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REES

MISTRA
Resource-Efficient and Effective Solutions

Effects on metal resource use from reusing laptops - A comparison of impact assessment methods

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Introduction

- Case study based on a Swedish IT resale company acquiring used but largely functional laptops from companies and reselling to public sector, private users and companies abroad.

- Circular Economy (CE) measures based on extended use, such as reuse, tend to reduce scarce metal losses in two principal ways compared to conventional alternatives:
    - through extending the use of products that can be reused
    - through collecting products that are deemed non-reusable at inspection and sending them to recycling, thereby increasing collection rates (Ljunggren Söderman & André, 2018)
- Metal resource use/depletion/consumption results are considerably dependent on the choice of life cycle impact assessment (LCIA) method (e.g. Finnveden et al., 2016; Peters & Weil, 2016; Rigamonti et al., 2016, Rørbech et al., 2014)
- Hence, fruitful to study the effects of reuse using several complementary LCIA methods

Research question

- How does the application of different LCIA methods for metal resource use influence interpretations of reuse of laptops, as mediated by a resale company?

Methodology

- Comparative life cycle assessment (LCA) between:
    - New laptop alternative: new production (every three years)
    - Second-hand laptop alternative (70 % of laptops collected by reuse company used for additional three years)

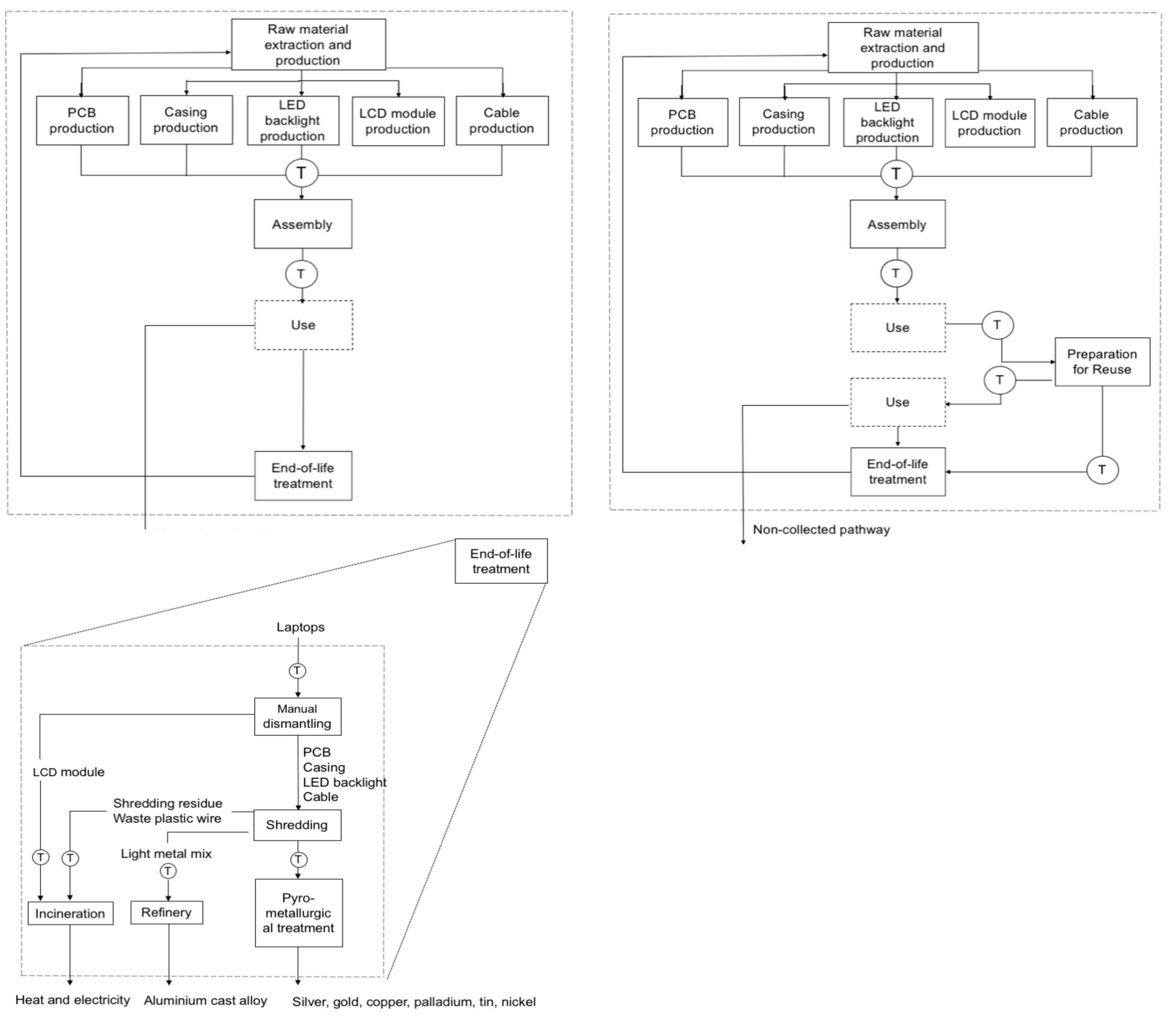

Figure 1. Flowcharts of: a) new laptop alternative, b) second-hand laptop alternative and c) EoL treatment.

Results & Discussions

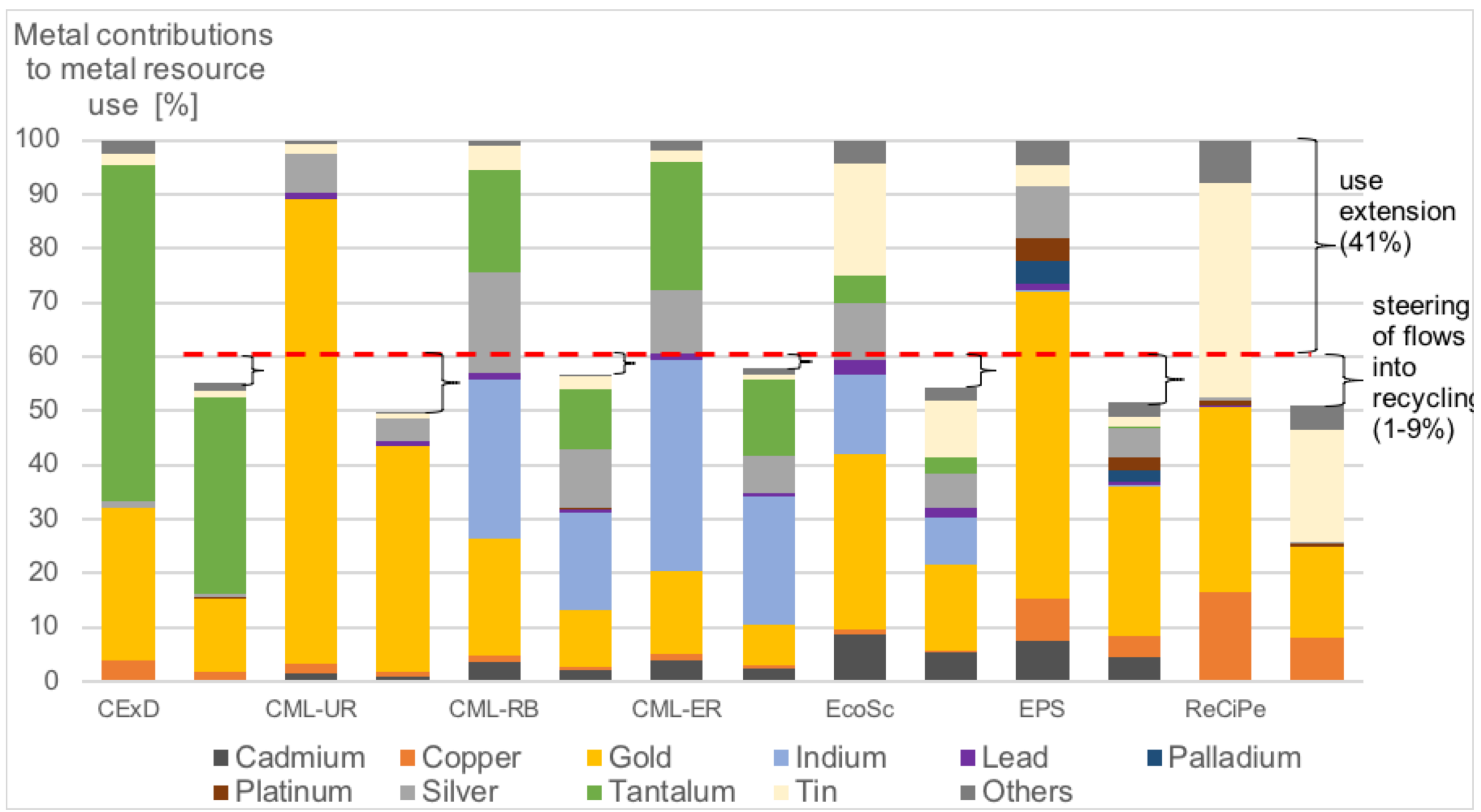

Figure 2. Metal resource use impacts: the reuse alternative compared to the new laptop alternative [%] with five impact assessment methods of which one has three versions. Metals with >1.5% contribution with at least two methods or >4% with at least one method are displayed individually. Others include 20 metals such as aluminium, iron, nickel and rare earth elements.

- Some metals noticeable in all methods: gold, copper and tin
    - these are relevant from several problem perceptions!
- Others notably important but only in some methods: tantalum, indium, palladium, platinum
    - relevant metals from some perspectives could be overlooked if only using one LCIA-method.
- Gold important across all methods
    - more in methods based on average crustal concentration (CML-UR and EPS)
    - less in exergy and reserve-based approaches (CML-RB, CML-ER, EcoSc)
- Indium important in reserve-based methods
    - due to being a by-product metal
    - not particularly scarce in average crustal concentration
- Tantalum important in exergy and reserve-based methods
    - high exergy demand for metals with low deposit concentrations
    - not particularly scarce in average crustal concentration
- Targeting gold, silver, copper in WEEE recycling reduces significant shares of metal resource depletion

Conclusions

- Major reduction from use extension
    - about 41% due to doubled lifetime of 70 % of sourced laptops
- Additional reduction from steering of flows into recycling depending on LCIA method
    - especially important according to some LCIA-methods (varying between 1-9% reduction compared to new laptops) which characterise metals that are functionally recycled as important (typically methods using average crustal concentrations) and negligible in others (typically reserve-based methods)
- The metals benefitting most from reuse are functionally recycled metals (silver, gold, copper, palladium, tin and nickel)
    - the reuse company's routine of steering flows into recycling decreases their losses in addition to use extension.
- Advisable to use complementary methods to minimise risks of overlooking relevant metal resource use aspects when studying circular economy measures applied to electronic products

Table 1. LCIA methods used, problem perceptions, indicator approach (Steen 2006, Sonderegger et al., 2017) and type of data used to derive characterisation factors.

LCIA methods used	Environmental problem perception of metal resource use	Indicator approach	Type of data for calculation of characterisation factor
Cumulative exergy demand (CExD) (Bösch et al., 2006)	Exergy poses limit	Exergy	Deposit
CML: ultimate reserves (UR) (Van Oers et al., 2002)	Scarcity of metals Metal depletion	Use to resource	Average crustal concentrations
CML: reserve base (RB) & economic reserves (ER) (Van Oers et al., 2002)	Scarcity of metals Metal depletion	Use to resource	Reserves
Ecological scarcity method (EcoSc) (Frischknecht, 2013)	Scarcity of metals Metal depletion	Use to resource Distance to target	Reserves
Environmental Priority Strategies (EPS) (Steen, 1999)	(Sustainable) mining cost poses limit	Increased future environmental impacts or costs of mining and material production due to decreasing ore grades	Average crustal concentrations
ReCiPe midpoint (Goedkoop M., 2009)	Mining cost poses limit	Increased future environmental impacts or costs of mining and material production due to decreasing ore grades	Deposit

References:

Finnveden, G., Arushanyan, Y., & Brandão, M. (2016). Exergy as a measure of resource use in life cycle assessment and other sustainability assessment tools. Resources, 5(3), 23.

Frischknecht, R. B. s. K., S. . (2013). Swiss eco-factors 2013 according to the ecological scarcity method. Methodological fundamentals and their application in Switzerland. Bern, Switzerland.

Goedkoop M., H. R., de Schryver A., Struijs J. and van Zelm R. . (2009). A life cycle impact assessment method which comprises harmonized category indicators at the midpoint and the endpoint level / Report I: Characterisation. ReCiPe 2008 - Ministerie van VROM, Den Haag (Netherlands), . Online-Version under: www.lcia-recipe.net.

Ljunggren Söderman, M., & André, H. (2018). Scarce metals in complex products - exploring the effects of circular economy measures. submitted to Resources, Conservation and Recycling.

Peters, J., & Weil, M. (2016). A critical assessment of the resource depletion potential of current and future lithium-ion batteries. Resources, 5(4), 46. doi:10.3390/resources5040046

Rigamonti, L., Falbo, A., Zampori, L., & Sala, S. (2016). Supporting a transition towards sustainable circular economy: sensitivity analysis for the interpretation of LCA for the recovery of electric and electronic waste. The International Journal of Life Cycle Assessment. doi:10.1007/s11367-016-1231-5

Rørbech, J. T., Vadenbo, C., Hellweg, S., & Astrup, T. F. (2014). Impact assessment of abiotic resources in LCA: Quantitative comparison of selected characterization models. Environmental science & technology, 48(19), 11072-11081. doi:10.1021/es5023976

Sonderegger, T., Dewulf, J., Fantke, P., de Souza, D. M., Pfister, S., Stoessel, F., . . . Hellweg, S. (2017). Towards harmonizing natural resources as an area of protection in life cycle impact assessment. The International Journal of Life Cycle Assessment, 22(12), 1912-1927. doi:10.1007/s11367-017-1297-8

Steen, B. A. (2006). Abiotic resource depletion - Different perceptions of the problem with mineral deposits. The International Journal of Life Cycle Assessment, 11(1), 49-54. doi:10.1065/lca2006.04.011

Steen, B. (1999b). A systematic approach to environmental priority strategies in product development (EPS): version 2000-Models and data of the default method: Chalmers tekniska högsk.

Van Oers, L., De Koning, A., Guinée, J., & Huppes, G. (2002). Abiotic resource depletion in LCA-Improving characterisation factors for abiotic resource depletion as recommended in the new Dutch LCA Handbook. Public Works and Water Management (V&W).