HOGESCHOOL UTRECHT

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

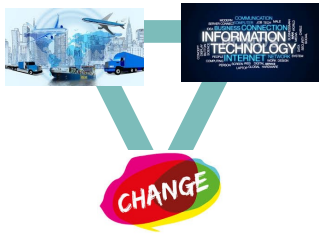
Measuring circularity

The Gordian Knot of the 21st century

Arjen Wierikx
October 5, 2022

SMART CIRCULAR
PASSION FOR LOGISTICS, ALLERGY TO WASTE

Passion For Logistics
Allergic To Waste



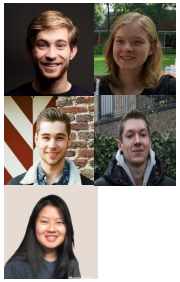
SMART CIRCULAR

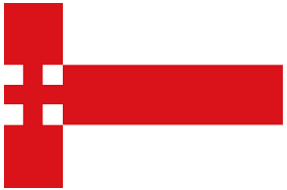
PASSION FOR LOGISTICS, ALLERGY TO WASTE

www.slimcirculair.info

TU Delft TNO BaaN mondeal the orgware company TU PhD

1985 1992 1995 2000 2020





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SER: Make Raw Materials transition a priority

Last Friday September 16:

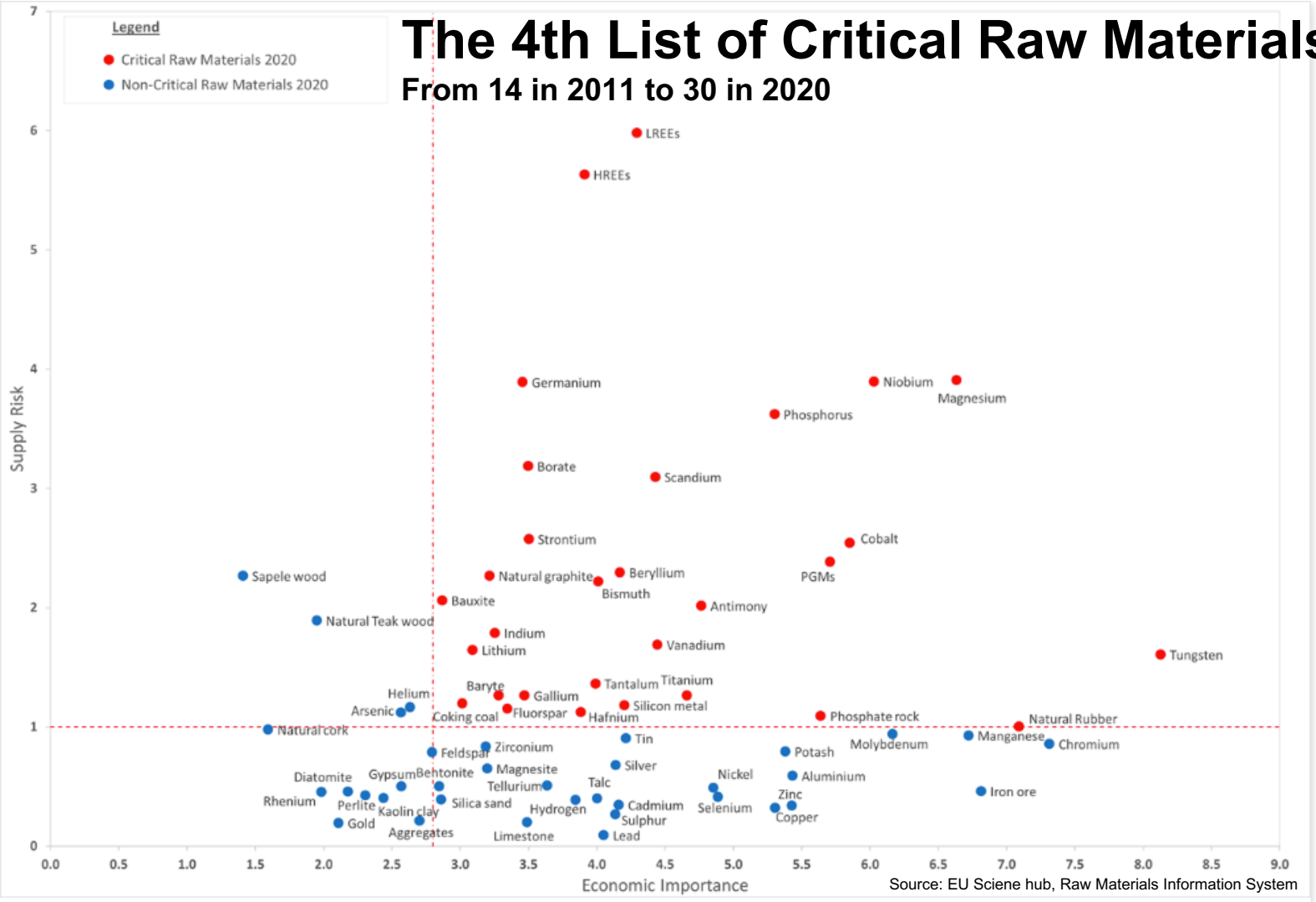
SER exploration: Climate targets will not be achieved without accelerating the raw materials transition

"High-quality reuse of raw materials and materials, high-quality use of bio-based raw materials and making international chains more sustainable are necessary conditions for both transitions. Cohesive policy is therefore crucial."
Ed Nijpels, chairman SER-commission Sustainable Development

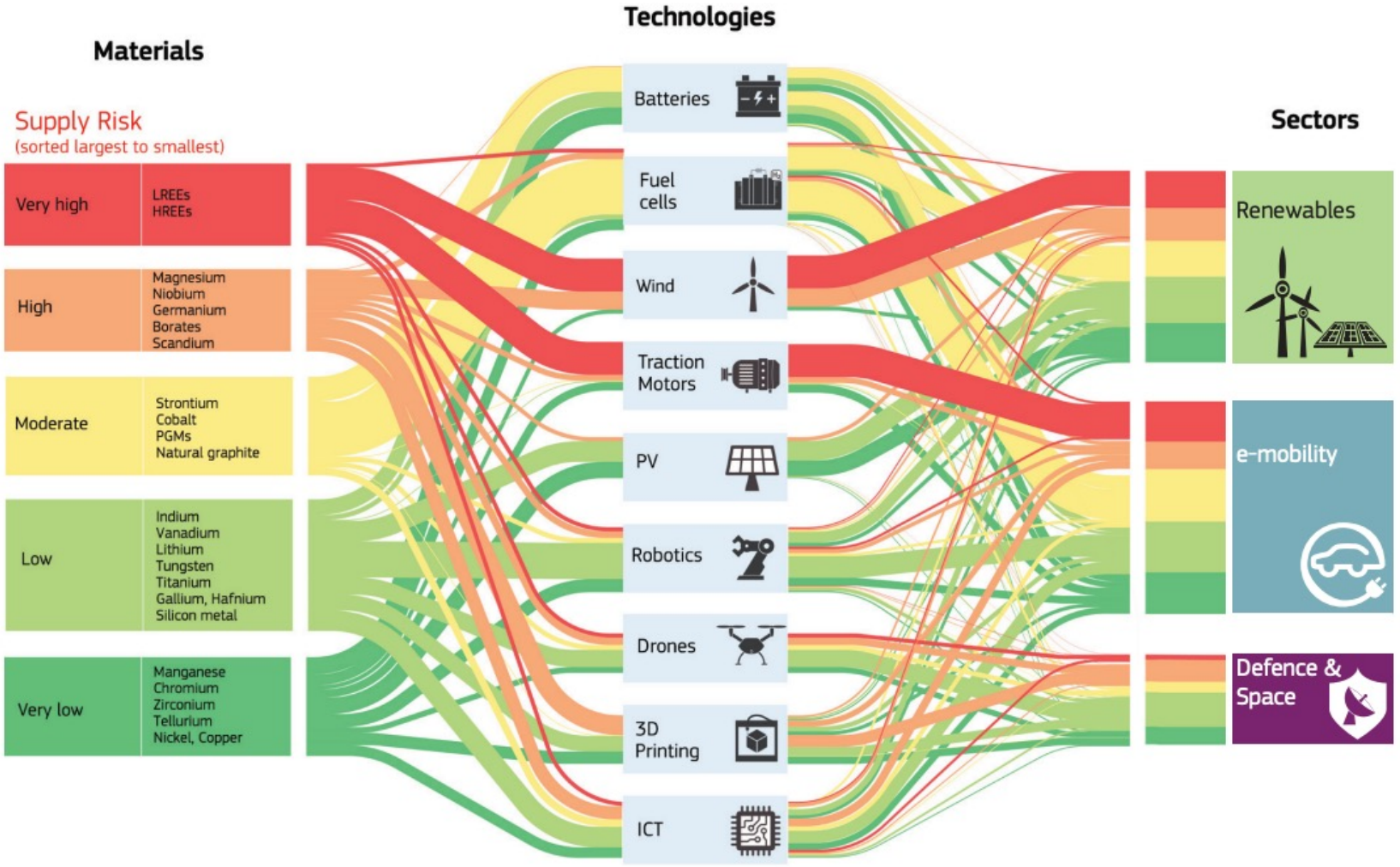
- Energy transition and Raw materials transition are at odds;
- With CO2 we can make the energy transition measurable. What about the raw materials transition / circularity?

The 4th List of Critical Raw Materials

From 14 in 2011 to 30 in 2020

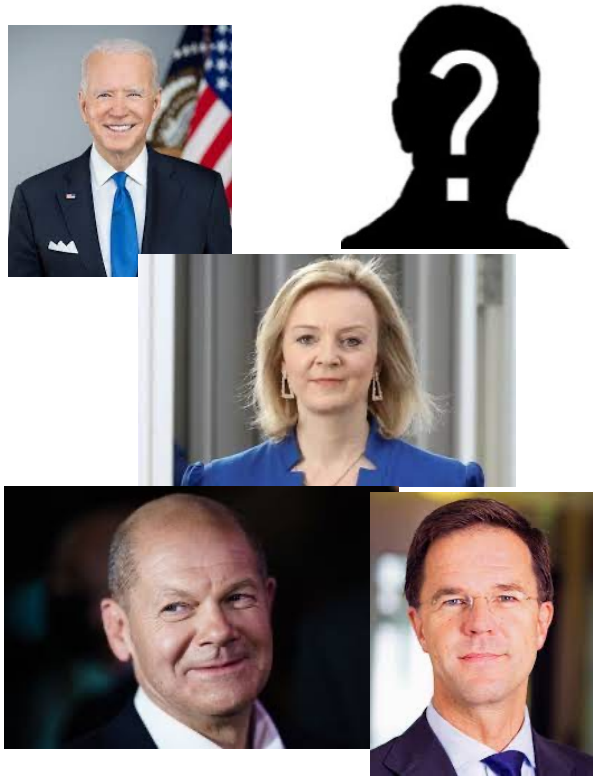


Source: EU Sciene hub, Raw Materials Information System



Source: https://rmis.jrc.ec.europa.eu/uploads/CRMs_for_Strategic_Technologies_and_Sectors_in_the_EU_2020.pdf

Waar staan we?

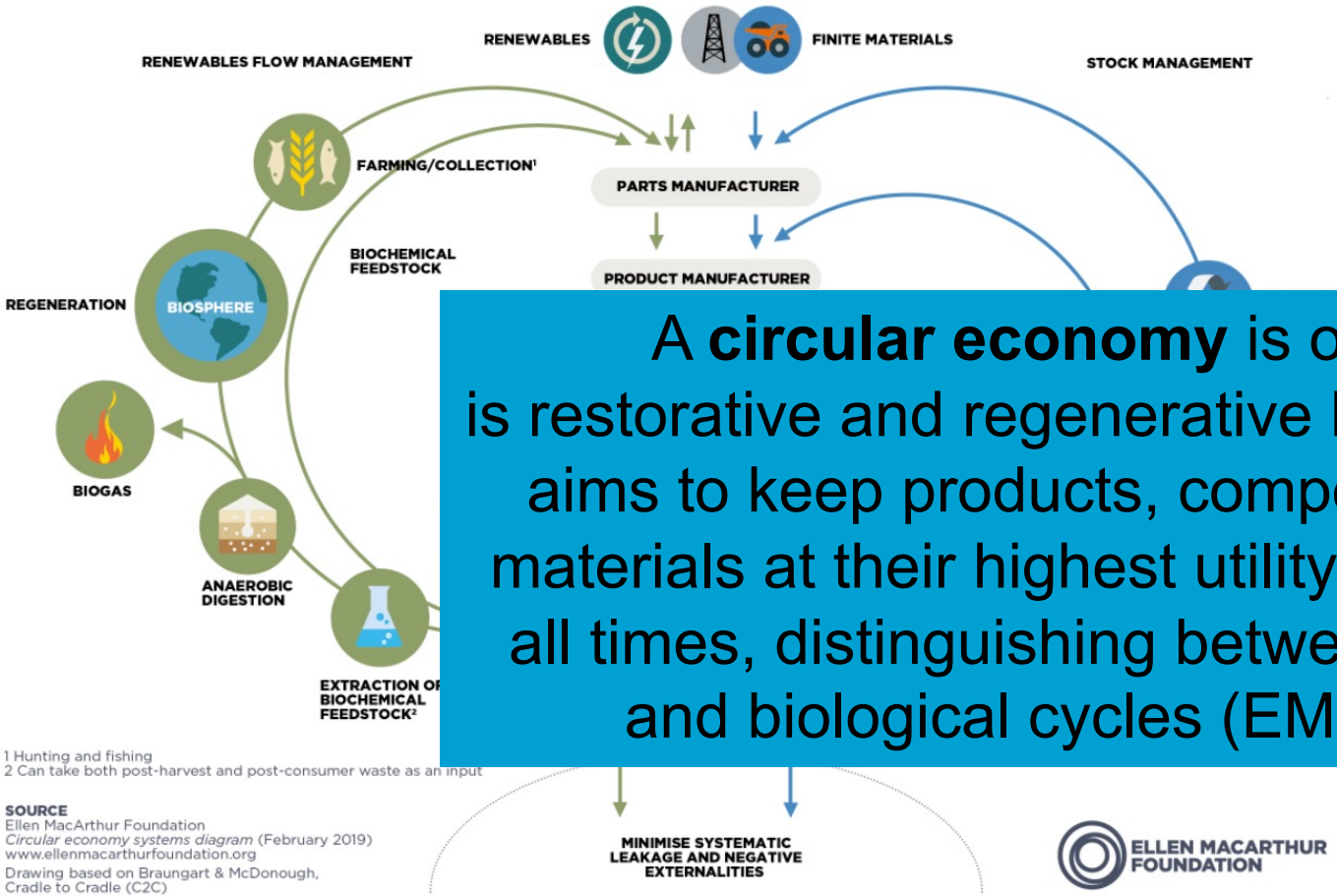


- Governments worldwide are announcing that they want to be 100% circular by 2050 (EC, 2011).
- In 2020 the world was 8.6% circular (Circularity Gap Report initiative, 2020)
- In 2005 the world was 5% circular. An increase of 3.6% in 15 years…. (CGRI, 2020)
- If we don't change anything, we will barely reach 20% by 2050…..
- When can you as a company say that you are 100% circular?

THE NETHERLANDS IS 24.5% CIRCULAR.

Major overhauls to the framework of the national economy - including jobs - will be necessary to achieve the government's ambitions of a fully circular economy by 2050.

CIRCULARITY METI
THE NETHERLAN



> 115 definitions
(Kirchher et al.,2017)

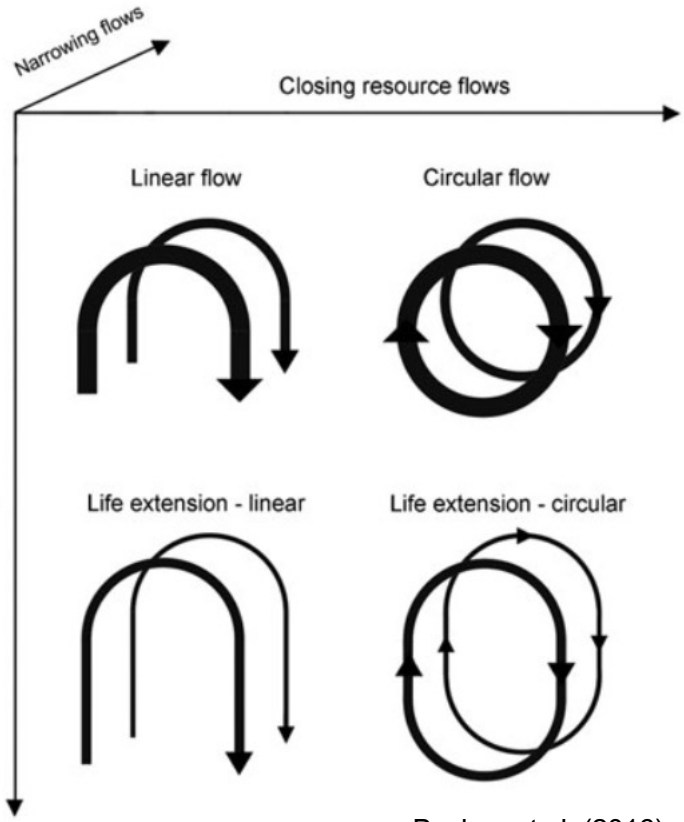
A **circular economy** is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles (EMF, 2013)

Strategieën

o.a. Potting et al. (2017) and Bocken et al. (2016)

Circular economy		Strategies	
Increasing circularity	Smarter product use and manu-facture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
		R1 Rethink	Make product use more intensive (e.g. by sharing product)
		R2 Reduce	Increase efficiency in product manufacture or use by consu-ming fewer natural resources and materials
	Extend lifespan of product and its parts	R3 Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
		R4 Repair	Repair and maintenance of defective product so it can be used with its original function
		R5 Refurbish	Restore an old product and bring it up to date
		R6 Remanufacture	Use parts of discarded product in a new product with the same function
		R7 Repurpose	Use discarded product or its parts in a new product with a different function
	Useful application of mate-rials	R8 Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
		R9 Recover	Incineration of material with energy recovery
Linear economy			

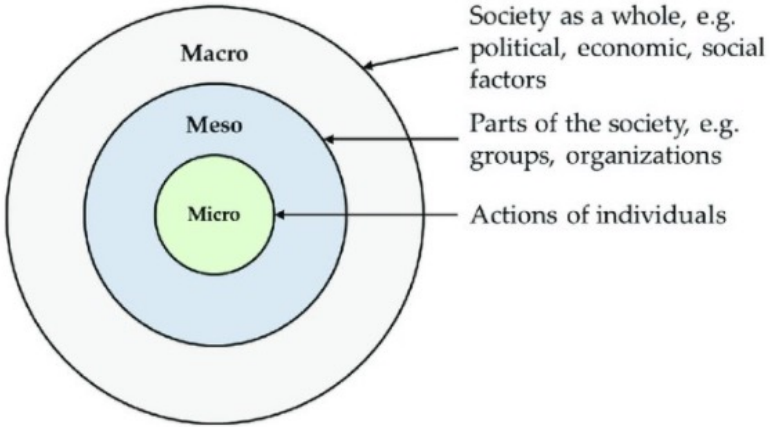
Kirchherr & Piscicelli (2019)



Bocken et al. (2016)

Nice and ”what’s in it for me?”

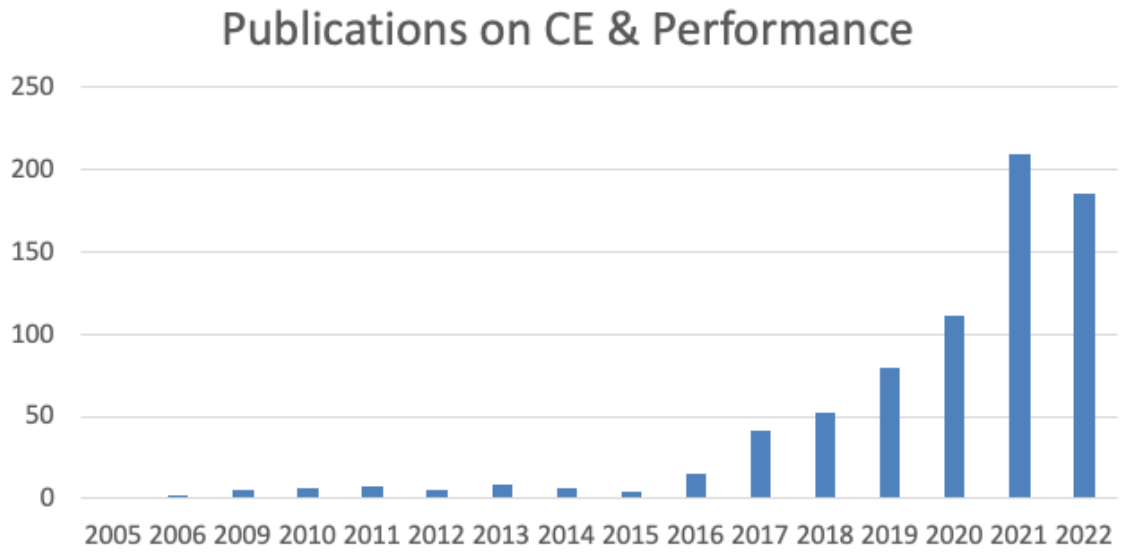
macro, meso, micro thinking in de circular economy



Macro, meso and micro level overview (Javaid, Javed & Kohda, 2019)

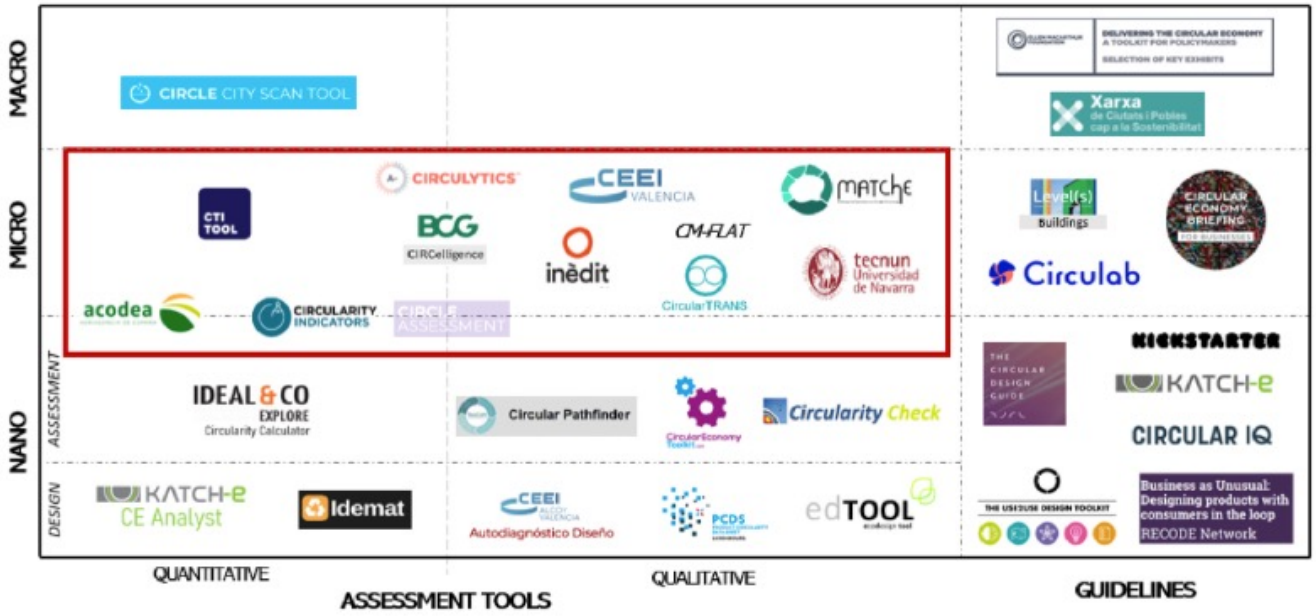
Macro, meso and micro explosion..

738 and counting



Source: constructed by authors

Snapshot (semi) commercially available tools



Existing tools for the assessment of the circular economy (Valls-Val et al., 2022)

Meta studies

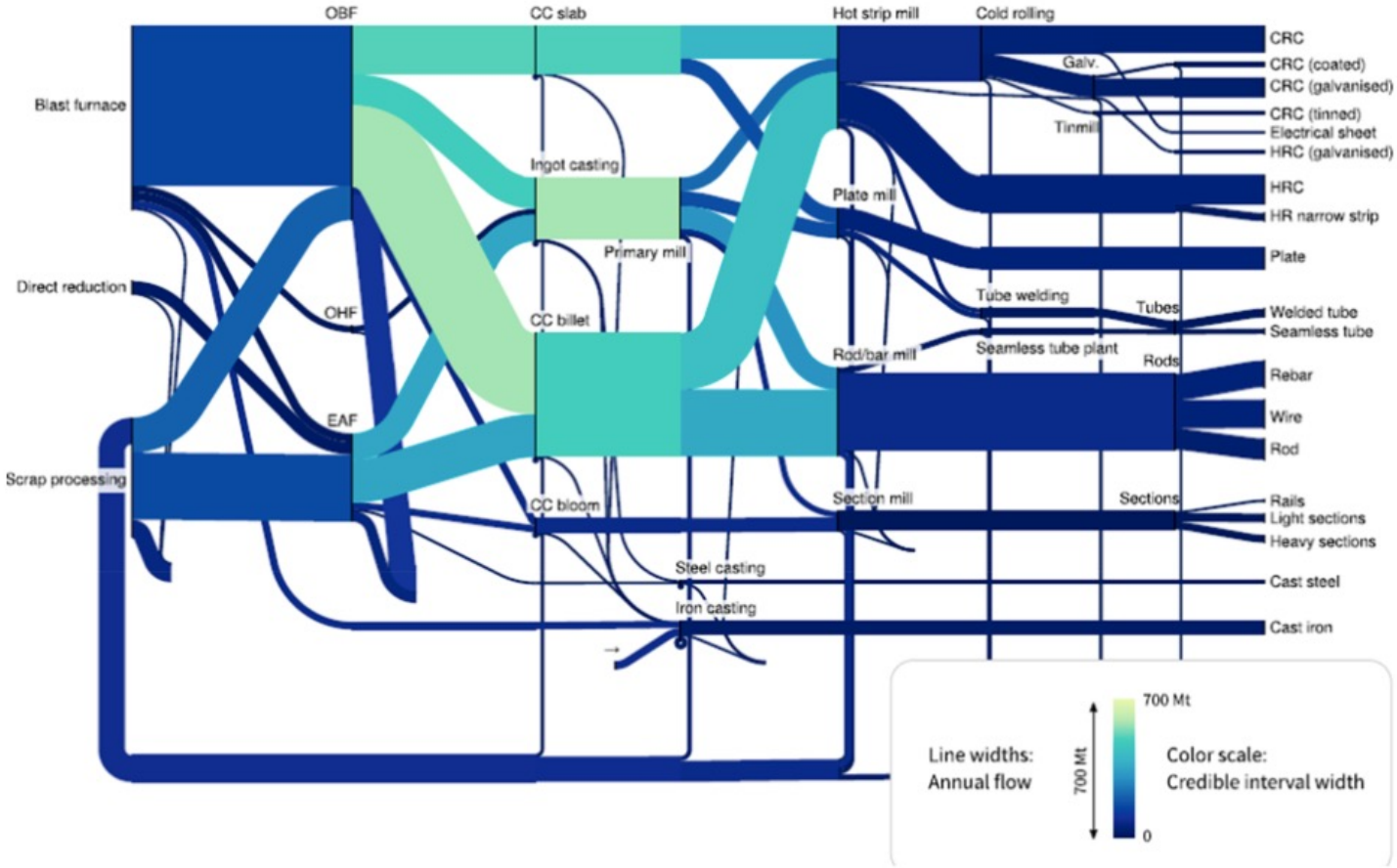
Reference	Approaches	Characteristic
(Valls-Val et al., 2022)	12	Tools capable of measuring the level of circularity of organisations.
(Vinante et al., 2021)		Focus on 365 different firm level metrics, classified in 23 categories.
(Kravchenko et al., 2020)		Review and ex-ante classification of sustainability performance indicators for proactive CE-strategies assessment
(Kristensen & Mosgaard, 2020)	30	Focus on micro level, zooming in on 'CE categories' and connection to Sustainable Development (SD) dimensions. Less attention for implementation perspective. Also includes grey literature.
(Lindgreen et al., 2020)	74	Newly constructed review framework, applying four review perspectives: A general, descriptive (methodological), normative (inclusion of SD/CE dimensions), and prescriptive (implementation-focused) perspective.
(Corona et al., 2019)	72	Zooms in on 'validity', 'reliability', and 'utility' of metrics, and connection to existing method-ologies (Life Cycle Assessment (LCA)/Material Flow Analysis (MFA), no focus on micro level.
(Moraga et al., 2019)	20	Introduces classification framework for CE indicators, both on macro- as well as micro level. Addresses different CE strategies captured by indicators.
(Parchomenko et al., 2019)	63	Applies Multiple Correspondence Analysis (MCA) to assess metrics. No distinction between different levels of assessment.
(Michael Saidani et al., 2019)	55	Proposes intricate taxonomy of indicators, applying 10 differentiation categories.
(Sassanelli et al., 2019)	45	Collects and reviews CE-performance assessment methods. Primary focus on methodological foundation. No specification of level of assessment.
(Elia et al., 2017)		Review, analyses, and comparison on how environmental assessment methodologies based on quantitative indicators are effective in measuring CE-strategies' level of application in companies, products and services.

125(!) models to make CE measurable

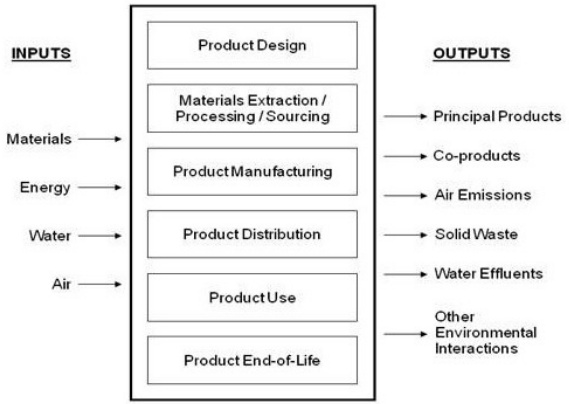
365 (!) micro level parameters

Sankey MFA diagram (example)

Graedel, 2019



LCA structure (example)



Material Selection

- Raw material acquistion
- Transportation of raw material
- Material production
- Transportation of produced material
- Additional fabrication

Construction

- Site preparation
- Energy consuption
- Tranportation of materials, personnel, and equipment
- Ancillary material

Maintenance

- Acquistion and fabrication of repair materials
- Traffic disrucption
- Transportation of materials, personnel and equipment for maintenance and inspection

End of Life

- Energy consumed by demolition equipment
- Site disruption
- Transportation of materials, personnel, and equipment
- Landfilling
- Traffic disruption

Hypothesis

There is not yet a really good tool for making circular performance holistically measurable that can also be used in SMEs in the Netherlands.

The Gordian knot

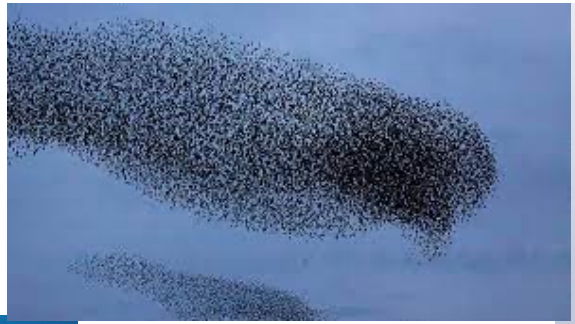
- Scientific transparency is lacking (Valls-Val et al., 2022) ;
- Varying substantiation (Sacco et al., 2021);
- Focus on in-& outflow / LCA & MFA;
- Inconsistent in purpose, scope and application (Saidani et al., 2019);
- Lack of standardization (Vinante et al.,2020; Kristensen et al., 2020);
- Terminology not formalized (Baratsas et al., 2022);
- Confusion and ambiguity (Vinante et al., 2020; Fiksel et al., 2012)

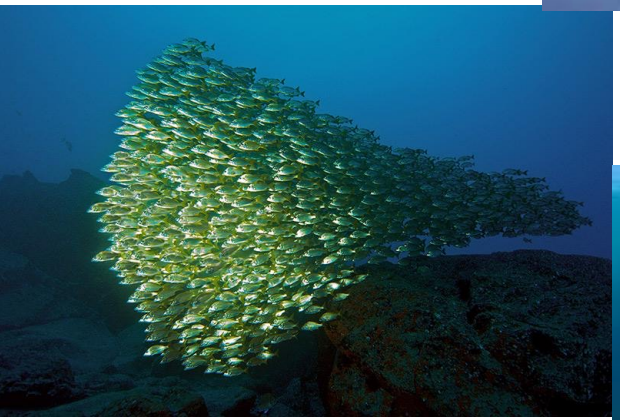
Interviews confirm the picture

- “We use CO2 because other units of measurement are not clear”;
- “Circular turnover is reported annually, based on four indicators that we measure company-wide”;
- ”I have no idea how to measure, I had hoped that you would come and tell me”;
- “We really want to measure circular performance, but we feel enormously hampered by regulations, laws and OEMs”;
- “If my customers want this, I will pay attention to it”;
- “For a small part of the business, we use a simplified version of the CTI Tool”;
- “We separate waste”….

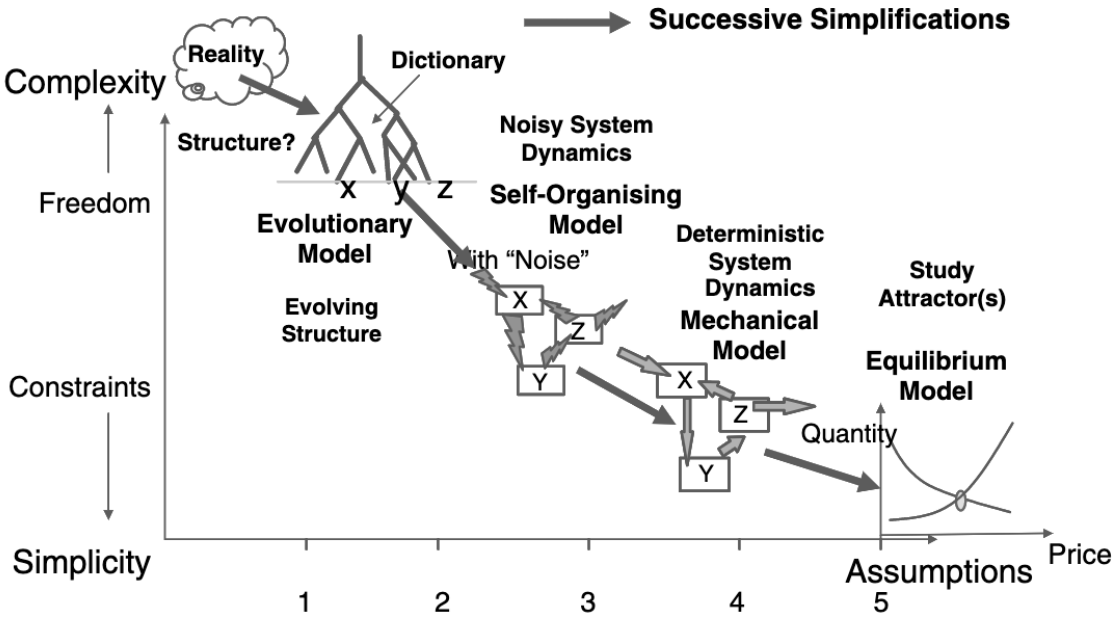
Co-evolution / complexity science

the one influences the other



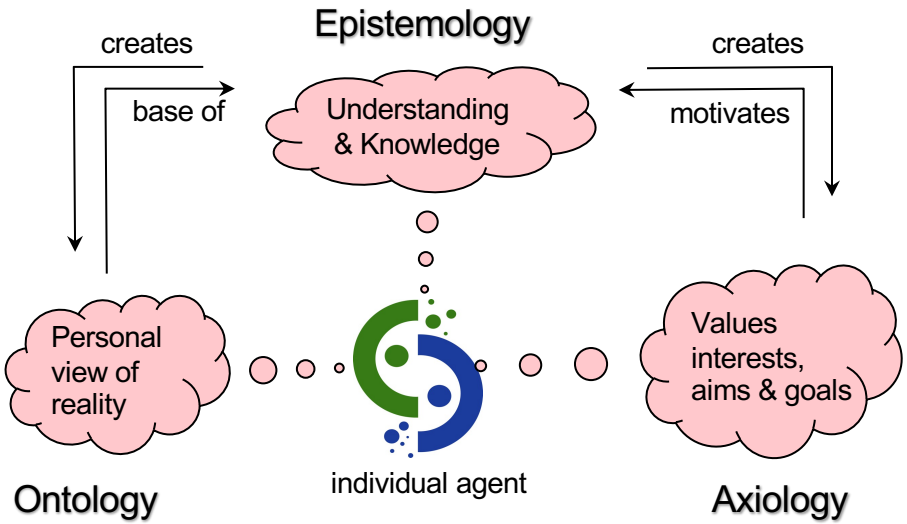


A co-evolutionary perspective on the Circular Economy



Source: Allen, P. M., & Varga, L. (2006)

Co-evolutionary development of CE



Source: created by Walraven, P. (2022) based on Allen, P. M., & Varga, L. (2006) and adjusted by author.

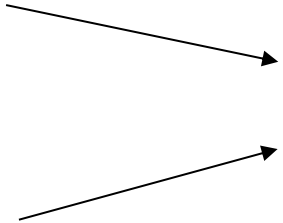
Development of CE metrics

source: Allen, P. M., & Varga, L. (2006)

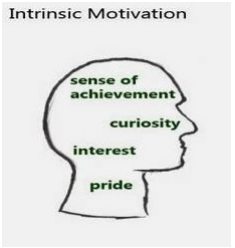
1. Emerging items, which describe new ideas but are not well defined;
2. Maturing items, on which there is consensus among a growing number of individuals;
3. Redefining items, replacing existing items;
4. Dying items,that have not reached critical mass;
5. Latent items, which can appear, but require stimulation or interaction to develop.

We are getting there

Converging knowledge



Intrinsic motivation



ISO

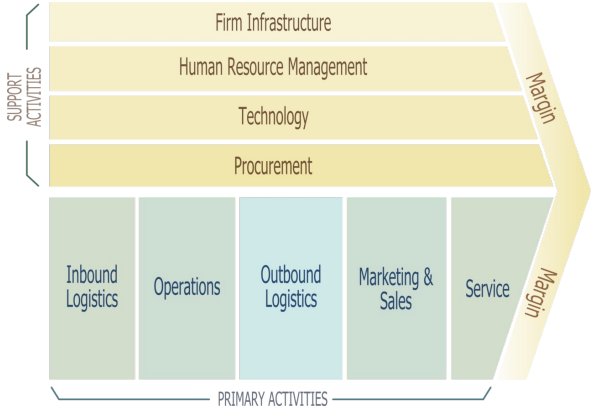
Standardization & Normation

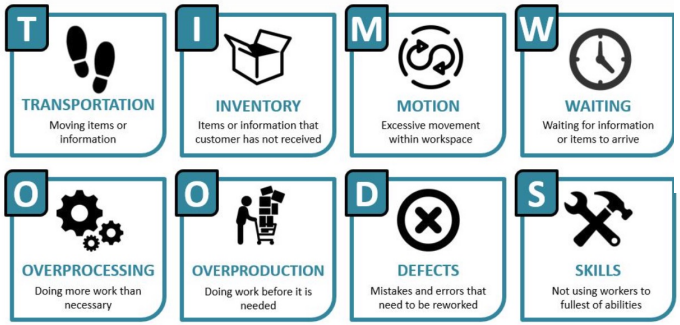
Regulations

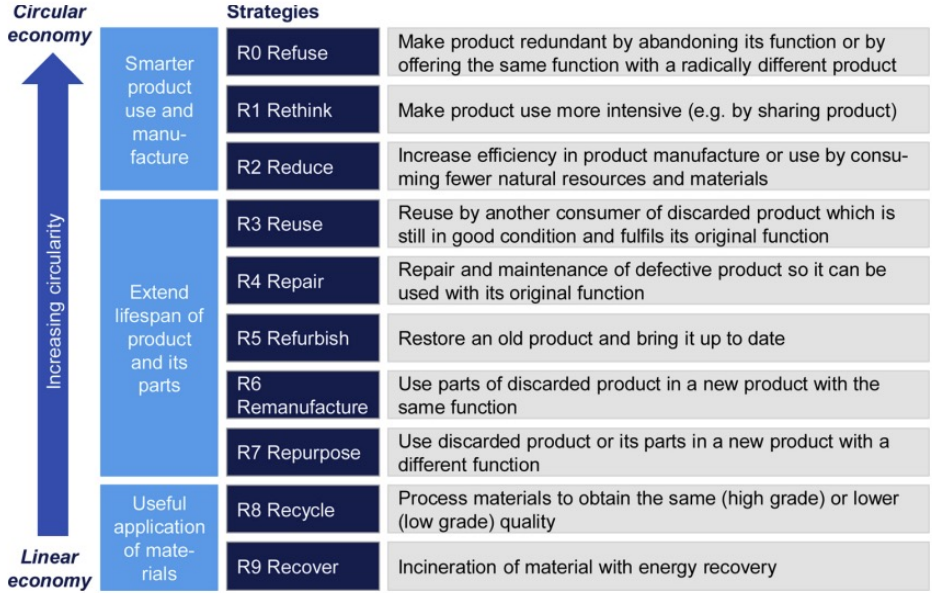
TU/e

Holistic ambitions

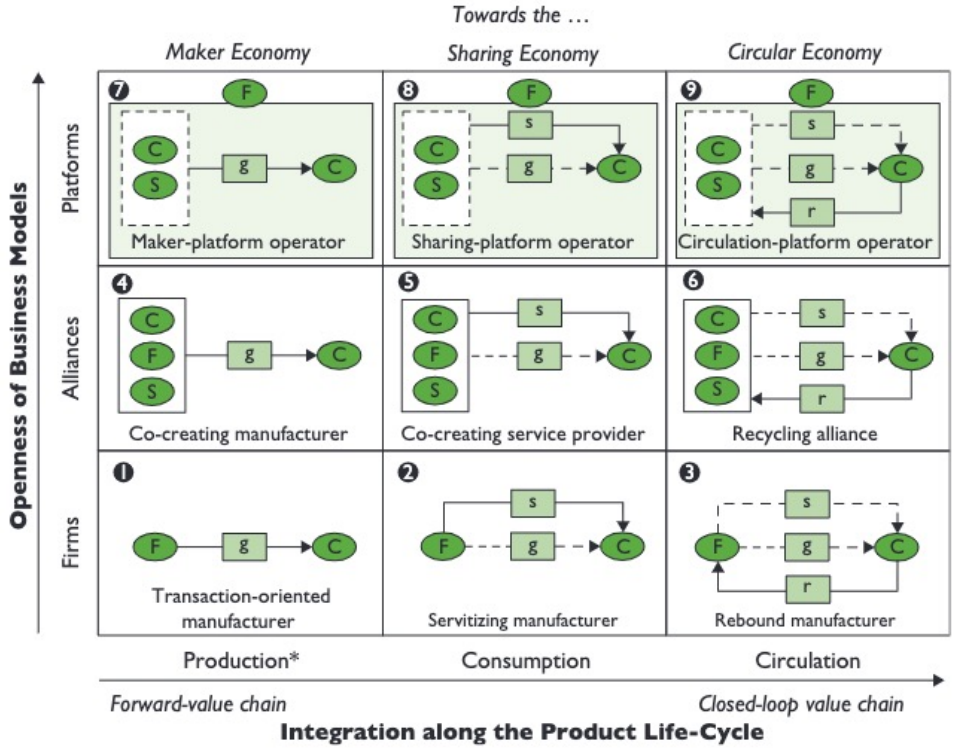
based on R-ladder, Porter & Lean







New initiatives…
Eliminating leaks..
Thinking differently…

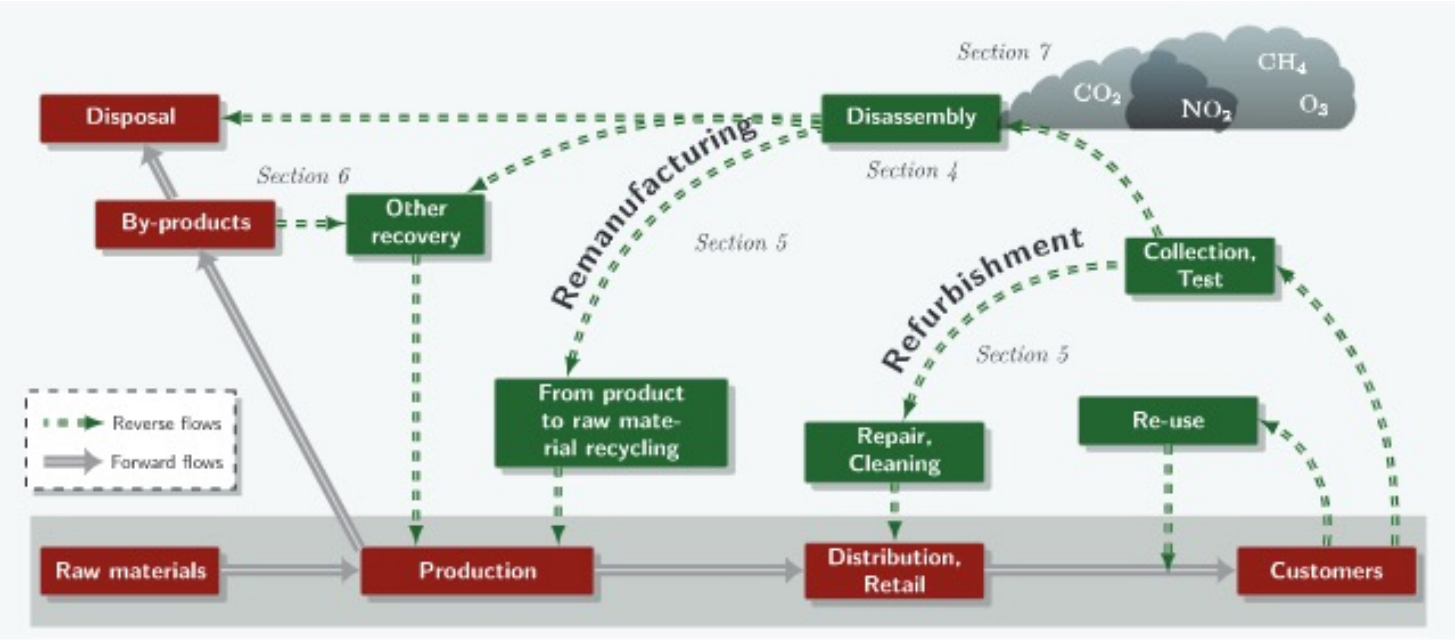


C Consumer
F Focal firm
S Supplier

g goods
s value added services
r re-acquired products

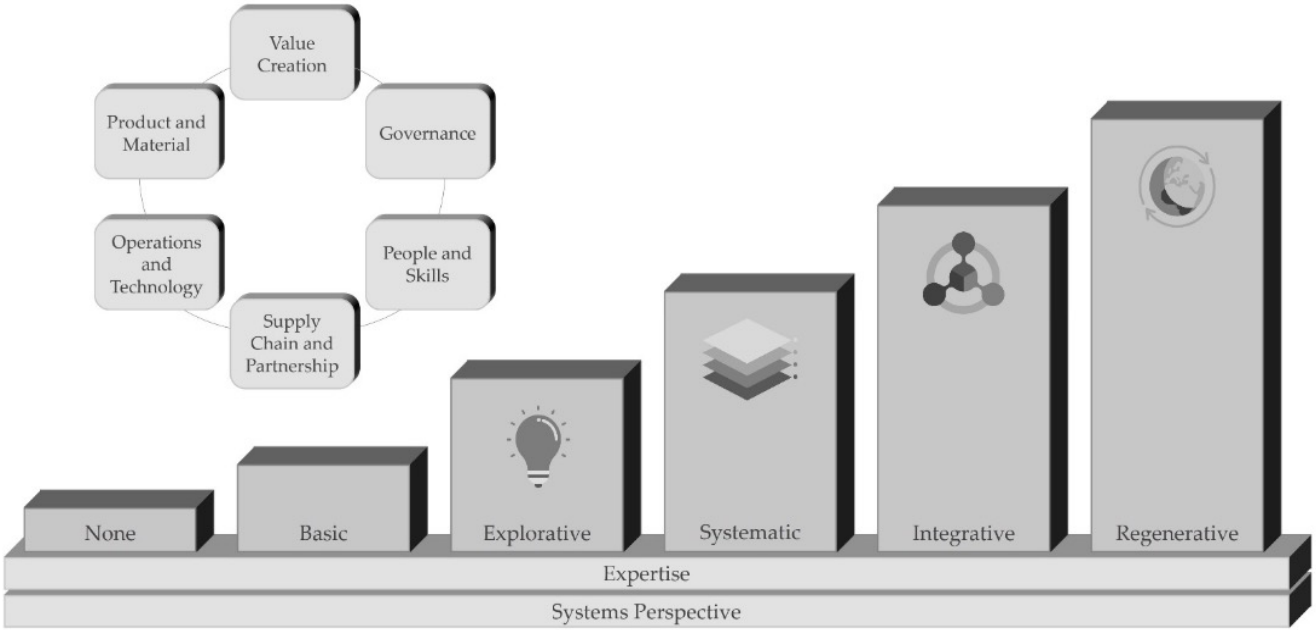
Source: Kortmann & Piller (2016)

New entities in new networks



Source: Suzanne et al. (2020)

Circular performance
Viewed through the lens of process maturity



Source Uhrenholt et al. (2022)

The challenge

holistic, dynamic, accessible and longitudinal

- Holistic: Circular performance is more than just a focus on material flows.
- Dynamic: Domain is in constant motion, capabilities can (will) change over time;
- Accessible: Attractive. Feeling invited to participate to increase response;
- Longitidunal: Being able to make visible what to do to develop to the next level based on a benchmark.

Hypothesis

Circular performance viewed through the lens of process maturity will give me insight into where I stand and what (through benchmarking) I can do to grow.

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Are you participating and/or do you have any questions?

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Measuring circularity, untangling a Gordian Knot

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