We, humans are the first and only “intelligent” species practicing linear economy on a circular planet and soon we’ll be the last to have practiced it!

- Amir Rashid

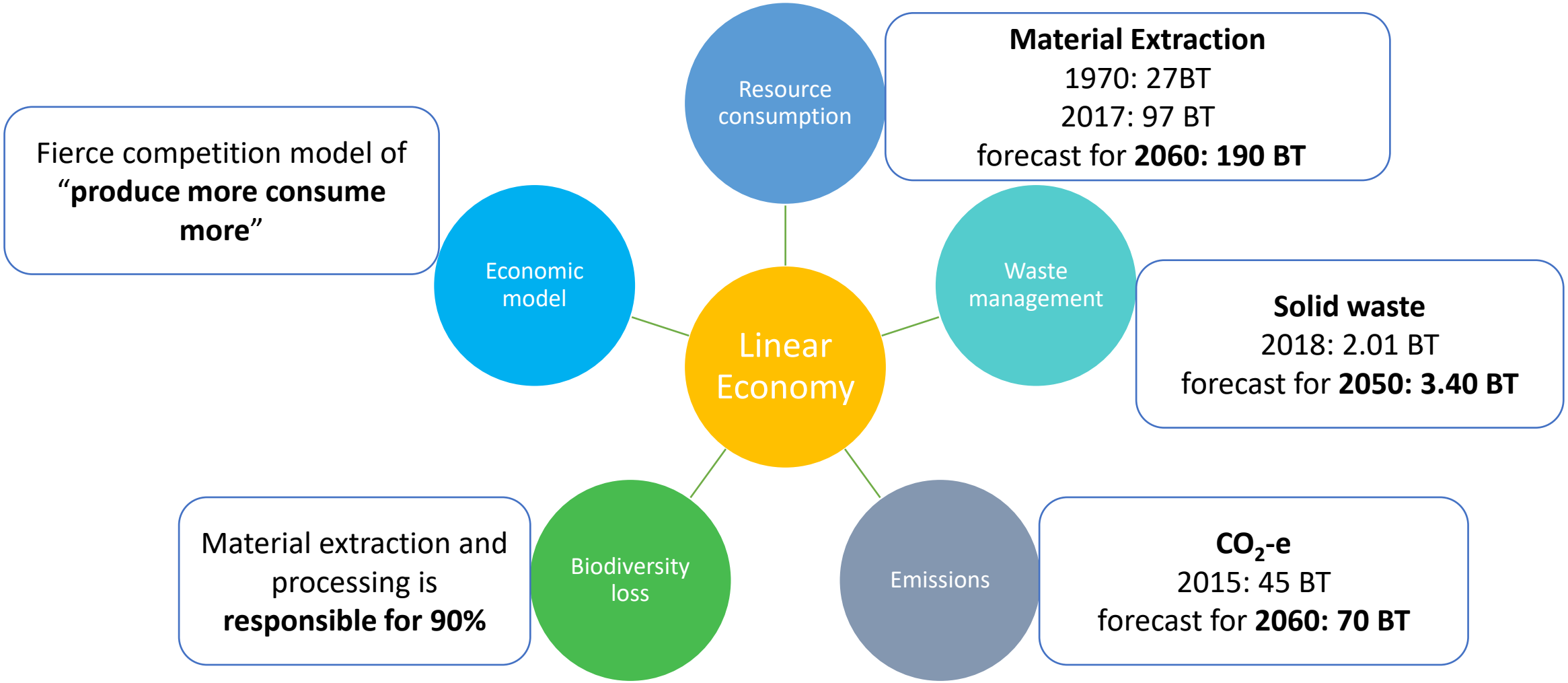
Circular Economy driven transformation in manufacturing

Challenges and opportunities

Agenda

- Understanding Circular Economy
- Manufacturing in Circular Economy
  - Challenges
  - Opportunities
- Circular Manufacturing System
- Call to action!

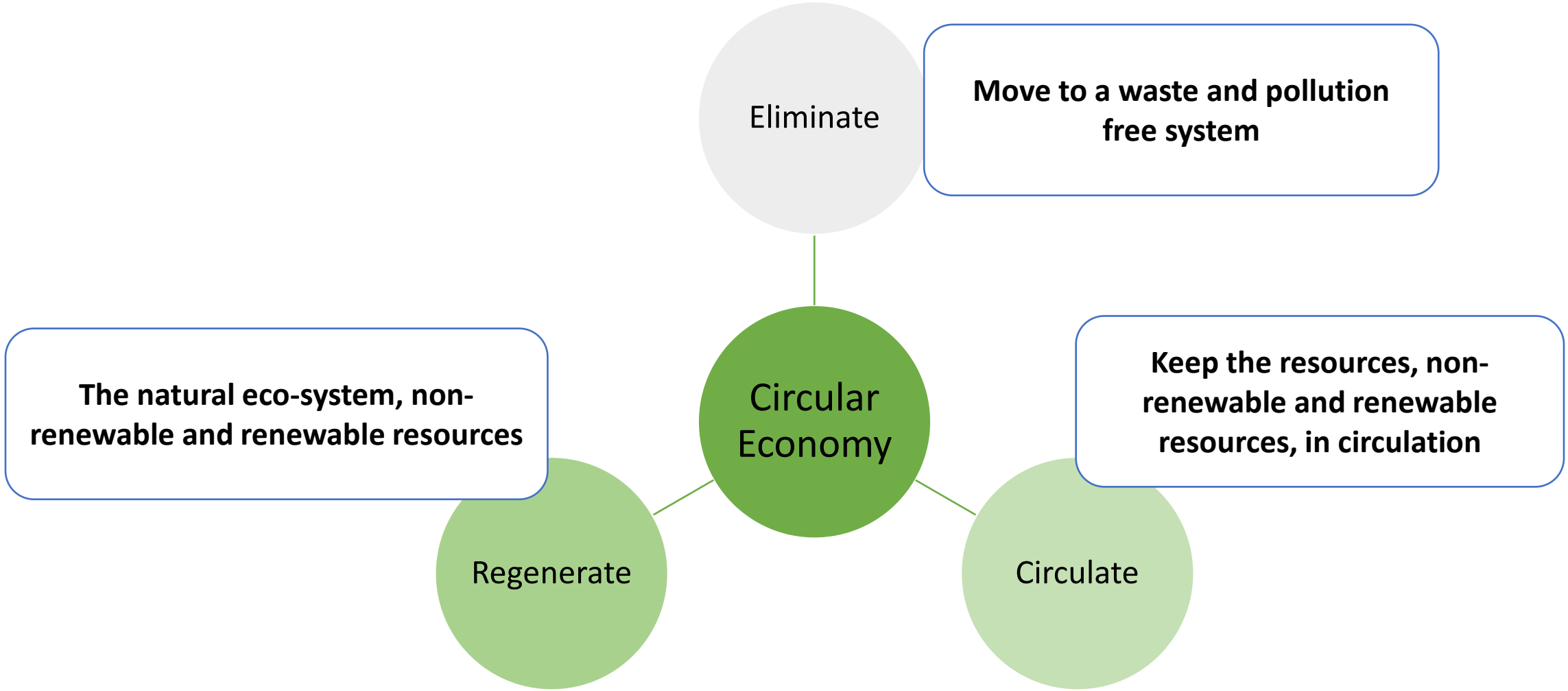
Sustainability challenges in Linear Economy



The natural eco-system damaged in doing business can be regenerated also in doing business; it’s just to change the way we do business!

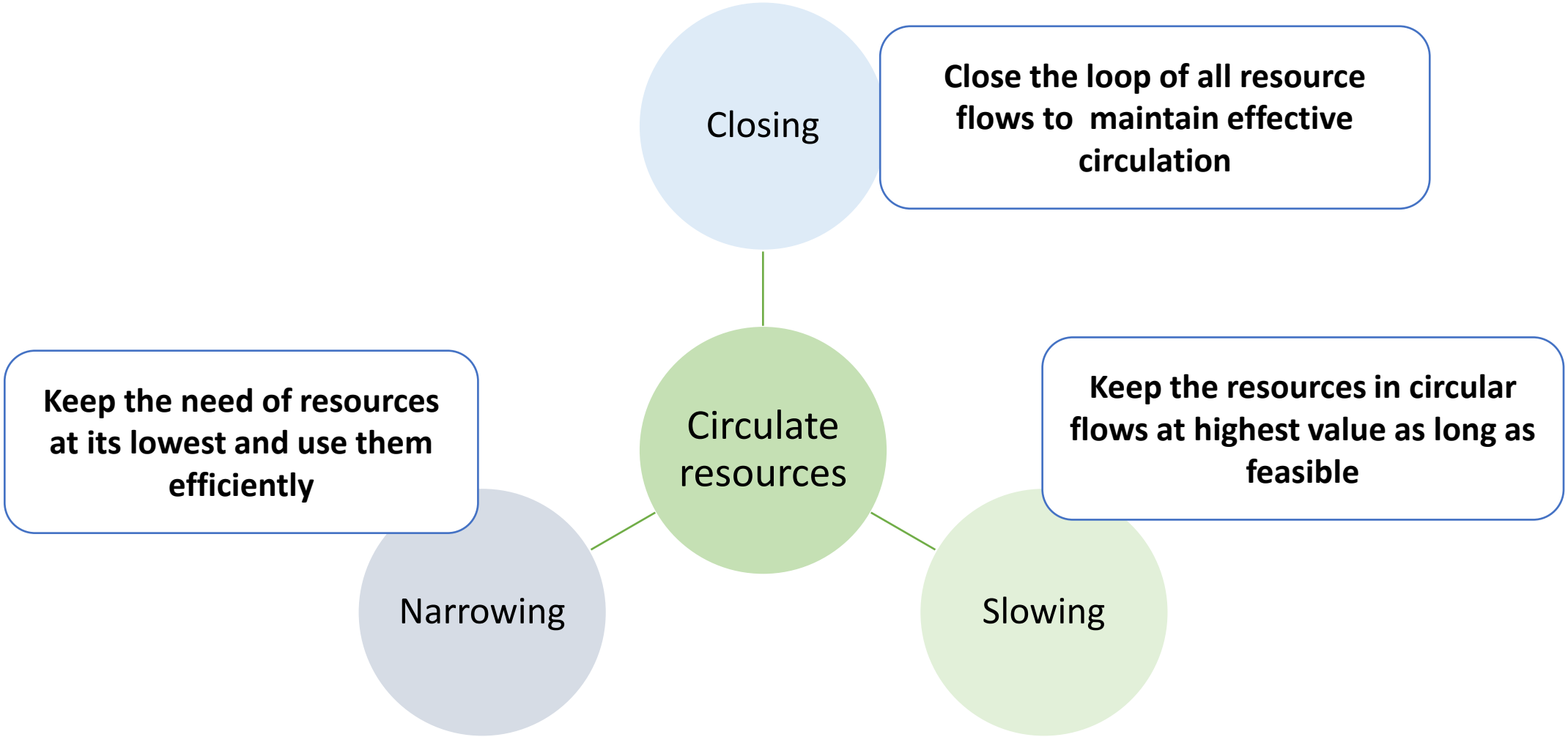
- Amir Rashid

Circular Economy: the fundamental principles!



Source: EMF

Circular Economy: the circulation principle!



Source: N Bocken et al 2015

Circular Economy: the inertia principle!

Do not repair

…. what is not broken!

Do not remanufacture

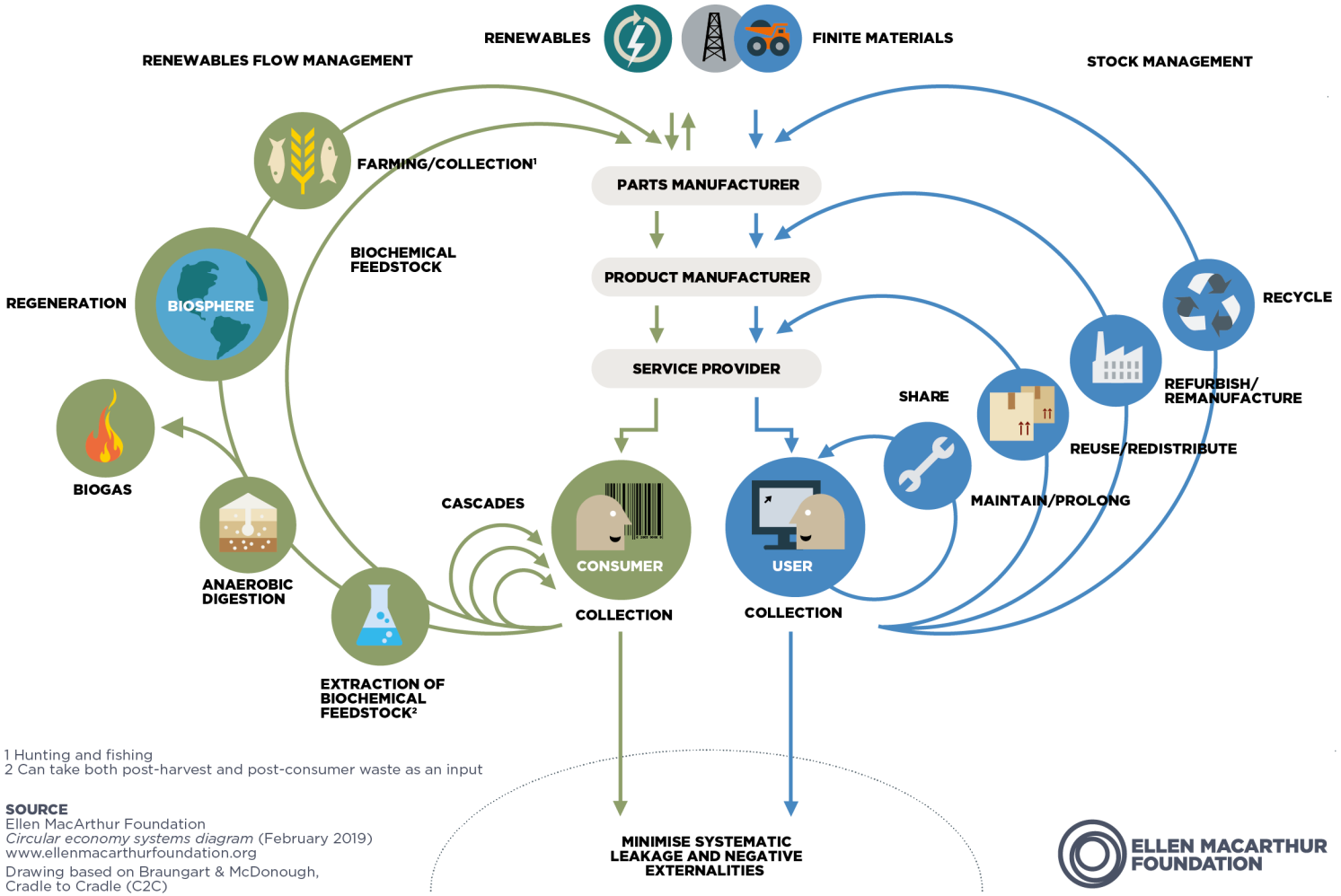
…. Something that can be repaired

Do not recycle

…. A product that can be remanufactured!

Source: Walter Stahel

Circularity as a system!

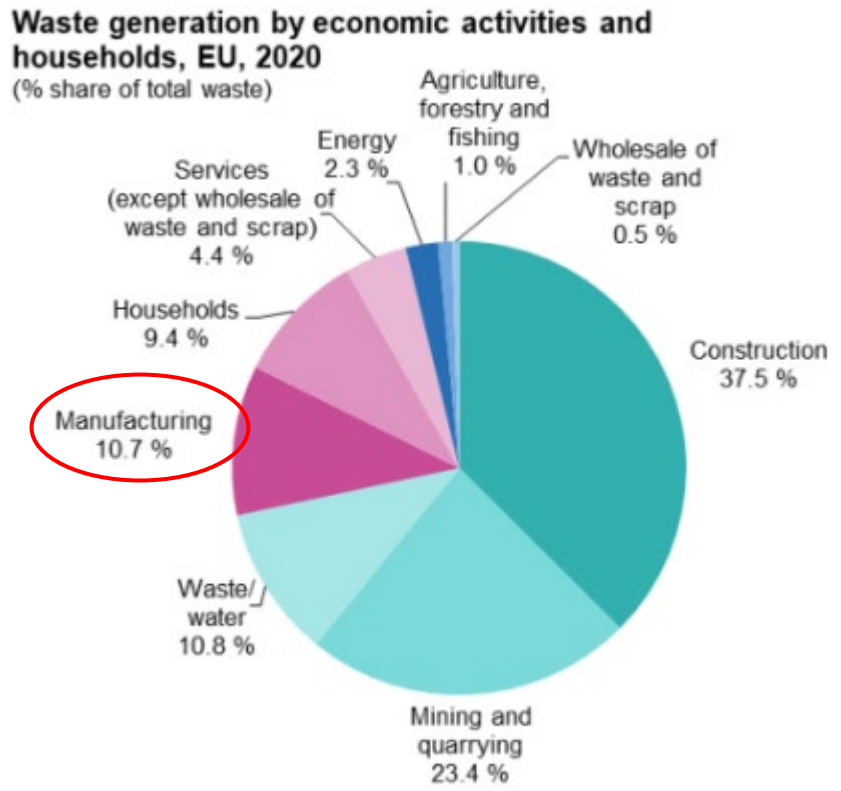


1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input

SOURCE
Ellen MacArthur Foundation
Circular economy systems diagram (February 2019)
www.ellenmacarthurfoundation.org
Drawing based on Braungart & McDonough, Cradle to Cradle (C2C)

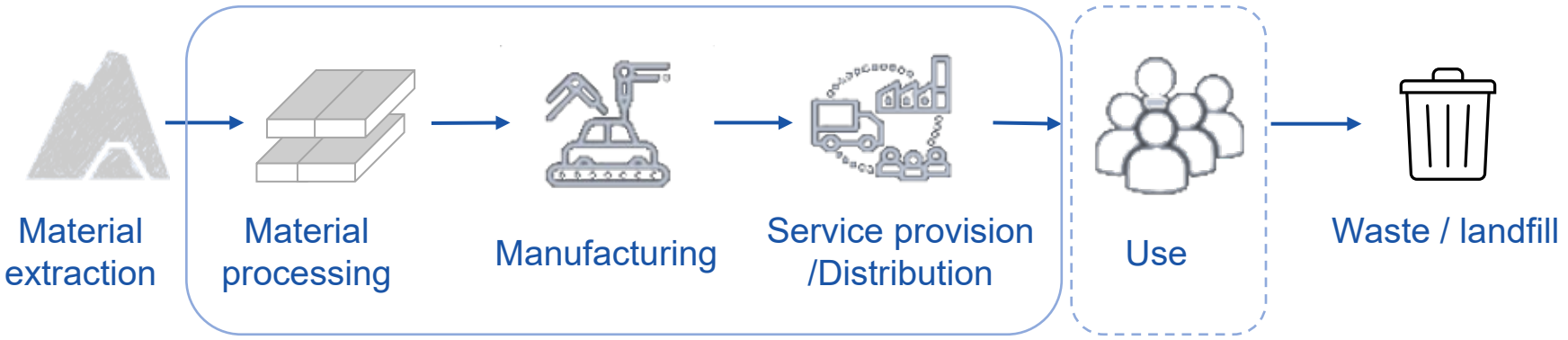
“Circularity” in linear environment!

- **4.8 tons** of waste generated per EU inhabitant in **2020** where Manufacturing industry was **4th** largest contributor
- Taking all waste into **account only 39.2 % of waste were recycled and 31.3 % landfilled** in the EU in 2020.
- Our **world** is considered only **8.6% “circular”** with **Sweden** being only **3.4%**
- **Remanufacturing intensity in Europe is only 1.9%** of the total manufacturing *(aerospace, automotive, heavy duty and off-road (HDOR) equipment, EEE, machinery and medical equipment, furniture, rail (rolling stock) and marine sectors)* activity



Linear Manufacturing:
Take- Make- Use- Dispose approach

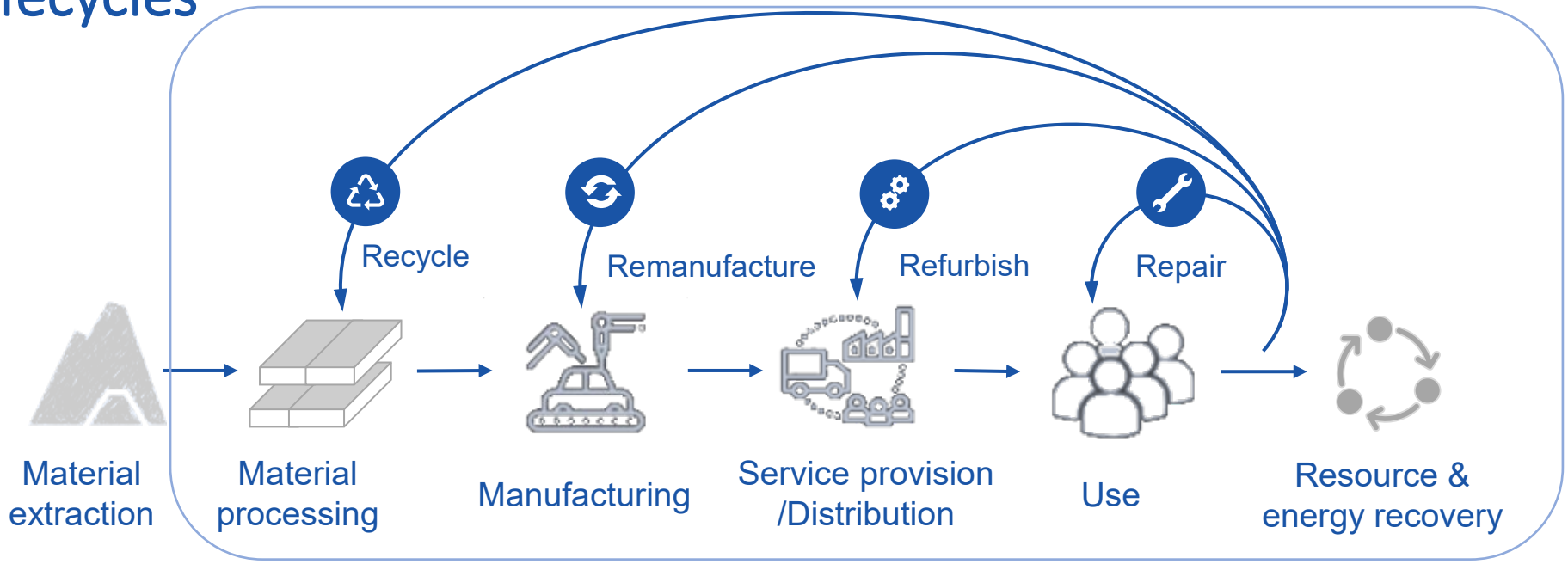
Modern manufacturing systems are material, energy and information intensive entities however **utilisation of the value** these systems create remains **suboptimal** in systemic and lifecycle perspective



Source: Roci, 2022 adapted from Lieder, 2017

Circular Manufacturing Systems (CMS) - Multiple USE and LIFEcycle approach

CMS refer to systems that are **designed intentionally to close the loop** of components or products preferably in their original form, through **multiple use & lifecycles**



Source: Roci, 2022 adapted from Lieder, 2017

Challenges!

- Deeply embedded linear models in the manufacturing sector present significant inertia to circular transformation
- **Technical challenges:**
  - Developing new technologies, processes and materials that can enhance RE- life of product and materials
  - New infrastructure to support the RE-life of product and materials in a transparent, reliable, secure and technically sound manner
- **Economic challenges:**
  - Higher upfront costs connected to circular manufacturing practices
  - Need for new business models for capturing full value of circular products and services
  - Lack of clear regulatory frameworks that can incentivize adoption of circular practices- level playing field in competition with the lingering liner economy
- **Cultural challenges :**
  - New mindset and ways of thinking about products and services
  - Collaboration and partnerships across the value cycles and networks
  - Engaging with users (consumers of the linear economy) in their roles as customers and suppliers at the same time

- This transformation is complex however it offers new opportunities as well as a sustainable future

Opportunities!

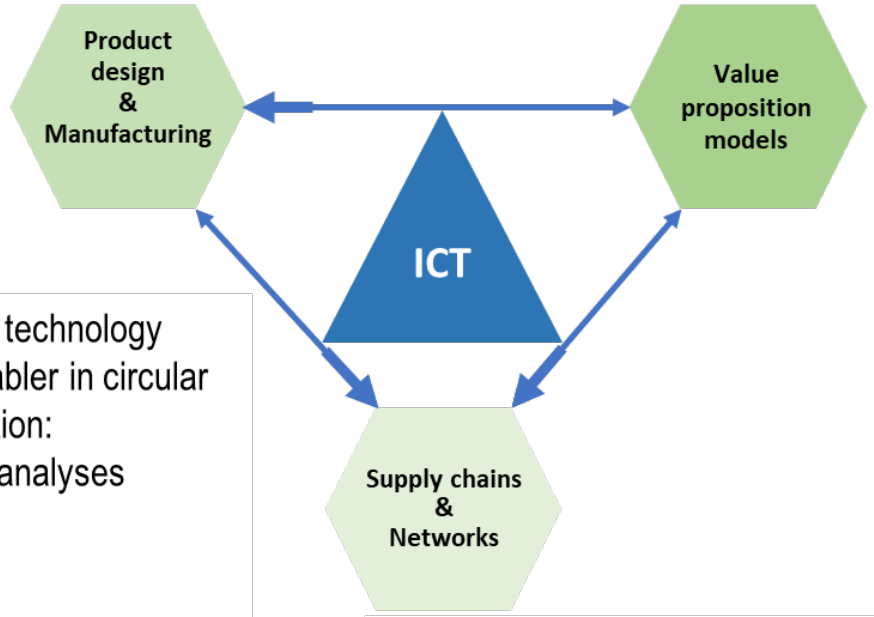
- Besides sustainability and resilience, circular manufacturing presents a plethora of opportunities to thrive as a future business

- **Economic opportunities:**
  - Increased resource efficiency- reuse enabled through products designed for repair, remanufacturing and recycling
  - New revenue streams- use-based value approach creates revenue streams beyond the cost-based approach
  - Brand reputation- sustainability embedded in the products and business models
  - Reduced costs- end of life responsibility is replaced with a business opportunity
- **Environmental opportunities:**
  - Reduced waste and pollution
  - Reduced emissions
  - Conserve natural resources
  - Supply chains resilient to natural/global disruptions
- **Societal opportunities:**
  - Inclusive and equitable business models benefiting all stakeholders
  - Increased access to products/services through affordability in the new business models
  - Drive social innovation through development of local economies to create new forms of value for society- social ties, trust, social resilience, socially responsible consumption behavior

Circular Manufacturing Systems framework- a systemic approach

Product design and manufacturing is driven primarily by the value proposition models

Value proposition models are the main driver for the circular system design



Information and communication technology (ICT) infrastructure is a vital enabler in circular system design and implementation:

- Information acquisition and analyses
- Tracking and tracing
- Transparency
- Collaboration

Supply chains and networks (esp. for reverse flows) are defined by both:

- Value proposition
- Product design

Source: adapted from Rashid et al., 2020

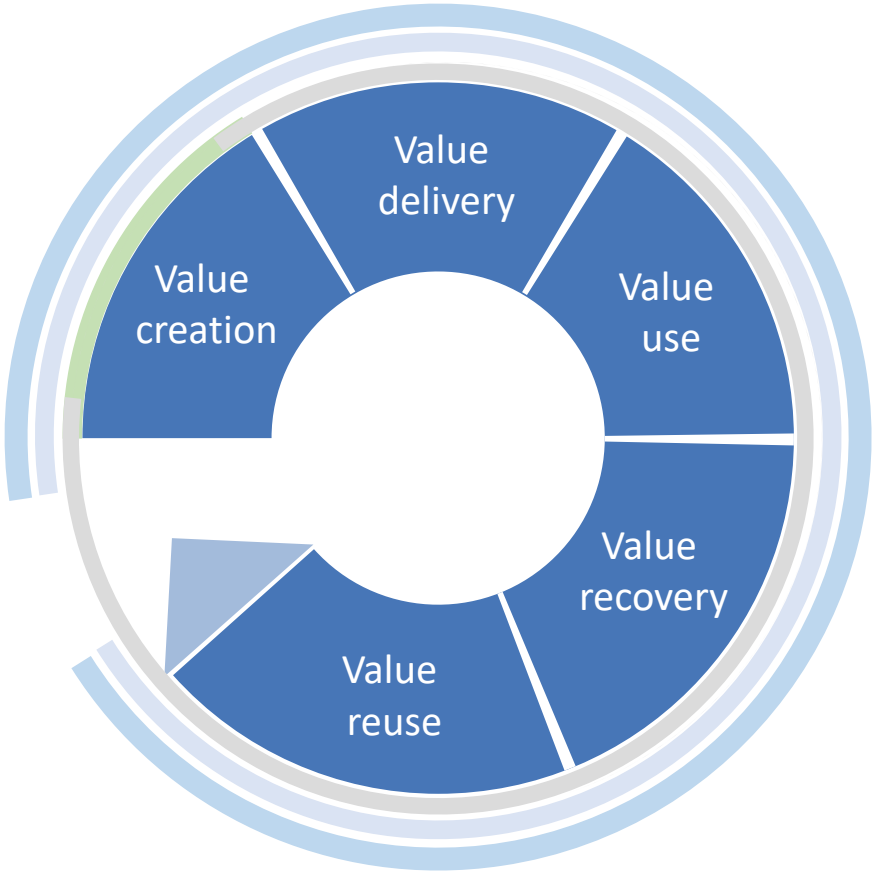
Circular Manufacturing Systems: mapping to Circular Value Management model

Value proposition model

Innovative value proposition models that aim at extending and intensifying use, circling and dematerializing resource loops

ICT

Information & Communication Technology as a system enabler that aims at information acquisition and analysis as well as tracing and tracking the products over their multiple lifecycles



Product design & manufacturing

Products designed and manufactured to intentionally close the loop (e.g., design for value retention through multiple lifecycles)

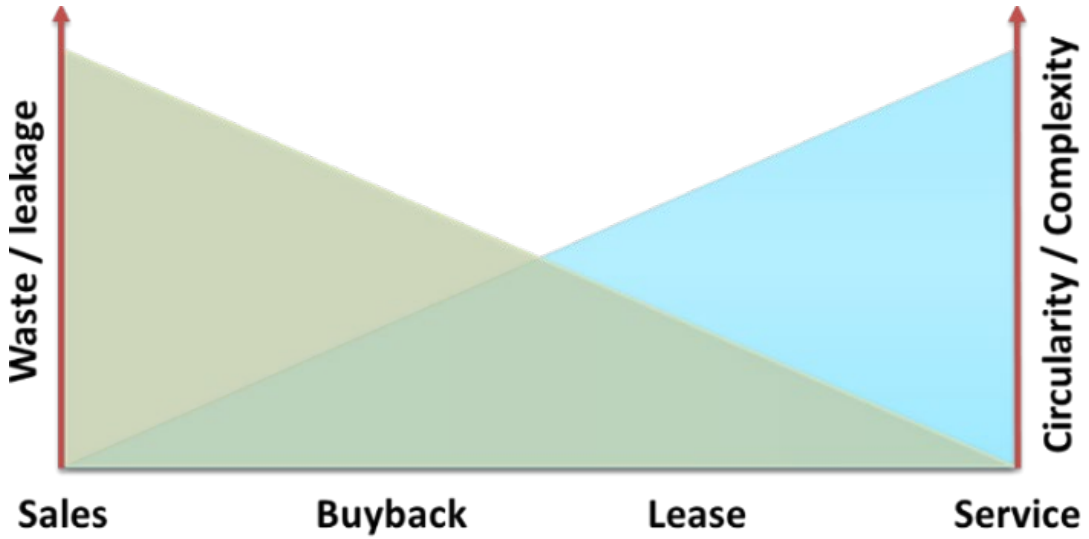
Supply chains & networks

Integrated forward & reverse supply chains and networks which can handle the dynamics of multiple lifecycle products used through appropriate value proposition model

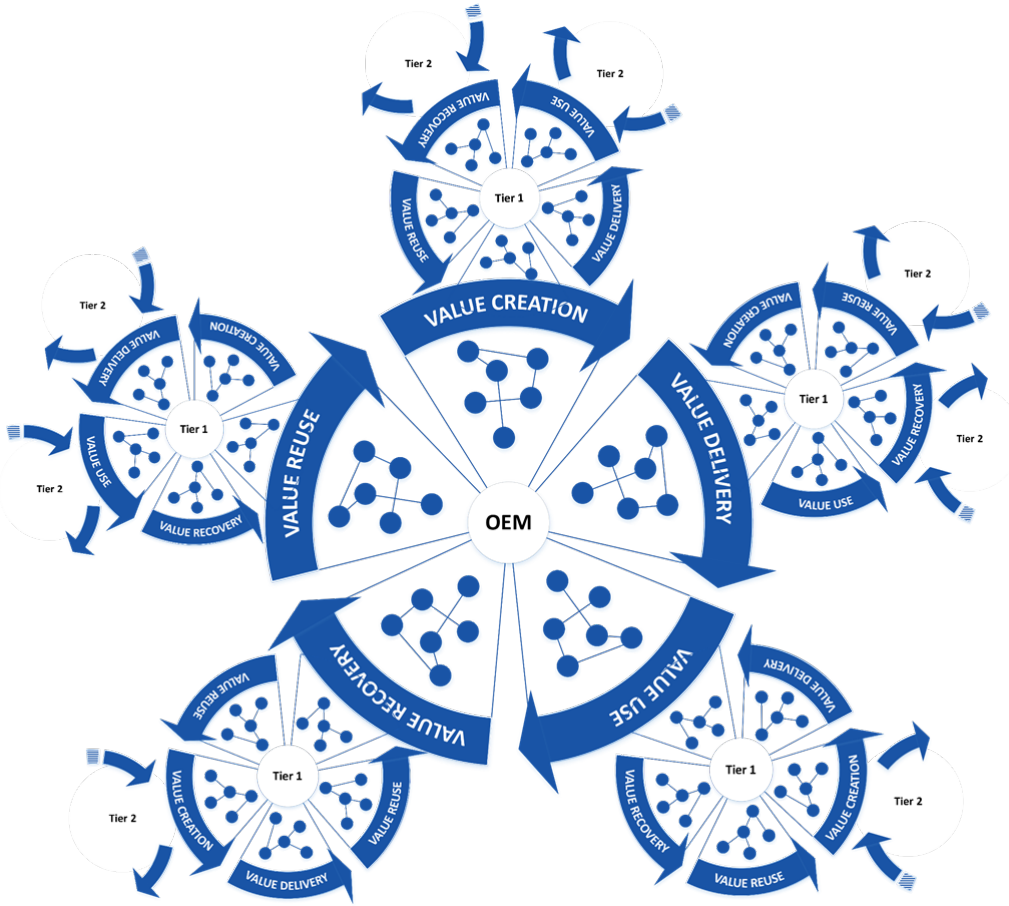
Source: adapted from Roci et al. 2022

Value proposition space for circular transition

- Transition from product-oriented to service-oriented business models
  - Increased circularity, i.e., reduced leakage in the system
  - Increased complexity, i.e., it requires a radical change in the way businesses operate

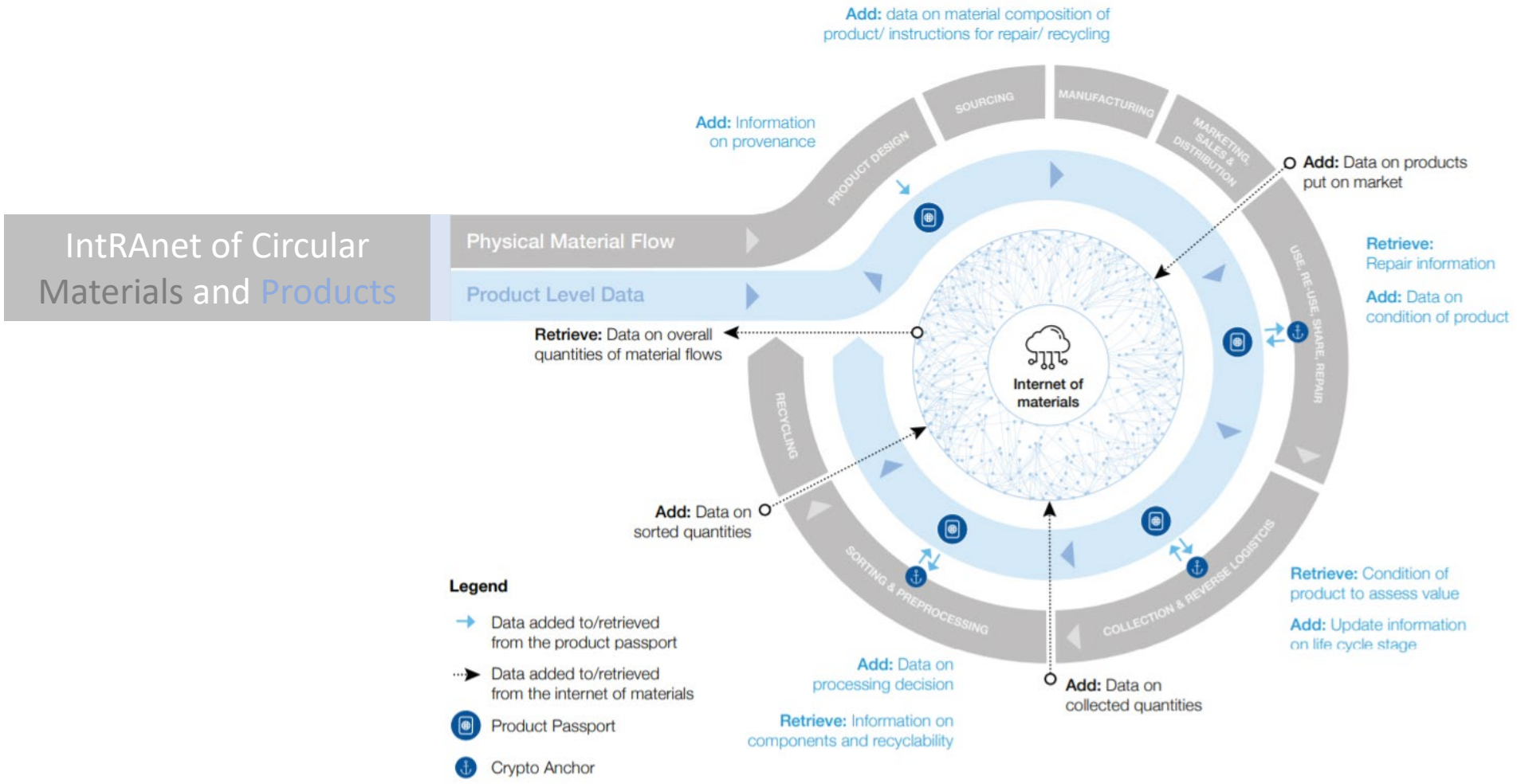


Value chains/networks in Circular Manufacturing Systems



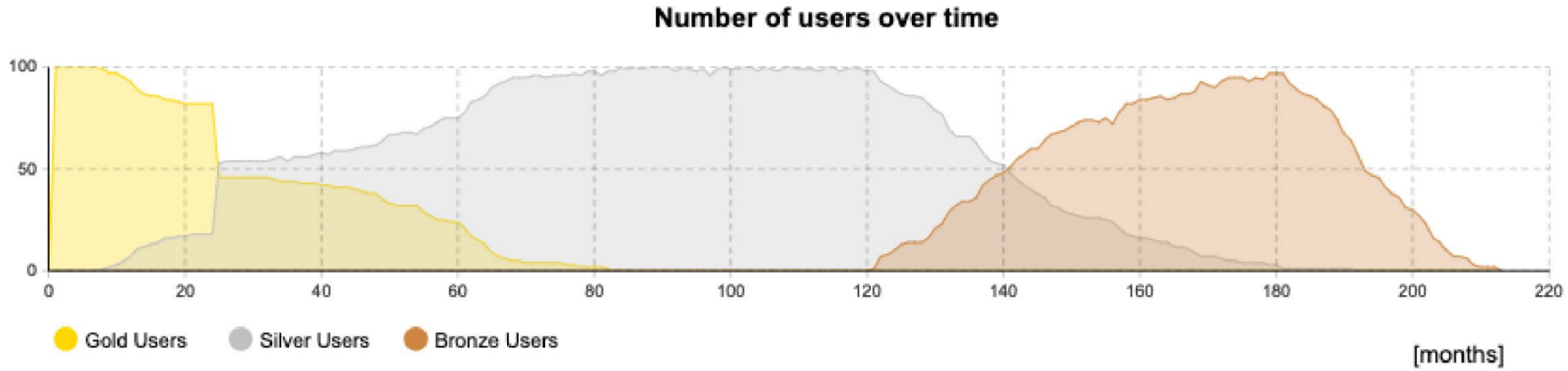
Source: Adapted from Roci et al. (2022)

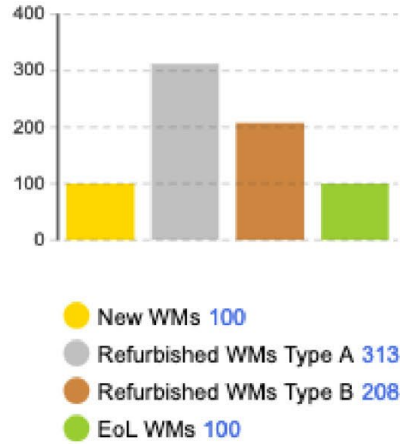
IntRAnet and Internet of circular products and Materials



Source: Adapted from World Economic Forum (2019)

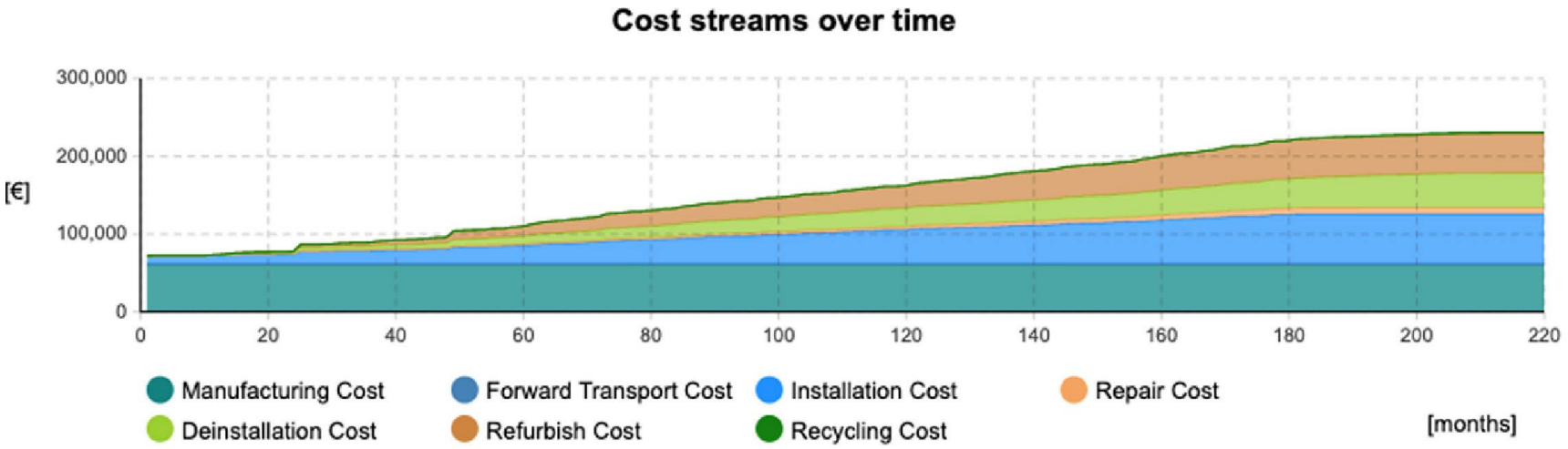
Example of a systemic analysis through modelling and simulation: Case of a washing machine- number of users in multiple lifecycles!

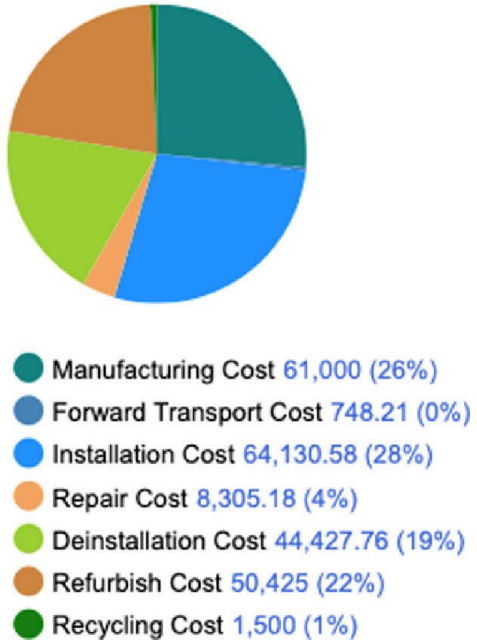




Source: Roci et al. 2022

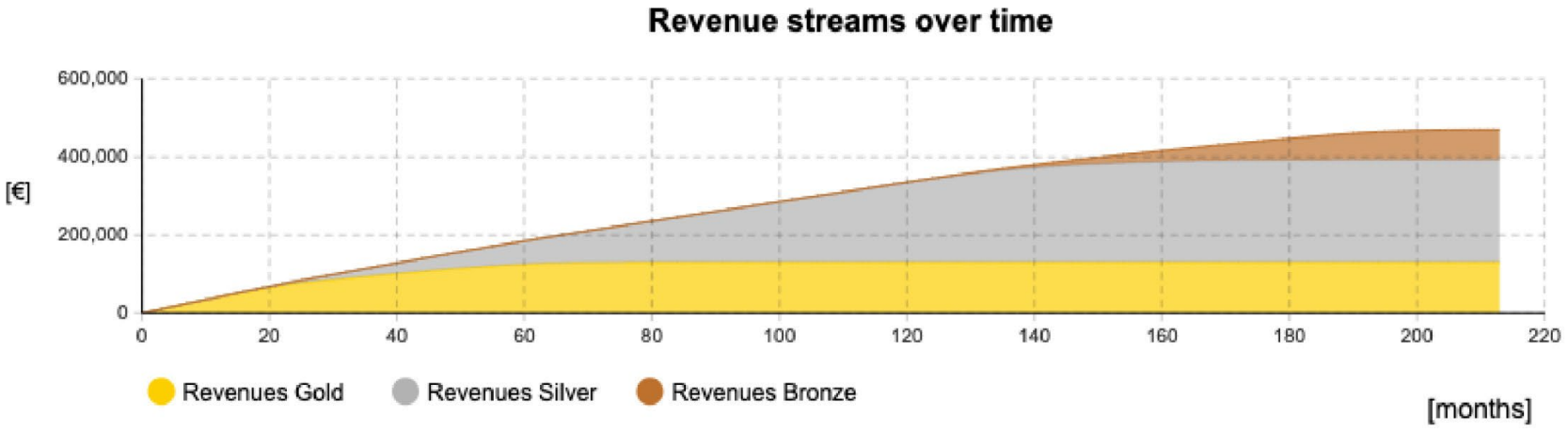
Example of a systemic analysis through modelling and simulation: Case of a washing machine- lifecycle costs!

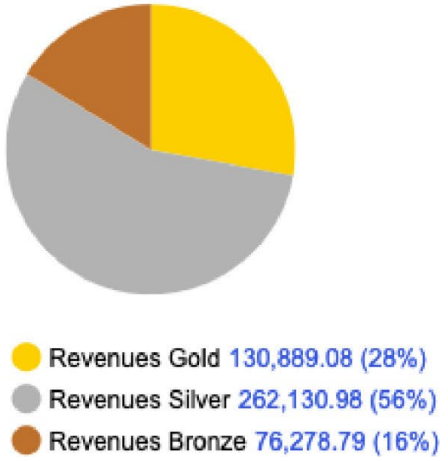




Source: Roci et al. 2022

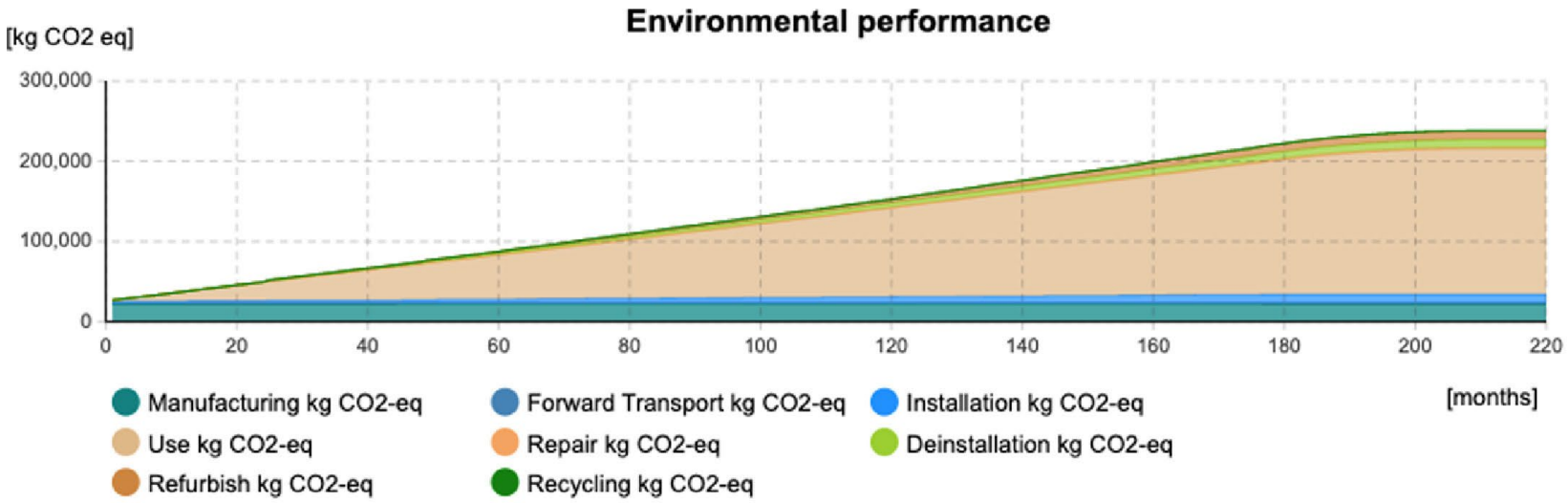
Example of a systemic analysis through modelling and simulation: Case of a washing machine- lifecycle revenues!

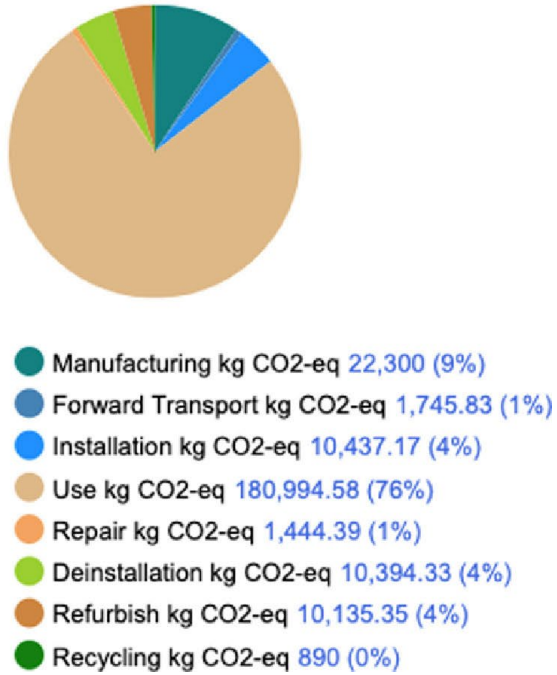




Source: Roci et al. 2022

Example of a systemic analysis through modelling and simulation: Case of a washing machine- lifecycle environmental performance!





Source: Roci et al. 2022

Example of a systemic analysis through modelling and simulation: Case of a washing machine- lifecycle profits

Source: Roci et al. 2022

Aristotle's wisdom:
took about 2500 yrs. for "common" understanding!

"Real wealth is based on use, not ownership"

Circular transition- points to ponder!

Produce less use more

Creative but regenerative

Compete to collaborate

Join forces to set-up:
A national hub of Circular Manufacturing Systems

Leading by example

the Swedish manufacturing **industry, research and academia** shall join forces

Systemic approach

research and innovation on **business, technology and policy**

The Focus

implementing circular business solutions in the manufacturing industry

THANK YOU!