Earth in Full View From Apollo 17, 1972 - NASA

Circular economy concepts

Dr. Martyn Wakeman

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Learning objectives

- Understand key concepts in the circular economy
  - Linear economic model
  - Over consumption and production
  - Circular economy principles
  - Barriers and enablers to a circular economy
  - Systems level thinking / mapping

Now is the most exhilarating time to be an innovator.

Wakeman

Overview

- Linear economy
- Circular economy
- Engineered product example
- Barriers and enablers to a circular economy
- Systems level systems thinking / mapping

Enablers: NetZero 2050 transition

Effective international collaboration	Orderly and just transition	Societal behavioral adaptation
Innovation in new and emerging technologies	Transportation transition to EVs	Petrochemical to Bio-mass feedstock
Renewable energy transition	Hydrogen economy	Agriculture, food, diet

Sufficiency | **Circular economy**

*the-net-zero-transition-what-it-would-cost-and-what-it-could-bring-final.pdf (mckinsey.com)

Economics definition: "Efficient allocation of scarce resources"

- The current economic model has failed* in that resources are not efficiently allocated

Over-production

Overproduction - Lean Strategies International

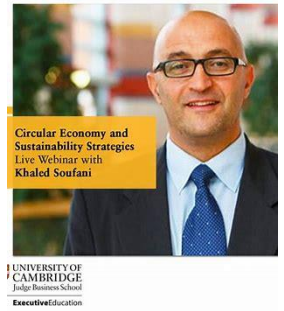
Over-consumption

Overconsumption – HiSoUR – Hi So You Are

Over-trading

How to Avoid Overtrading | by TradersAsset

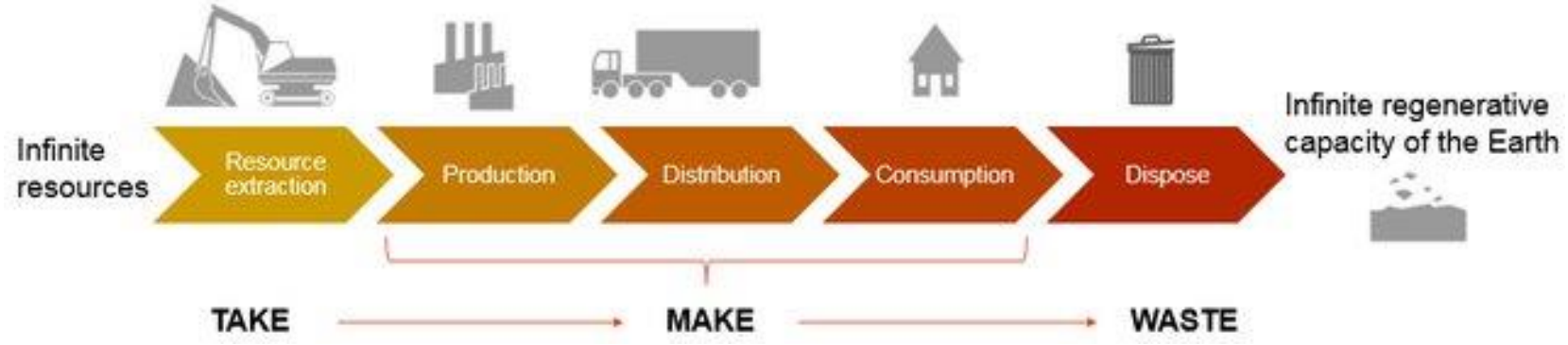
- **We need a new economic model**



* Failure means that the current system is not the optimum solution

An issue: our linear economy

- A uni-directional approach of extract, make, use, and dispose.



- Linear models can be seen in economic terms as a market failure (we have not yet found and applied models where we as society can reflect the hidden environmental costs in market prices)

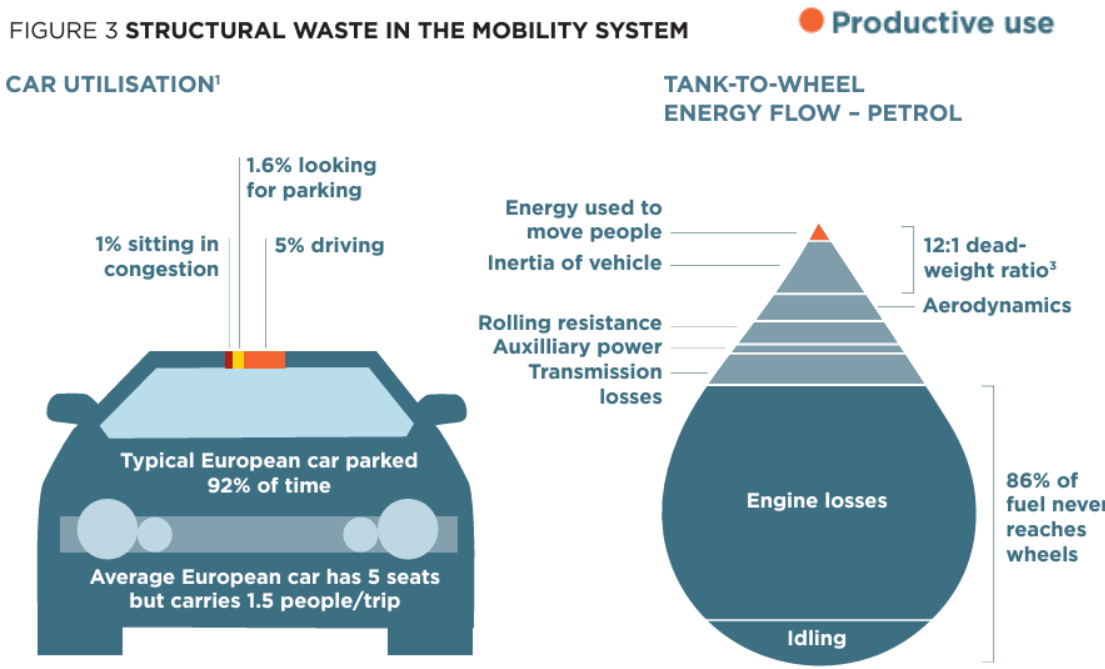
Caused significant impacts on the environment such that serious changes are needed

(18) (PDF) Exploring the role of independent retailers in the circular economy: a case study approach (researchgate.net)

Shocking statistics (in the EU)

- Agriculture uses 70% of global water consumption.
- 46% of fruit and vegetable still useful edible mass is lost,
- 60-75% of packaging is lost after the 1st use cycle,
- 8 million T of plastic floods into the ocean each year.

- 90% of the time our cars are idle,
- 60% office space is not used in daytime
- Fast fashion = 10% of global CO_2 emissions.

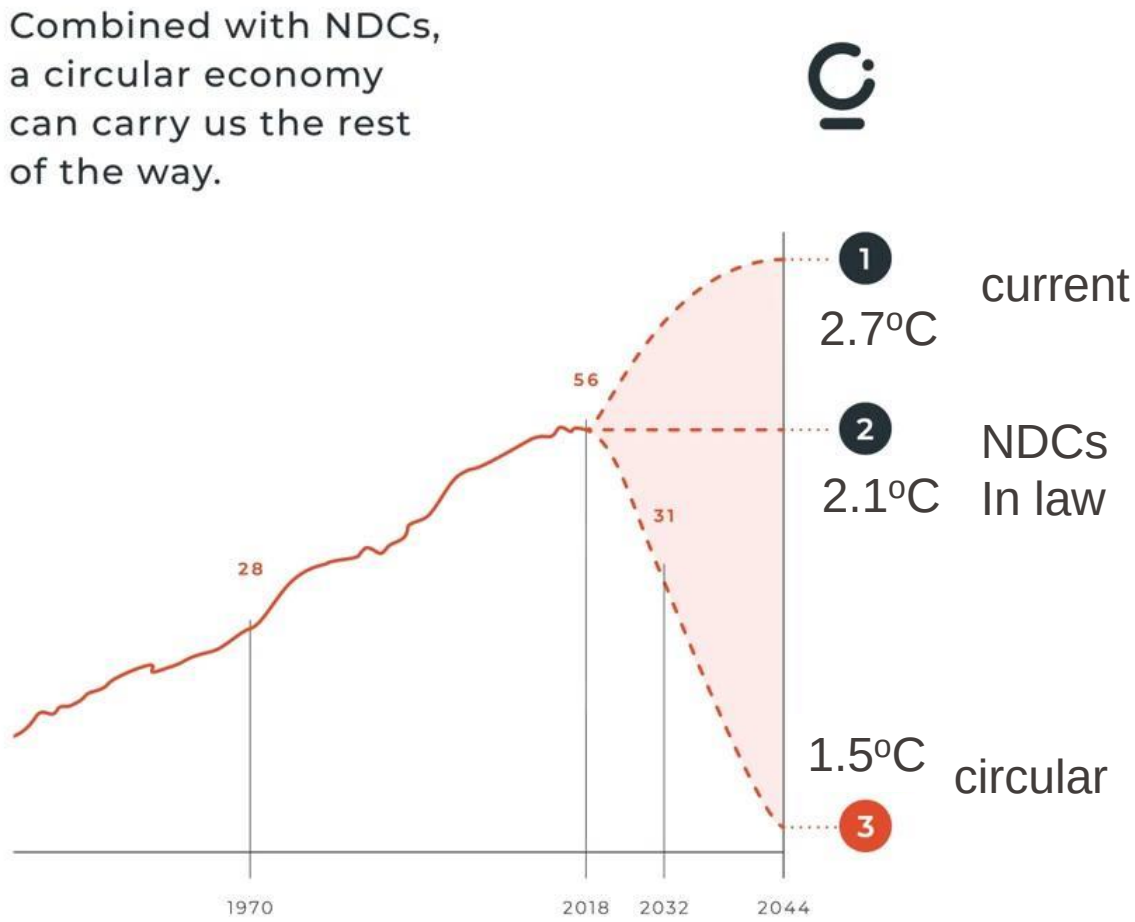


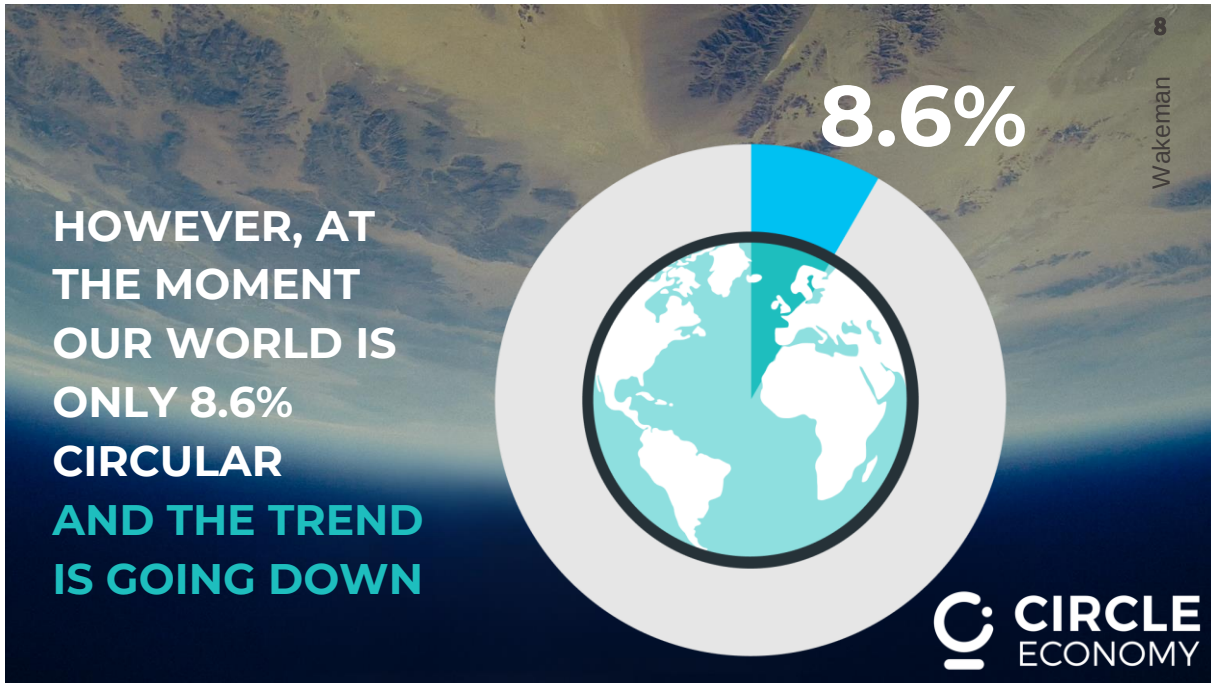
72% of all economic activity is related to the end user

What we buy will drive what people produce

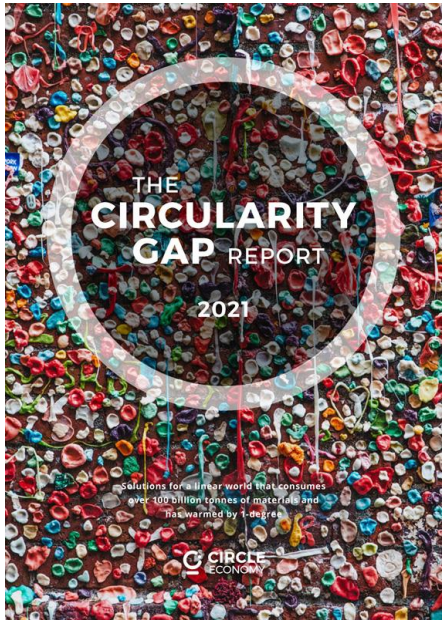
We are inefficient as a society and need to improve this. Many inefficiencies are money lying on the floor, which if we pick up will hugely benefit the environment.

Circularity gap





- **Significantly increase GLOBAL rate towards >20% to limit global warming to well below 2ºC**



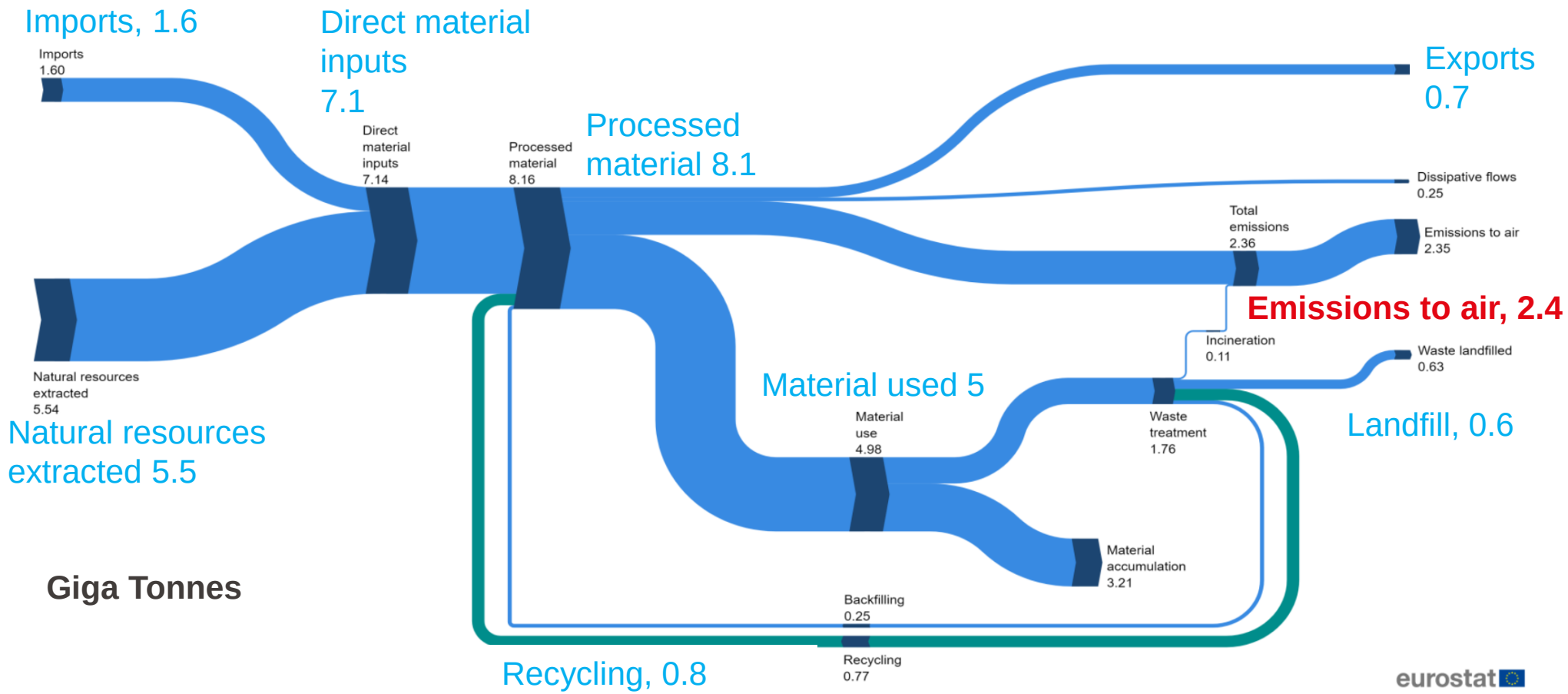
Circularity Gap Report 2021.pdf - Google Drive

CGR 2021 (circularity-gap.world)

Material flows in EU, 2022

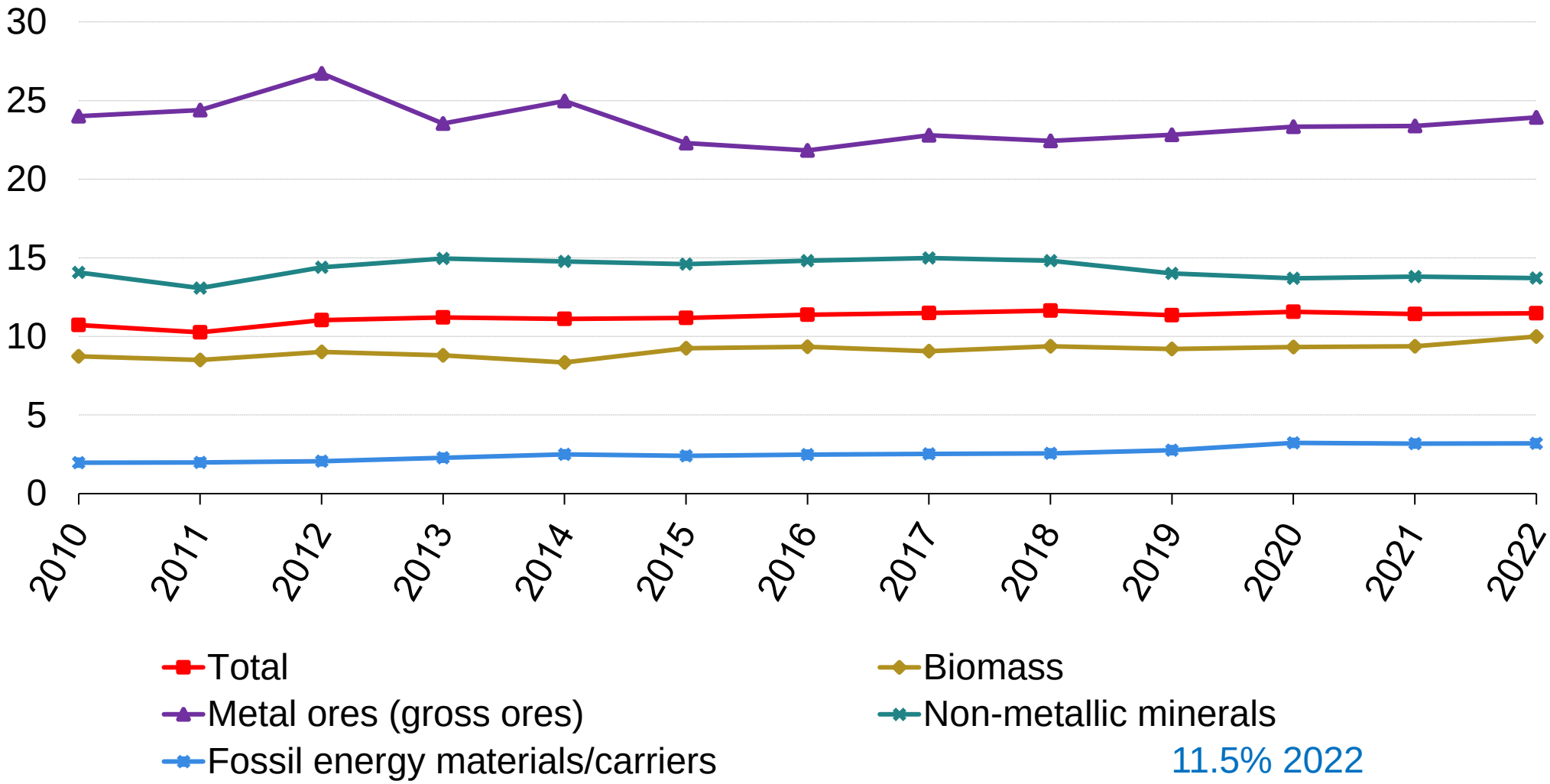
Global 2023 = 7.2%,
EU 2022 = 11.5%
Switzerland = 6.9%

- raw materials processed in the EU (8.16 Gt)
  - 68 % (5.54 Gt) domestic extraction,
  - 20 % from imports (1.60 Gt)
  - 12 % from recycling and backfilling (1.02 Gt),
- 61 % used to make products (4.98 Gt).
- The rest were mainly exported or used for producing energy.



Circular economy - material flows - Statistics Explained (europa.eu) Circular economy flow diagrams (europa.eu)

Circularity rate by main type of material, EU, 2010-2022 (%)



Source: Eurostat (online data code: env_ac_curm)

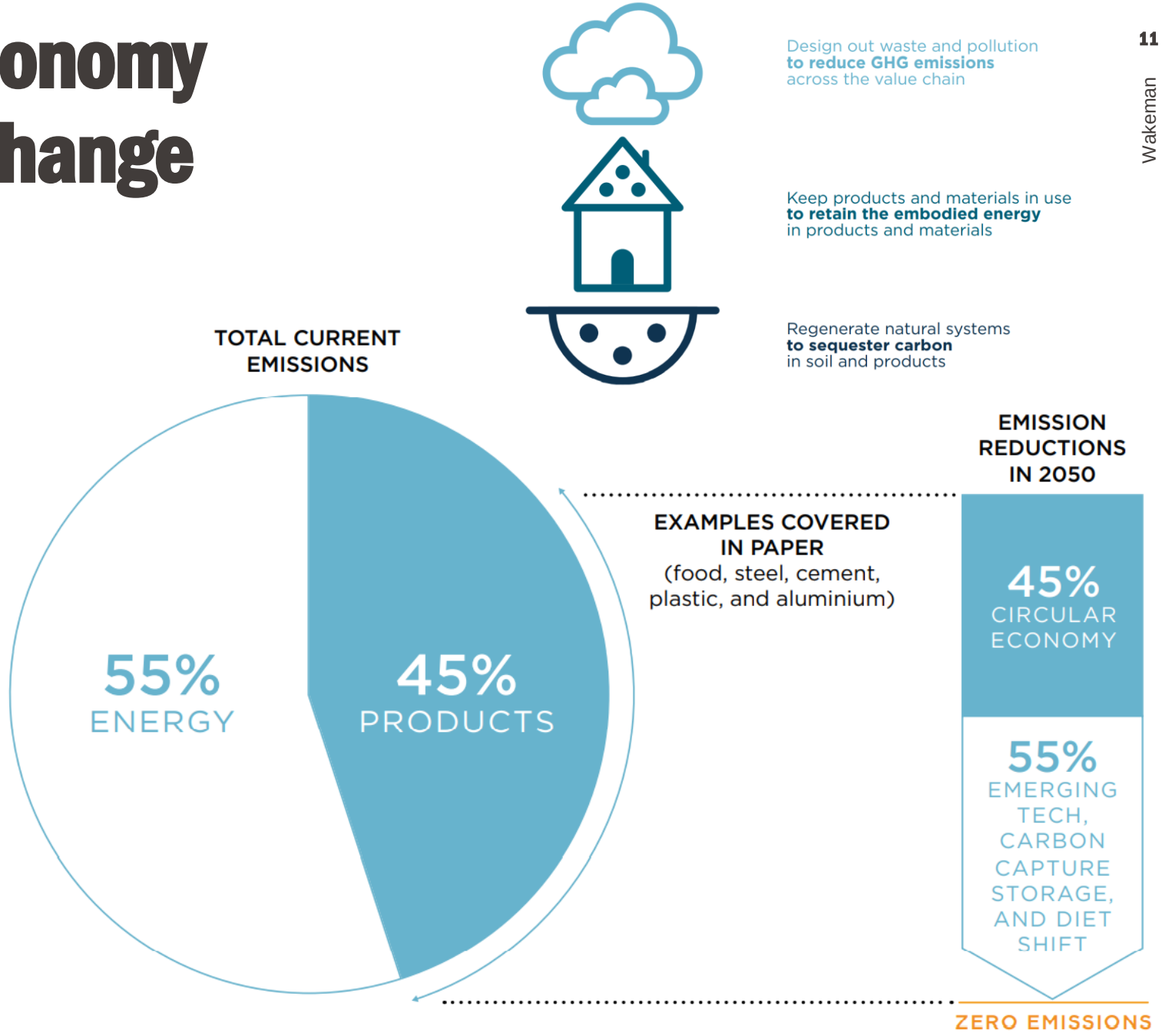
11.5% 2022
Circularity rate, EU (Eurostat), 2004-2022 (%)

CGR 2024 (circularity-gap.world)

How a circular economy tackles climate change

- Emissions today
  - A) energy (55%)
  - B) Products (45%)

- Looking at products
  - Emissions reduction potential in 2050 enabled by circular economy



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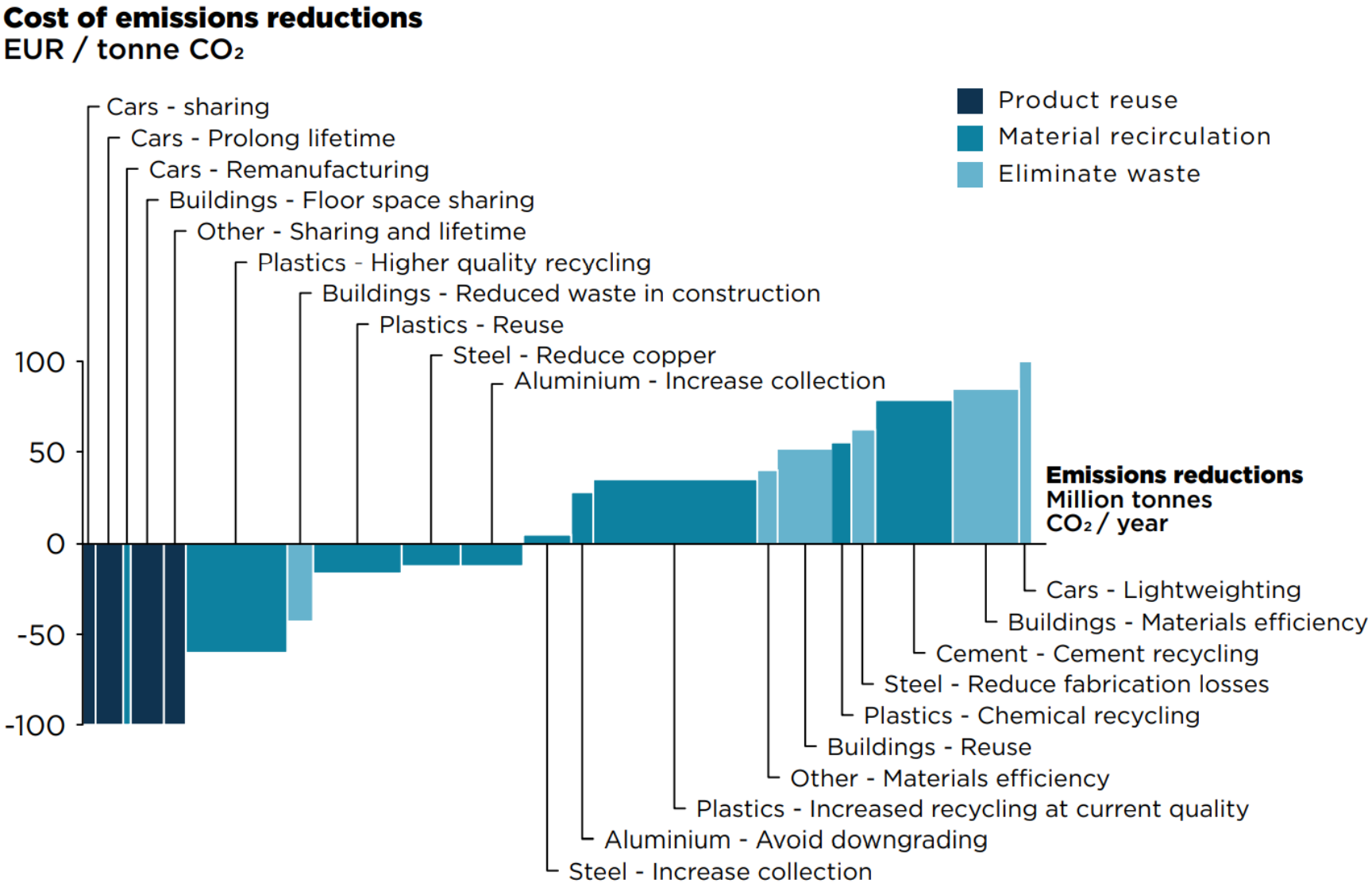
Completing The Picture - How The Circular Economy Tackles Climate Change | Shared by Comms (thirdlight.com)

Emissions reduction potential from circular economy business models



Completing The Picture - How The Circular Economy Tackles Climate Change | Shared by Comms (thirdlight.com)

Key elements of a circular economy

- Beyond a necessary energy transition

A FUNDAMENTAL CHANGE IN **THE WAY GOODS ARE MADE AND USED** IS REQUIRED TO MEET CLIMATE TARGETS

Design out waste and pollution

Keep products and materials in use

Regenerate natural systems

Completing The Picture - How The Circular Economy Tackles Climate Change | Shared by Comms (thirdlight.com)

Overview

- Linear economy
- Circular economy
- Engineered product example
- Barriers and enablers to a circular economy
- Systems level systems thinking / mapping

7 principles of the circular economy

1. **Design for longevity**; component replacement and update through modularity
2. **Reuse** through refurbishment, repair or remanufacturing
3. **Resource-efficient manufacturing** to minimize waste generation
4. **Recycling-friendly materials** and **design for ease of disassembly**
5. **Collaboration across the value chain** to optimize resource utilization and waste
6. **Local sourcing and production** to reduce transportation emissions
7. **Innovative business models** such as product-as-a-service, leasing, subscription, and take-back programs to incentivize circularity, to encourage sharing and access over ownership

From MGT-555 2024 course description

Circular economy business models

Close	Slow	Intensify	Dematerialize
• Material and energy recycled within the system • Via reuse, refurbishment and recycling	• Extends the use phase • Increased durability	• Asset is used more via sharing	• Virtual approaches to a physical asset

✓efficiency and productivity,
✓economic and financial viability,
✓design for dis-assembly
✓recovery, recycling,
✓sharing platforms,
✓extending the life of assets,
✓service vs. product
✓if the machine is turned off, the asset is not working for you

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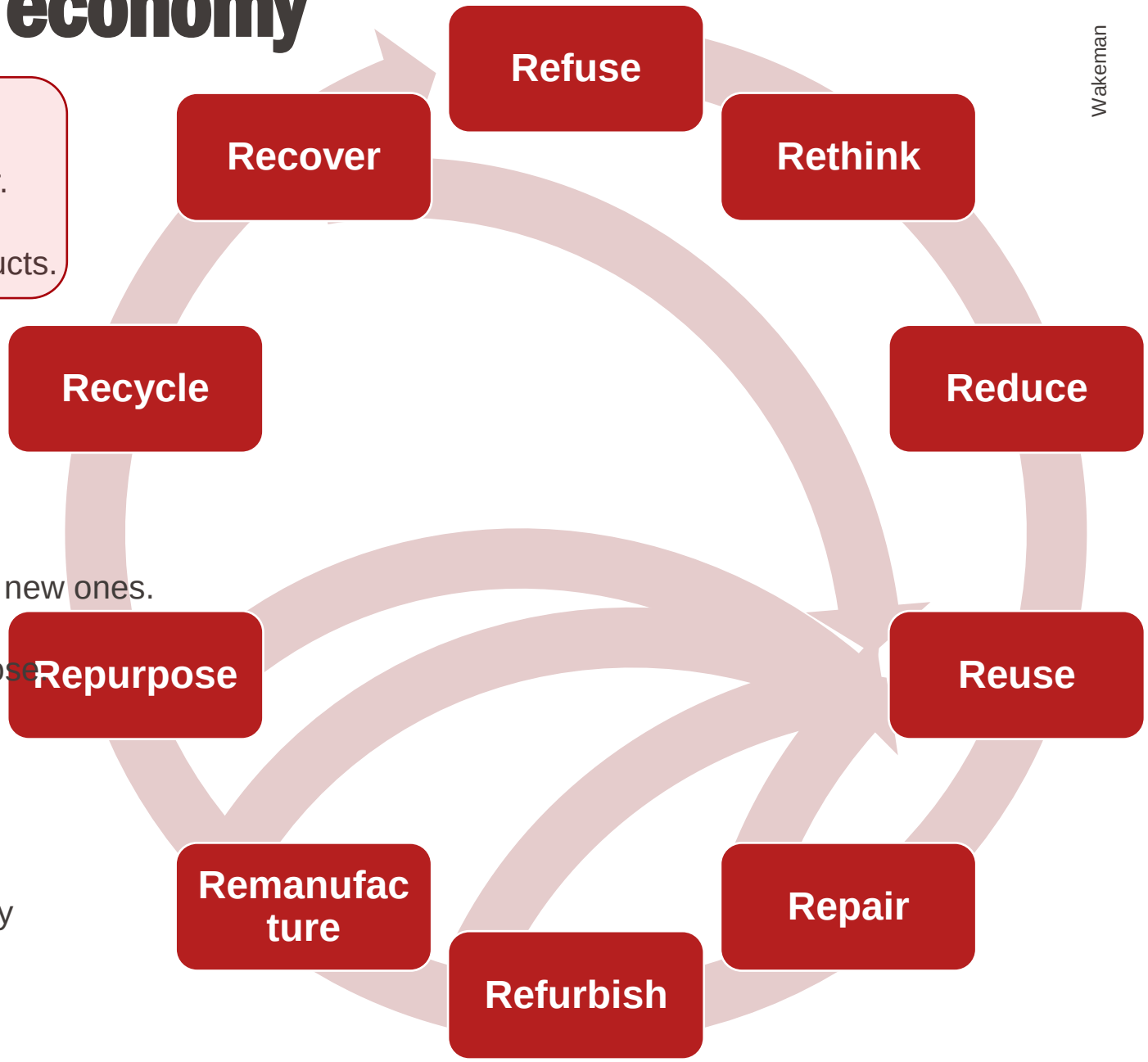
10 R's of the circular economy

1. **Refuse:** Say no to unnecessary products and services.
2. **Rethink:** Design products and systems to be more circular.
3. **Reduce:** Use fewer resources / materials to produce products.

Sufficiency

4. **Reuse:** Use products and materials multiple times.
5. **Repair:** Fix broken products versus throwing them away.
6. **Refurbish:** Restore old products to their original condition.
7. **Remanufacture:** Disassemble / rebuild products to create new ones.
8. **Repurpose:** Use old products or materials for a new purpose.
9. **Recycle:** Convert waste materials into new products.
10. **Recover:** Extract energy or materials from waste.
11. **Relocate:** Removal of waste to a different region or country



Which one of these is incorrect?

Platform for Accelerating the Circular Economy (pacecircular.org)

DEVENDEUR, POLO Refuse

Re-thinking

Re-thinking

DEVENDEUR, POLO Refuse

La ponceuse Reduce – dematerialization, share

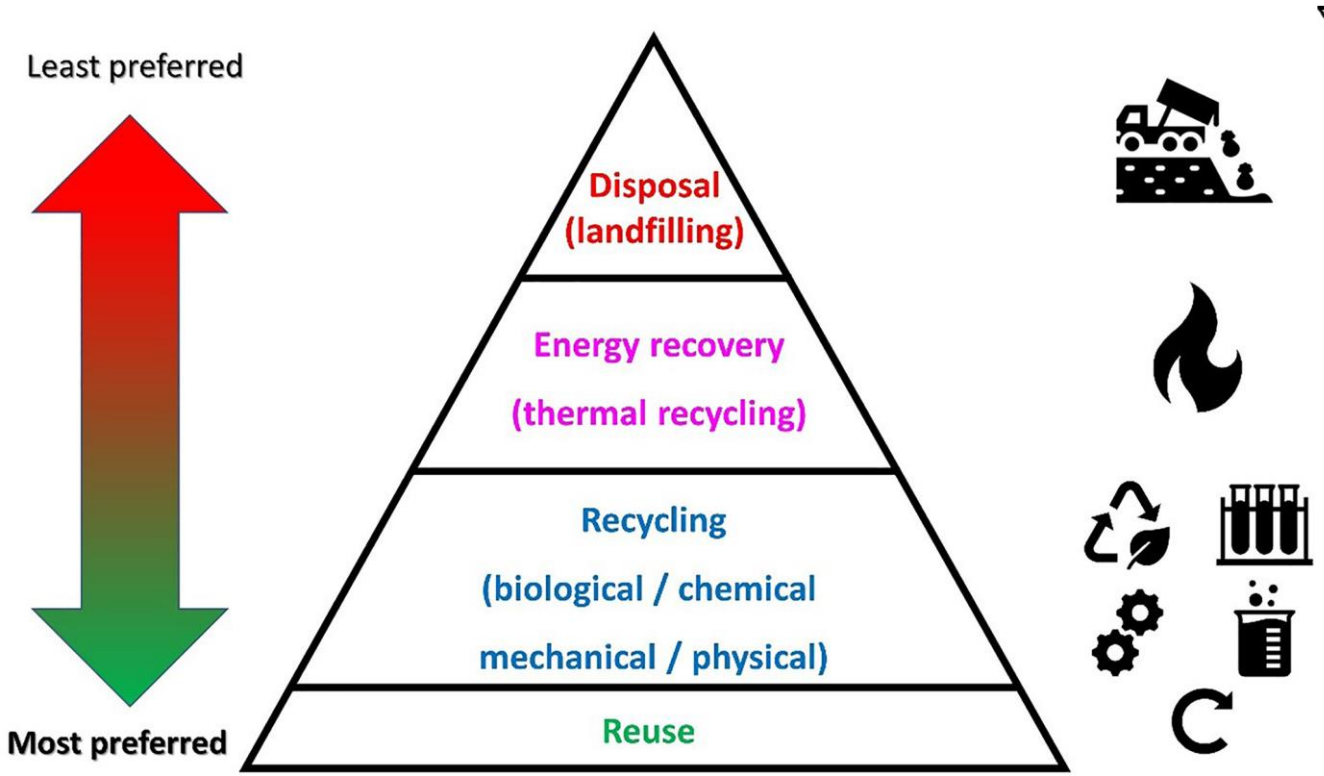
Le lave-linge Repair

Le smartphone Reuse / refurbish

Economy	Strategy	R-factor	Example	Innovations needed: Tech.	Design	Revenue	Societal
Circular	Smarter product use and manufacture	Refuse	Make product redundant by abandoning its function or by offering the same function with radically more efficient product				
		Rethink	Make product use more intensive (sharing, multi-functional)				
		Reduce	Increase product manufacturing efficiency / consume fewer natural resources and materials				
	Extend life time of product and parts	Reuse	Another customer reuses products still in good condition fulling original function				
		Repair	Bring a defective product back to state where it fulfills original function				
		Refurbish	Restore an old product to bring it up to date				
		Remanufacture	Use of discarded products/parts in a new product with same function				
		Repurpose	Use of discarded products/parts in a new product with different function				
Linear	Useful re-application of materials	Recycle	Process materials to obtain same (high grade) or lower grade quality				
		Recover	Incineration of materials with energy recovery				

Adapted from: pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf

Beyond recycling to bigger 'R' levers



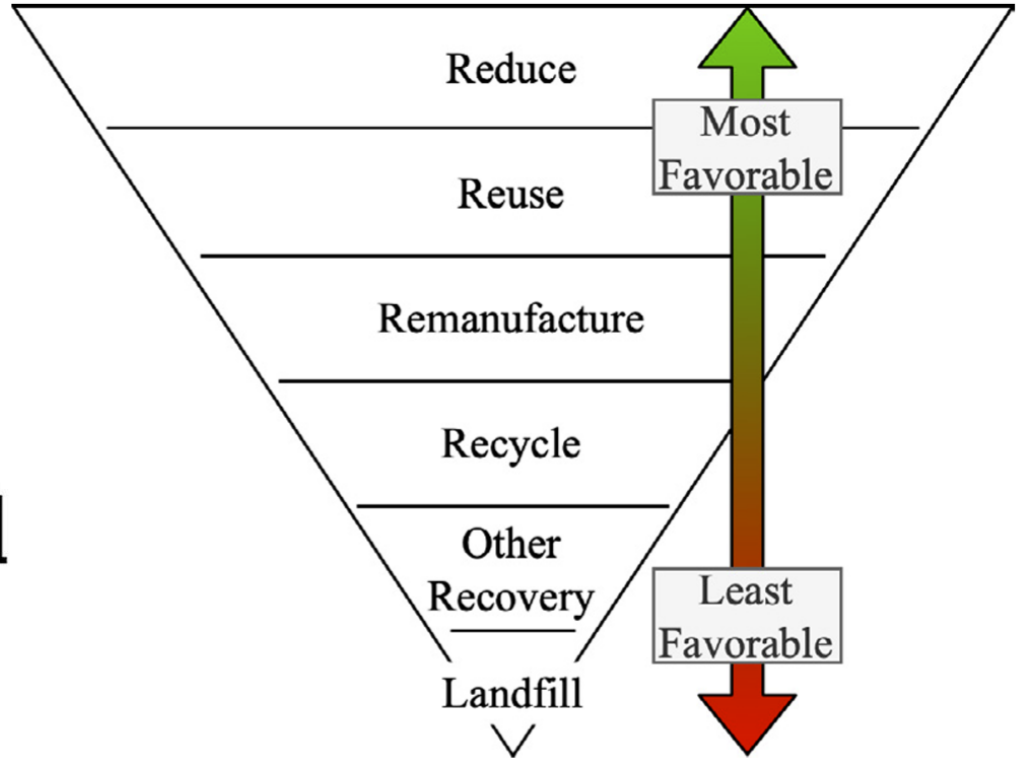


Fig. 3. The waste hierarchy (adapted from the EU Waste Framework Directive 2008/98/EC.

Journal of Polymer Science, Volume: 61, Issue: 17, Pages: 1937-1958, First published: 19 May 2023, DOI: (10.1002/pol.20230154)

https://youtu.be/AiKKY2AC71w

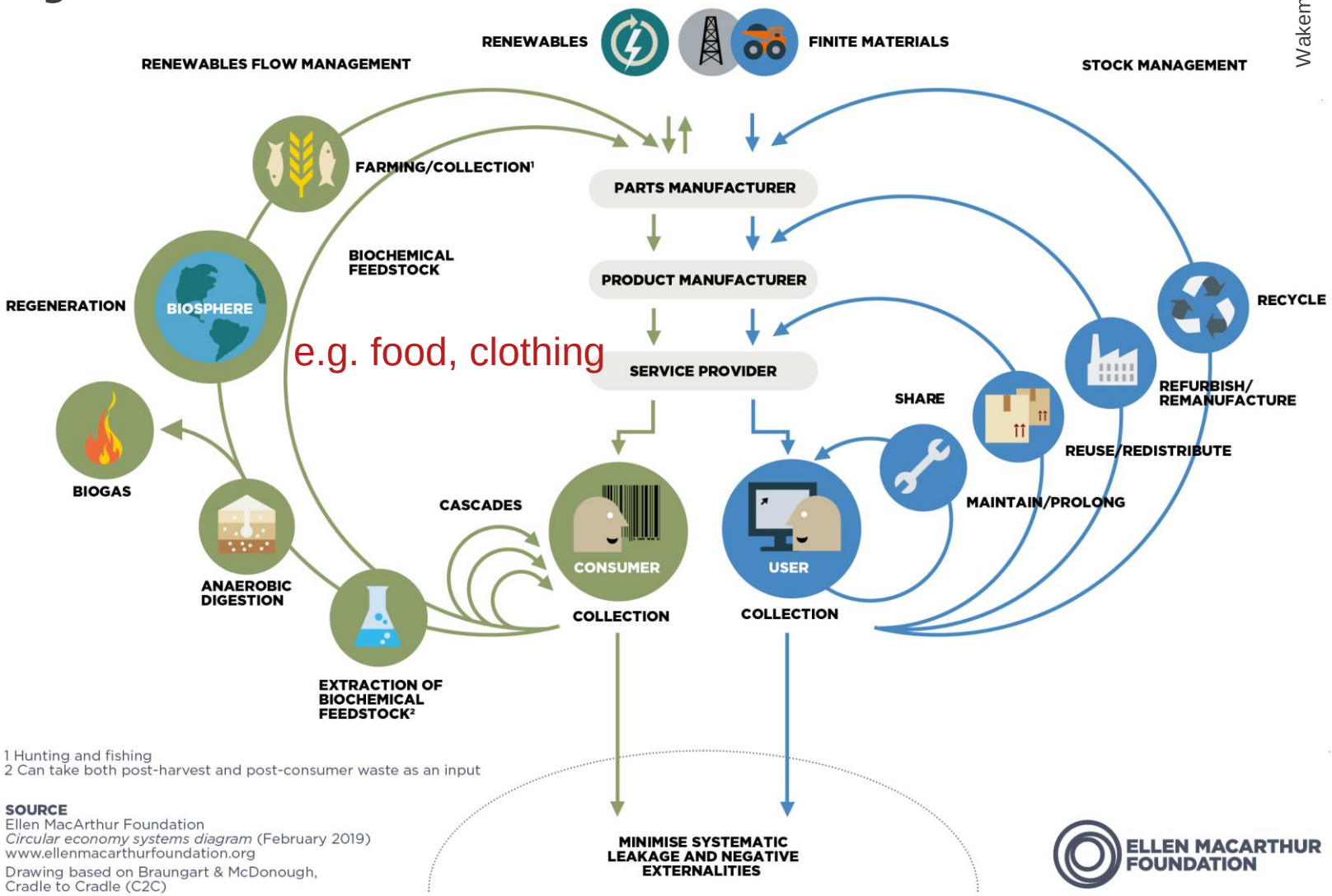
Understanding circularity - UNEP circularity platform (buildingcircularity.org)

Circular economy

Biological cycle

Technical cycle

- Seeks to rebuild capital
  - Financial
  - Manufactured
  - Human
  - Social
  - Natural
- Ensures enhanced flows of goods and services.



Circular Design Guide - Butterfly Diagram - YouTube

How to build a circular economy | Ellen MacArthur Foundation

Circular economy diagram (ellenmacarthurfoundation.org)

ReSOLVE framework

REGENERATE

- Shift to renewable energy and materials
- Reclaim, retain, and restore health of ecosystems
- Return recovered biological resources to the biosphere

P-REX, Nespresso, Iberdrola, SLM, Savory Institute

SHARE

- Share assets (e.g. cars, rooms, appliances)
- Reuse/secondhand
- Prolong life through maintenance, design for durability, upgradability, etc.

airbnb, patagonia, Nearly New Car by Mercedes-Benz, autolib', Bla Bla Car

OPTIMISE

- Increase performance/efficiency of product
- Remove waste in production and supply chain
- Leverage big data, automation, remote sensing and steering

Cisco, wrap, Toyota, BSB Broad Sustainable Building, The Vauban Quarter

LOOP

- Remanufacture products or components
- Recycle materials
- Digest anaerobically
- Extract biochemicals from organic waste

CAT, patagonia, Renault, Dell, Paques, Veolia, Winsun 盈创, mazuma mobile

VIRTUALISE

- Books, music, travel, online shopping, autonomous vehicles etc.

Cisco, Netflix, zalando, kindle, skype, Google, iTunes

EXCHANGE

- Replace old with advanced non-renewable materials
- Apply new technologies (e.g. 3D printing)
- Choose new product/service (e.g. multimodal transport)

DESSO A Tarkett Company, Tesla, Beyond Meat, Philips Lighting, skyTran

growth_within.pdf (mckinsey.com)

D **Design For the Future:** Adopt a systemic perspective during the design process, to employ the right materials for appropriate lifetime and extended future use.

I **Incorporate Digital Technology:** Track and optimise resource use and strengthen connections between supply-chain actors through digital, online platforms and technologies.

S **Sustain & Preserve What's Already There:** Maintain, repair and upgrade resources in use to maximise their lifetime and give them a second life through take-back strategies, where applicable.

R **Rethink the Business Model:** Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.

U **Use Waste as a Resource:** Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.

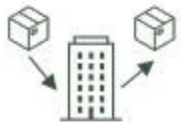
P **Prioritise Regenerative Resources:** Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.

T **Team Up to Create Joint Value:** Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create shared value.

The DISRUPT framework - Insights - Circle Economy

6 Circular Business Model Strategies to Slow Down Consumption

Design for durability and repair. Design determines most of a product's environmental impacts. Strategies like modularity make future repairs easier.



"Remanufacturing," or restoring a product's original function. Manufacturers can take back products after use and remake or restore them.

Lifetime warranties and repair services. Help customers make their products last.

"Sufficiency," or reducing end-user consumption. Don't push unnecessary products (ex: 2 for 1) on consumers.

Product reuse. Companies can resell used products to keep them in circulation.

"Product Service Systems." Provide services to satisfy users' needs so that they don't need to own products.

Source: Bocken & Geradts, 2022

Business Models for the Circular Economy — and Which Make a Difference - Network for Business Sustainability (NBS)

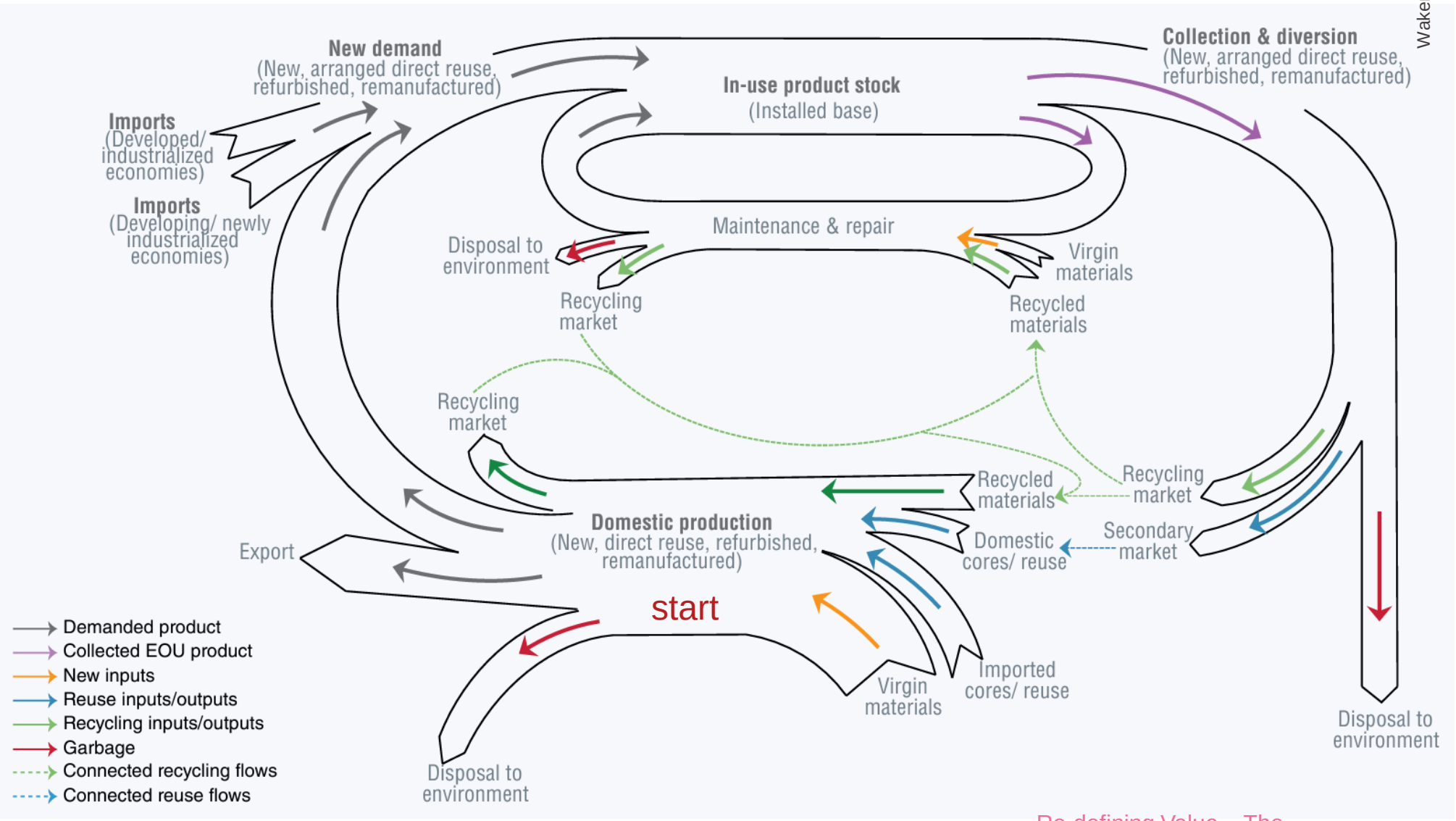
Design: Abby Litchfield

Value-retention processes design principles

The ability to (1) create value;

(2) protect and preserve value;

(3) easily and cost-effectively recover value.



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[Re-defining Value – The Manufacturing Revolution | Resource Panel]

What does a circular economy bring?

- Combat climate change
- Crisis response frame work beyond optimizing economic and environmental performance
  - Early 2020's, multiple convergent crises, significant supply chain disruption:
    - Acute and abrupt: Covid, Ukraine, Middle East
    - Chronic: Climate change, dissipation of natural resources, wealth inequality, bio-diversity loss, pollution, human health impacts
- Increase supply chain resilience
  - Decouple operations from natural resource extraction, increasing material security and reducing exposure to price volatility
- Significant improvements in human health
- Improve long term financial performance

Journal of Cleaner Production
Volume 434, 1 January 2024, 140140

Review

Circular economy as crisis response: A primer

Kris Hartley [a], Brian Baldassarre [b c], Julian Kirchherr [d e f]

Circular economy as crisis response: A primer - ScienceDirect

Dealing with VUCA

Overview

- Linear economy
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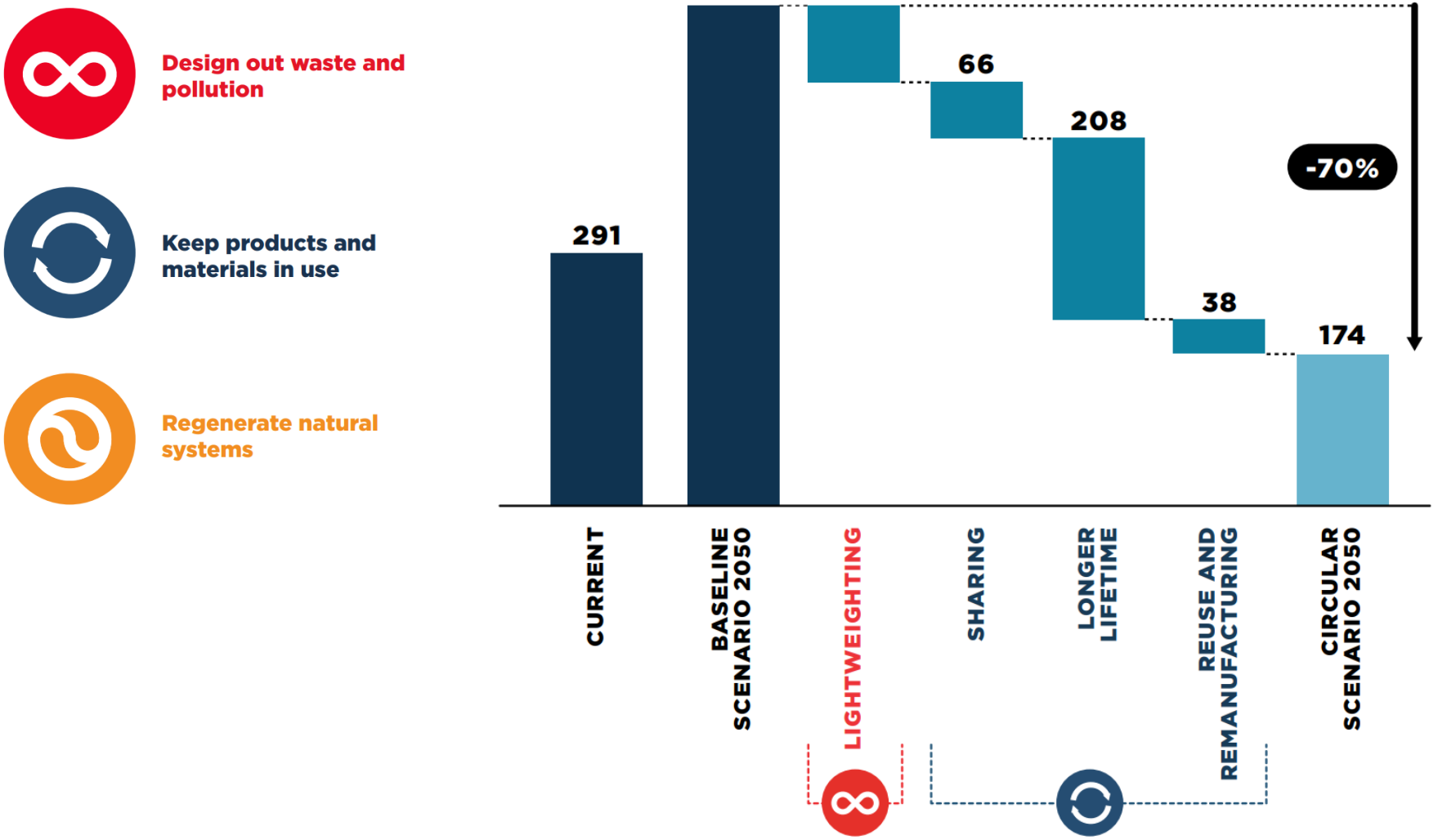
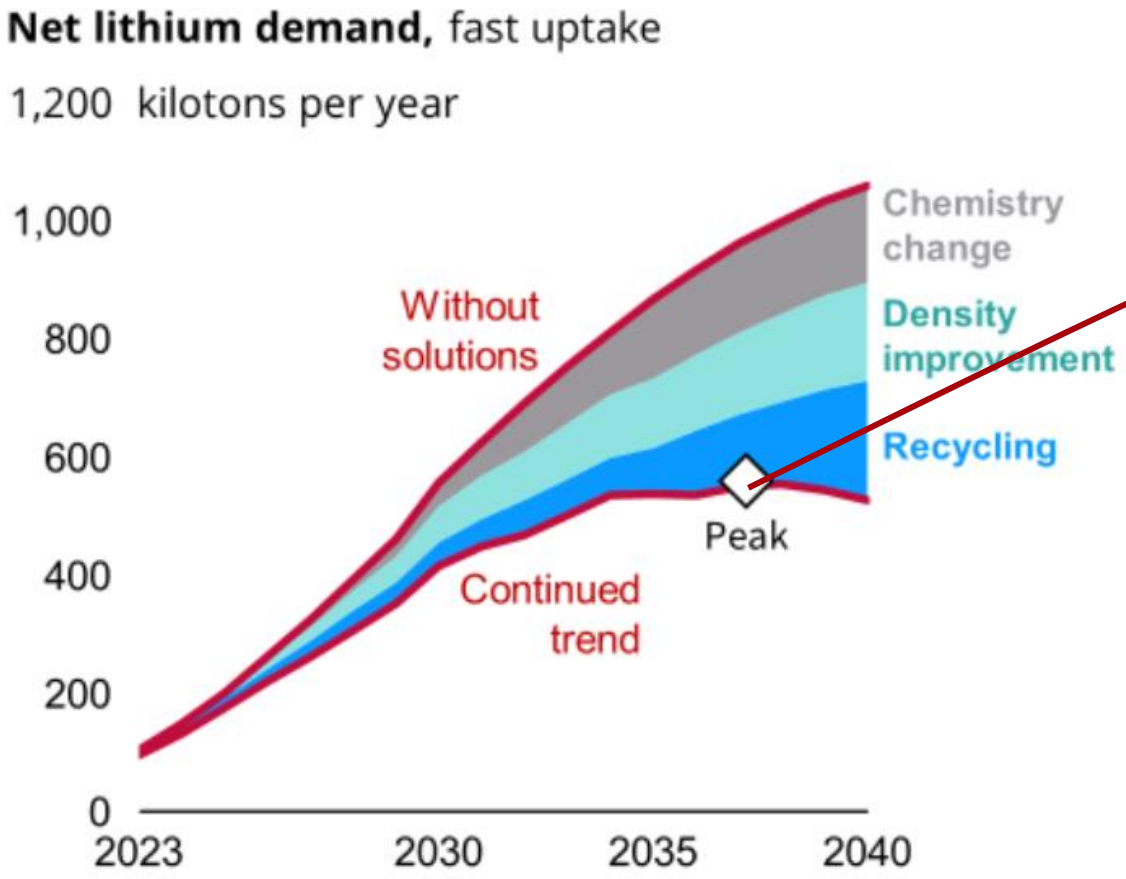
Circular scenario for passenger cars to reduce CO2 by 70% in 2050

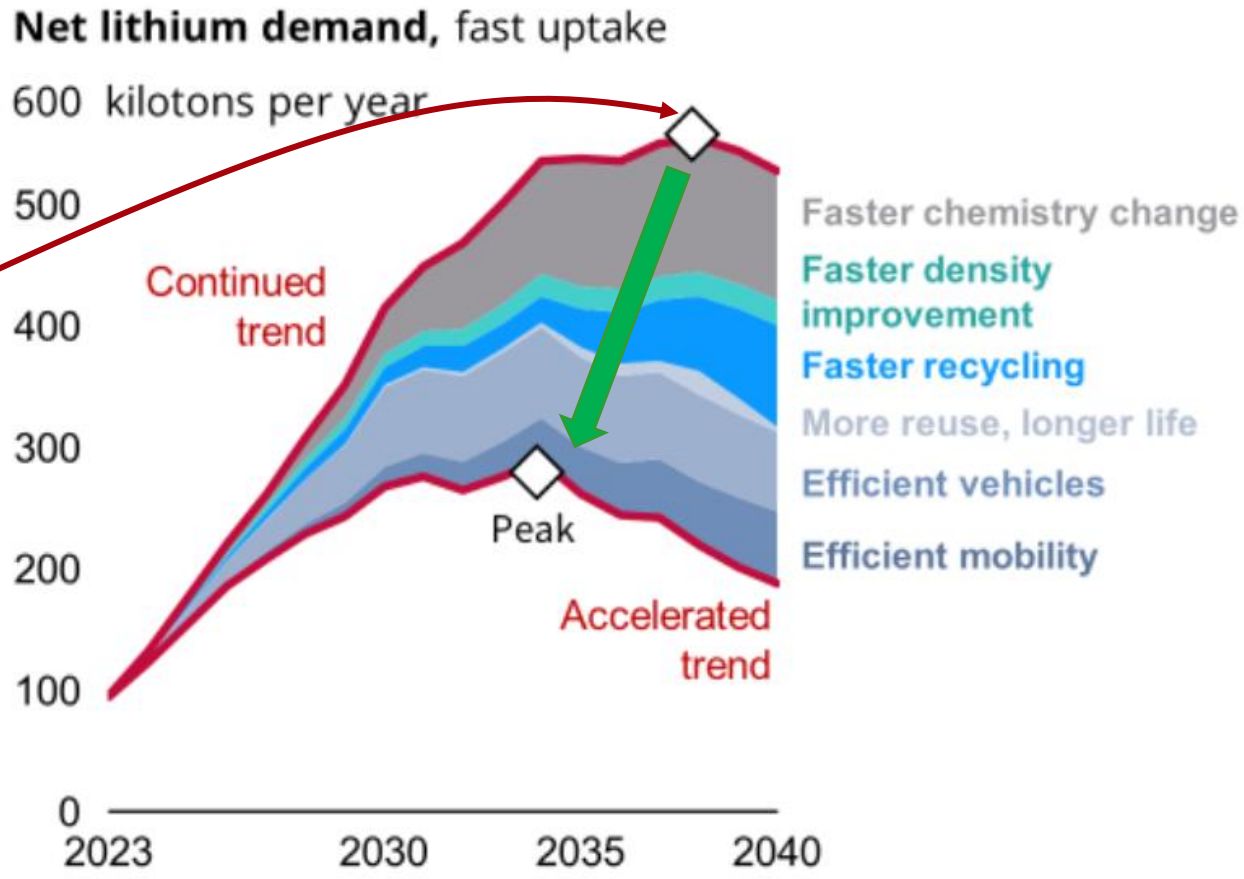
Emissions from all materials used in passenger cars
Million tonnes of CO_2 per year, globally



Completing The Picture - How The Circular Economy Tackles Climate Change | Shared by Comms (thirdlight.com)

Circular approaches critical to raw materials extraction and EVs





The Battery Mineral Loop - RMI

How we approach EV batteries (technology & supply chains, adoption of “R” principles)
has significant impact

Re-manufacturing example: Renault REfactory

Remanufacturing operation

- Reverse logistics ecosystem of partner companies
- Collects the old parts, dismantles and checks conformity,
- Reassembles, sells on as genuine and guaranteed parts
- Parts 40% less expensive vs. new, undergo same quality tests

volume of remanufactured engine parts is significant

- Gearboxes
- Engines
- Turbos
- Injectors)

Since 2012

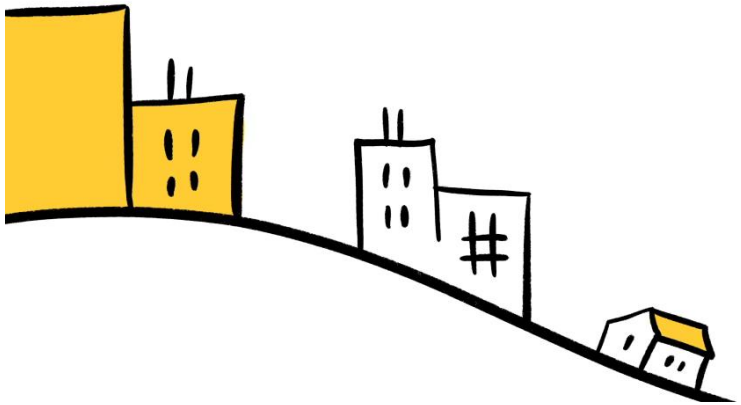
- Gearboxes > 112’000, 60% of components renovated.
- Engines > 73’000, 60 to 70% of components renovated.
- Turbos > 50’000, 40% of components renovated.
- Injectors > 94’000 (since 2010)

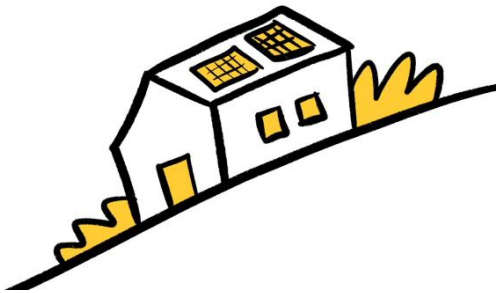
Groupe Renault creates the first european factory dedicated to the circular economy of mobility in Flins - Newsroom Renault Group

Examples

- The circular economy in action (ellenmacarthurfoundation.org)

GROUPE RENAULT





2min40s

Groupe Renault creates the first european factory dedicated to the circular economy of mobility in Flins - Newsroom Renault Group

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Circular Supply Chains Are More Sustainable. Why Are They So Rare?

by Khaled Soufani and Christoph Loch

June 15, 2021

Harvard Business Review

Circular Supply Chains Are More Sustainable. Why Are They So Rare? (hbr.org)

slido

What is inhibiting wider adoption of a circular economy?

ⓘ Start presenting to display the poll results on this slide.

Barriers to Circular supply chains?

- Successful examples tend to be local with products and services made of relatively limited number of components
- Human supply chains:
  - 1) performance via parts specialization AND
  - 2) economic efficiency via economies of scale

Consumers: give up performance for environmental sustainability

Business: give up some of the economies of scale and make less sophisticated products

More standardization designed in (for local recycling vs. aggregation)

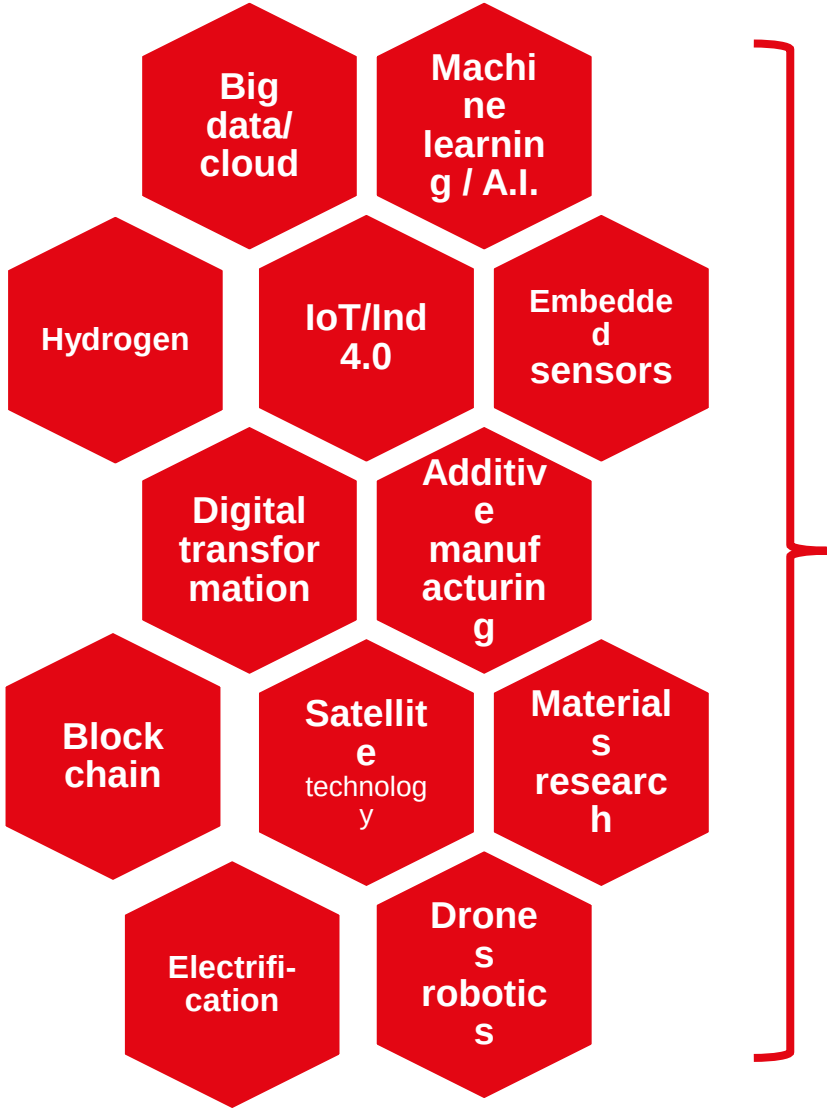
Society needs to embrace this change

VRP's: Barriers to circularity

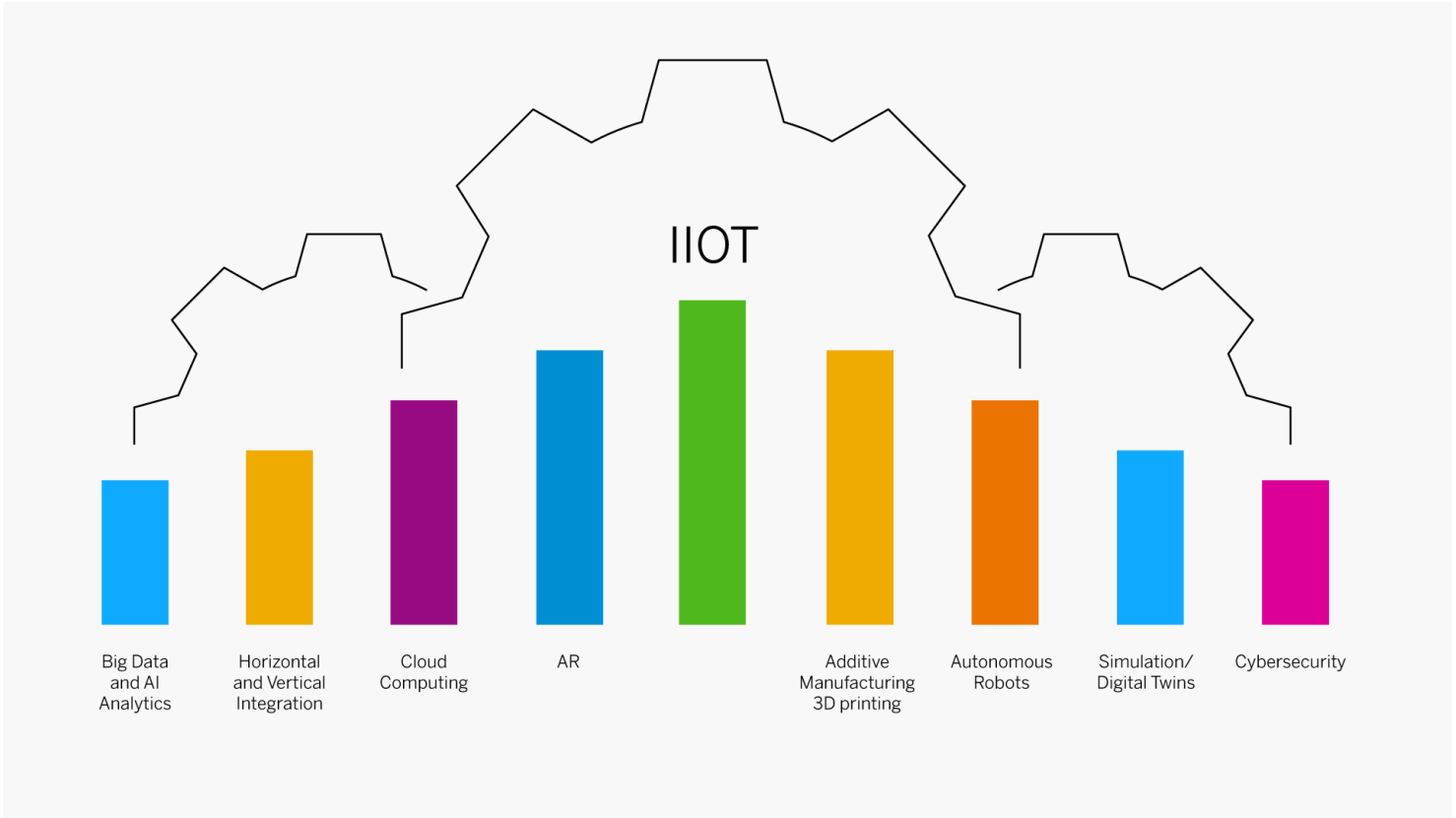
Regulatory and access barriers	Technological barriers	Financial barriers	Market barriers	Collection barriers
• Some used goods classified as "waste" • Macro level taxes and regulations • Special classification and/or import treatment of VRP products • Lack of industry standardization and defined standards	• Limited 3rd party access to OEM specifications • OEM design that inhibits VRP options for product	• CAPEX to VRP facility to existing manufacturing operations • Cost and overhead burden of collection infrastructure and logistics • New labor skills	• New low quality imported products vs. domestic VRP products • Marketing strategies inconsistent & customer confusion? • Lack of customer awareness or market pull (preference for new vs. sustainable products?) • Cannibalization of new products by VRPs (different gross margins?)	• Supply and quality of reuse inputs • Centralized vs. decentralized collection systems / reverse logistic costs • Regulated shared collection cost burden vs. firm-initiated (entire cost burden) • Convenience of diversion vs. disposal options

Re-defining Value – The Manufacturing Revolution | Resource Panel

Technological enablers to circularity / NetZero

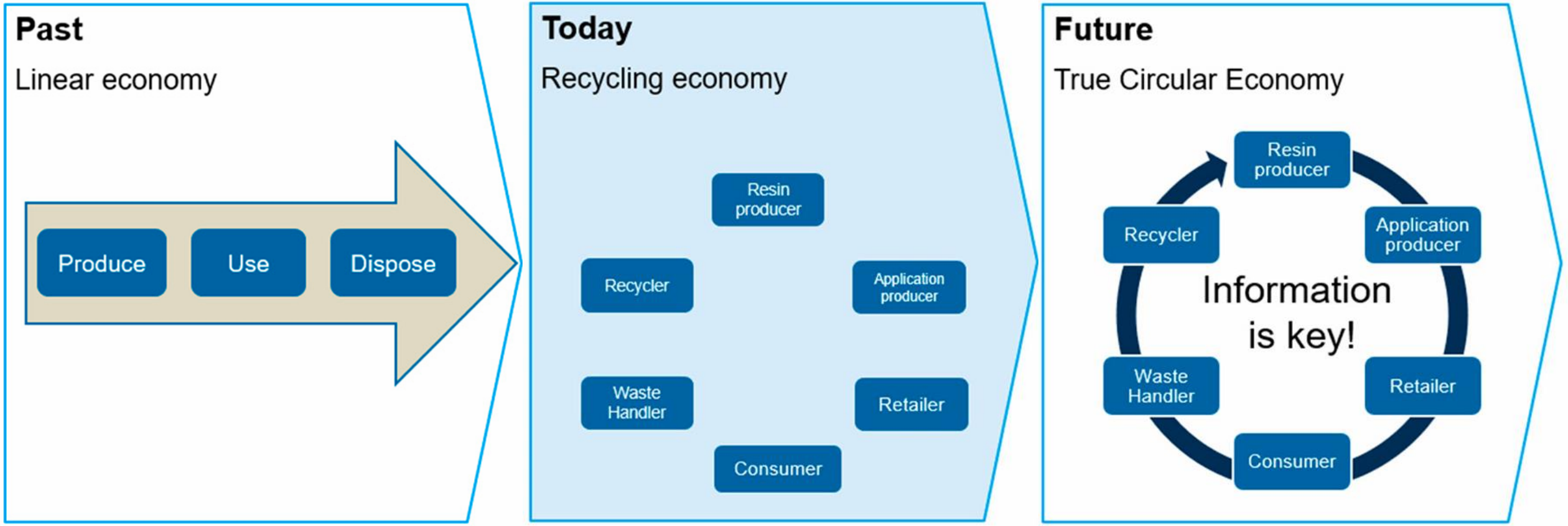


Industry has a huge opportunity to create a circular economy, create clean energy, to mitigate climate change …



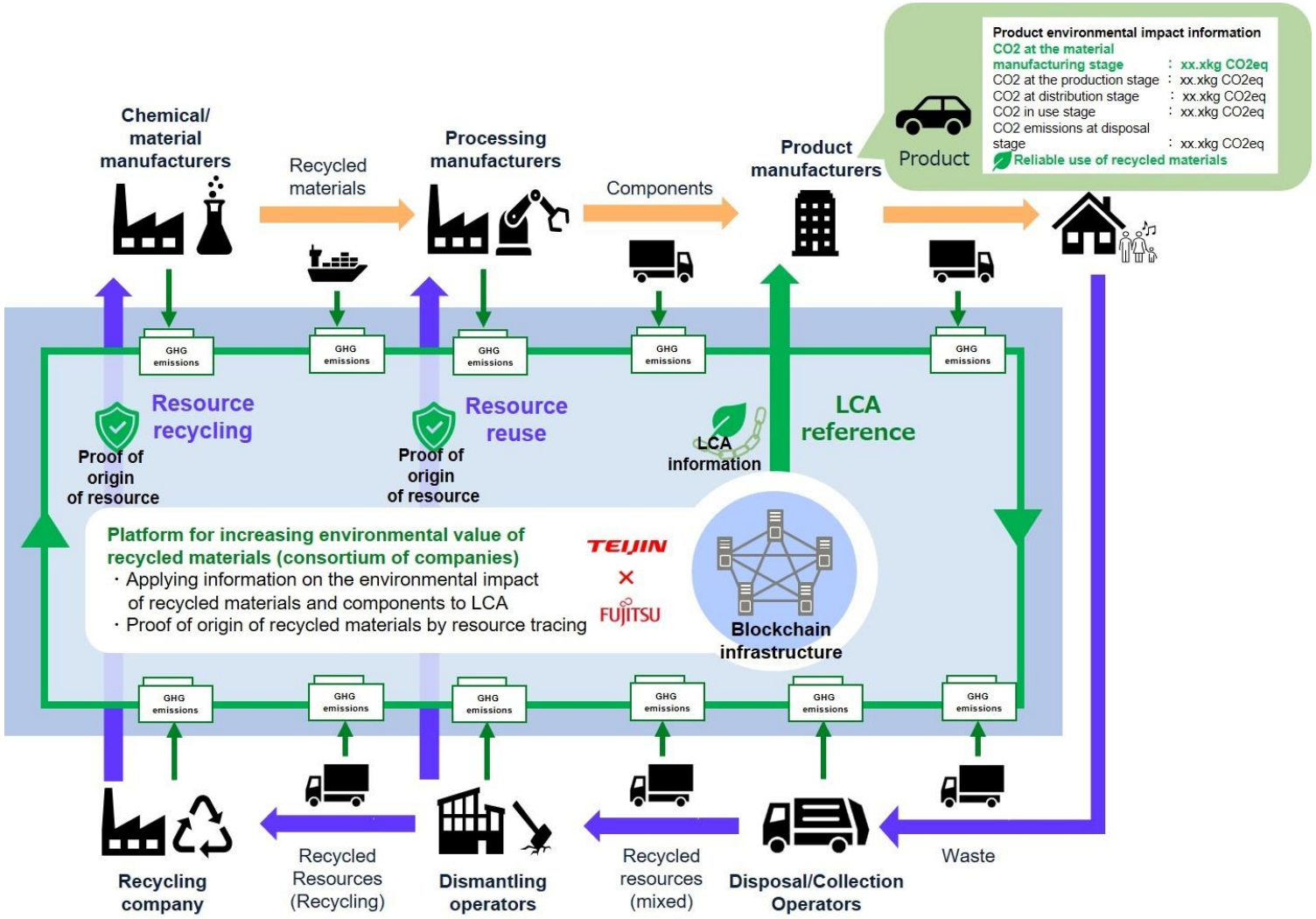
What Is Industry 4.0? | Definition, Technologies, Benefits | SAP Insights

We need a transition in business models …



Polymers | Free Full-Text | Information-Based Plastic Material Tracking for Circular Economy—A Review (mdpi.com)

Block chain enabled carbon fiber composite recycling



Teijin, Fujitsu to develop blockchain-based commercial platform for recycled materials manufacturing | CompositesWorld

PLASTICS TODAY
COMMUNITY FOR PLASTICS PROFESSIONALS

SIGN UP TODAY | Sign in

End Markets | Plastics Processing | Materials | Sustainability | Business | Resin Pricing | NPE News

Blockchain Deployed to Track Sustainability of Composites for Bicycles

Fujitsu and Teijin have started joint trials with Germany's V Frames and Advanced Bikes to enhance the environmental value of recycled carbon fiber used in the manufacture of bicycle frames.

Stephen Moore
January 20, 2023
2 Min Read

IMAGE COURTESY OF V FRAMES

Japan's Fujitsu Ltd. and Teijin have launched a joint project to promote the sustainable use of recycled materials and trace emissions in the bicycle industry using a blockchain platform. The two Japanese firms will work with V Frames GmbH, a German manufacturer and distributor of carbon-fiber-reinforced plastic bicycle frames, and E Bike Advanced Technologies GmbH, a German manufacturer of bicycles, in the joint project running from January to March 2023.

Editor's Choice


MEDICAL
Former Medtech CEO Convicted of Healthcare Fraud
MAR 13, 2024


SUSTAINABILITY
The Next Step to Unlocking Plastic Circularity
MAR 13, 2024


PACKAGING
EPR Goes to Washington
MAR 13, 2024

Blockchain Deployed to Track Sustainability of Composites for Bicycles (plasticstoday.com)

How to achieve the benefits of a circular economy?

Stakeholders	Production systems	Decouple	Retain value	Overcome waste
• Engage value chain stakeholders in behavioral and social system transformation.	• Designing industrial economic and production systems • to enable, accept, and support system circularity.	• Adoption of practices that decouple the rate economic growth from the rate of environmental impact.	• Retain value within the economic system (value-retention processes), including: arranging direct reuse, repair, refurbishment, remanufacturing	• Need emphasis on overcoming waste and retaining value within production- and product-systems

- **Otherwise the pursuit of circular economy can only be incremental, at-best.**

Re-defining Value – The Manufacturing Revolution | Resource Panel

Overview

- Linear economy
- Circular economy
- Engineered product example
- Barriers and enablers to a circular economy
- Systems level systems thinking / mapping

Engineered products and a circular economy

Business models

- NetPositive / regenerative
- Circular financial flows
- Product differentiation
- Leasing
- Servitization
- Sharing (access over ownership)
- Take back programs
- Customer communication / marketing

Supply chain

- Local sourcing and production
- Collaboration co-invest across value chain
- Reduce transportation emissions
- Sell waste as product
- Reverse logistics
- Engage wider stakeholders
- Reduce upstream scope 3 emissions

Production

- Minimize production waste
- Resource efficient manufacturing assets
- Avoid low utilization physical assets via lease
- Reduce scope 1 and scope 2 indirect emissions
- Renewable energy
- Plant / partnerships to enable refurbishment / remanufacturing

Design

- Durability/ longevity
- For dis-assembly
- Optimized (reduce mass)
- For repair
- Supply chain collaboration
- For lowest scope 3 downstream / use phase / EL emissions

Materials

- Lowest embodied energy materials
- Use lower environmental impact materials
- Use recycled / 2ndary / waste materials
- Use less types of material
- Use easier to recycle materials

Business model canvas

Wakeman

2min 20s

Steps: Business model canvas

- 1. Download the Business model canvas
- 2. Sit down with your team and start to fill out the sections of the Business Model Canvas —this will help you use a circular lens for your business.
- 3. There is not a rigid start and end point. Circular design thinking is an iterative process of continuous learning, prototyping and feedback loops. As such, you may continuously come back to the user(s) as their perspectives fit within the system as iterate on this business model.
- 4. When you fill it out the first time, expect there to be holes. It's okay not to know exactly how everything will work. Adapt as needed and continue to reference this as you iterate on your solution.

THE CIRCULAR DESIGN GUIDE

WORKSHEET

Business Model Canvas

A3 or bigger

The business model canvas has been developed by Osterwalder & Pigneur (strategyzer.com). You might have filled one of these in before - here we have added some prompts and questions that you might find helpful in the context of the circular economy.

If you need more space, create your own canvas using post-its.

IDEO

ELLEN MACARTHUR FOUNDATION

MSE-433

Circular design guide - Business Model Canvas | Shared by Digital (thirdlight.com)

EPFL

Which SDGs do you target?

(1) scope 1&2, 3 upstream & downstream (EL)
(2) use/consumption)

SDG	(1)	(2)
1 No Poverty		
2 Zero Hunger		
3 Good heath		
4 Education		
5 Gender		
6 Clean water		
7 Clean energy		
8 Decent work		
9 Innovation / industry		
10 Reduced inequalities		
11 Cities and communities		
12 Consumption / production		
13 Climate		
14 Life below water		
15 Life on Land		
16 Peace & justice		
17 Partnerships for goals		

MSE-433

Which impacts do you reduce? (quantify)

	Climate change	Freshwater loss	Chemical & plastic pollution	Forest & seabed loss	Biodiversity loss	Suit nutrient pollution
Scope 1 direct						
Scope 2 indirect						
Scope 3 upstream						
Scope 3 downstream						

Your design space

Examine
- Business
- Supply chain
- Production
- Materials

Wakeman

Where are you circular?

7 principles	
1 Longevity	
2 Reuse (refurbish / repair/ remanufacture)	
3 Resource-efficient manufacturing	
4 Recycling / design for disassembly	
5 Collaboration in value chain	
6 Local sourcing & production	
7 Business model innovation	

Draw product and supply chain flows: higher thickness is higher intensity

- Monetary-flow
- Mass-flow
- Emissions-flow
- Information-flow

What are your SMART quantified initiatives?

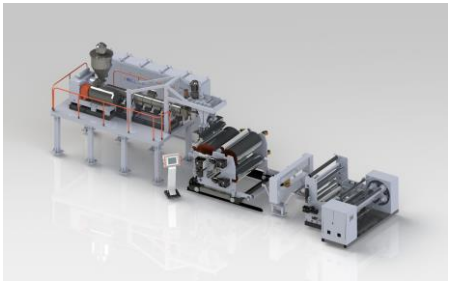
Specific	Measurable	Attainable	Relevant	Time-oriented	Slow	Close	Narrow	Regenerate

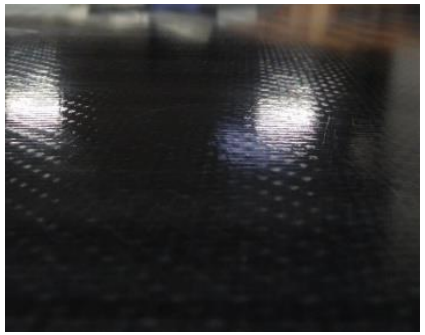
GF/PA Seat back structure –supply chain cradle to gate



Glass fiber raws





Tier 4: DBP
(TPC sheet lamination)

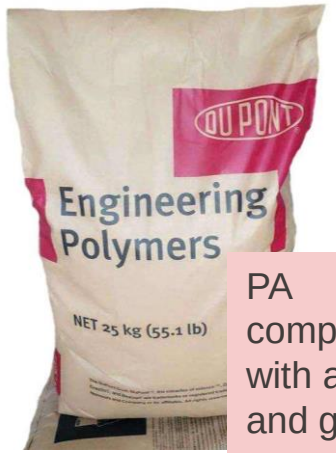
Tier 3: Molding machines
(press)

Tier 4: DBP
(PA pellets)

Tier 3: Molding machines
(injection, robots)


PA polymerization

PA intermediates



PA compounding with additives and glass

PA raws (Petrochemicals)

OEM: Volvo
(mount seat in car)

Tier 1: Johnson Controls
(seat assembly)

Tier 2: KB
(molding seat frame)

Wakeman

EPFL

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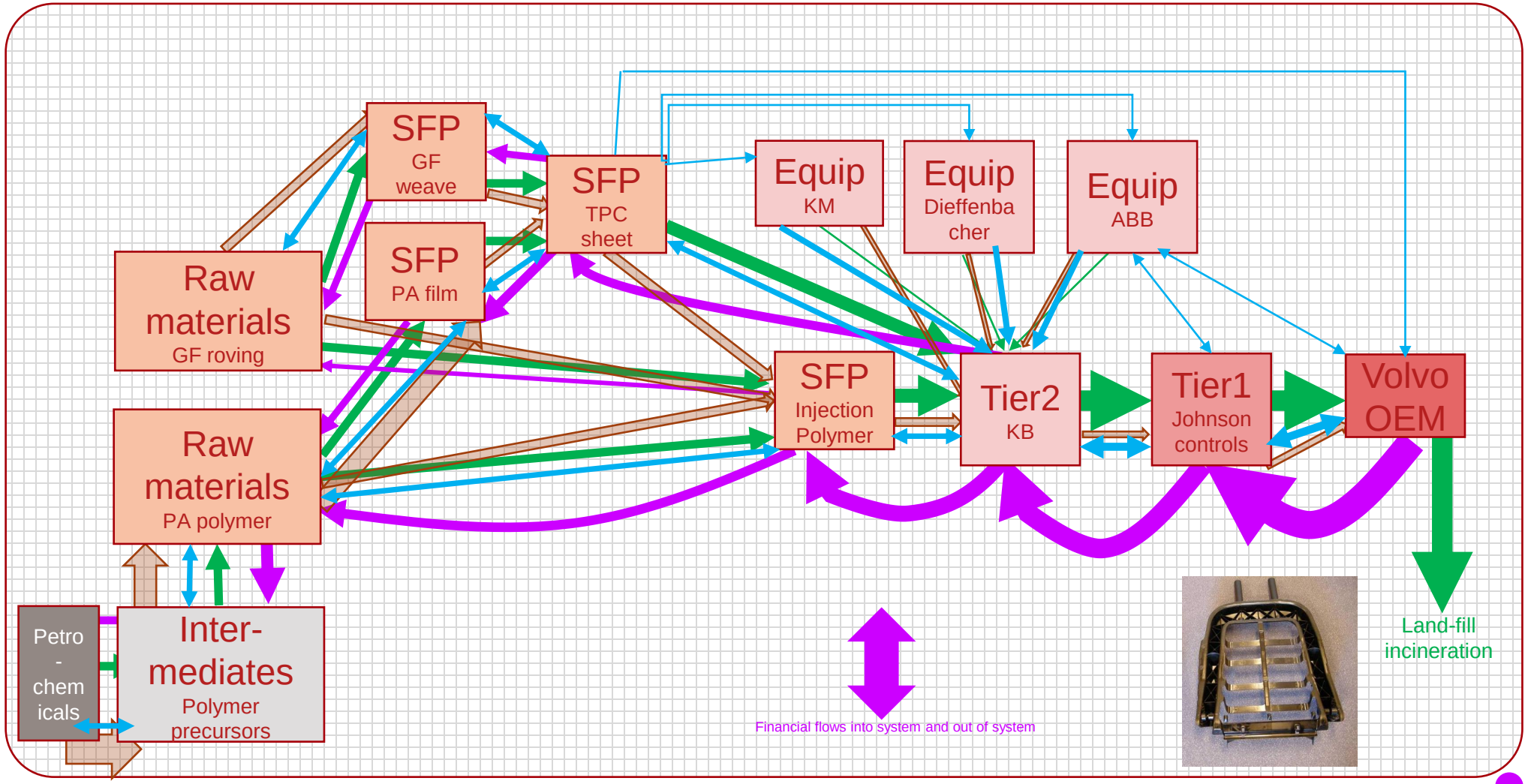
MSE-433

Which impacts do you reduce? (quantify)

	Climate change	Freshwater loss	Chemical & plastic pollution	Forest & seabed loss	Biodiversity loss	Suit nutrient pollution
Scope 1 direct						
Scope 2 indirect						
Scope 3 upstream						
Scope 3 downstream						

Your design space



What are your SMART quantified initiatives?

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Examine

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Wakeman

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EPFL

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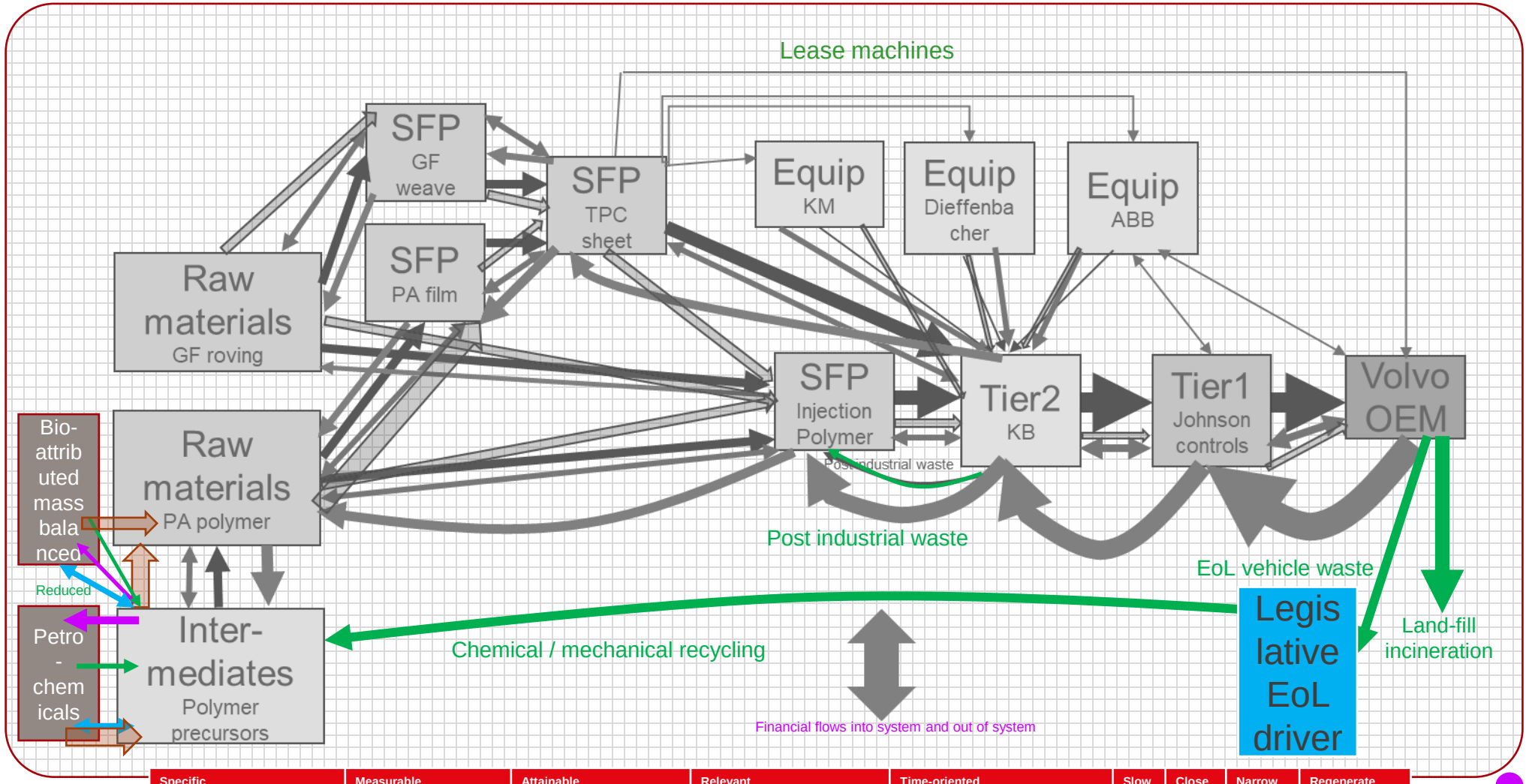
4 Education		
5 Gender		
6 Clean water		
7 Clean energy		
8 Decent work	■	
9 Innovation / industry	■	
10 Reduced inequalities		
11 Cities and communities		
12 Consumption / production	■	
13 Climate	■	■
14 Life below water	■	■
15 Life on Land	■	■
16 Peace & justice		
17 Partnerships for goals		

■ MSE

Which impacts do you reduce? (quantify)

	Climate change	Freshwater loss	Chemical & plastic pollution	Forest & seabed loss	Biodiversity loss	Suit nutrient pollution
Scope 1 direct	■					
Scope 2 indirect	■					
Scope 3 upstream	■		■	■		
Scope 3 downstream	■		■	■		■

Your design space



What are your SMART quantified initiatives?

Specific	Measurable	Attainable	Relevant	Time-oriented	Slow	Close	Narrow	Regenerate
25% of plastic recycled of which 25% from automotive sector	Only 19% of plastics in automotive recycled today	Proposed EU legislation Cost less than 70 euro/car	Automotive accounts for 10% of EU plastics use	Targets awaited	■	■	■	
Use mass-balanced bio-attributed PA grades	e.g. DSM Stanyl, 50% CO2e reduction	Commercially available (at what % of demand?)	Petro-chemical emissions dominant in product CO2e/part	Whole DSM portfolio available in bio- and/or recycled alternatives by 2030	■	■	■	
Post industrial waste recycled	90% returned from Tier 2 for recycling	2% reject rate, known materials	Polestar have block chain labelled materials	Driven by legislation	■	■	■	

Examine
- Business
- Supply chain
- Production
- Materials

Wakeman

Where are you circular?

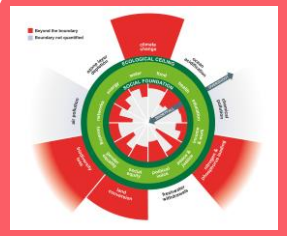
7 principles	
1 Longevity	■
2 Reuse (refurbish / repair/ remanufacture)	■
3 Resource-efficient manufacturing	■
4 Recycling / design for disassembly	■
5 Collaboration in value chain	■
6 Local sourcing & production	■
7 Business model innovation	■

Draw product and supply chain flows: higher thickness is higher intensity

- Monetary-flow
- Mass-flow
- Emissions-flow
- Information-flow

PESTLE level, trans-disciplinary thinking

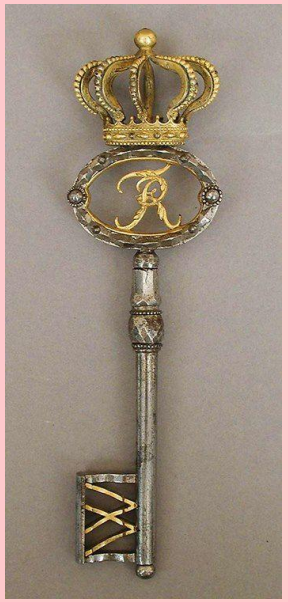
Political	Environmental	Social	Technological	Legal	Economic
Give vision	Great acceleration	Shifting baseline	Entrepreneurship	Reporting	People
Guide	Earth system trends	Trade flows	Bio-mass	Transparency	Planet
Incentives	Planetary boundaries	Consumption	Stranded assets	Close loop holes	Profit
Collaborations	Tipping points	Wealth inequality	Energy	Financial regulation	SROI
Policy	Bio-diversity	SDGs	Transportation	Favor circularity	ESGs
		Social foundation	Electrification	Prosecute offenders	Reporting: scope 1,2,3
			Agriculture	Manage markets	Sustainable finance
			Hydrogen		Impact investments
			A.I.		Transparency
					Net Positive

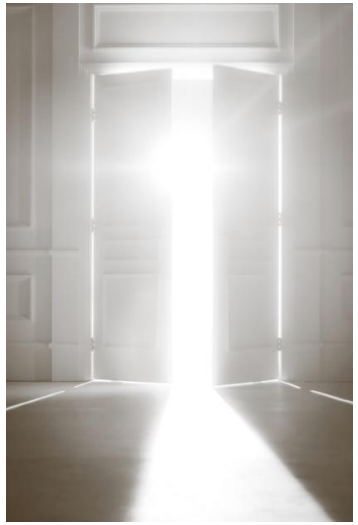


- Innovation is needed: Government, Policy, Finance, Universities
- Technology: works best in a systems approach

PESTLE level thinking for systemic change

Political	Environmental	Social	Technological	Legal	Economic





Images from MS Bing

Summary: Eliminate. Circulate. Regenerate.

to reduce emissions and meet the targets set out in the Paris Agreement

Half of the story

- The transition to renewable energy is vital in order to tackle climate change

2nd Half of the Story

- 45% of global greenhouse gas emissions come from the way we make and use products and food.

That means we need to redesign our economy

- Eliminate waste and pollution
- Recirculate products and materials
- Regenerate nature

- We need a circular economy to help us reach NetZero

Completing the picture - How the circular economy tackles climate change - YouTube

2min15s

Annex

Circular design space instructions

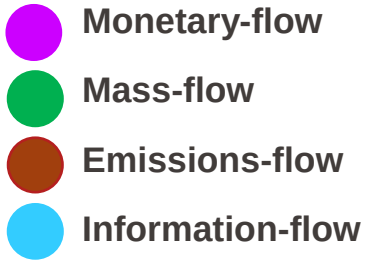
Draw two supply chain maps of:

1) Linear incumbent supply chain
2) Their proposed circular alternative

- First draw boxes of the main supply chain steps (companies involved) and then connect these blocks with 4 sets of lines using the color code in the file. Use thicker lines where the flows are stronger using experience and what data you can find.

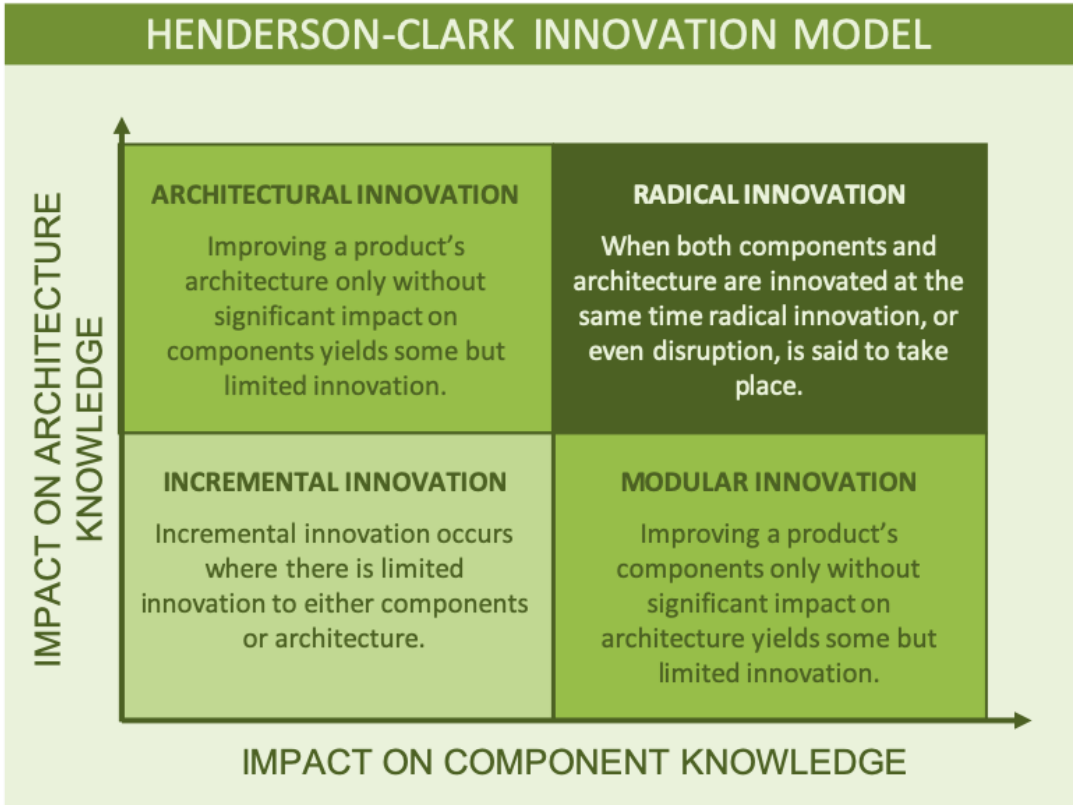
- **Monetary flow**
  - payment for virgin products, payments for waste products, payments for recycled products, payments for leased services, payments for waste disposal
  - income from selling products, income from selling waste bi-products to a different company, income from supply a service, income from royalties/licensing etc
  - investments in: own facilities (primary), own facilities (re-furbish, repair, remanufacture etc), in a supply chain partner (JDA) / shared assets, in wider stakeholders
- **Mass flows**
  - Virgin products
  - Post-industrial waste
  - End of life waste
  - Re-use of recovered products: re-furbish, repair, remanufacture
  - Use of recycled materials to replace virgin feedstock
  - Use of lower embodied energy virgin feedstock to replace primary (petrochemical) feedstock
  - Lease of materials / ownership & take back
- **Emissions flows**
  - Examine scope 1, 2, 3 (upstream and downstream of where your 'start-up' is in the supply chain
  - As a first pass examine CO2e
  - As a second pass, emissions examined through broader lens: climate change (CO2e), freshwater impact, Chemical and plastic pollution reduction, Forest and seabed impacts, biodiversity impacts, suit pollution impacts)
  - Look at where in the supply chain the emissions occur
- **Information flow**
  - How can information flow be enhanced?
  - Sharing of LCA data
  - Blockchain/other
  - Enhance recycling stream purity
- **Mappings**
  - Where are you circular (7 principles)
  - Examine which SDGs you address
    - Direct (scope 1 & 2, scope 3 upstream and scope 3 downstream at end of life_
    - Indirect (scope 3 downstream in the use / consumption phase)
  - Which impacts do you reduce?
  - What are your SMART (quantified) initiatives?

Draw product and supply chain flows: higher thickness is higher intensity



Henderson – Clark innovation model

- Four innovation quadrants, keys towards sustainable solutions:
  - Incremental (existing concepts of technology that enhance value to the customer via improved features and design changes),
  - Architectural (apply lessons and skills to a different market),
  - Modular (stealth innovation, applying new technology or processes to the companies current market, disruptive),
  - Radical (giving birth to a new industry, new product or a revolutionary technology.
- Innovation needs to find restorative and regenerative solutions that affect
  - research (imagination, creativity, design, product, process),
  - teamwork,
  - communication,
  - management drive and interest together with a commitment for results.



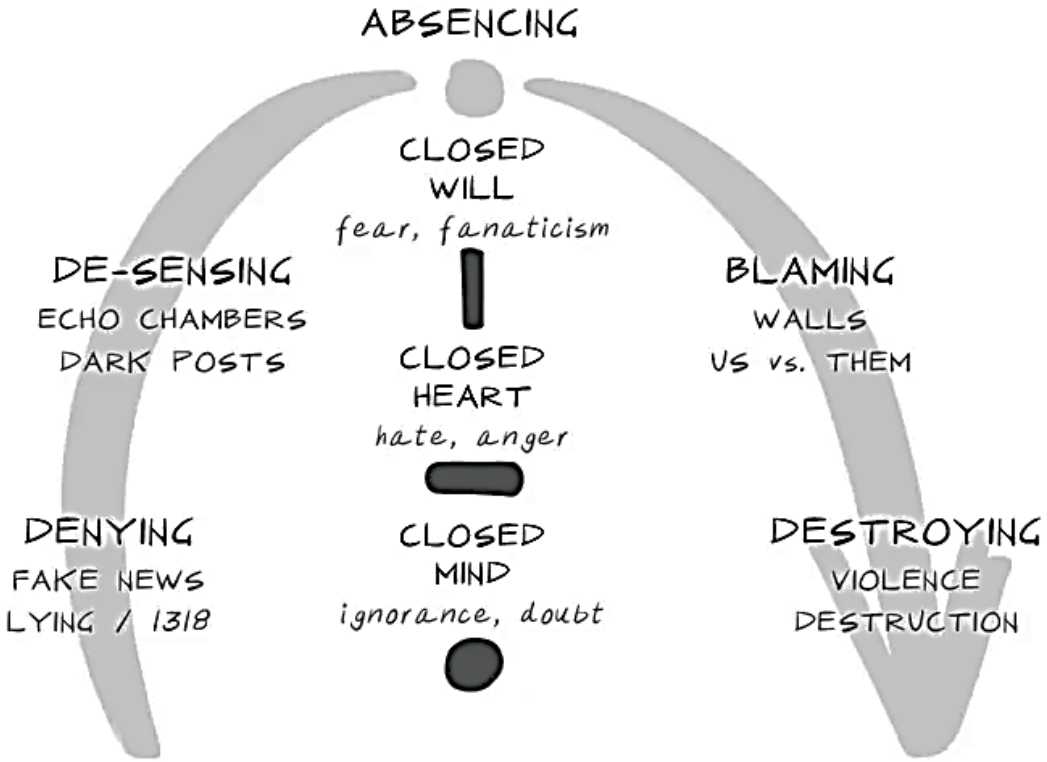
The Henderson-Clark Innovation Model: A Simple Summary - The World of Work Project

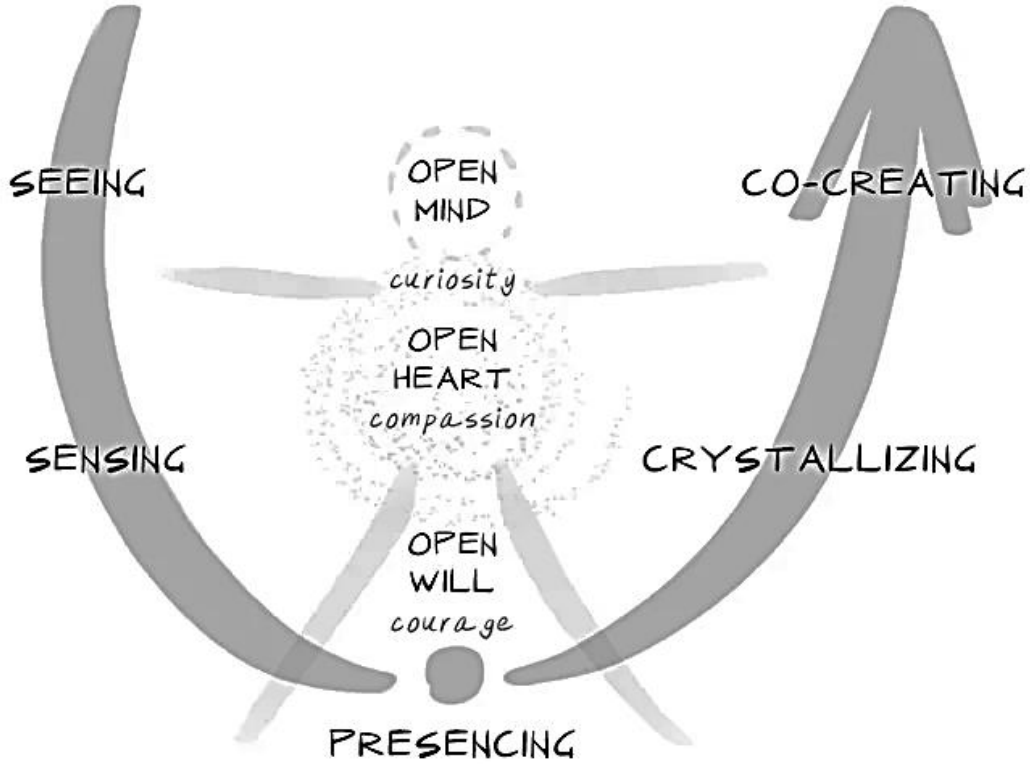
Four Levels of Responding to Change

Introduction to U-Lab: Leading Profound Innovation for a More Sustainable World | U-Lab: Leading Profound Innovation for a More Sustainable World | Sloan School of Management | MIT OpenCourseWare

Theory U

- How we think and communicate affects our ability to drive change





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Non-violent communication

- 1. Listening Accurately
  - Listening is half of the process in NVC. Listening Accurately Worksheet to improve your listening skills to identify the feeling and need underneath your partners' words.
- 2. Conflict Resolution Checklist
  - When using NVC in a conflict resolution situation, this helpful Conflict Resolution Checklist will help you keep track of which aspects of the conflict have been resolved. Use this to eliminate loose ends and prevent unresolved conflicts from festering.
- 3. Anger Exit and Re-Entry Routines worksheet
  - Anger is the emotion that may be most likely to block compassion from occurring. If anger holds you back in your pursuit of using NVC, use this Anger Exit and Re-Entry Routines worksheet to learn a strategy for defusing your anger.
- 4. TRAPS to Avoid and TIPS for Success
  - This worksheet breaks down some of the common traps in an emotionally loaded conversation. Consider reviewing this sheet with a client preparing to have a difficult talk with an important other.
- 5. Using "I" Statements worksheet
  - Using "I" statements is a vital component of NVC, as it allows the speaker to own their statements and take responsibility for their needs and feelings. Use this worksheet to help yourself or your client with this important skill.