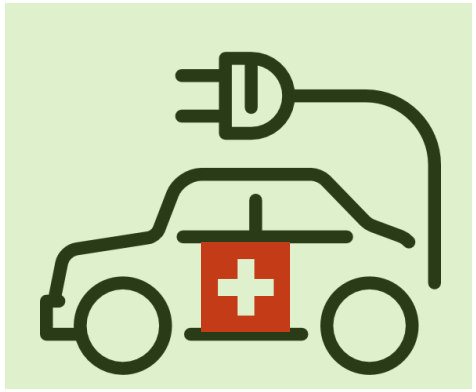


$Impact\ score_{ICEV,total}$

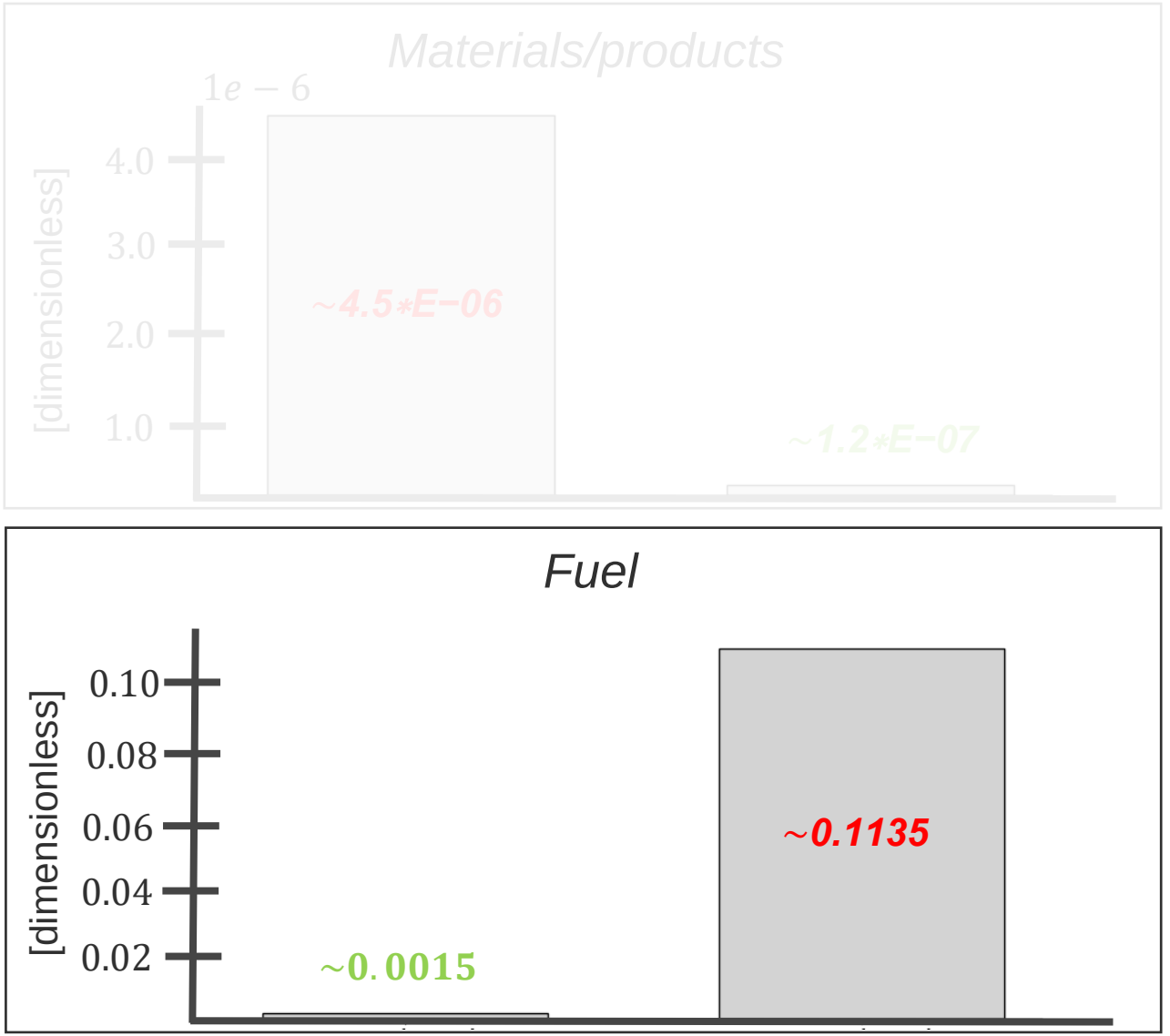
BEV: Battery electric vehicle

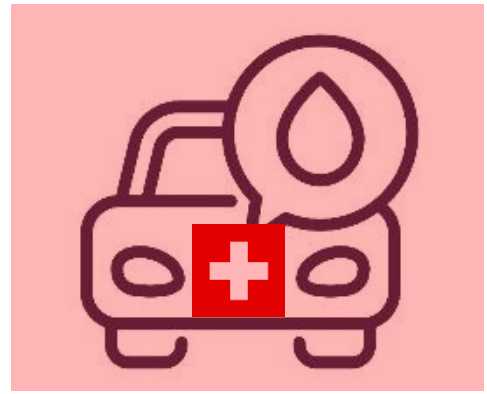
$ICEV$: Conventional vehicle

…but lower risks are identified for fuel supply



$Impact\ score_{BEV,total}$



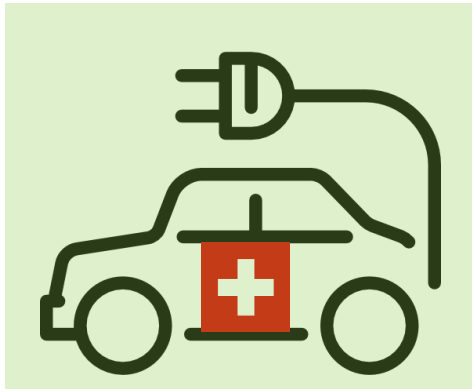


$Impact\ score_{ICEV,total}$

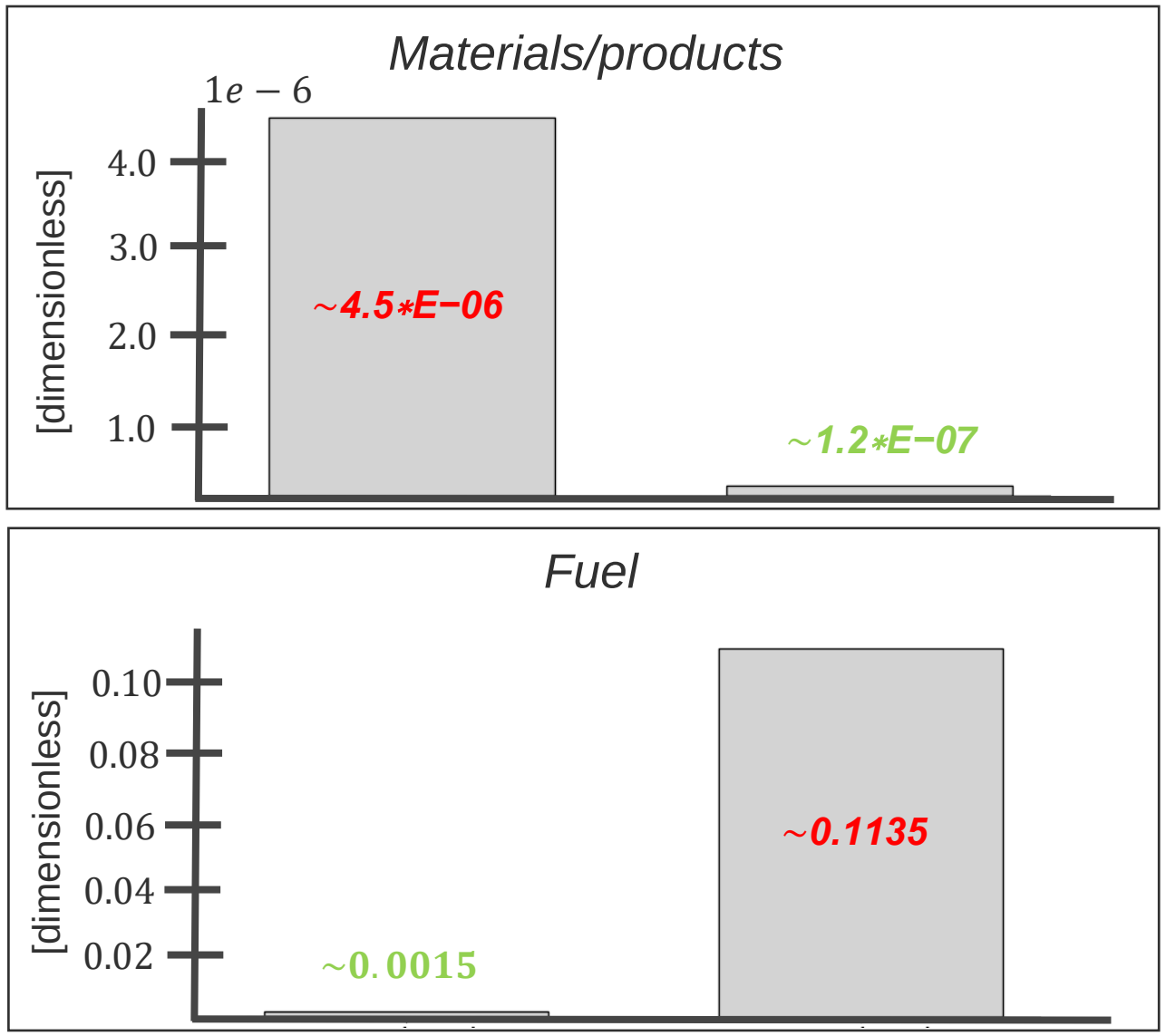
BEV: Battery electric vehicle

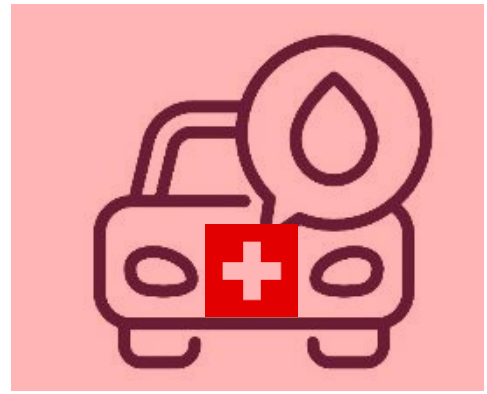
$ICEV$: Conventional vehicle

Context affects the interpretation of results



$Impact\ score_{BEV,total}$





$Impact\ score_{ICEV,total}$

BEV: Battery electric vehicle

$ICEV$: Conventional vehicle

Conclusion & Outlook

Summary and future research

- A potential integration of supply disruption impacts into the LCSA framework is demonstrated by the example of the SPOTTER approach.
- The application of SPOTTER is demonstrated on a case study of the Swiss economy.
- Flows of battery cells, cobalt, gallium and natural graphite are identified as hotspots.
- Lower supply risks are identified for electric vehicles compared to conventional vehicels.
- Besides its application on a country-level, SPOTTER could be applied in the context of a company-specific analysis.
- The supply chain modelling with SPOTTER could serve as a baseline for the inventory analysis of country-specific environmental and social LCA studies.

Questions?

Thank you for your attention!

Marcus Berr
E-mail: marcus.berr@myclimate.org
Phone: +41 43 502 08 74
Consulting & Solutions department
myclimate Foundation

myclimate Foundation
Pfingstweidstrasse 10
8005 Zurich, Switzerland
www.myclimate.org

Empa St. Gallen
Lerchenfeldstrasse 5,
9014 St. Gallen, Switzerland
https://www.empa.ch/web/s506

References

Underlying articles:

- Berr, M., Beloin-Saint-Pierre, D., Hischier, R., Hool, A., Wäger, P., 2022. SPOTTER: Assessing supply disruption impacts along the supply chain within Life Cycle Sustainability Assessment. Cleaner Logistics and Supply Chain. 4, 100063. https://doi.org/10.1016/j.clscn.2022.100063.
- Berr, M., Hischier, R., Wäger, P., 2023. Assessing Short-Term Supply Disruption Impacts within Life Cycle Sustainability Assessment – a Case Study of Electric Vehicles. Environmental Science & Technology. https://doi.org/10.1021/acs.est.3c05957.
- Berr, M., Hischier, R., Wäger, P., 2024. Assessment of Short-Term Supply Disruption Impacts for the Swiss Mobility, Energy and ICT Sectors – Application of the SPOTTER approach. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2024.143810.

Images:

- https://hdrei.org/pictures/wiki/File:Viktor-forgacs-FcDqdJUM6B4-unsplash.jpg (Covid-19 virus image)
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References

Literature:

- NRC, 2008. Minerals, Critical Minerals, and the US Economy. National Research Council of the National Academies, USA.
- UNEP/SETAC Life Cycle Initiative, 2011. Towards a Life Cycle Sustainability Assessment: Making Informed Choices on Products, in UNEP/SETAC Life Cycle Iniative (ed.), (Valdivia S, Ugaya CML, Sonnemann G, Hildenbrand J, editors edn.; Paris, France: United Nations Environment Programma (UNEP)).
- Cimprich, A., Bach, V., Helbig, C., Thorenz, A., Schrijvers, D., Sonnemann, G., Young, S.B., Sonderegger, T., Berger, M., 2019. Raw material criticality assessment as a complement to environmental life cycle assessment: Examining methods for product-level supply risk assessment. Journal of Industrial Ecology. 0 (0). https://doi.org/10.1111/jiec.12865.
- Sonnemann, G., Gemechu, E.D., Adibi, N., De Bruille, V., Bulle, C., 2015. From a critical review to a conceptual framework for integrating the criticality of resources into Life Cycle Sustainability Assessment. Journal of Cleaner Production. 94, 20-34. https://doi.org/10.1016/j.jclepro.2015.01.082.
- Bach, V., Berger, M., Henßler, M., Kirchner, M., Leiser, S., Mohr, L., Rother, E., Ruhland, K., Schneider, L., Tikana, L., Volkhausen, W., Walachowicz, F., Finkbeiner, M., 2016. Integrated method to assess resource efficiency – ESSENZ. Journal of Cleaner Production. 137, 118-30. https://doi.org/10.1016/j.jclepro.2016.07.077.
- Sun, X., Bach, V., Finkbeiner, M., Yang, J., 2021. Criticality Assessment of the Life Cycle of Passenger Vehicles Produced in China. Circular Economy and Sustainability. https://doi.org/10.1007/s43615-021-00012-5.
- Cimprich, A., Young, S.B., Helbig, C., Gemechu, E.D., Thorenz, A., Tuma, A., Sonnemann, G., 2017. Extension of geopolitical supply risk methodology: Characterization model applied to conventional and electric vehicles. Journal of Cleaner Production. 162, 754-63. https://doi.org/10.1016/j.jclepro.2017.06.063.
- Cimprich, A., Karim, K.S., Young, S.B., 2018. Extending the geopolitical supply risk method: material “substitutability” indicators applied to electric vehicles and dental X-ray equipment. The International Journal of Life Cycle Assessment. https://doi.org/10.1007/s11367-017-1418-4.