Sustainability and Circular Economy

Webinar for CAIA South Africa

Thursday 9 October 2025

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Circular Economy & Clean Growth:

Concepts and Research Direction

Prof. Benny Tjahjono – Centre for E-Mobility and Clean Growth

What is Circular Economy? What's new

What is Circular Economy? What’s new

Clean Growth

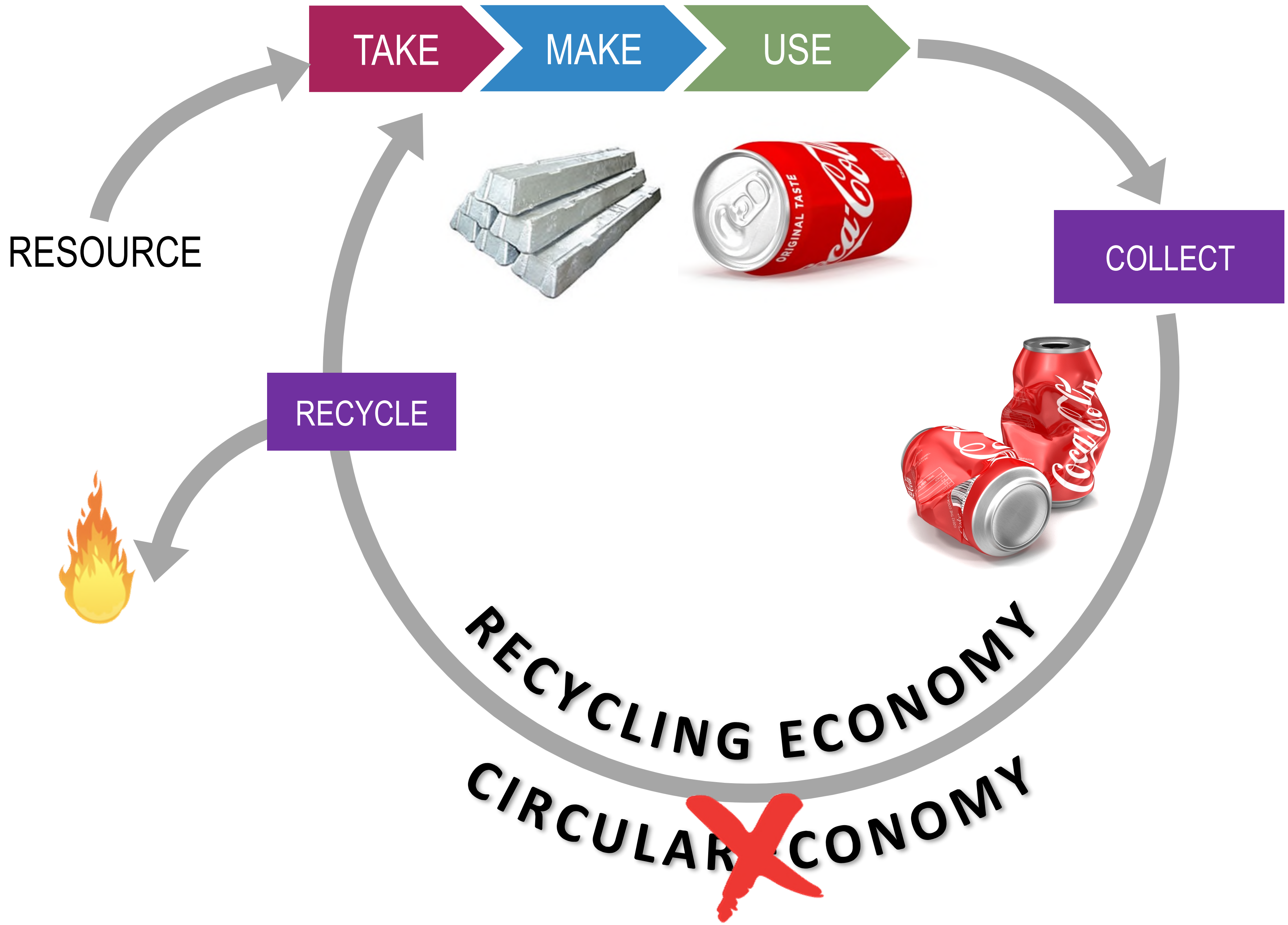
- Economic growth or development that focuses on minimising environmental impact, restores nature, not depletes it.

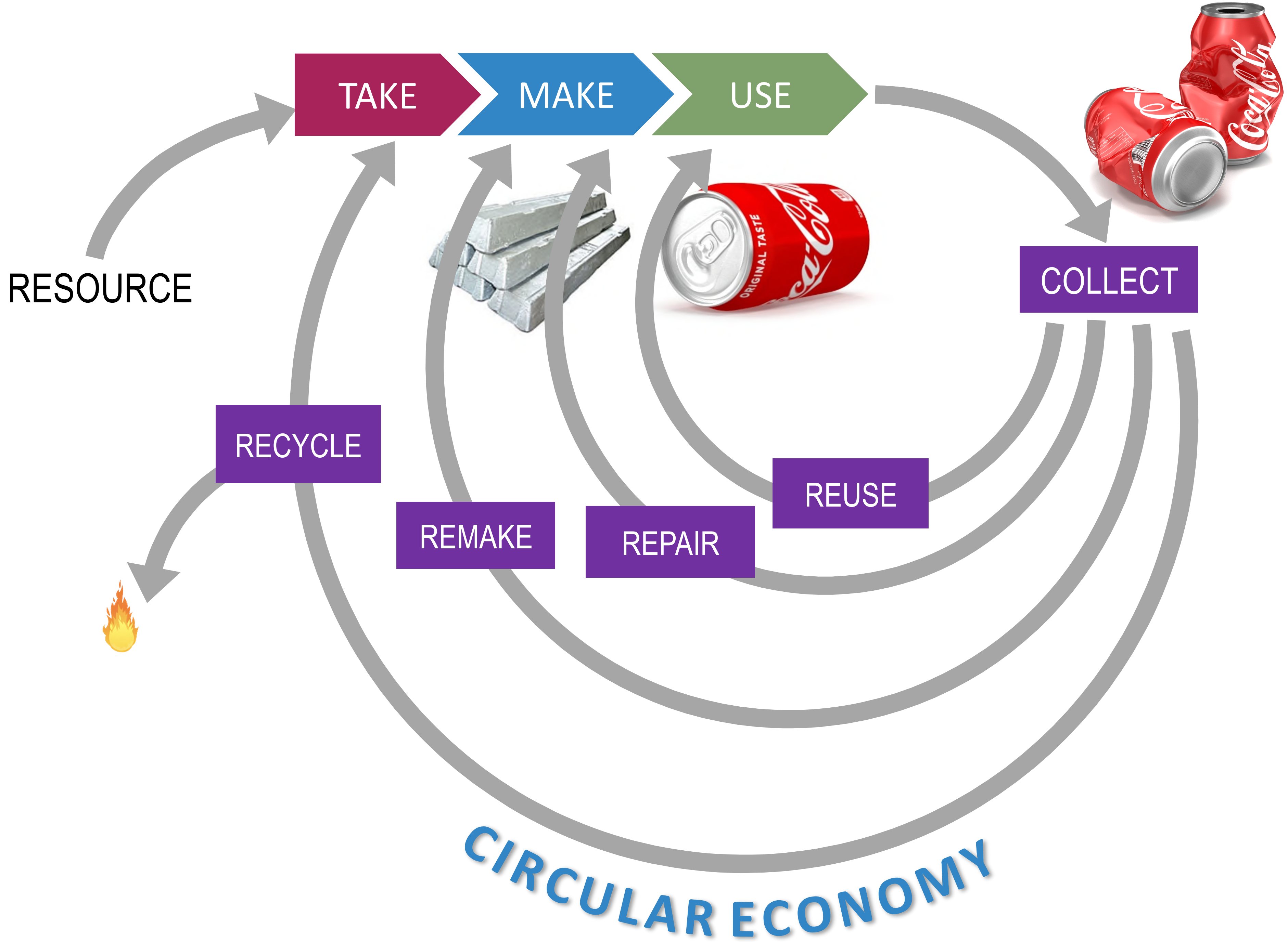
- Growth that respects limits and unlocks new possibilities.

- Circular Economy, green tech, clean energy are the pillars of clean growth.

- An economic model – short product life, buy more
- The availability of cheap, easily accessible materials and energy
- ‘Cradle to grave’

Not sustainable!!


TAKE
MAKE
USE
COLLECT
RECYCLE
RESOURCE
RECYCLING ECONOMY
CIRCULAR ECONOMY



TAKE
MAKE
USE
RESOURCE
COLLECT
RECYCLE
REMAKE
REPAIR
REUSE
CIRCULAR ECONOMY

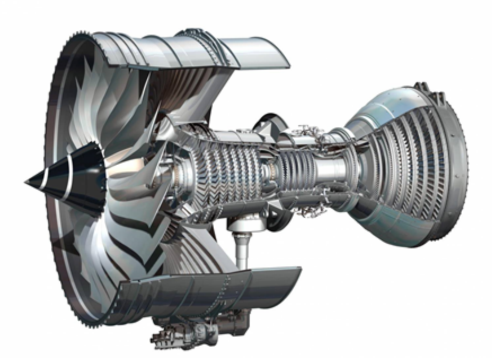
- Industrial economy: **restorative and regenerative**
  1. **Minimise the consumption** of finite resources and/or raw materials in the manufacture of products
  2. Aimed at keeping products at their **highest utility** and value - Maximising the **recirculation**
  3. Minimising the contents that could end up in landfill or **incineration**
- 'Cradle to cradle'

Recovery options


Maintenance


Reuse


Refurbish


Remake/remanufacture

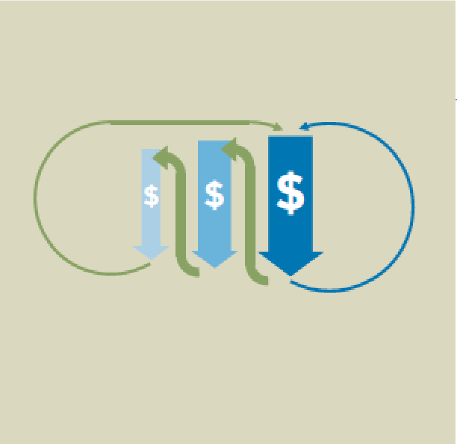

Recycle

Choices depend on the characteristics of products
Ideas are the same; longer in use & retain value

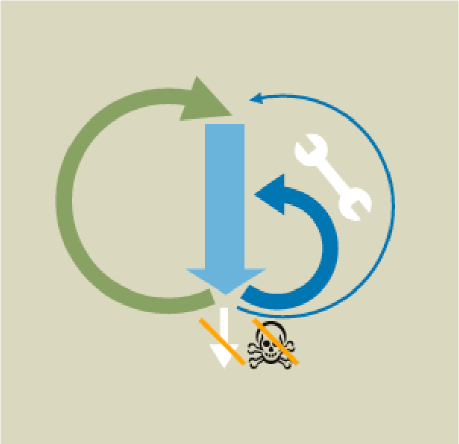
Sources of value creation in CE

Power of the inner circle

Power of circling longer



Power of cascaded use



Power of pure, non-toxic, or at least easier-to-separate inputs and designs

Source: www.ellenmacarthurfoundation.org

PRINCIPLE	ATTRIBUTE	ENABLER
CASCADES ORIENTATION	SYSTEMS THINKING	TECHNOLOGY
WASTE ELIMINATION	CIRCULARITY	
ECONOMIC OPTIMISATION	BUILT-IN RESILIENCE	MARKET
MAXIMISATION OF RETAINED VALUE	COLLABORATIVE NETWORK	
ENVIRONMENTAL CONSCIOUSNESS	SHIFT TO RENEWABLE ENERGY	INNOVATION
LEAKAGE MINIMISATION	OPTIMISATION OF CHANGE	

CIRCULAR ECONOMY VALUES

Redefining Circular Economy Principles (Ripanti & Tjahjono, 2019)

The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/0957-4093.htm

Unveiling the potentials of circular economy values in logistics and supply chain management

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Abstract

Purpose – The purpose of this paper is to unveil the circular economy (CE) values with an ultimate goal to provide tenets in a format or structure that can potentially be used for designing a circular, closed-loop supply chain and reverse logistics.
Design/methodology/approach – This is desk-based research whose data were collected from relevant publication databases and other scientific resources, using a wide range of keywords and phrases associated with CE, reverse logistics, product recovery and other relevant terms. There are five main steps in the reformulation of CE principles: literature filtering, literature analysis, thematic analysis, value definition and value mapping.
Findings – In total, 15 CE values have been identified according to their fundamental concepts, behaviours, characteristics and theories. The values are grouped into principles, intrinsic attributes and enablers. These values can be embedded into the design process of product recovery management, reverse logistics and closed-loop supply chain.
Research limitations/implications – The paper contributes to the redefinition, identification and implementation of the CE values, as a basis for the transformation from a traditional to a more circular supply chain. The reformulation of the CE values will potentially affect the way supply chain and logistics systems considering the imperatives of circularity may be designed in the future.
Originality/value – The reformulation principles, intrinsic attributes and enablers of CE in this paper is considered innovative in terms of improving a better understanding of the notion of CE and how CE can be applied in the context of modern logistics and supply chain management.

Keywords Sustainability, Literature review, Reverse logistics
Paper type Literature review

1. Introduction

The circular economy (CE) is defined as a global economic model to minimise the consumption of finite resources, which focuses on the intelligent design of materials, product and systems (EMF, 2013a). It also supports separating treatment between technical and biological materials to maximise the design for reuse, to return to the biosphere and retain value through innovations across fields (Webster, 2015; Lacy and Rutqvist, 2015). Transitioning from the linear to a CE not only requires a fine-tuning that reduces the negative impacts of the linear economy, but also a whole system approach that builds upon a number of guiding principles. These principles allow resilience to be built into the CE system, ensuring the long-term generation of economic opportunities and at the same time offering societal and environmental benefits.

CE principles have been elaborated by several researchers in various manners and from various viewpoints: Feng (2004) in Yuan *et al.* (2006), Pintér (2006), Yuan *et al.* (2006), Yong (2007), Geng *et al.* (2012), EMF (2013a, 2015), Stahel (2013) and Pan *et al.* (2015). Principles, in theory, can support the understanding of a concept; however, principles alone are often insufficient to support the practicality of that concept. This paper therefore aims to reformulate the existing CE principles into CE values (or tenets) in a format or structure that supports the design of a circular, closed-loop supply chain and reverse logistics. In this paper, CE principles were reformulated through five steps: data filtering, literature analysis, thematic analysis, CE values definition and CE values mapping.

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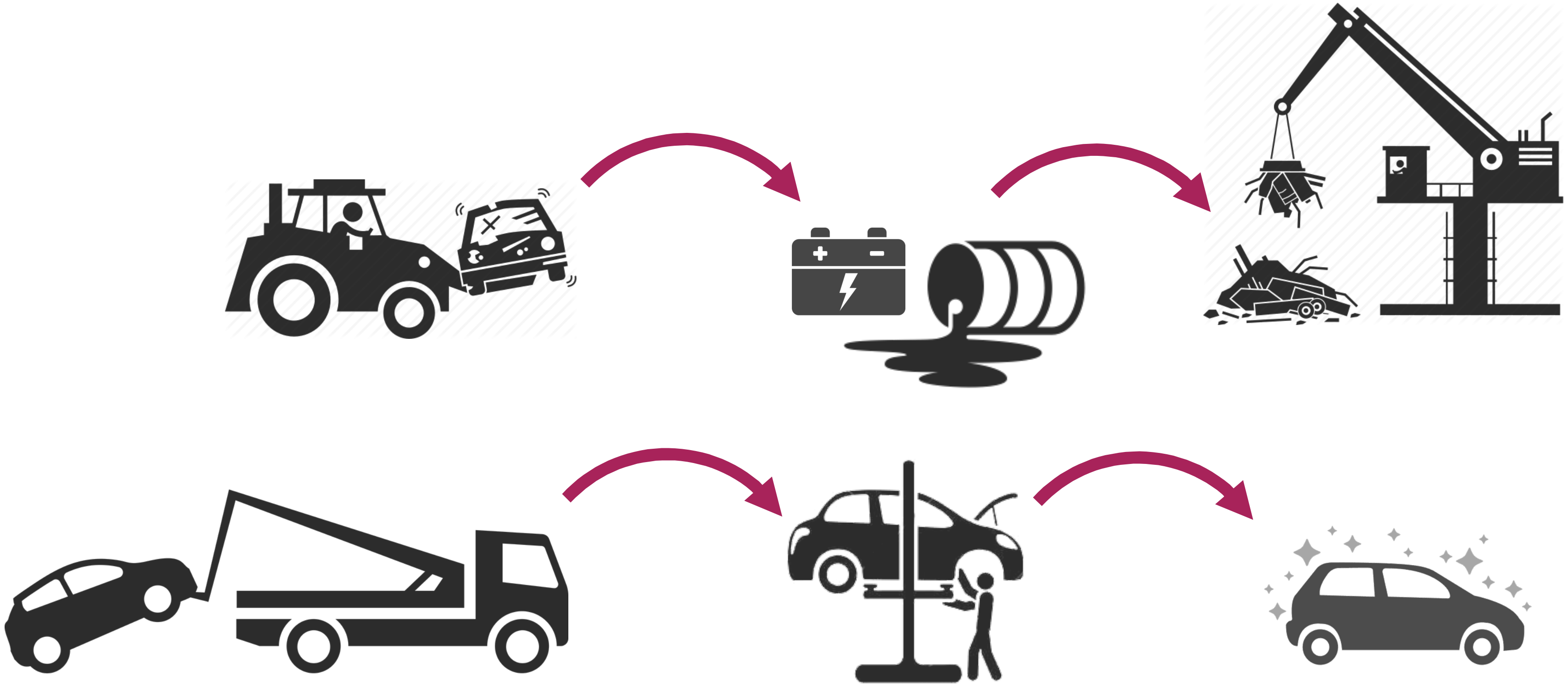
PRINCIPLE

LEAKAGE MINIMISATION

Avoidance of loss of opportunities to maximise the cascading of (a) biological materials and the inability to incorporate the nutrient back into the biosphere due to contamination, and (b) technical materials that are lost due to loss of materials, energy, components and materials are not (or cannot be) recovered



CIRCULAR ECONOMY VALUES

ATTRIBUTE

CIRCULARITY

DESIGN FOR DISASSEMBLY

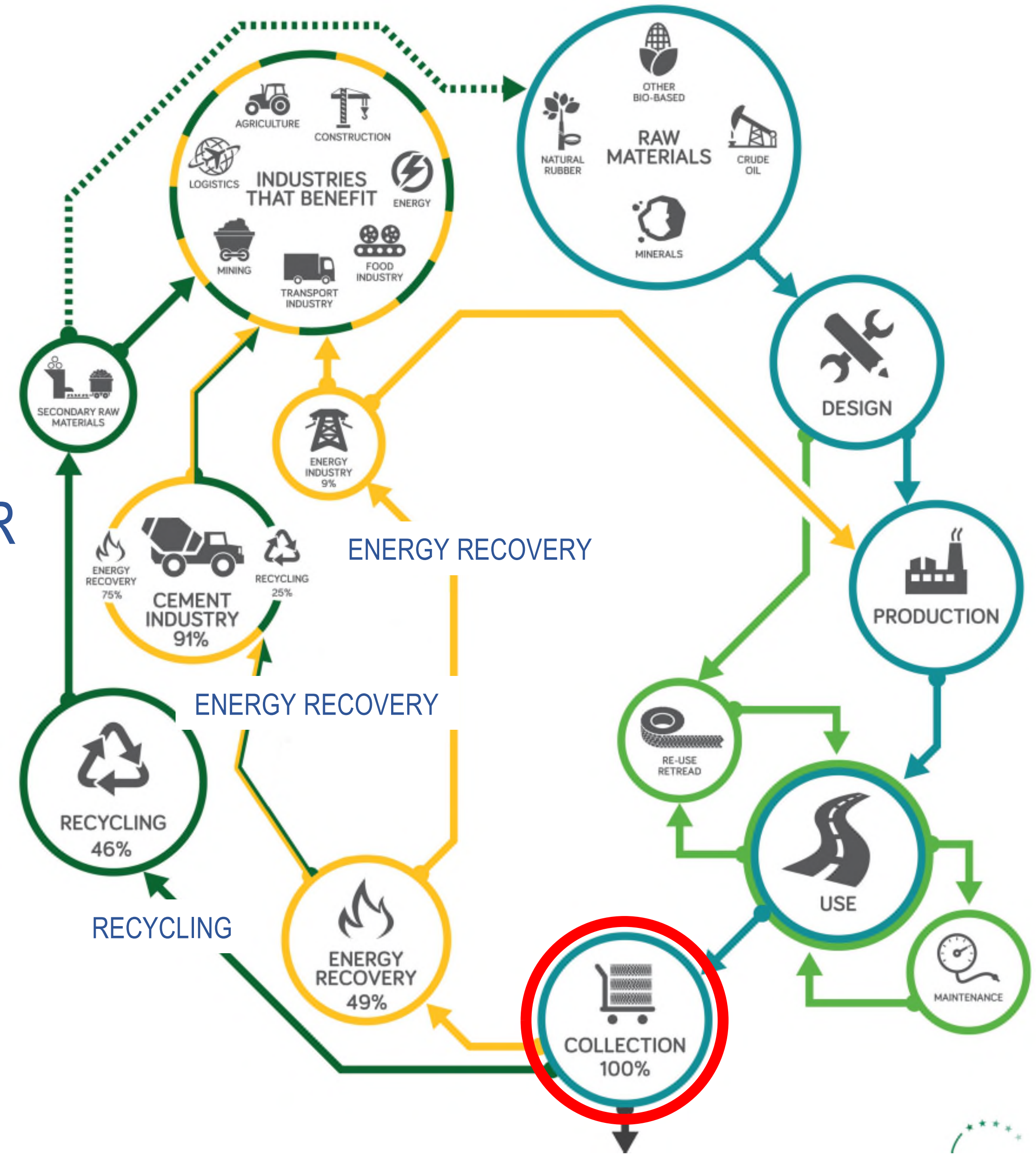
Products that lend themselves to a circular process; preserving their value or component by keeping them in use longer through repair, reuse, remanufacture and recycle

CIRCULAR ECONOMY VALUES

ENABLER

MARKET

TYRE & RUBBER

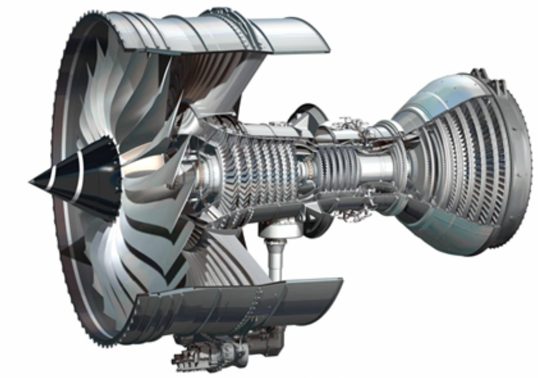


CIRCULAR ECONOMY VALUES

Model	Meaning	Examples
Dematerialisation	Replacing physical infrastructure and assets with digital/virtual services (digitisation)	Shift from physical DVD stores to online film and music services, etc.
Product/service on-demand	Producing a product or providing a service only on-demand	3D printed parts, furniture and designer clothes/footwear are only manufactured once ordered.
Recovery of secondary materials/by-products	Value optimization by creating products from secondary raw materials/by-products and recycling	Plastics bottles back into plastics bottles; plastic bottles recycled into fleece jackets and fibres for shoe lining;
Repair, refurbish, remanufacture and recondition	Product has a next life (e.g. after remanufacture – the process of restoring the product or part functionality to "as-new" quality; facilitated by design for disassembly).	Aero-engines having been overhauled
Performance based (Pay per use) - PSS	Delivers product performance or results rather than the product or service itself. The customer pays defined level of performance	Printing (pay per print); aero-engines (power by the hour).

BUSINESS MODELS CIRCULAR ECONOMY

Rolls-Royce



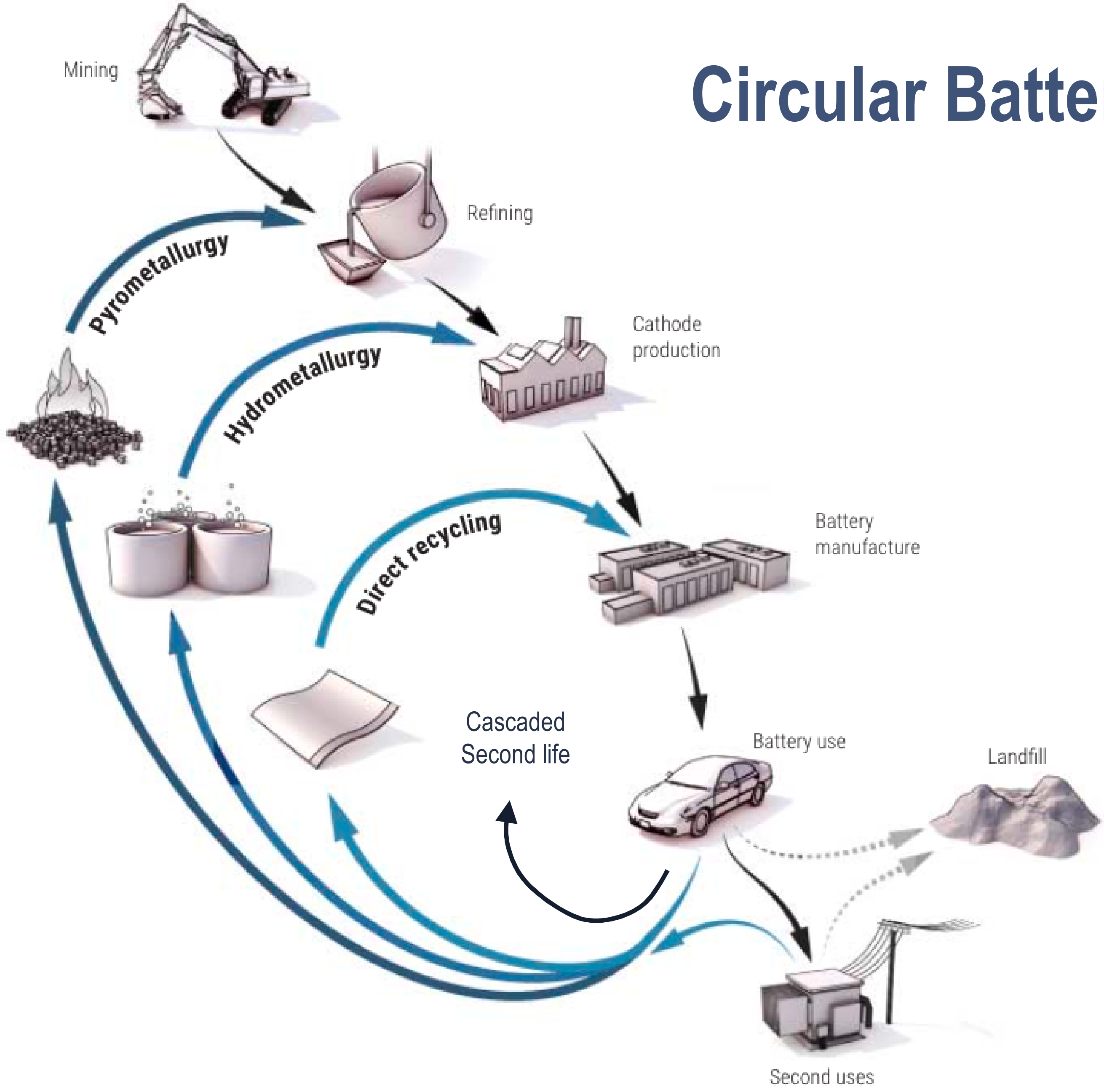
ALSTOM

CATERPILLAR®

xerox

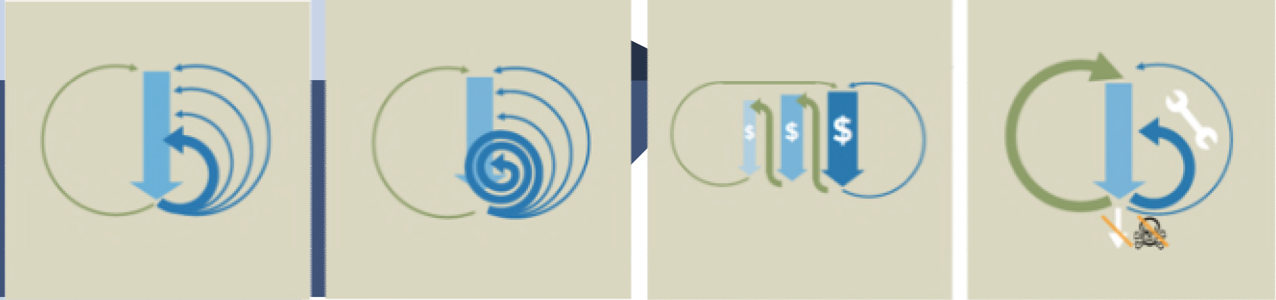
MAN

Circular Batteries



Ian Morse (2021) - https://www.science.org/doi/10.1126/science.372.6544.780

Battery as a Service (BaaS)



Power of the inner circle | Power of circling longer | Power of cascaded use | Power of pure, non-toxic, or at least easier-to-separate inputs and designs

- Long charging time
- Limited charging station
- Buying performance rather than the batteries
- Swap battery (like Mineral Water and LPG)
- Battery second life

The Business Model Canvas

Designed for:	Designed by:	Date:	Version:

Key Partners

- Battery manufacturer and installer
- Monitoring systems.
- Distributed Ledger Technology platform enabling transactions within the community.

Key Activities

- Provide ways to pay per use or up front
- Programmable electricity usage

Key Resources

- Physical resources:
  - Batteries; Smart meters; DAQ, processing & mgt system.
- Financial resources:
  - Initial investments.

Value Propositions

- By selling the energy as a bundle to hotel guests, it is expected that guests will manage their own electricity consumption.
- Hotels reduced potential waste of electricity
- Cost reduction passed on to guests.

Customer Relationships

- booking.com

Channels

- Distributed ledger technology energy transaction platform:
- Cryptocurrencies.
- Blockchain technology (or other).

Customer Segments

- Hotels

Cost Structure

- Cost of the investment, installation and maintenance of the physical batteries.

Revenue Streams

- Remuneration obtained by providing available capacity to hotels, that serves to reduce their electricity bill.

Goitia-Zabaleta et al. (2024)

Reframing Circular Economy and Clean Growth

- Growth is not the enemy; pollution is, waste is, inequity is.
- Growth is not a sacrifice; it is not about less; it is about better.
- Growth is needed, but should be cleaner, smarter, more innovative, more inclusive.

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STEPHEN YOUNG INSTITUTE FOR INTERNATIONAL BUSINESS

The Circularity Ladder

Implications for chemical and allied industries

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Chemical industry

Global chemicals sector plays a critical role in global transition towards net-zero carbon emissions

Science Based Targets.org (2023)

Chemical industry

Global chemicals sector plays a critical role in global transition towards net-zero carbon emissions

- Complex and diverse product value chains involving every other sector:

  energy, transportation, built environment, consumer goods, agriculture.

Science Based Targets.org (2023)

Chemical industry

Global chemicals sector plays a critical role in global transition towards net-zero carbon emissions

- Complex and diverse product value chains involving every other sector: energy, transportation, built environment, consumer goods, agriculture.
- Production of chemicals is a leading industrial source of CO2 emissions: 3rd behind cement and iron/steel manufacturing.
- The largest industrial consumer of energy products worldwide.
- Growing demand for chemicals over the coming decades.

Science Based Targets.org (2023)

Boundaries and interconnectedness

- Complex overlapping, intersecting value chains
  including geographic regions and other sectors.

- Chemical industry’s Scope 2 emissions:
  includes generation of purchased energy or heat.

Science Based Targets.org (2023)

Boundaries and interconnectedness

- Complex overlapping, intersecting value chains
  including geographic regions and other sectors.

- Chemical industry’s Scope 2 emissions:
  includes generation of purchased energy or heat.

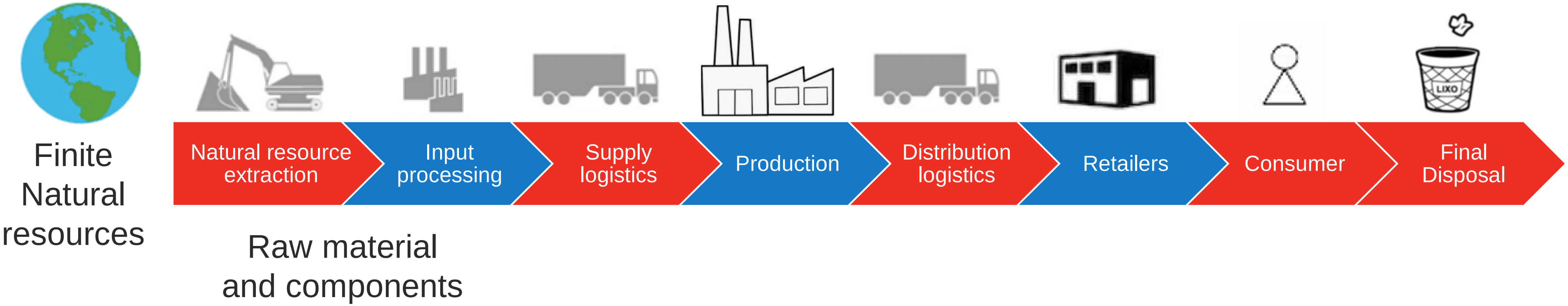
- Your Scope 1 & 2 is their Scope 3:
  Downstream producers consider Chemical Industry’s Scope 1/2 emissions within ***their*** Scope 3 (indirect value chain).

- Carbon emitted from chemical products is typically downstream
  during use or end-of-life incineration or decomposition.

Science Based Targets.org (2023)

What do linear operations mean?

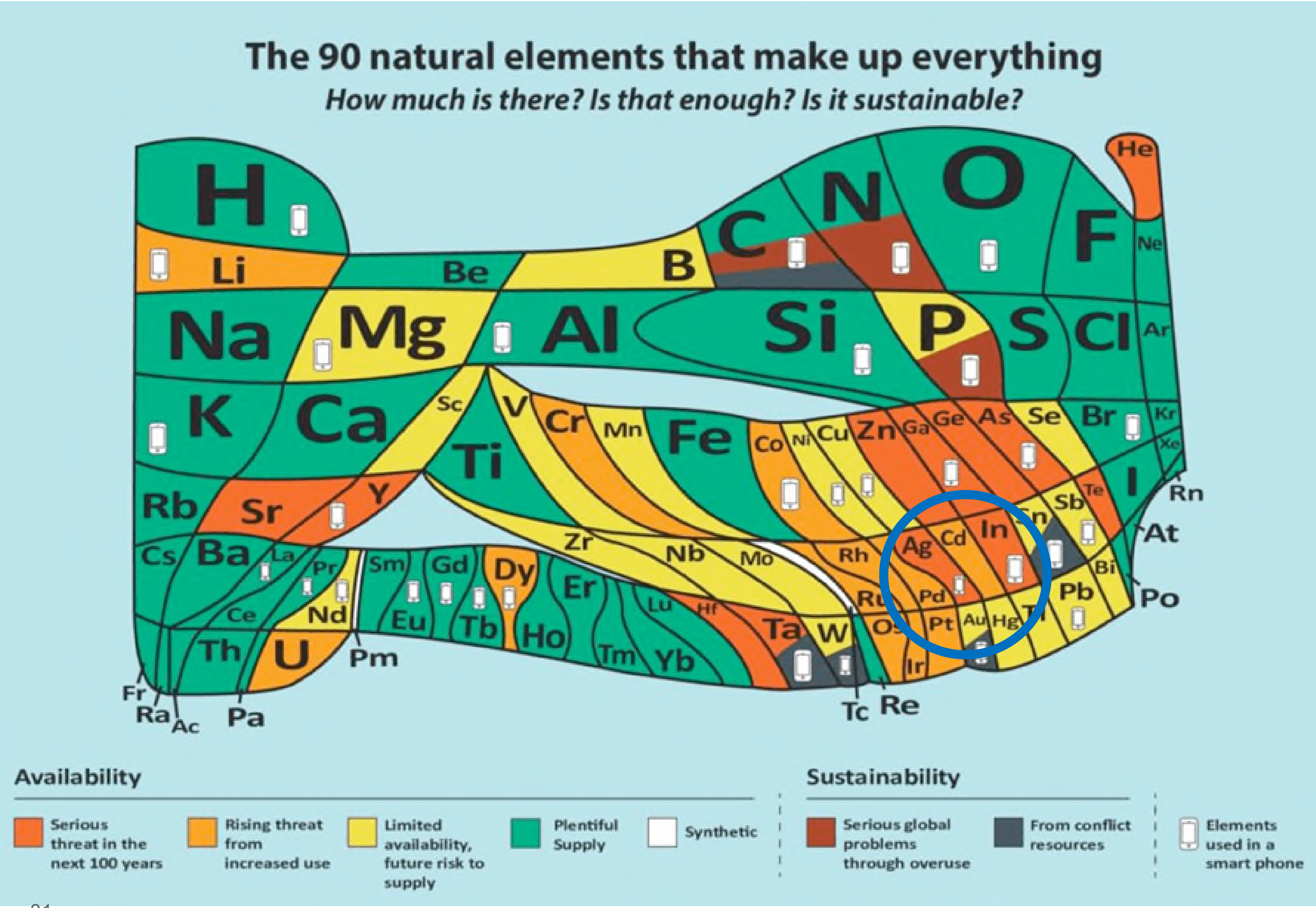
During the last 200 years, companies have profited from linear business models



Currently:
92.8% of the Global economy is linear

What are the problems emerging from the linear logic?

Scarcity of resources to conduct economic activities



1 kg of smartphones contains approximately:

- 1,732.9 mg of silver (Ag)
- 190.9 mg of gold (Au)
- 40.1 mg of palladium (Pd)

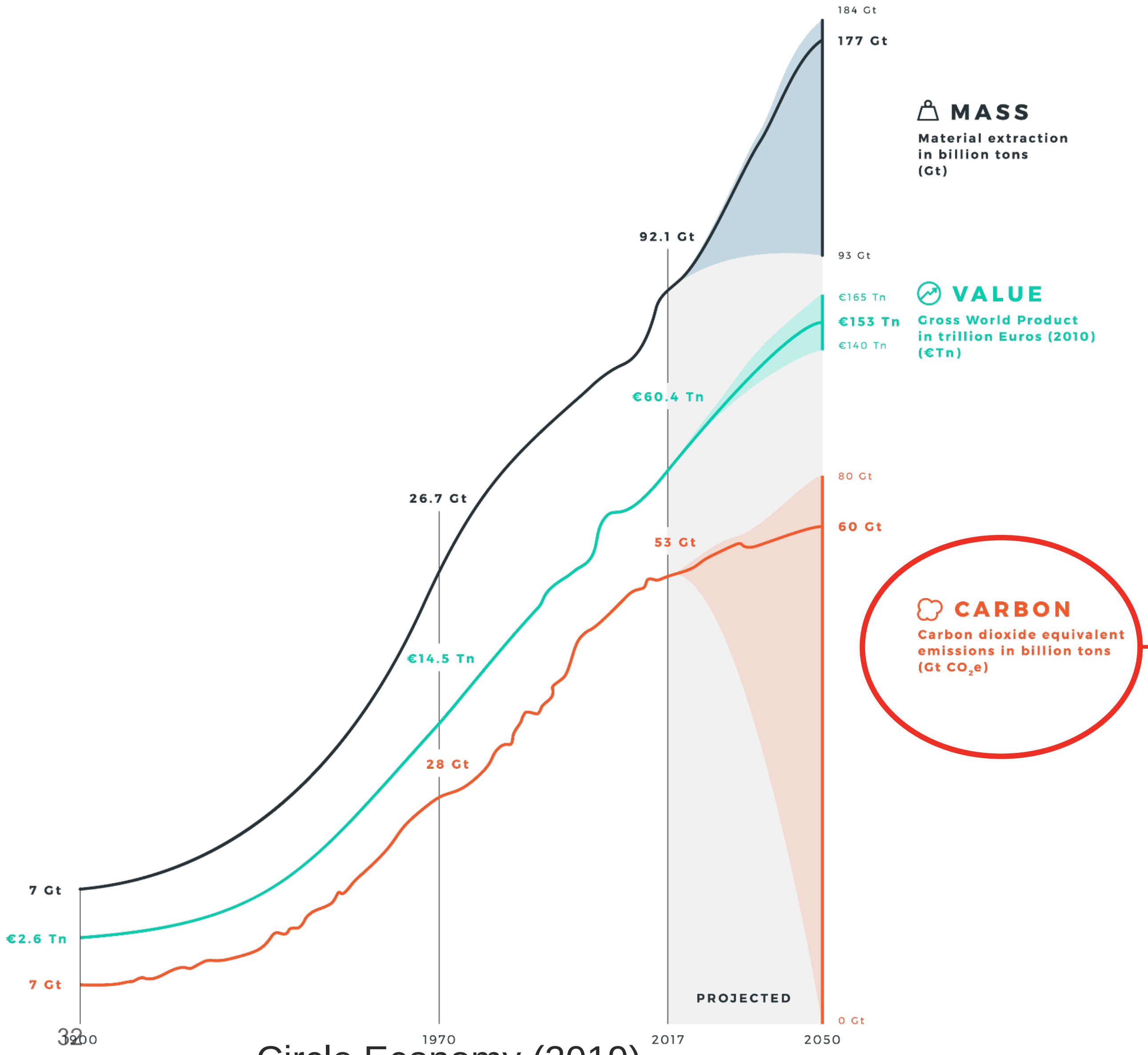
Smartphones constitute a potential new resource for the mining of rare and precious metals

European Chemical Society (2023)

Singh *et al.* (2018)

What are the problems emerging from the linear logic?

Environmental impacts – Climate change



Circle Economy (2019)

Traps extra energy in the atmosphere near the Earth's surface, causing the planet to heat up.

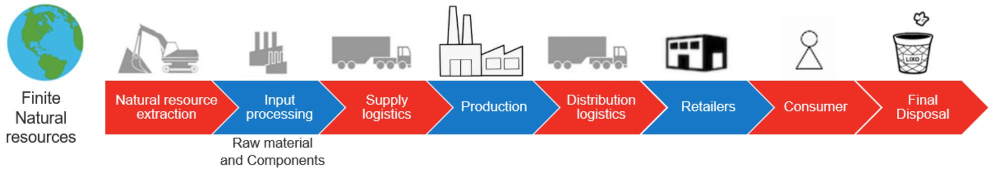
Causes a shift in weather conditions

Shifts towards more frequent and intense extreme weather:

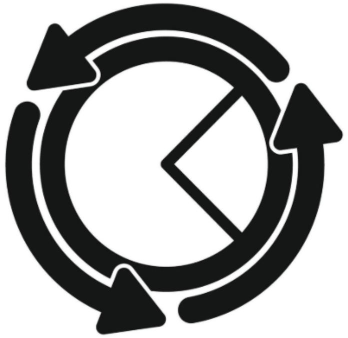
- Floods
- Drought
- Heatwaves
- Heavy rainfall

BBC (2024)

How to transition to circular business models?



- Post-consumed and post-industrial materials
- Technical and biological cycles
- Circular chemistry
- Circular ladder



From: Linear business

- Waste of valuable resources
- Overconsumption of natural resources
- Environmental impacts

To: Circular business

- Valuable resources are not wasted
- Profit generation is maintained
- Environmental impacts prevented or minimised

The circular logic:
Continuous reapplication of non-virgin material resources

- **Post-consumed materials**
  - Products and materials discarded by customers/end-users after use (Ottoni, Dias and Xavier, 2020)
- **Post-industrial materials**
  - Materials leaked from the operational process of a company (Kleinhans et al., 2021)

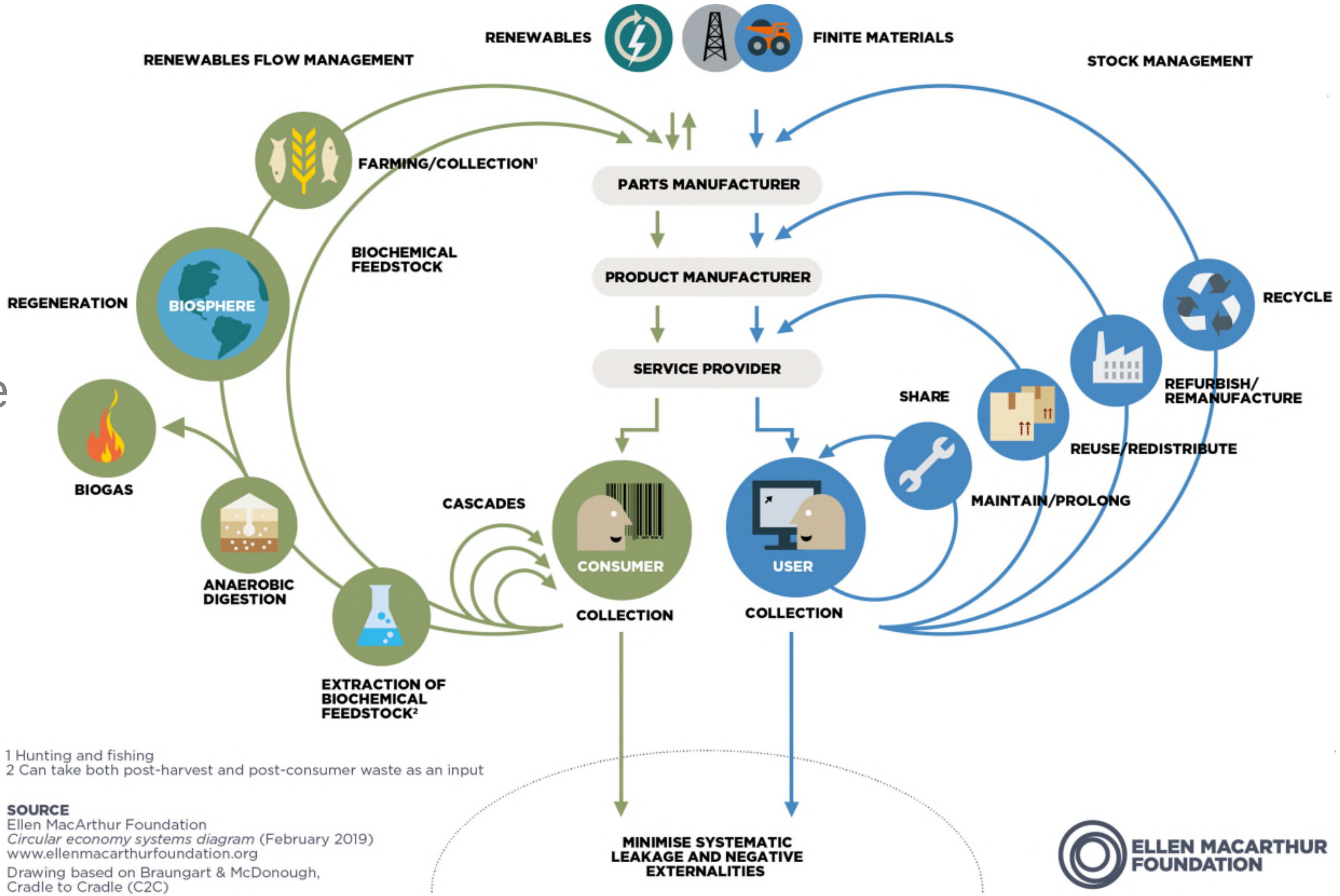
The circular logic

Biological cycle

Nutrients from biodegradable materials are returned to the Earth

Technical cycle

Products and materials are kept in circulation



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)

ELLEN MACARTHUR FOUNDATION

Circular chemistry

1. Collect and use waste	**5.** Enhance process efficiency	**9.** Apply ladder of circularity
2. Maximize atom circulation	**6.** No out-of-plant toxicity	**10.** Sell service, not product
3. Optimize resource efficiency	**7.** Target optimal design	**11.** Reject lock-in
4. Strive for energy persistence	**8.** Assess sustainability	**12.** Unify industry and provide coherent policy framework

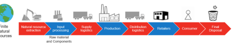
Keijer et al. (2019), Nature Chemistry

Ladder of circularity

Circular operations

R0 Refuse	Make product redundant by abandoning its function or by offering same function with a radically different product
R1 Rethink	Make product use more intensive through sharing products, or by putting multi-functional products in the market)
R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
R3 Re-use	Re-use by another consumer of discarded product still in good condition and fulfilling original function
R4 Repair	Repair & maintenance of defective product for use in 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 parts in a new product with a different function.
R8 Recycle	Process material to obtain the same (high grade) or lower (low grade) quality.
R9 Recover	Incineration of materials with energy recovery.

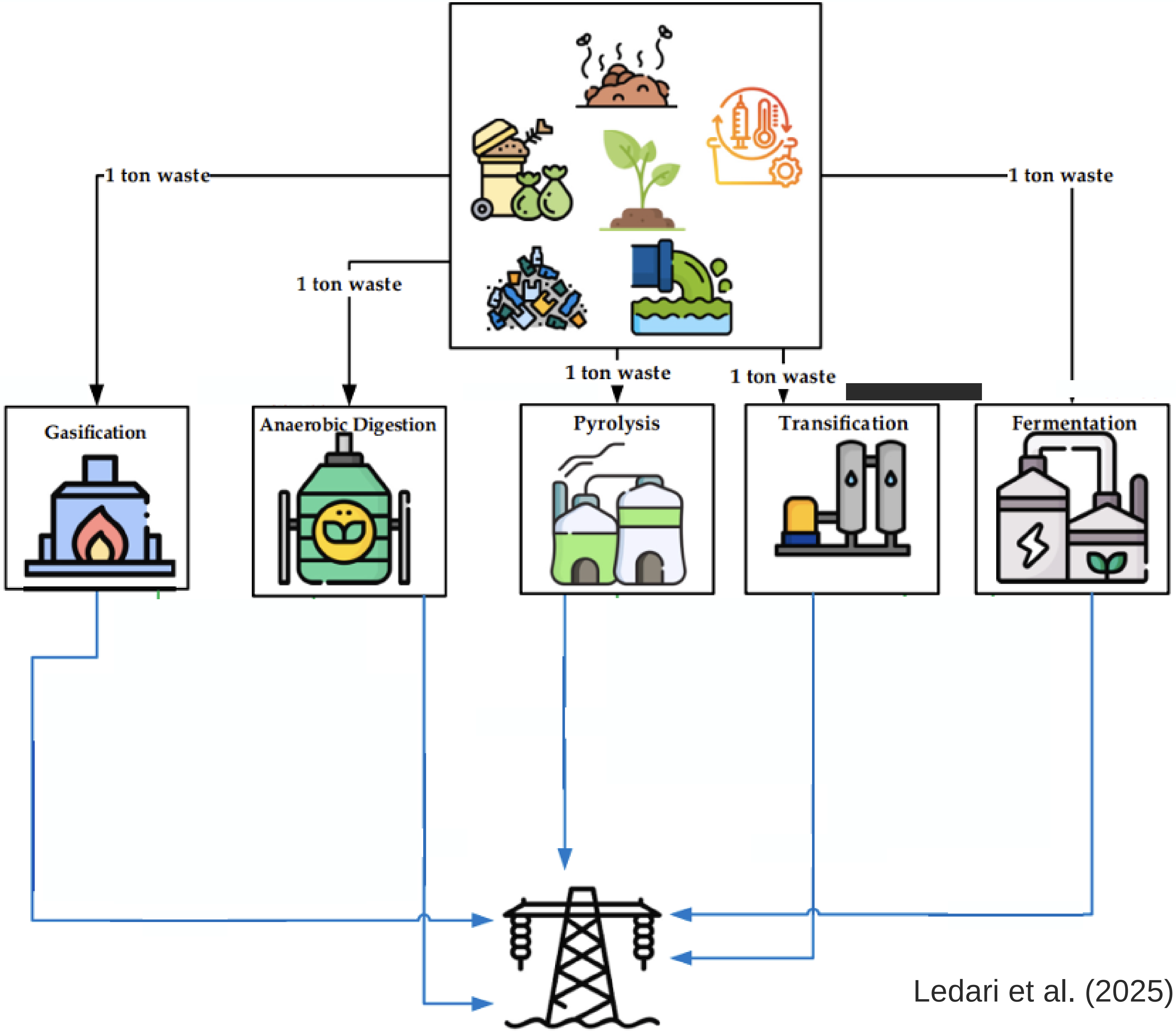
Linear operations



Potting et al. (2017) - PBL Netherlands Environmental Assembly Agency

R9 - Recover

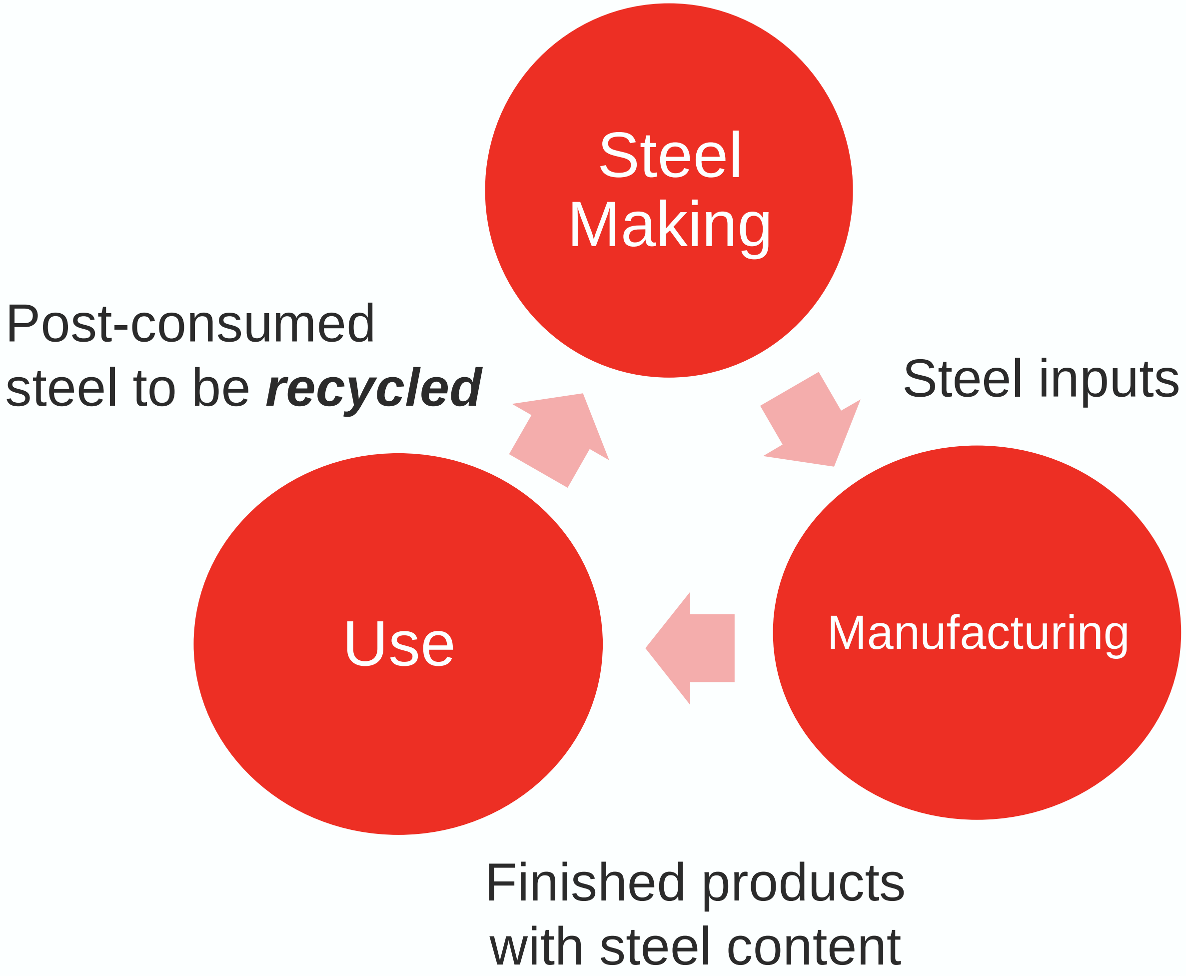
Generation of electricity from post-consumed and post-industrial materials



Ledari et al. (2025)

R8 - Recycle

- Process material to obtain the same (high grade) or lower (low grade) quality
  - Liquifying materials (such as smelting) to act as a feedstock for new material production



de Souza and Pacca (2021)

R7 - Repurpose

- Use discarded product or its parts in a new product with a different function

nutella

A food company can package its products in packaging that, once empty, can be used by end-user for different purposes, such as food storage or as a measuring cup.

Blomsma *et al.* (2019)

R6 - Remanufacture

- Use parts of discarded product in a new product with the same function
  - Includes disassembling, replacing worn broken parts, and reassembly

Renault working with partners on:

(1) Disassembly of after-sales turbochargers.

(2) Component testing to verify operating conditions.

(3) Reassembly of components from different after-sales turbochargers, within original operating specifications, to assemble a new turbocharger.

(4) Earn profits from the sale of the **remanufactured turbocharger** to end consumers.

Blomsma *et al.* (2019)

R5 - Refurbish

- Restore an old product and bring it up to date.

> Obsolete smartphones have their outdated components replaced with new ones to update their functions to a working condition close to recent technological standards.

Bigliardi, Filippelli and Quinto (2022) Blomsma et al. (2019)

R4 - Repair

- Repair and maintenance of defective product so it can used with its original function

Corrective maintenance

Interventions to restore the product's operating conditions after a failure.

Preventive maintenance

Scheduled replacement of components or adjustments to prevent failures in working conditions.

Predictive maintenance

Sensors are installed on critical components of a product/equipment.

Hollander et al. (2017), Ashraf et al. (2023), Li et al. (2022)

R3 – Re-use

- Reuse by another consumer of discarded product which is still in good condition and fulfils its original function

(1) A company can profit by selling to customers access to a product through a rental agreement based on a monthly payment.

(2) At the end of the agreement, the end user is responsible for returning the product to the manufacturer in usable condition.

(3) Once at the manufacturing facilities, the product is cleaned and repackaged to be shipped for reuse by a new end user through a new rental agreement.

Blomsma *et al.* (2019)

R2 - Reduce

- Increase efficiency in product manufacture or by reducing use of materials

(1) Focus on reducing resources consumed in manufacturing

- Compared to previous versions, design a product that requires reduced amount of resources to manufacture.

(2) Focus on reducing resources consumed during use

- Educational campaigns to encourage users to reduce resource consumption.

Dokter et al. 2021; Mostaghel et al. 2023

R1 - Rethink

- Make product **use** more intensive

(1) Product Sharing

- A washing machine located in a central location of a building for multiple wash cycles per day, unlocked for collective use.

(2) Multifunctional Products

- Electronics manufacturers transition from selling single-function printers and scanners to offering multifunction devices with printing and scanning capabilities.

Potting et al. (2017); Kara et al. (2022)

R0 - Refuse

- Make a product redundant

(1) Abandoning the Product Function

- Technological advances that enabled video and music streaming on smartphones have made devices like CD and DVD players obsolete.

(2) Providing the same function with a separate product

- A smartphone combines multiple functions - GPS location, phone calls, music player, alarm notifications, photography, etc.
- Previously, these functions were only available on individual devices

Reike et al. (2018)

Connections between circularity and the climate change

Reduces CO_2 emissions

HIGH GHG EMISSIONS	MATERIALS EXTRACTION
MEDIUM GHG EMISSIONS	MATERIALS PROCESSING
MEDIUM GHG EMISSIONS	PRODUCTS USE
LOW GHG EMISSIONS	PRODUCTS RE-USE (2ND LIFE)

The move towards circularity

Leal Filho et al. (2024)

X STRATHCLYDE BUSINESS SCHOOL

Challenge to increase global circularity rates

- 9.1% - 2018
- 7.2% - 2023
- 6.9% - 2025

- The global economy consumes 100 billion tons of materials per year
- Estimated reuse of non-virgin materials in consumption and production activities.

Circle Economy Reports (2018, 2023, 2025)

Climbing the circularity ladder

- Incorporate a circular mindset in the early stages of design
- Scan non-virgin materials available in the chain for reapplication
- Create circular partnerships with value distribution to all stakeholders
- Digitalise circular practices

Collaboration for environmental innovation

- Work collaboratively to create multiple forms of value
- Consider partnerships with sector players and stakeholders
- Harness different capabilities of collaborators /partners

JOURNAL OF PRODUCT INNOVATION MANAGEMENT
pdma Connecting Innovators Worldwide

Original Article

Harnessing Difference: A Capability-Based Framework for Stakeholder Engagement in Environmental Innovation

Rosina Watson, Hugh N. Wilson, Palie Smart, Emma K. Macdonald

First published: 02 June 2017 | https://doi.org/10.1111/jpim.12394 | Citations: 267

Abstract

Innovation for environmental sustainability requires firms to engage with external stakeholders to access expertise, solve complex problems, and gain social legitimacy. In this open innovation context, stakeholder engagement is construed as a dynamic capability that can harness differences between external stakeholders to augment their

Watson et al. (2017) https://doi.org/10.1111/jpim.12394

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The Circularity Ladder

Implications for chemical and allied industries

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Mulţumesc Merci Tack Tak

Danke

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Ačiū Tänan

Dzięki

Благодаря ти

Enkosi

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Ndzi khense ngopfu

Grazie

Efharistó

ndiyabulela

Děkuji vám

Gracias

Dankie

Paldies

Kiitos

Grazzi

Obrigado

Thank you

Bedankt

Köszönöm