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Is the circular economy an ecological sustainability strategy?

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Who am I?

Personal homepages:
https://www.researchgate.net/profile/Dominik-Wiedenhofer
https://boku.ac.at/personen/person/EC2B15284DC69568

University of Natural Resources and Life Sciences, Vienna
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Senior Scientist and University Assistant, BOKU, since 2018

- Senior scientist at the Alpen-Adria University Klagenfurt, 2010-2017
- Doktor der Naturwissenschaften, with honors, „Human- und Sozial Ökologie", Alpen-Adria University Klagenfurt (2012-2017)
- Magister der Naturwissenschaften, with honors, Fachbereich „Human- und Sozial Ökologie", Alpen-Adria University Klagenfurt (2008-2011)
- Bakkalaureus der technischen Wissenschaften, „Umwelt- und Bioressourcen Management", BOKU (2004-2008)

Professional roles:

- Principal investigator, work package leader, research scientist, project manager in a variety of research projects
- Lead Author in the APCC special report on climate-friendly living (forthcoming)
- Contributing Author in the IPCC WG3 Report on Climate Change Mitigation (2022)
- Board Member for Input-Output Analysis Section of the International Society for Industrial Ecology
- Coordinator of the thematic area: socio-ecological modelling, at the Institute of Social Ecology, BOKU

International research stays:

- Nagoya University, Japan, Juni – August 2013;
- Leeds University, United Kingdom, February 2012;
- Sydney University, Australia, February – April 2011;
- Flinders University, Adelaide, Australia, February – July 2008

Research foci: Industrial Ecology & Ecological Economics

- Circular Economy
- Sustainable Consumption & Production
- Environmental Footprints of Everyday Living
- Socio-Economic Metabolism
- Climate Change Mitigation

Contents

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- What is the „Circular Economy“ ?
- The social metabolism and its un-sustainstability crisis
- Empirical insights into Global, European and Austrian resource use and it‘s circularity
- Conclusions

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What is the circular economy? (I)

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- From the „throwaway society“ to a circular economy/society
- Japan & China developing circularity policy since the 2000‘s
- In the European Union, the Allen McArthur Foundation popularized the concept since the 2010s
- European & Austrian Policy Packages since 2018 & 2021

Dame Allen McArthur, https://de.wikipedia.org/wiki/Datei:Ellen-McArthur_(1).jpg

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What is the circular economy? (II)

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“A circular economy means rejecting the linear take-make-waste economy and **adopting a regenerative model: using processes that restore, renew or revitalise their own sources of energy and materials and wasting as little as possible**.

Moving to circularity requires **novel materials and products with new design, new technologies and production processes**. **Using less material to get the same or higher utility from products is an important part of the shift to circularity**.

High impact materials like concrete will need to be replaced with low impact ones such as ones made of renewable bio-based resources.”

(European Circular Economy Strategy)

What is the circular economy? (III)

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CE discourse connects existing ideas & concepts into a novel framework
(Blomsma et al 2017)

- Factor 4, Factor X
- Performance & Blue Economy
- Industrial Symbiosis, Life-Cycle Thinking
- Ressourcen-Effizienz, Energie-Effizienz
- 3R – Reduce, Reuse, Recycle
- Eco-Design

⇒ ***„Slow, narrow and close loops"*** ***(Bocken et al. 2015)***

Blomsma et al. 2017 The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity.
https://doi.org/10.1111/jiec.12603

The Butterfly Diagram of Allen McArthur Foundation as globally recognized concept

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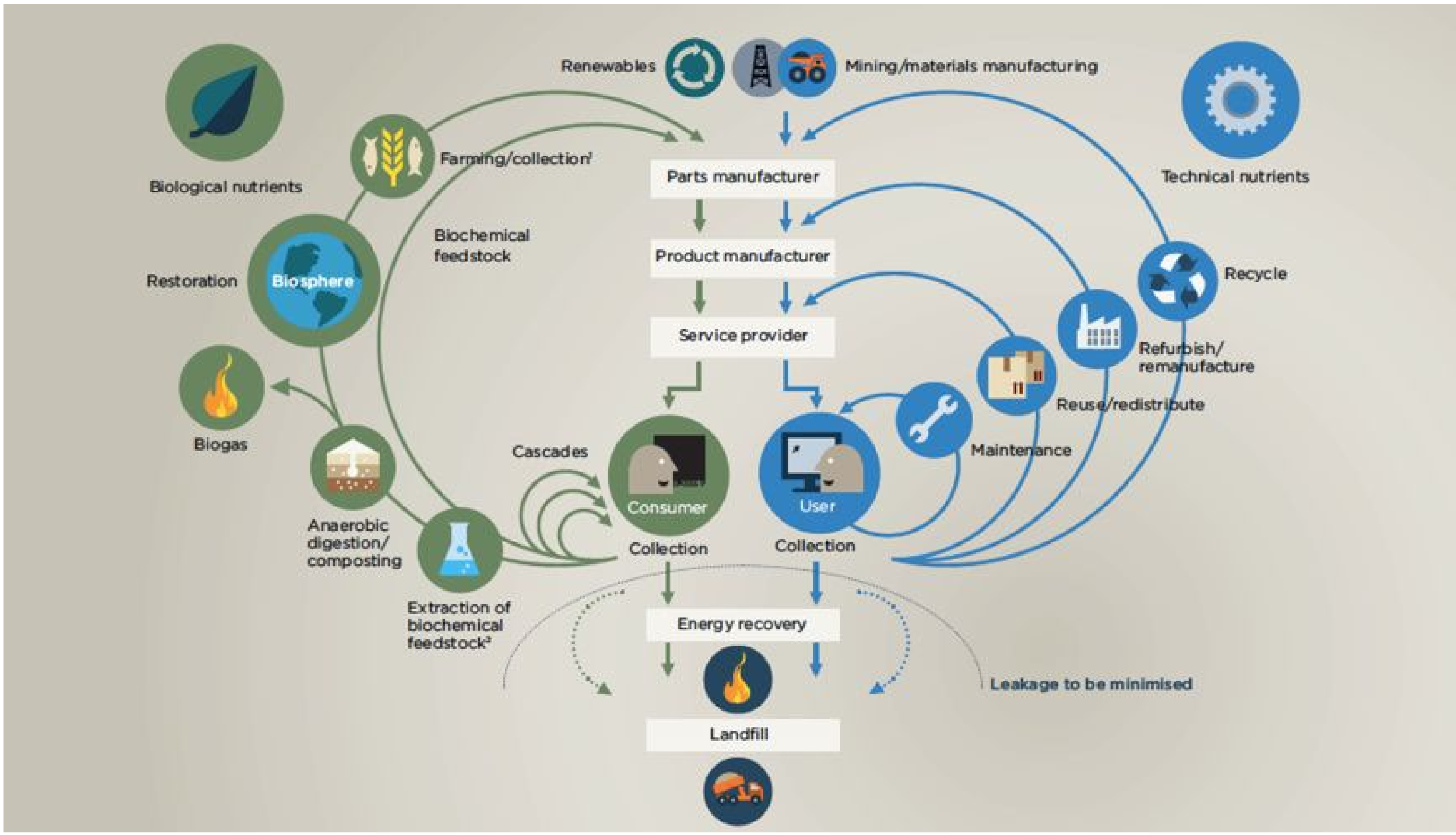

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Multiple ecological limits for a circular economy: the planetary boundaries

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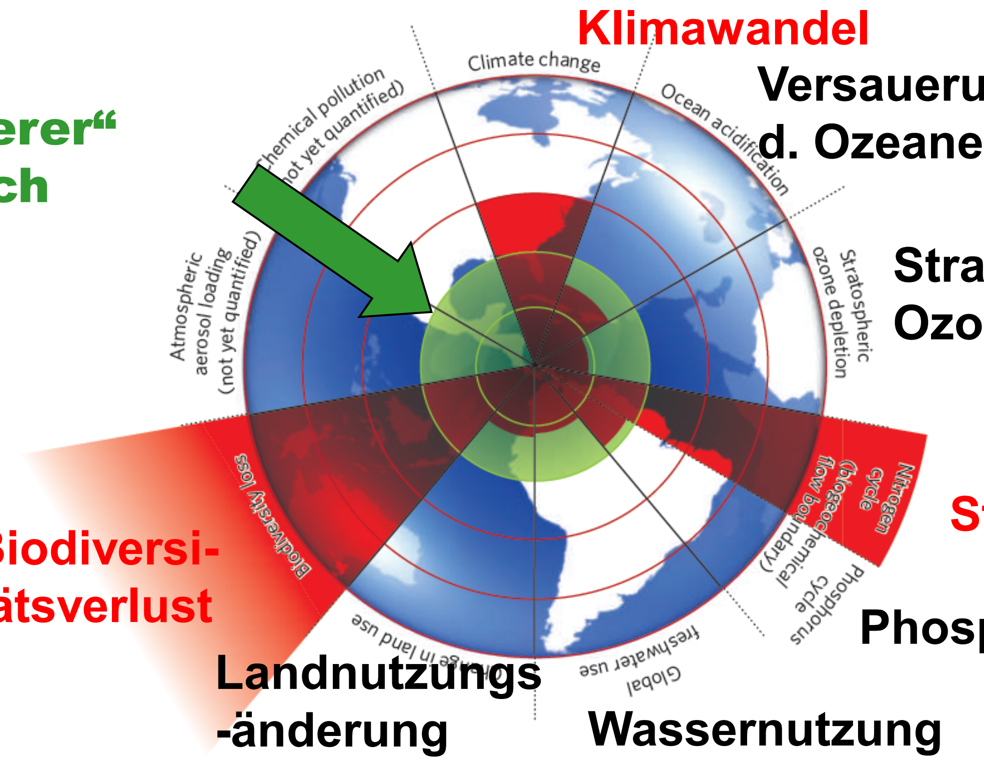
„Sicherer“ Bereich



Rockström et al. Nature 2009

Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

Little time is left to stabilize the climate crisis at < +1.5°C

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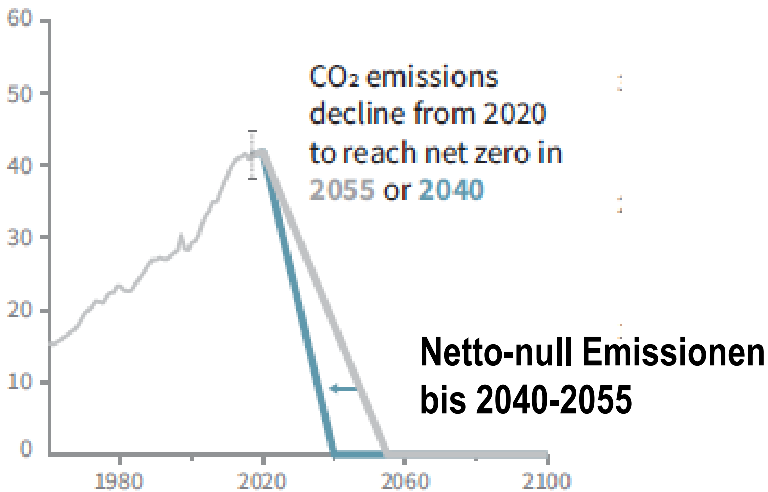
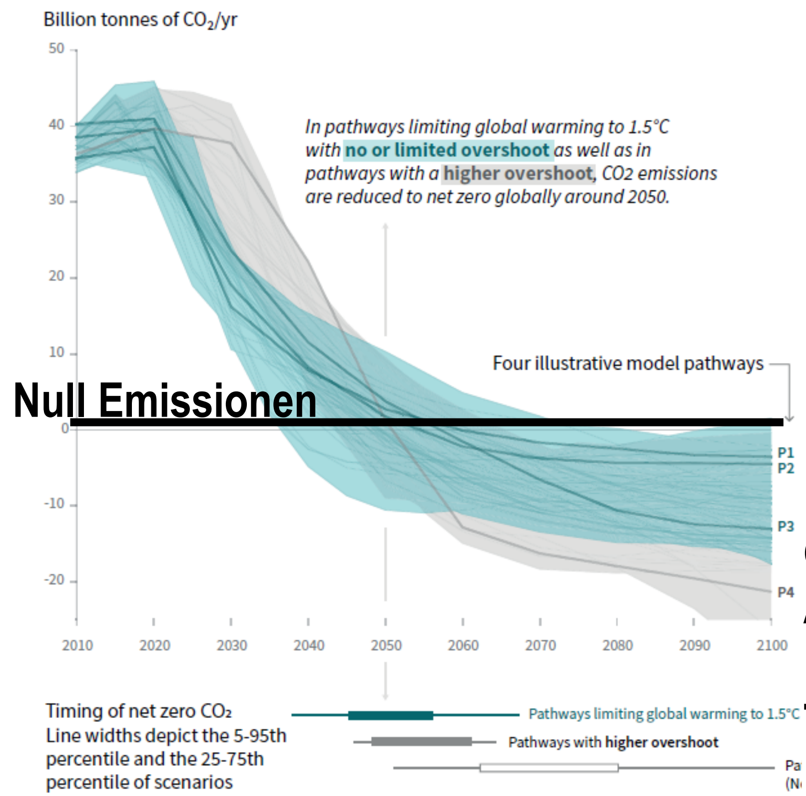


Faster immediate CO_2 emission reductions limit cumulative CO_2 emissions shown in panel (c).



Negative Emissionen, z
durch massiv
Aufforstunge
und neue
Technologien

IPCC (2018) Global Warming of 1.5°C. Special Report. Summary for Policy Makers

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THE SOCIAL METABOLISM AND ITS UN-SUSTAINSTABILITY CRISIS

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The social metabolism and its un-sustainstability crisis

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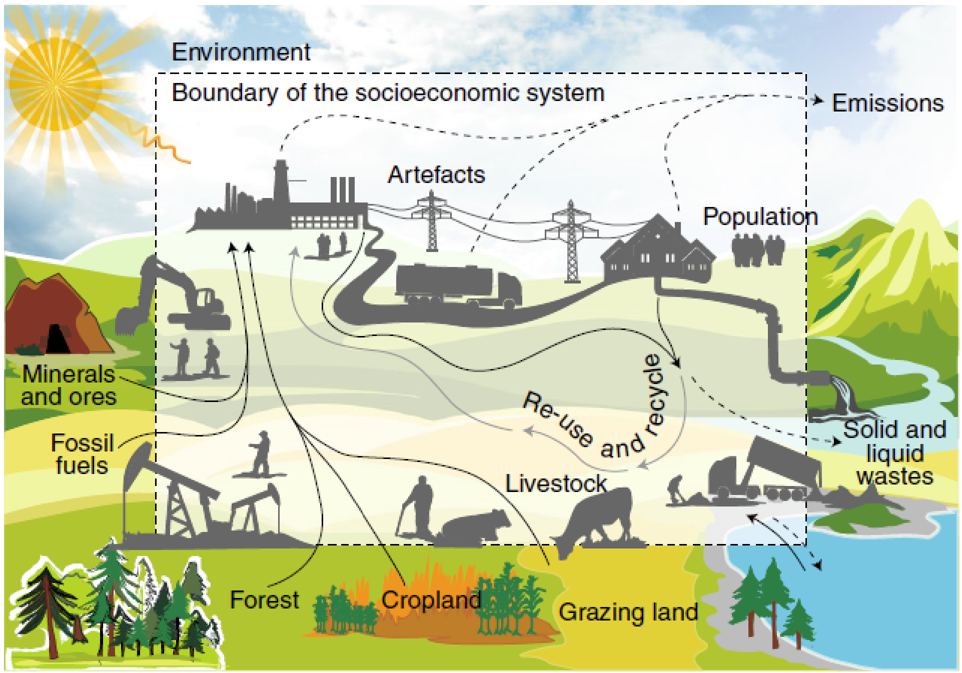

Scale & composition of the social metabolism drives ecological impacts, via the resources, energy, water, and land utilized for socio-economic activity, which necessarily results in either stock accumulation or waste and emissions

<u>Social metabolism as comprehensive systems based framework to assess contributions, problem-shifts & trade-offs of widely debated strategies:</u>

- Resource productivity & efficiency
- Innovation
- Decoupling
- Circular Economy
- Bio-Economy
- Decarbonisation
- Degrowth
- ….

Haberl, H, Wiedenhofer, D., et al. „Contributions of Sociometabolic Research to Sustainability Science“. *Nature Sustainability* (2019). https://doi.org/10.1038/s41893-019-0225-2

Biophysical structures of society are pivotal for the social metabolism

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- Biophysical structures: Population, Livestocks & all material stocks of buildings, infrastructure & machinery
- Material stocks = physical fixed „capital“, societal artefacts, includes our entire built environment and infrastructure enabling and supporting socio-economic activities
- Material stocks and the social metabolism are subject to physics and thermodynamics
- Material stocks structure socio-economic activity in space and time
- Material stocks transform resource use into societal functions and services (e.g. living space, nutrition, mobility, communication, identity, …)
- The development of material stocks is culturally and historically specific; their use and transformation is subject to societal struggle and organisation => Power and dominance are inscribed into material stocks and subsequently into the social metabolism

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(Fischer-Kowalski and Weisz 1999; Haberl, Wiedenhofer, et al. 2017; 2019)

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Artistic interpretations of the social metabolism

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Circular economy and sustainability requires a systems based assessment of resource use, waste and emissions

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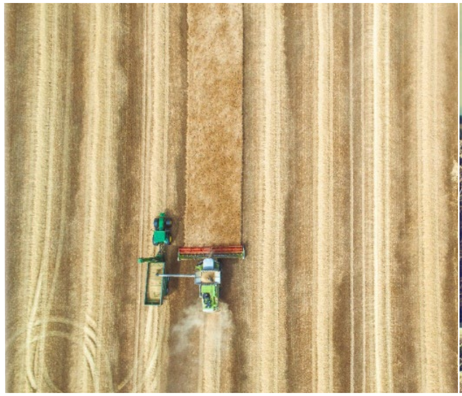
Fossil fuels

Biomass



Metals: ores & waste rock

Non-metallic minerals: Construction & industrial

"Material Flow Accounting: Measuring Global Material Use for Sustainable Development". Krausmann et al. (2017) *Annual Review of Environment and Resources*. doi:10.1146/annurev-environ-102016-060726

Haberl, H, Wiedenhofer, D., et al. „Contributions of Sociometabolic Research to Sustainability Science". *Nature Sustainability* (2019). https://doi.org/10.1038/s41893-019-0225-2

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The circular economy promises absolute decoupling

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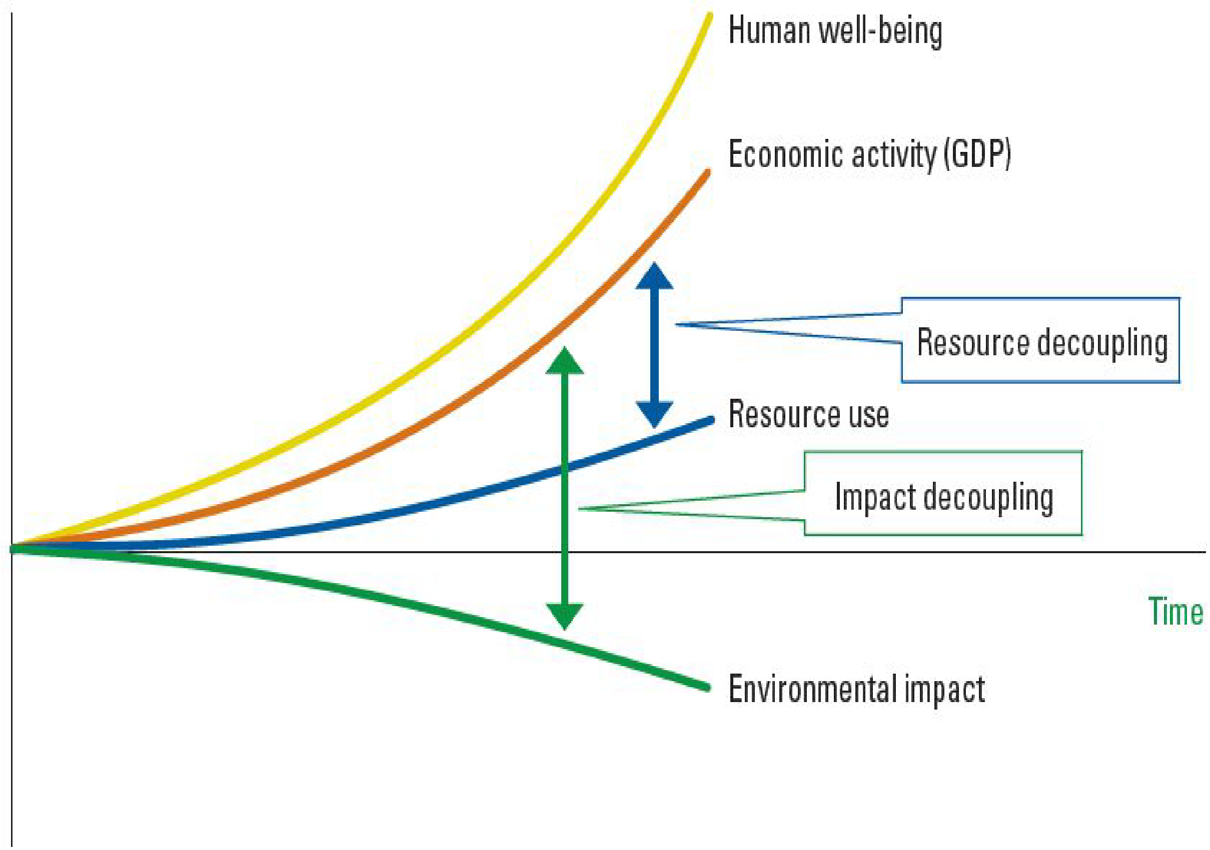
Relative decoupling:
- resource use and emissions grow slower
- GDP grows faster

Absolute decoupling:
- Resource use and emissions decrease absolutely
- GDP is stable/keeps growing

Political relevance: all mainstream sustainability & climate strategies build on this idea of decoupling



UNEP – International Resource Panel Decoupling Report (2011) and Global Resource Outlook (2019; 2021)

Wiedenhofer et al. „A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part I: bibliometric and conceptual mapping“. *Environmental Research Letters* (2020). https://doi.org/10.1088/1748-9326/ab8429.
Haberl, Wiedenhofer, et al. „A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: synthesizing the insights“. *Environmental Research Letters* (2020). https://doi.org/10.1088/1748-9326/ab842a.

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EMPIRICAL INSIGHTS INTO NATIONAL TO GLOBAL CIRCULARITY

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Global dynamics of resource use and emissions

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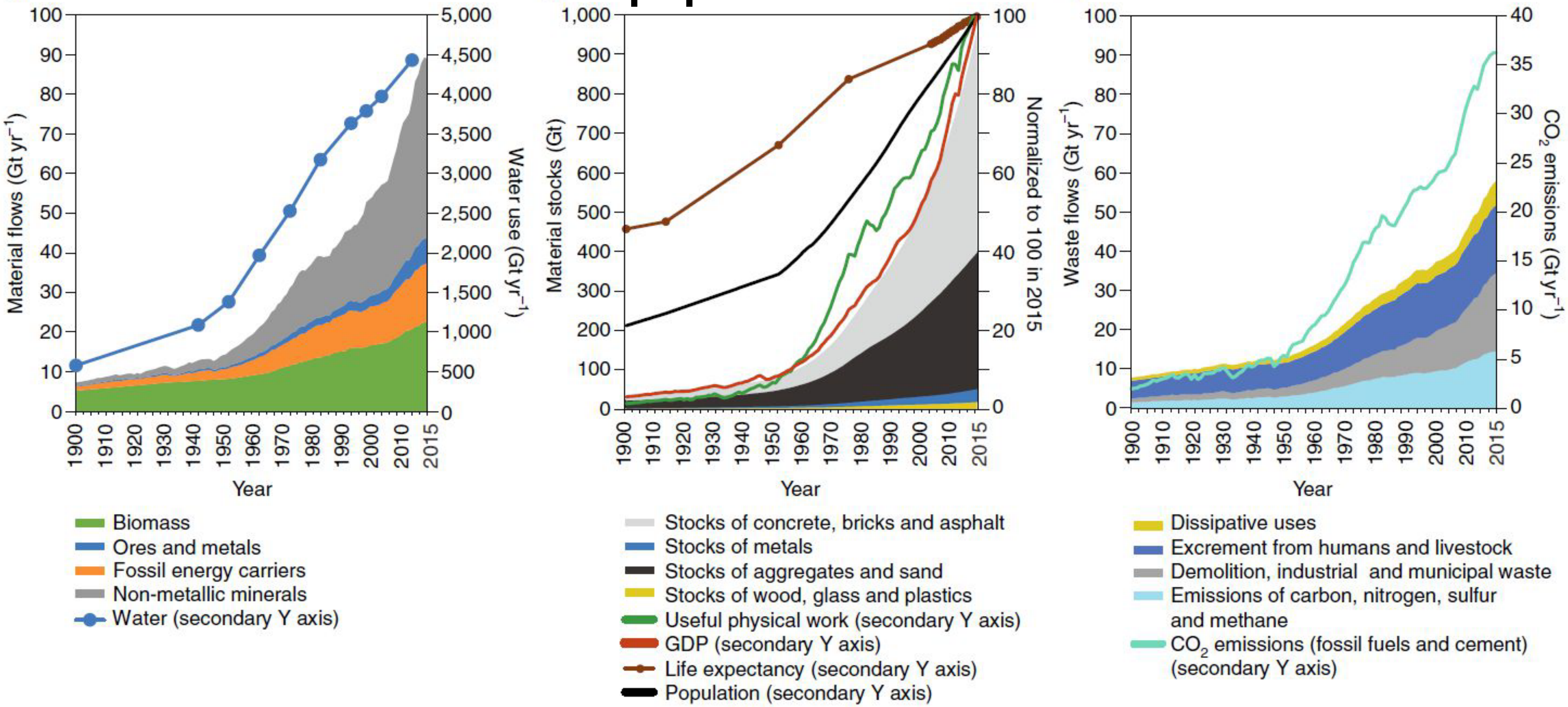
Resource use

Societal material stocks, GDP, population

Emissions and waste



Haberl, Wiedenhofer, *et al.* 2019. *Nature Sustainability.*
https://doi.org/10.1038/s41893-019-0225-2

Material use causes 25-35% of global GHG emissions

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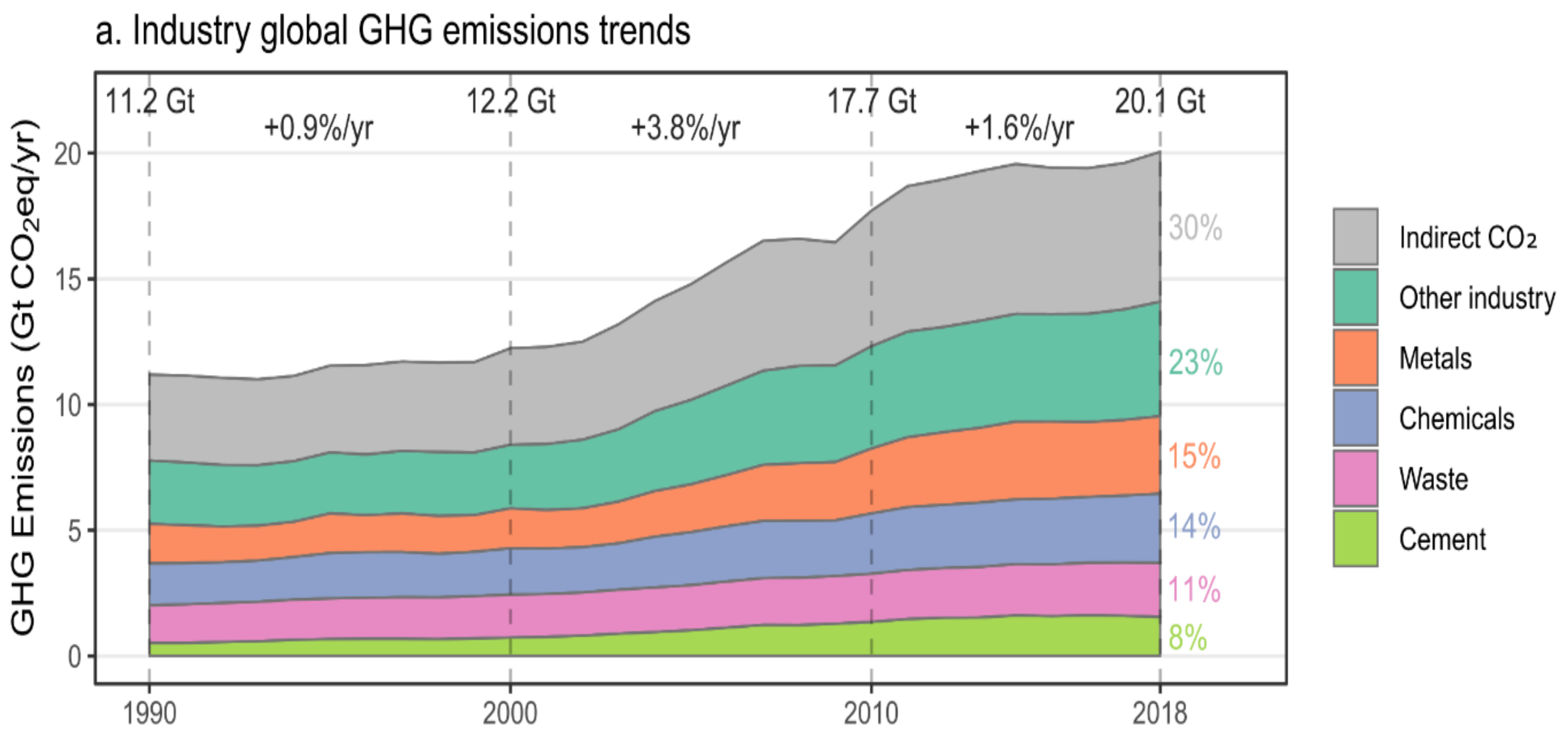

Lamb, Wiedmann, Pongratz, Andrew, Crippa, Olivier, Wiedenhofer, et al. „A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018". *Environmental Research Letters* (2021). https://doi.org/10.1088/1748-9326/abee4e.

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Nearly the entire period system is contained in our material stocks: circularity & esp. recycling limited

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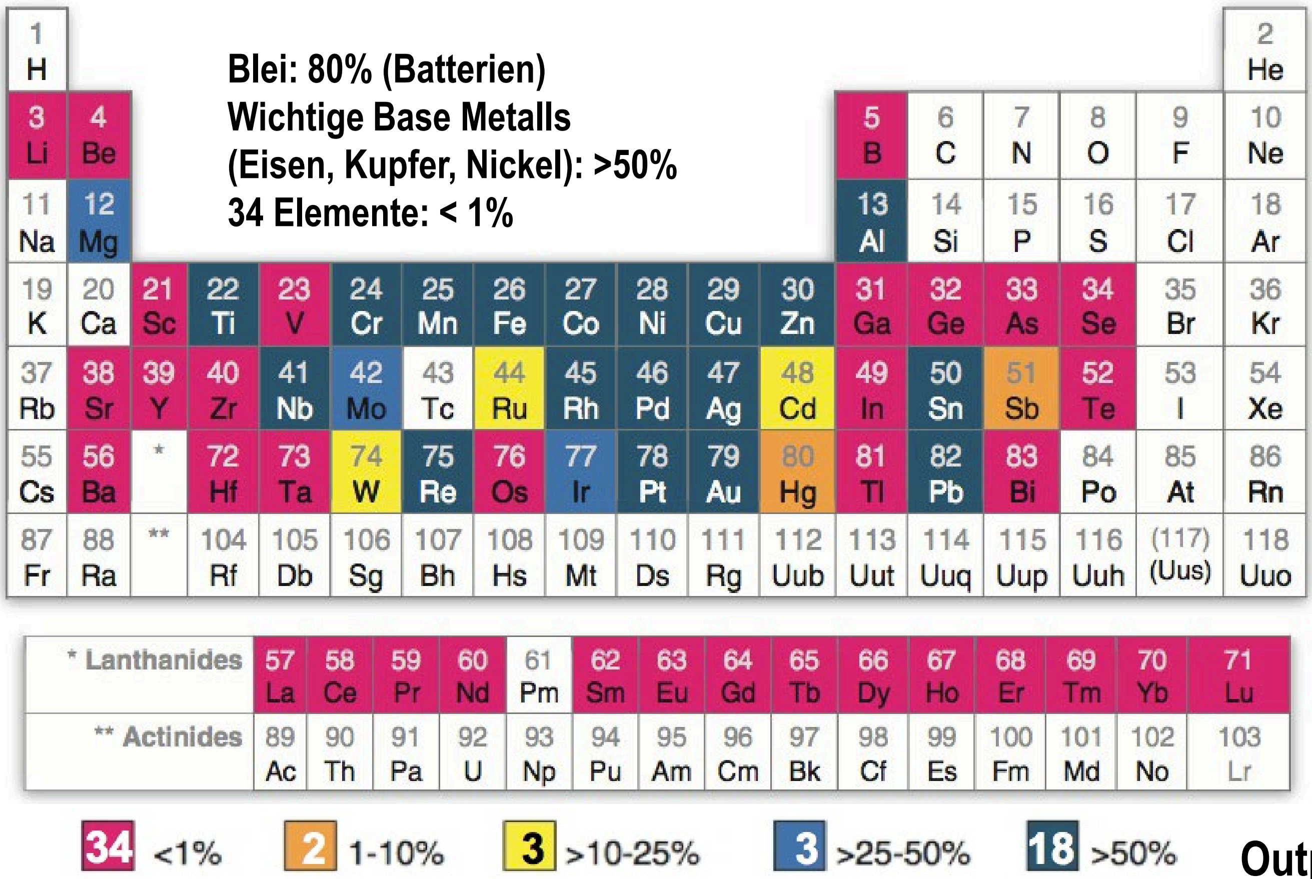

Source: Reck and Graedel, 2012, *Science*

Output recycling Rate

Monitoring the circular economy: our socio-metabolic operationalization

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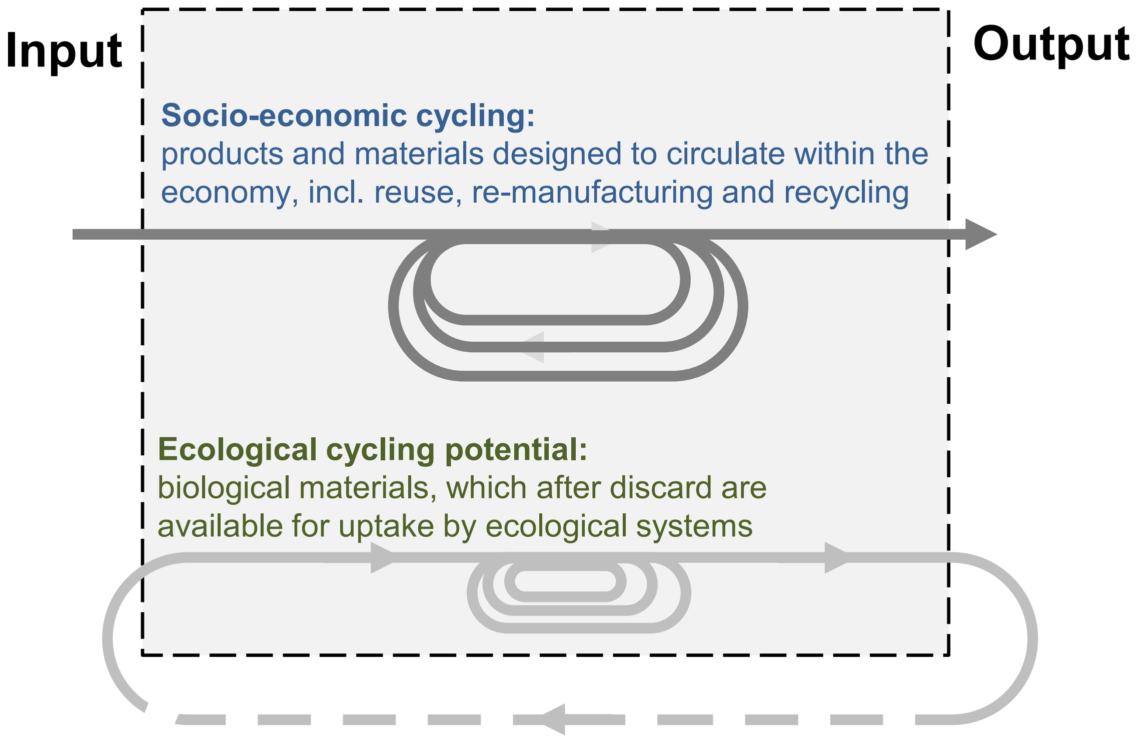

Sustainability conditions:

- **effective reduction of primary material**
- **carbon neutral energy use**

- **biomass produced in a renewable way**
- **no net carbon emissions**

Very difficult to assess these criteria – especially beyond emissions

Haas, W., Krausmann, F., Wiedenhofer, D., and Heinz, M. 'How Circular Is the Global Economy?: An Assessment of Material Flows, Waste Production, and Recycling in the European Union and the World in 2005'. *Journal of Industrial Ecology* (2015): https://doi.org/10.1111/jiec.12244.

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The global metabolism and its (non-) circularity

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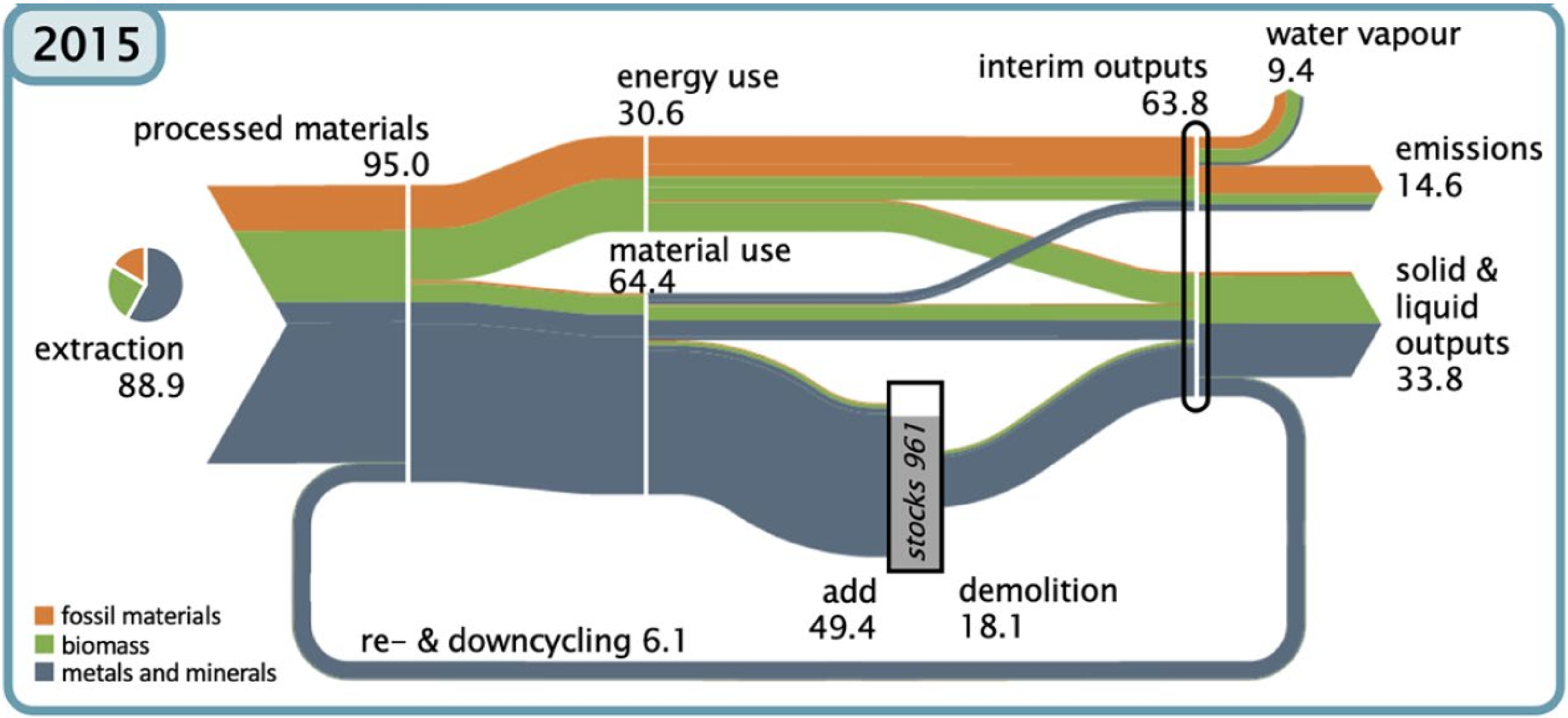

Haas, Willi, Fridolin Krausmann, Dominik Wiedenhofer, Christian Lauk, und Andreas Mayer. „Spaceship Earth's Odyssey to a Circular Economy - a Century Long Perspective". (2020): 105076. https://doi.org/10.1016/j.resconrec.2020.105076.

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Resource use and circularity in China, in 2015

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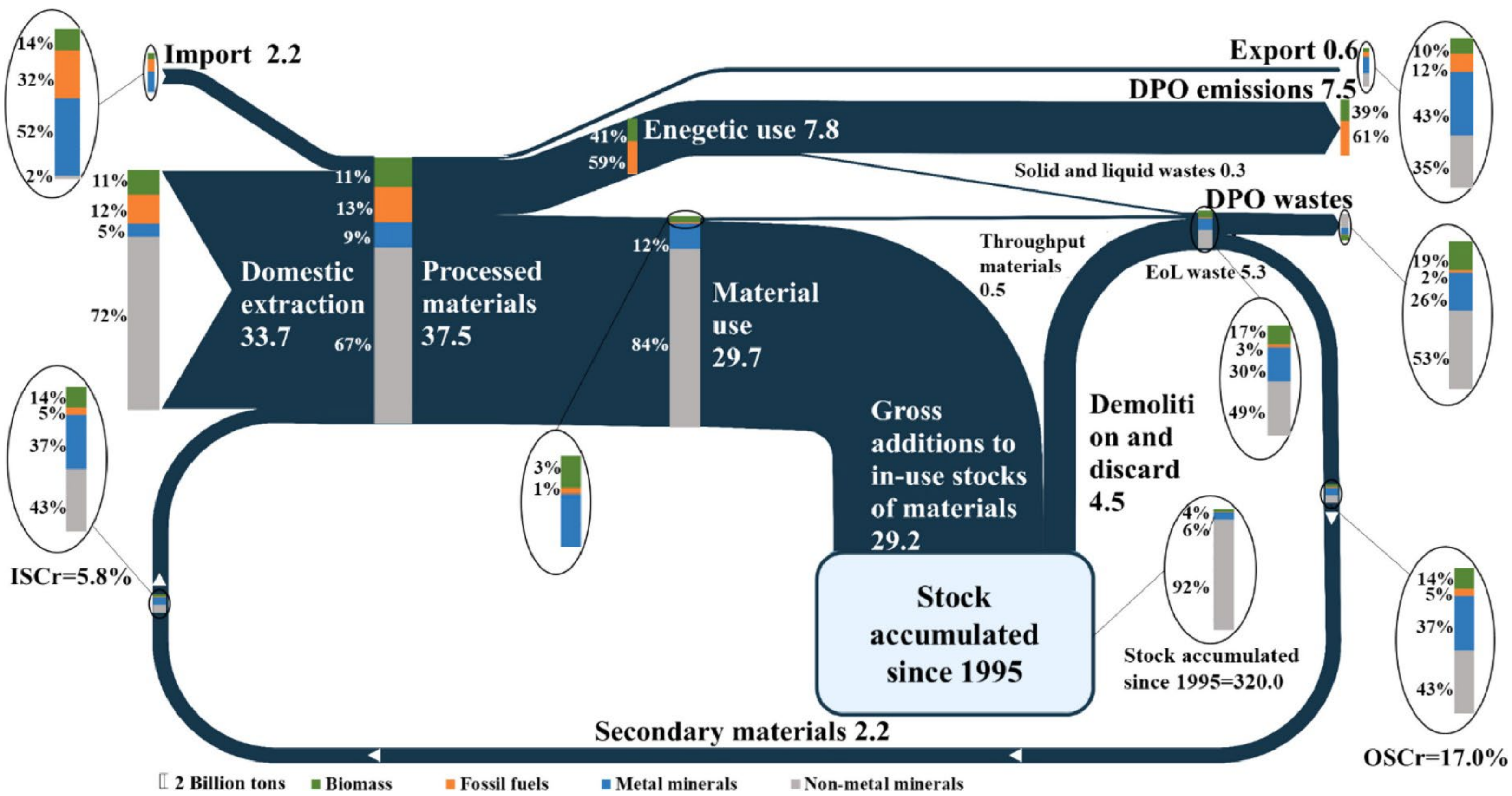

Wang et al. 2020 Measuring progress of China's circular economy.
https://doi.org/10.1016/j.resconrec.2020.105070

Resource use and circularity, in Europe, in 2014

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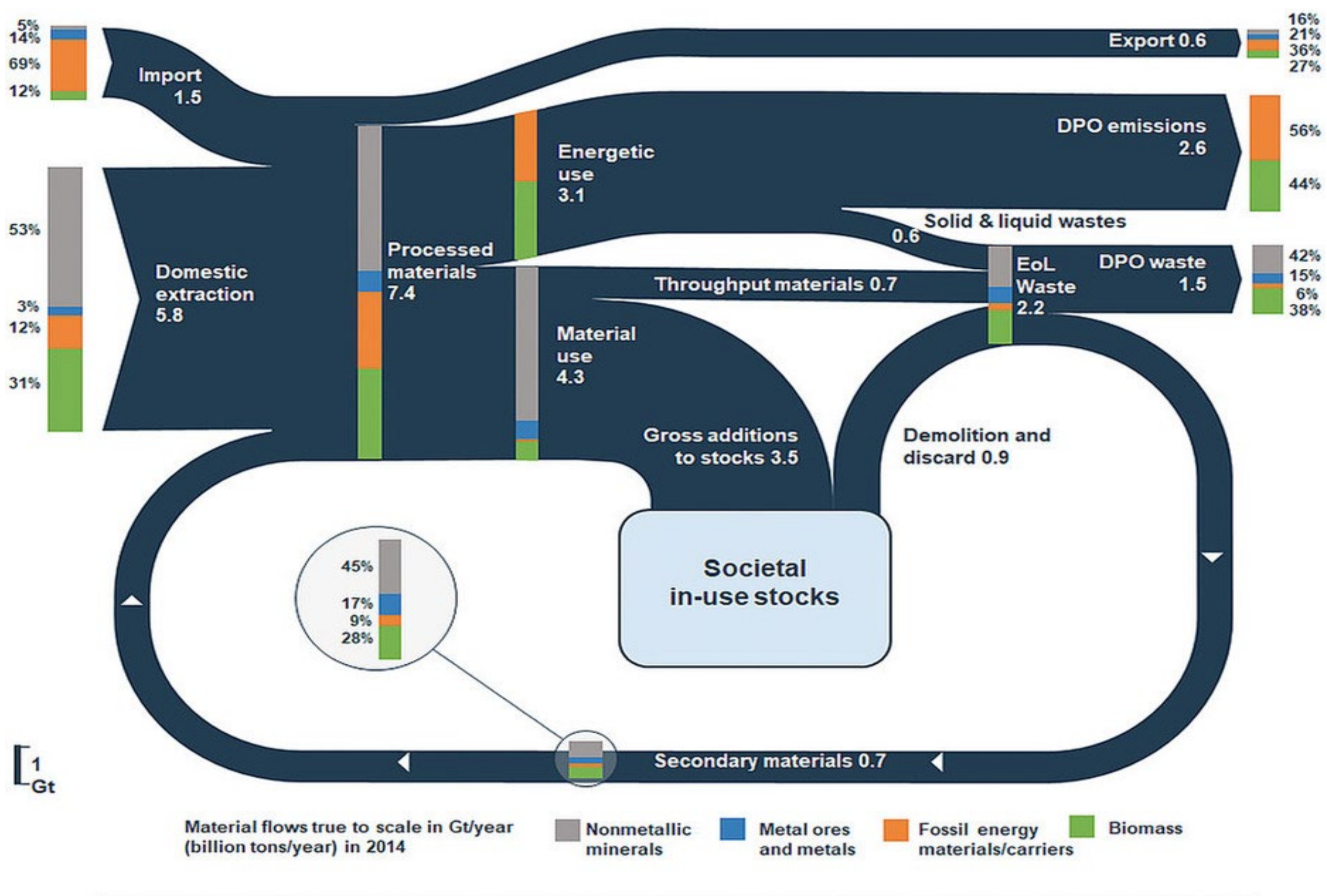

Mayer, A., Haas, W., **Wiedenhofer, D.**, Krausmann, F., Nuss, P., and Blengini, G.A. ‘Measuring Progress towards a Circular Economy - a Monitoring Framework for Economy-Wide Material Loop Closing in the EU28.’ https://doi.org/10.1111/jiec.12809

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Circularity assessment for major material flow groups

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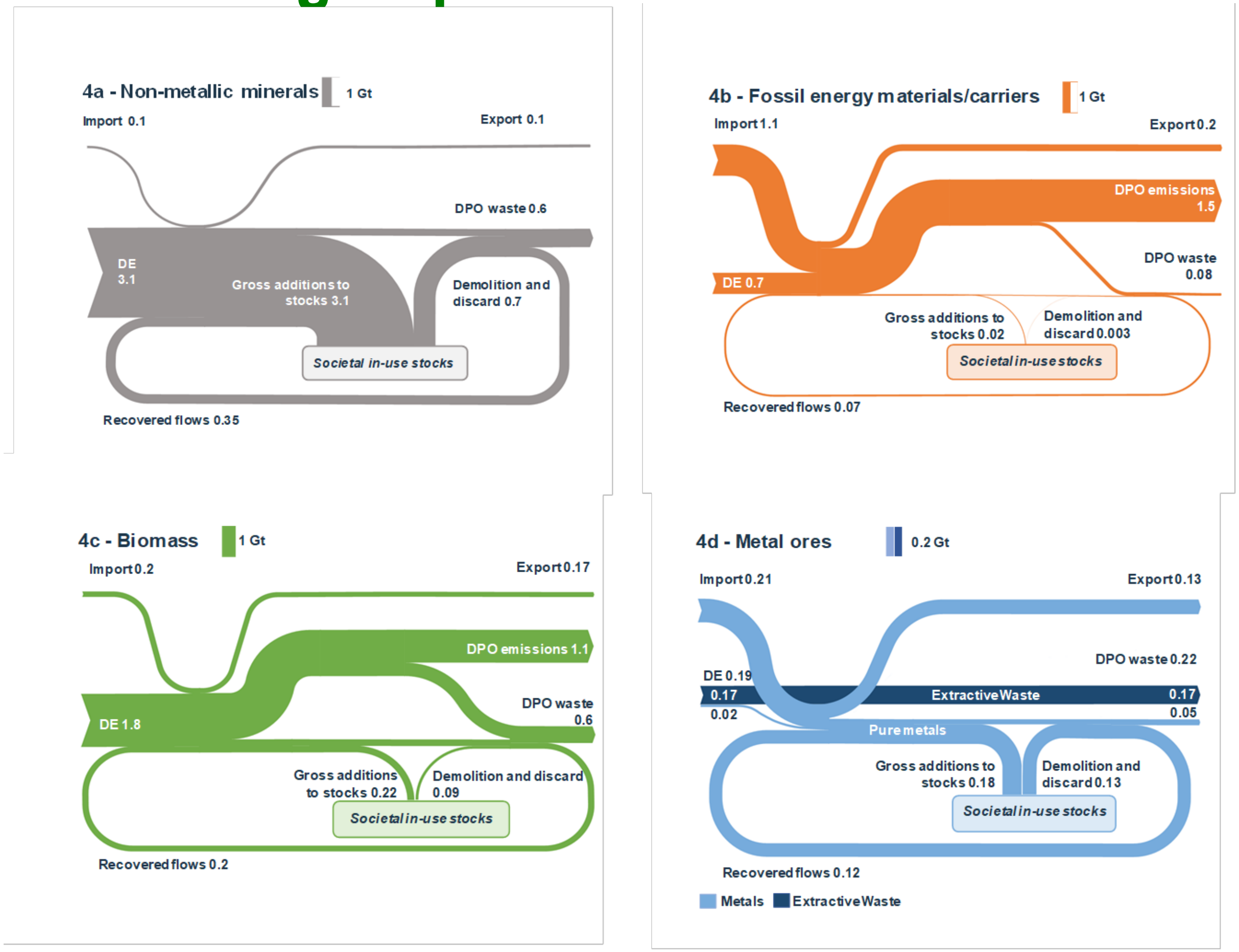

Mayer, A., Haas, W., **Wiedenhofer, D.**, Krausmann, F., Nuss, P., and Blengini, G.A. 'Measuring Progress towards a Circular Economy - a Monitoring Framework for Economy-Wide Material Loop Closing in the EU28.' *Journal of Industrial Ecology*, 2018. https://doi.org/10.1111/jiec.12809

Policy relevant headline indicators for the circular economy

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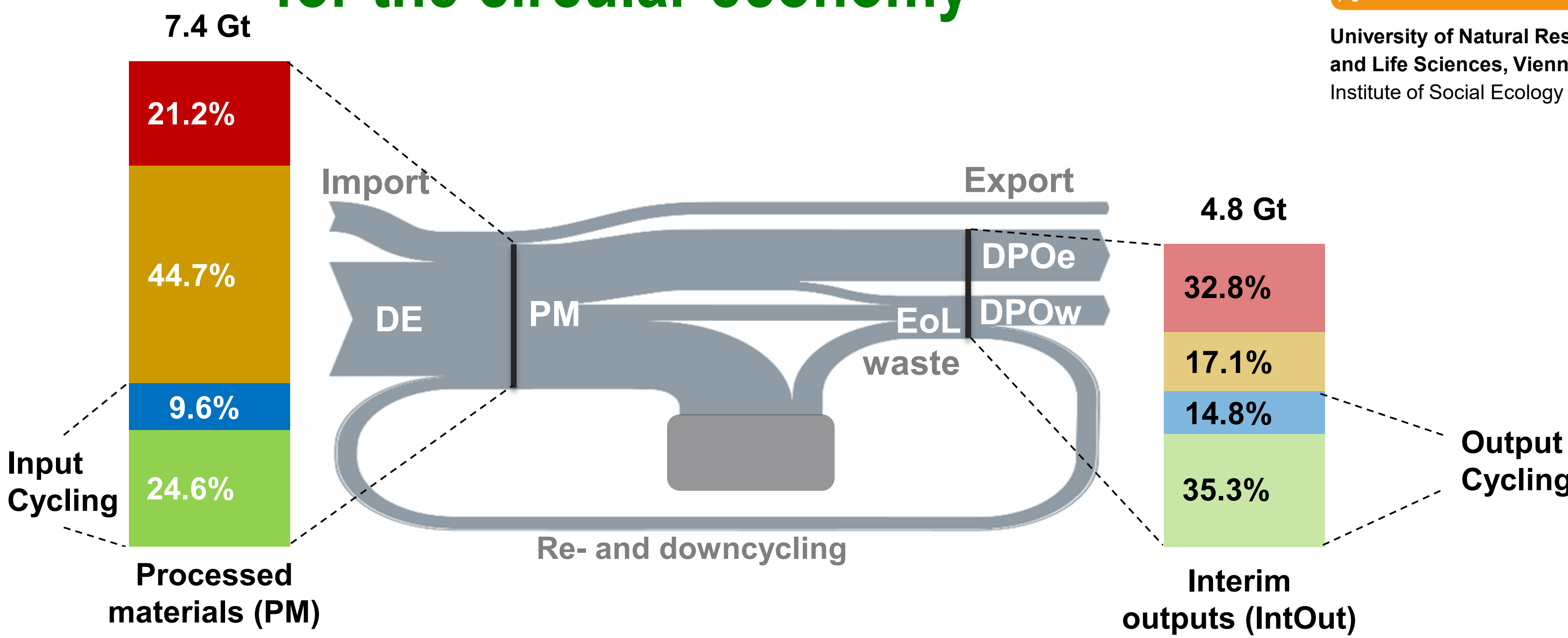

- Input non-circularity rate (INCr)
- Remaining non-renewable primary resources
- **Input socio-economic cycling rate (ISCr)**
- **Input ecological cycling rate potential (IECrp)**

- Output non-circularity rate (ONCr)
- Remaining interim outputs
- **Output socio-economic cycling rate (OSCr)**
- **Output ecological cycling rate potential (OECrp)**

Mayer, A., Haas, W., **Wiedenhofer, D.**, Krausmann, F., Nuss, P., and Blengini, G.A. 'Measuring Progress towards a Circular Economy - a Monitoring Framework for Economy-Wide Material Loop Closing in the EU28.' *Journal of Industrial Ecology*, 2018. https://doi.org/10.1111/jiec.12809

European circularity

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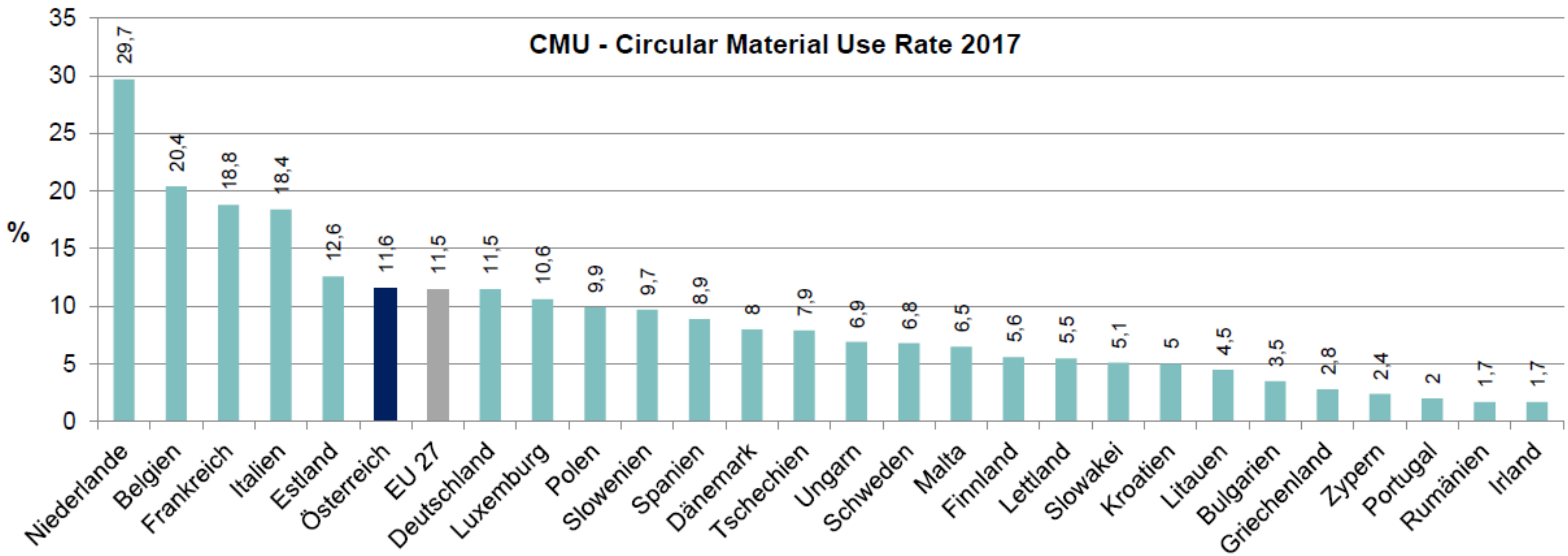
NUTZUNGSRATE WIEDERVERWENDBARER STOFFE



Quelle: Umweltbundesamt, Daten: Eurostat

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CONCLUSIONS

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Conclusions (I)

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- Key challenge of squaring the circle: a growing economy with absolute decoupling and net-zero emissions in 2-4 decades?
- The circular economy has substantial potential and growing global support, now it needs to prove its viability and actual socio-ecological benefits!
- Production & consumption always require materials and energy
- Growing stocks require more resource use than can be circulated/recycled (mass balance!)
- Recycling requires energy and always has losses (no perpetual motion machine!)
- Path dependencies due to existing material stocks and widespread lock-ins

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Conclusions (II): towards a sustainable circular economy within planetary boundaries?

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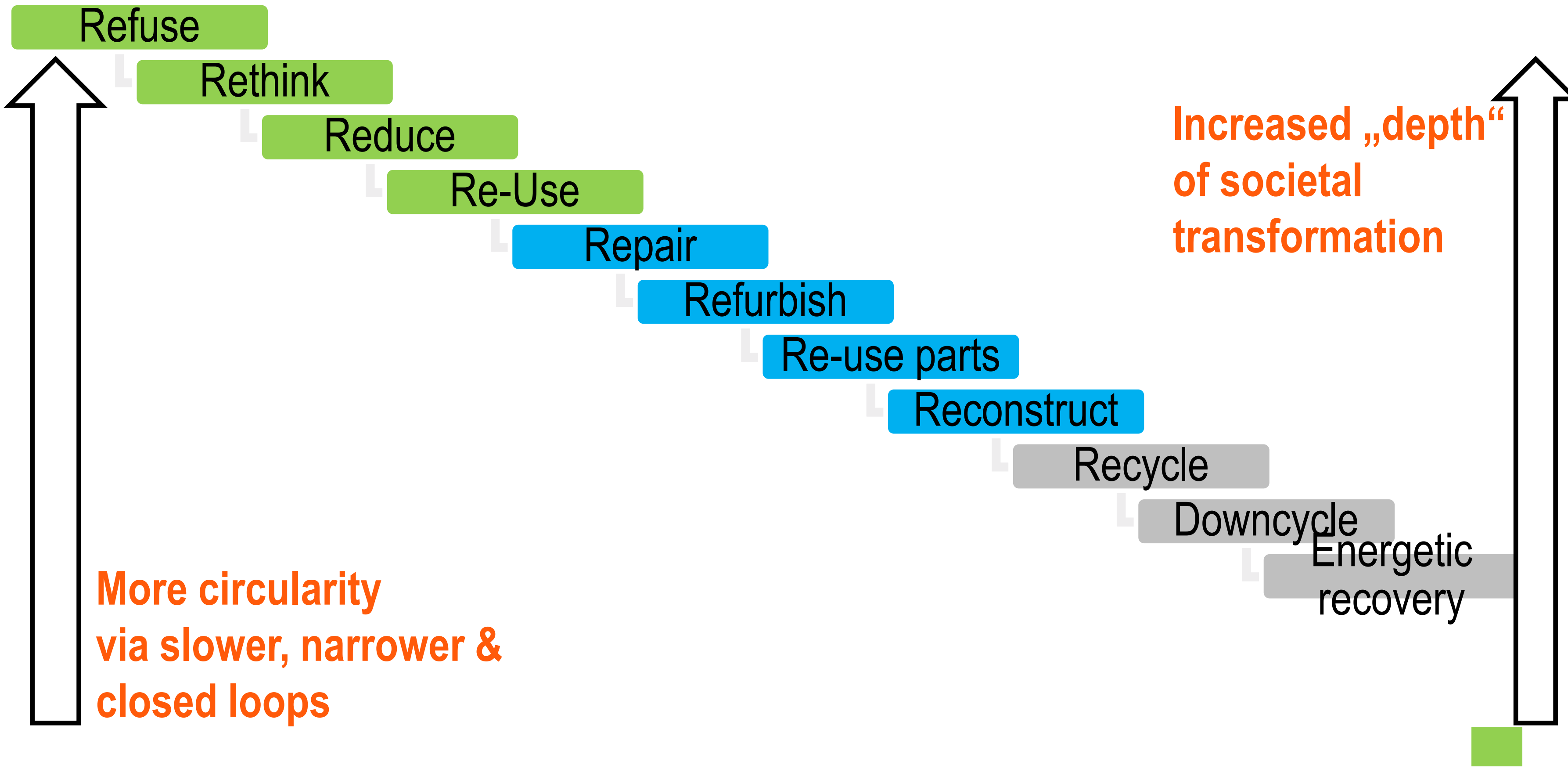

Inspired from Potting et al. (2017) https://space.library.uu.nl/handle/1874/358310

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Conclusions (III): clear targets and strong measures required

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„Absolute“ targets necessary, not only relative ones (narrow the cycles)

- E.g. net-zero emissions in 2040/50, instead of GHG-intensity of the economy
- Stabilize/reduce amount of total processed materials; not only circularity rates
- Absolute limits for resource use and for the expansion of material stocks
- Biomass, land use and biodiversity considerations require limits and diet transformation

Supply and demand-side measures required

- Infrastructures for dematerialized and carbon-free everyday life (narrow and slow the cycles)
- Focus on high standards for repair, upgrades, refurbishing to extend lifetimes (slow and narrow the cycles)
- Socio-ecological tax reforms to internalize true costs and shift tax base from labour towards materials, energy and capital (narrow, slow, close)
- Limit business models which require accelerating of product cycles/lifetimes (narrow & slow)
- Upscale recycling systems (close the cycles)

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https://boku.ac.at/understanding-the-role-of-material-stock-patterns-for-the-transformation-to-a-sustainable-society-mat-stocks

https://www.researchgate.net/profile/Dominik-Wiedenhofer

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