Circular economy business models for the manufacturing industry

Circular Economy Playbook for Finnish SMEs

SITRA Technology Industries of Finland accenture High performance. Delivered.

This playbook is tailored to companies in the Finnish manufacturing industry, giving detailed examples for the following four sub-sectors:

(1) Machinery & Equipment, (2) Marine, (3) Energy and (4) Transportation

It specifically addresses companies that want to

- Better meet customer expectations and deliver customer outcomes
- Enable outcome-oriented solutions and new levels of efficiency through technology and digitalisation
- Improve resource utilisation and mitigate risk from regulatory, investor and societal pressures

The playbook calls for action by

- Describing the rationale for why circular economy is relevant (Chapter 1)
- Identifying circular business models with highest value potential per sub-sector (Chapters 2 & 6)
- Outlining required organisational and operational changes (Chapters 3 & 4)
- Providing a blueprint of a transformation journey for companies to achieve circular advantage (Chapter 5)

Playbook content

A set of tools complement the playbook, and help you get started with your circular journey

Tool	Description	Relevant chapter(s)
Business model development toolkit	Set of exercises for identifying inefficiencies and customer pain points, assessing relevance of circular business models, and prioritising them.	Chapters 1, 2, 6
Business model canvas	Template for crystallising your circular business model.	Chapters 2-6
Value case tool	Tool for calculating high-level business case for circular business models.	Chapter 2
Capability maturity assessment	Tool for assessing your company's maturity in circular capabilities.	Chapter 3
Technology maturity assessment	Tool for assessing your company's maturity in technologies enabling circular economy.	Chapter 4
Culture gap analysis	Tool for analysing how circular your company culture is.	Chapter 5
Ecosystem partner identification	Tool for identifying ecosystem partners to support your circular business idea.	Chapter 5
Funding requirement analysis	Tool for reflecting on funding requirements and required activities to secure funding for your circular idea.	Chapter 5
Roadmap development	Tool to support you in planning your circular transformation journey.	Chapter 5

Executive summary

- The way we currently design, produce and use products is leaving a lot of value on the table, which is why we need to rethink the linear manufacturing industry
- The aim of circular economy is to maximise the time products, components and materials are kept in use – it is an endless cycle that captures untapped value potentials of the traditional take-make-dispose value chain
- Successful transition towards circular economy is critical to innovation and continued growth, and time is now right to drive the pace of adoption in the Finnish manufacturing industry
- Circular economy principles have been around for centuries, but it is not until recently that circular business models have gained increased traction as they are being powered by rapid technology development and increased focus on delivering customer outcomes
- Leading companies are focusing on customer outcomes and redefining their value chains to enable efficient delivery
- Circular business models can be applied across the entire value chain – however, the biggest value potential is typically achieved during the product usage phase, requiring increased forward integration of manufacturing companies
- Successful transformation into circular business requires a considerable shift in capabilities, mindset and collaboration as manufacturing companies will have to adapt their products and solution design, and continuously engage with their customers and ecosystem partners
- Business intelligence derived from IoT, sensors and analytics to improve life-time productivity can increase value by enabling high life-time revenues and increased profit margins on installed base
- Companies within the Finnish manufacturing industry are strongly committed to circular economy and recognises its connection to growth and profitability, and the supporting ecosystem is also starting to mature
- Circular economy cannot be achieved by one company alone, and collaboration between traditional and new actors in the ecosystem will be required to close the loops efficiently
- We invite you to use this playbook to find your role in the circular ecosystem

Quotes from the authors

"Circular economy is far from common knowledge in the Finnish manufacturing sector. Especially, companies struggle to take the last leap towards 'as a service'-models, as it requires a huge shift in business logic, mindset and culture. With digital solutions, and this playbook and tools, companies are receiving the missing link, a measurable business case, that turns inefficiencies in current linear value chains and new circular opportunities into business value."

Jyri Arponen, Senior Lead, Business Development, Circular Economy, Sitra

"Finnish technology companies have already taken big steps, when it comes to energy and material efficiency. However, circular business models are still a largely unexploited opportunity. I am glad that we now have concrete examples and tools to help Finnish SMEs forward in their transformation journey"

Laura Juvonen, Executive Director, Growth and Renewal, Technology Industries of Finland

"Deep-down, circular economy is all about customer-centricity - creating customer-centric solutions using new technologies in a sustainable way. This requires a new mindset, new capabilities and new kinds of partnerships. This playbook provides practical guidance for companies willing to achieve the circular advantage."

Pekka Vanne, Managing Director, Accenture Strategy

Quotes from selected companies

"It is great to see a systematic and thought provoking set of concrete tools and a process to assist companies moving towards circular economy. The sooner the corporate strategy and activities are steered towards circular economy, more competitive advantage and sustainable growth can be gained. This will attract financiers and in the long run it will become a requirement for their participation."

Jussi Hattula, Director, TESI

"Nokia realises that it is ideally placed to enable the move towards a zero-emission digital future. In our own operations we are continually driving efficiencies in our supply chain, improving on already high levels of product takeback, reuse and recycling offering and supporting sharing business models by providing leading edge connectivity. Collaborating using this capability and ambition to build toolkits and improve understanding of the importance and opportunities of circularity will build sustainable momentum needed in closing the loop."

Pia Tanskanen, Head of Environment, Nokia

"An eye-opening experience, with not only on path to follow, but several interesting avenues to pursue circular economy possibilities and opportunities. Circular economy is not only a case of recycling things, this is an opportunity to re-invent your business – an opportunity to re-think your business model."

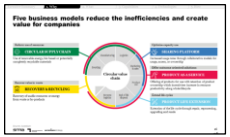
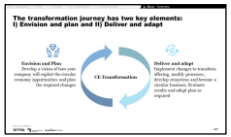
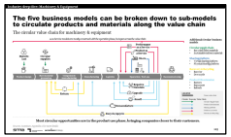
Jouni Teppo, Managing Director, Sisu Axles

"The circular economy playbook gave us a great framework for assessing where the best circular economy opportunities for our company would be. It also helped us to define the most attractive ideas and guided us think about the business cases behind them. The first projects that lead us to the right direction have already been started"

Matias Impivaara, Vice President Business Growth and Development, Beneq

The playbook and supporting tools will provide you with in-depth understanding on how to achieve circular advantage

The playbook consists of 6 chapters and supporting tools for identifying company specific circular opportunities

	1. Why circular economy?	2. What opportunities exist?	3. Which capabilities are required?	4. Which technologies can support?	5. How to design the transformation journey?	6. Industry deep dives
						
Content	Burning platform for circular economy • Inefficiencies of the linear value chain • Drivers of circular economy • Leading examples	Circular opportunities for manufacturing industry • Current state analysis • Circular business models • Value benefits	9 circular capabilities • Detailed description • Required know-how • Recommended approach • Leading practices	19 technologies enabling circular business models • Detailed descriptions • Circular relevance • Assessment parameters • Risk assessment	Circular transformation journey and roadmap • Envision and plan • Deliver and adapt • Barriers incl. culture, ecosystem collaboration, finance	Current state analysis and circular opportunities for • Machinery & Equipment • Marine • Energy • Transportation

+ Supporting tools, including for example value case tool, business model canvas, capability gap assessment tool, etc

Why is Circular Economy relevant?

Rationale for Finnish manufacturing companies to engage in circular economy

This chapter will help you to:

- Understand why circular economy offers an advantage compared to the linear value chain in terms of addressing inefficiencies and untapped value potential
- Learn why now is a good time to shift from linear to circular business

CHAPTER SUMMARY

Why is Circular Economy relevant?

- Circular economy is relevant as it offers companies the opportunity to turn inefficiencies in linear value chains into business value
- These inefficiencies look beyond production waste, focusing on underutilised capacities, premature product lives, unsustainable materials, wasted end-of-life value and unexploited customer engagements
- Three drivers underpin the shift towards circular: the trend of increased customer-centricity, sustainability and enabling technologies
- Global and Finnish early movers have already started to successfully address inefficiencies through circular principles

Circular economy is about turning inefficiencies in linear value chains into business value

Inefficiencies of linear value chains

UNSUSTAINABLE MATERIALS

Material and energy that cannot be continually regenerated

– for example, direct and indirect materials are not renewable or bio-based

UNDERUTILISED CAPACITIES

Underutilised or unused products and assets

– for example, products are not operating full hours or full functionality is not useful

PREMATURE PRODUCT LIVES

Products are not used to fullest possible working life

– for example due to new models and features or lack of repair and maintenance

WASTED END-OF-LIFE VALUE

Valuable components, materials and energy are not recovered at disposal

– for example, not recycled or recovered at end of life

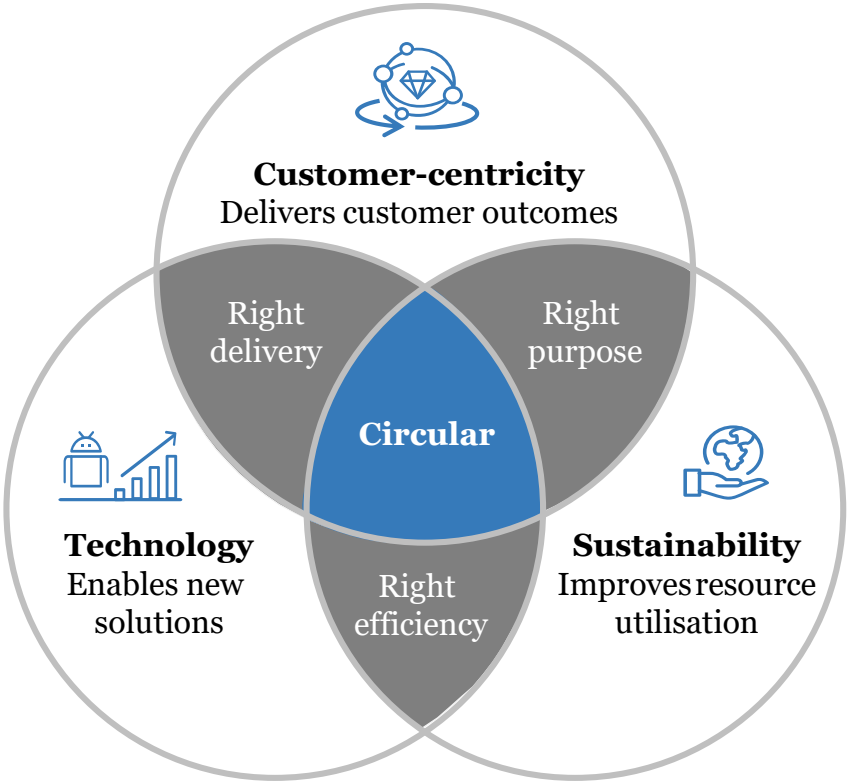
UNEXPLOITED CUSTOMER ENGAGEMENTS

Sales organisation focus on selling functionality of product rather than the customer problem

– for example, missing opportunities to engage customers throughout the product life-cycle to offer additional services and add-on sales

Source: Accenture, Appendix 2 for more details

Three drivers underpin the shift towards circular



Source: Accenture, Appendix 2 for more details

Better customer values can be delivered through offering outcomes instead of selling products

From selling products…

Profit is generated by selling as **many products** as possible, **fuelling inefficiencies** along the value chain

Example: From Rolls Royce selling engines…

… to offering outcomes

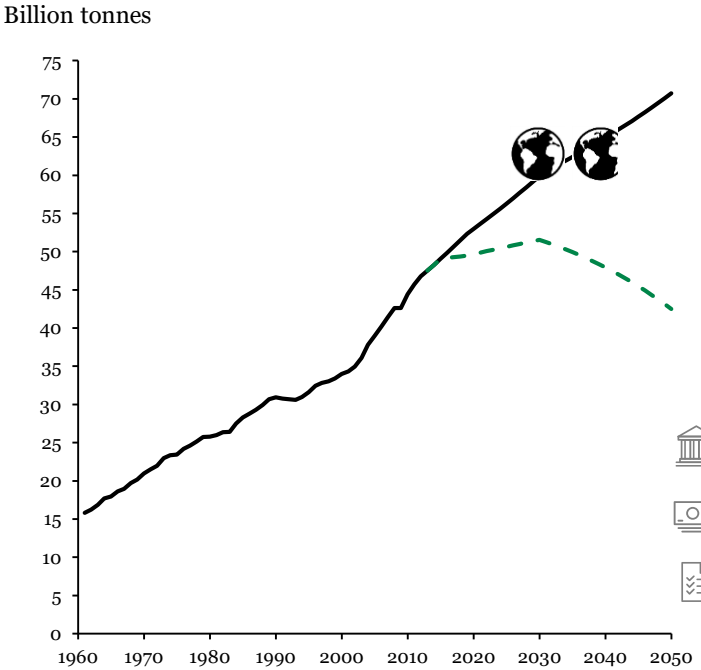
Profit is generated by **delivering solutions** that fit specific customer needs, **minimising inefficiencies** and **increasing consumer experience**

… to Rolls Royce selling "Power by the hour" to customers for a fixed charge per hour of operation, per ship. Rolls Royce offers planned maintenance and monitoring services for the equipment aboard from on-shore with the help of sensors[1]

Source: 1: Company website

Our overuse of natural resources drives regulators, investors and companies towards sustainability

Development of resource demand[1]



New consumption pattern needed

Gap in supply is driving changing market conditions

- Regulatory pressure is increasing
- Investments are shifting towards responsible businesses
- Businesses raise supplier requirements

In 2015, the UN general Assembly, representing 193 countries, set the Sustainable development goals. Goal 12 aims, amongst others, at decoupling economic growth from natural resource use

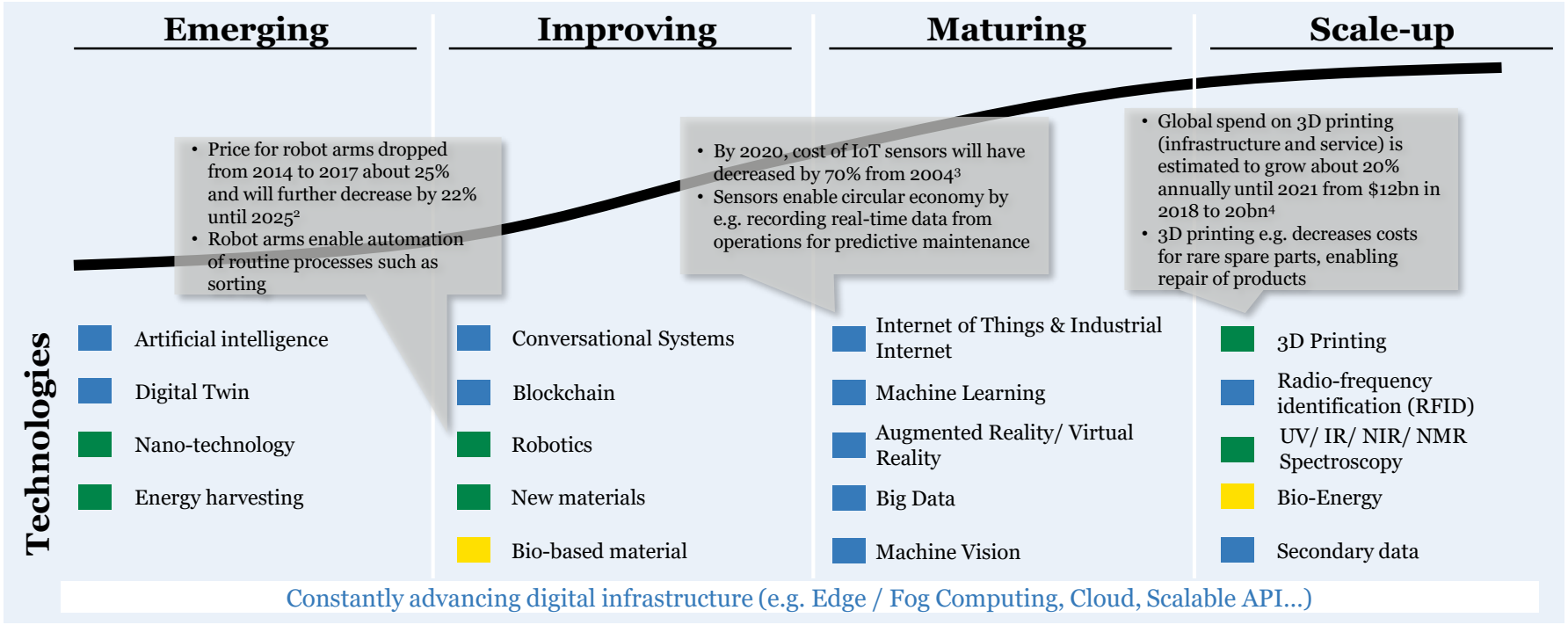
BlackRock CEO Larry Fink asks companies to make positive contribution to society[2]

Companies request suppliers to disclose sustainability performance – 27% of CDP supply chain programme members, representing $2.7 tn in procurement spend, have supplier carbon emission targets[3]

Sources: 1: Accenture, Appendix 2 for more details, 2: CNN, 3: CDP

Technologies are developing at a rapid pace and enable companies to deliver on circular economy objectives

Level of technology development[1]



Sources: 1: Accenture, Appendix 2 for more details, 2: IEEE Engineering360; 3: Bank of America, Merrill Lynch; 4: International Data Corporation (IDC)

Legend: Type of technology — Digital — Physical — Biological

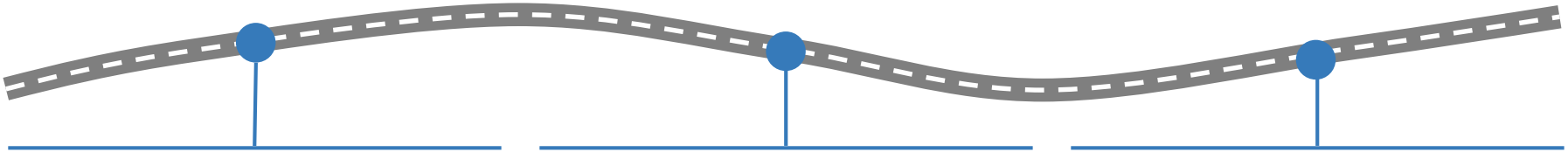
Early movers from manufacturing industry have already started addressing inefficiencies using circular principles

Inefficiency	Illustrative examples from manufacturing companies
UNSUSTAINABLE MATERIALS	Volvo uses **one third recycled materials** in new trucks and designs them for recycling so that 90% can be recycled Wärtsilä applies a **modular engine design** to enable increased commonality and backward compatibility of parts
UNDERUTILISED CAPACITIES	Caterpillar acquired Yardclub, a **platform facilitating equipment sharing**
PREMATURE PRODUCT LIVES	Bosch operates **remanufacturing** chains for high-quality components to ensure a high fraction stays in its loops The Schneider Electric Circuit Breaker Retrofit-program **modernises and updates** electrical distribution centres Konecranes provides a Lifecycle Care-program that includes consultation services, **modernisation & maintenance**
WASTED END-OF-LIFE VALUE	GM recycles 84% of its worldwide manufacturing waste and has **111 landfill-free facilities** Maersk introduced a Cradle-to-Cradle Passport for vessels, a **database listing the material composition** of the main parts of the ship, enabling better recycling of materials and parts
UNEXPLOITED CUSTOMER ENGAGEMENTS	Michelin offers **tire as a service** (pay per mile) and sensor-based data analytics for predictive maintenance Philips has several contracts signed for providing **light as a service** on a pay-per-lux basis or monthly subscription

Source: Company websites

CFOs of Finnish manufacturing companies fear competition from digital disruptors that take over customer relationships

19% **of CFOs from Finnish manufacturing** companies named **customer data managed by other companies as the biggest risk** from disruptive companies or technologies



Disruptors may start with one service…

Disruptor gets access to customer data

***2000-2010**: Google evolved from providing search engine to browser to smart phone operating system*

… developing into a key digital platform for users …

Disruptor extends access to digital and physical (e.g. location) data, becoming the interface for digital services for a certain product whose producer did see the opportunity and answered the need for digital innovations quick enough

***2010 - ? :** Google offers all sorts of applications incl. navigation and engages in development of self-driving car technology through Waymo collaboration*

… with potential to commoditise products in the future

Disruptor getting into position to control all data and thus enabled to define customer experience, making the product in the field a commodity

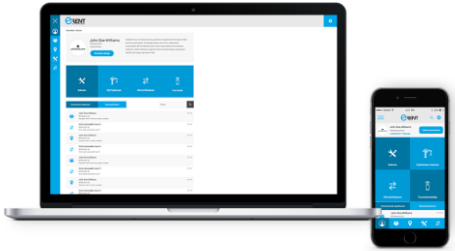
***Vision:** Alphabet establishes biggest fleet of autonomous vehicles, wins race to safest technology and generates momentum to urge OEMs to use its platform and establishes monopoly*

Source: 1: CTO survey results, Fall 2017

Finnish technology adaptors are already successfully using the three drivers to generate value and fight disruptors

Tamturbo provides 'Compressed air-as-a-Service' to industrial companies

- Compressor has high-efficiency electric motor
- Customers avoid high initial investment and hassles with maintenance
- Compressors are reinstalled at new clients at the end of contract



eRent[1] offers a platform to track, manage, rent and rent out equipment

- Service combines digital tracking methods, internet of things and cloud services
- Customers get easily accessible, mobile application
- Platform maximises usage rate of equipment

Wärtsilä subsidiary Eniram offers full visibility of onboard operations of a vessel with an analytics solution

- Advanced algorithms decompose and model data
- Mobile app was jointly developed with customers
- Fuel savings are derived from optimisation and breakdown is reduced

[1] Start-up company in early stage-development

What concrete opportunities exist?

Current state analysis and circular opportunities for manufacturing industry

This chapter will help you to:

- Assess your company's current state through evaluation of inefficiencies in your value chain
- Understand and identify circular business models that can help your company address inefficiencies and achieve a competitive advantage

Supporting tools:

- Business model development toolkit
- Value case tool

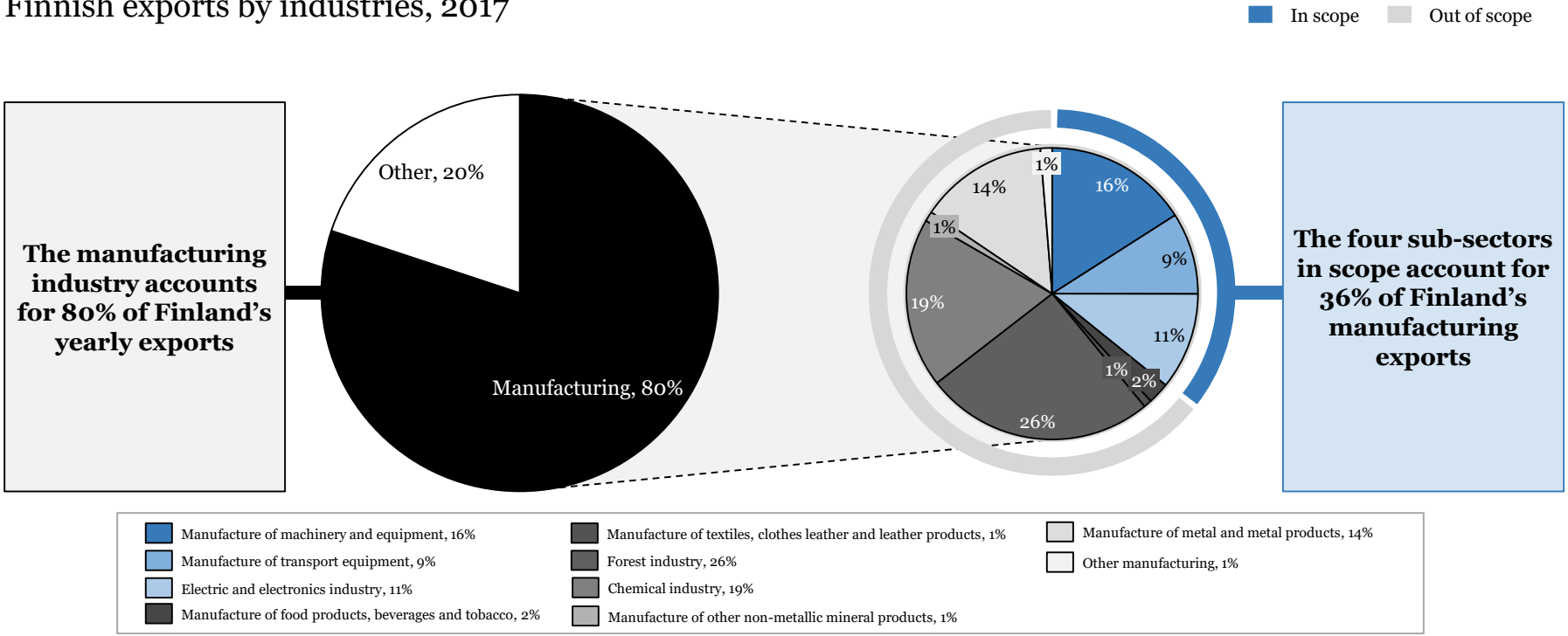
CHAPTER SUMMARY

What concrete opportunities exist?

- To address inefficiencies in the linear value chain and circulate products and materials, manufacturing companies should explore the five circular business models and their sub-models
  - Circular Supply Chain
  - Sharing Platform
  - Product Life Extension
  - Recovery & Recycling
  - Product as a Service
- Currently, the adoption of circular business models of SME's in the Finnish manufacturing industry is limited
- Compelling circular business model examples from leading Finnish and global manufacturing companies demonstrates a strong case for circularity
- Understanding current inefficiencies of the linear model is a helpful starting point to identify most promising circular business models

Manufacturing is the backbone of the Finnish economy, accounting for 80% of all exports

Finnish exports by industries, 2017



Source: Finnish Customs

The playbook takes a deep dive into four important ecosystems within the Finnish manufacturing industry

Machinery & Equipment

Manufacture of machinery and equipment, including e.g. engines and turbines, pumps, compressors and valves, agriculture, forestry, mining and metallurgy machinery, and lifting and handling machinery.

Largest sector of the Finnish manufacturing industry, accounting for 13% of Finland's exports and employing 15% of the workforce.

Marine

Manufacture of ship parts and marine equipment, such as hull, propulsion and power engines, other systems and solutions and interior equipment.

Over 900 companies with a turnover of EUR 8 billion, of which approximately EUR 1 billion from shipbuilding.

Energy

Manufacture of electrical equipment, such as batteries, accumulators, wiring and wiring devices, electric lighting equipment, transformers and electricity control apparatus.

Employs over 15 000 people in Finland.

Transportation

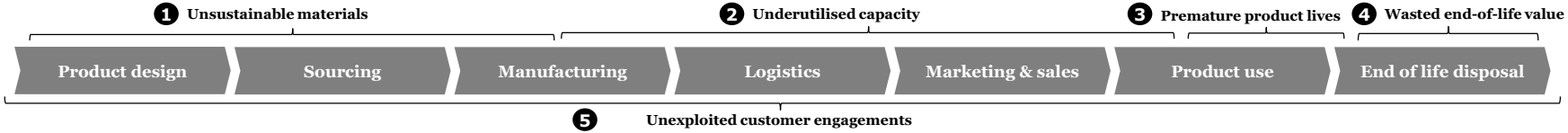
Manufacture of motor vehicles, trailers and semi-trailers, and their parts and equipment.

Export value of EUR 3 billion with strong expertise in special vehicle manufacturing.

A detailed overview of the current state and leading circular economy examples of each industry can be found in Chapter 6.

Sources: Statistics Finland, Finnish Customs, Finnish Marine Industries

Substantial inefficiencies occur in all parts of the manufacturing value chain[1]



	Inefficiency	Inefficiency level	Description of quantitative results	Comments on the current state
1	Direct materials	Medium	For 55% of companies the spend on recyclable/renewable materials is 50% or more of direct material spend, while 20% spend less than 5% on renewables.	Most input materials are recyclable and durable (e.g. steel) and the use of recycled material is fairly common.
	Indirect materials	High	55% of companies spend less than 20% of their indirect material spend on recyclable/renewable materials, and only 11% spend more than 80%.	Only some companies use sustainable indirect materials in production, such as renewable energy or recycled packaging materials.
2	Availability	Medium	58% of companies report that their products are idle for over 20% of the time, of which half say products not used for 50% or more of the available time.	The full available time of products is often not utilised, e.g. due to seasonal downtime. Also, all companies do not operate on a 24/7 basis.
	Operational fit	Very low	70% of companies fully customise their products to meet customer needs and requirements, while the rest meet customer expectations with a standard solution.	Products are designed to fit customer needs and requirements, e.g. in terms of operational efficiency.
3	Lifetime	Low	50% of companies report that their products last for over 20 years, while another 43% report that their product lifecycle is 11-20 years long.	Most products are built for long lifecycles with high durability.
	Functionality	Very low	For 65% of companies the share of revenues coming from products that are designed for a long life is 80%.	Products are designed to be long-lasting – however, design for enhanced reparability, modularity and upgradeability is limited.
	Waste in production	Medium	38% of companies recycle over 80% of their production waste. However, 38% of companies say they recycle less than 10%.	Most production waste is recycled, and many companies report that in general their level of production waste is very low. Still, there are companies with limited efforts.
4	Take-back	Very high	For 87% of companies the share of products taken back from customers in dedicated return schemes at end-of-life is less than 5%.	Few companies have dedicated take-back schemes as disposing products at their end-of life is often seen as the customer's responsibility.
	Recycling	Low	40% of companies recycle over 80% of products at end-of-life. Nevertheless, 28% say that they recycle less than 5% of products.	Product recycling rates are high for most companies. However, some companies do not recycle their product at all.
	After-sales	High	For 68% of companies the share of revenues from add-on sales is less than 10%, while for industry leaders it can be up to 60% depending on their strategy.	The full potential of after-sales services is not exploited.
5	Add-on sales	Very high	86% of companies state that their share of revenues from add-on sales is less than 10%.	For most companies add-on sales efforts are currently limited.

[1] Analysis based on survey responses of 30 Finnish manufacturing SMEs, desktop research and interviews with industry experts. More detailed information on the survey in Appendix 1.

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can make the same analysis for your company.

Five business models reduce the inefficiencies and create value for companies

Reform use of resources

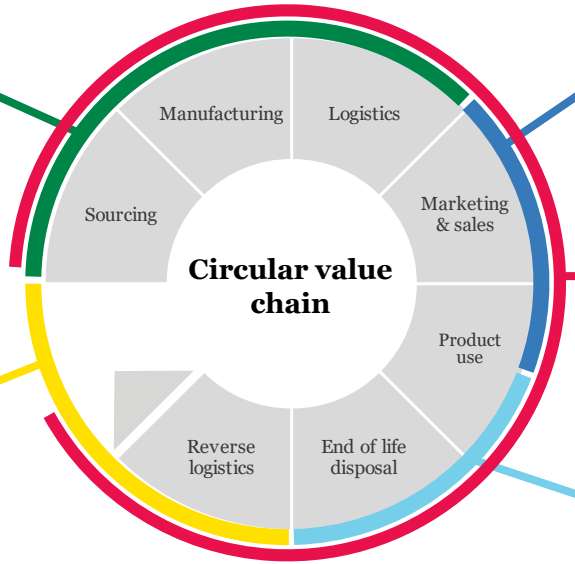
CIRCULAR SUPPLY CHAIN

Use of renewable energy, bio-based or potentially completely recyclable materials

Recover value in waste

RECOVERY & RECYCLING

Recovery of usable resources or energy from waste or by-products



Optimise capacity use

SHARING PLATFORM

Increased usage rates through collaborative models for usage, access, or ownership

Offer outcome oriented solutions

PRODUCT AS A SERVICE

Offering of products for use with retention of product ownership which incentivises increase in resource productivity along the whole life cycle

Extend life cycles

PRODUCT LIFE EXTENSION

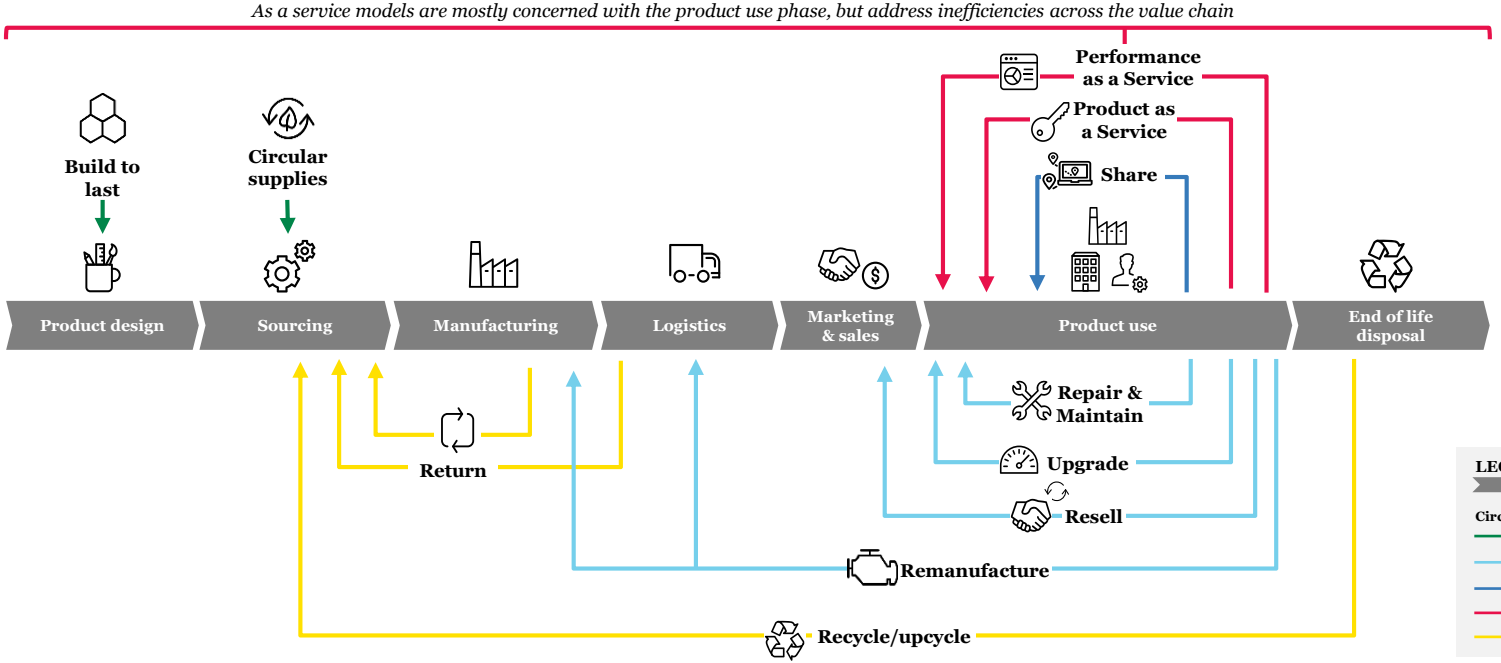
Extension of the life cycle through repair, maintenance, upgrading, resale and remanufacturing

Source: Accenture, Appendix 2 for more details

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can analyse the relevance of each circular business model for your company.

Business model specific sub-models modify different steps of the value chain to make it circular

Illustrative circular value chain



Additional circular business models

Circular supply chain
- Recycled direct materials
- Sustainable indirect materials

Sharing platform
- Virtual sharing platform
- Physical sharing platform

Recovery & Recycling
- Recover
- Downcycle

Product life extension
- Restore
- Repurpose
- Refresh

LEGEND

Linear value chain

Circular Economy Value Chain

- Circular Supply Chain
- Product Life Extension
- Sharing platform
- Product as a service
- Recovery & Recycling

Most circular opportunities are in the product use phase, bringing companies closer to their customers.

Source: Accenture, Appendix 2 for more details

Did you know?
In **Chapter 6**, there is an industry-specific circular value chain illustration for Machinery & Equipment, Marine, Energy and Transportation industries.

Companies can explore the sub-models individually or as powerful combinations

Example synergy:
Modular product design enables enhanced reparability and upgradeability

Business model	Sub-model	Description
Circular Supply Chain	Build to last	Design products that are durable and easy to repair (e.g. modular).
	Circular supplies	Use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates.
Sharing Platform	Share	Develop solutions that enable increased use of capacity.
Product as a service	Product as a service	Offer customers to use a product against a subscription fee or usage based charges instead of owning it.
	Performance as a service	Offer customers to buy a pre-defined service and quality level and commit to guaranteeing a specific result.
Product Life-extension	Repair & Maintain	Deliver repair and maintenance services to extend the life of existing products in the market.
	Upgrade	Improve product performance by upgrading existing components with newer ones.
	Resell	Resell products that have reached their useful life to second and third hand markets.
	Remanufacture	Take back and perform industry-like restoration or improvement of original functionality of products and remarket them with lower price.
Recovery & Recycling	Recycle / upcycle	Collect and recover materials of end-of-life products and reuse them in own production.
	Return	Return wasted parts and materials to the source (e.g. waste and by-products from own production).

Source: Accenture, Appendix 2 for more details

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, which helps you to identify the most relevant sub-models for your company.

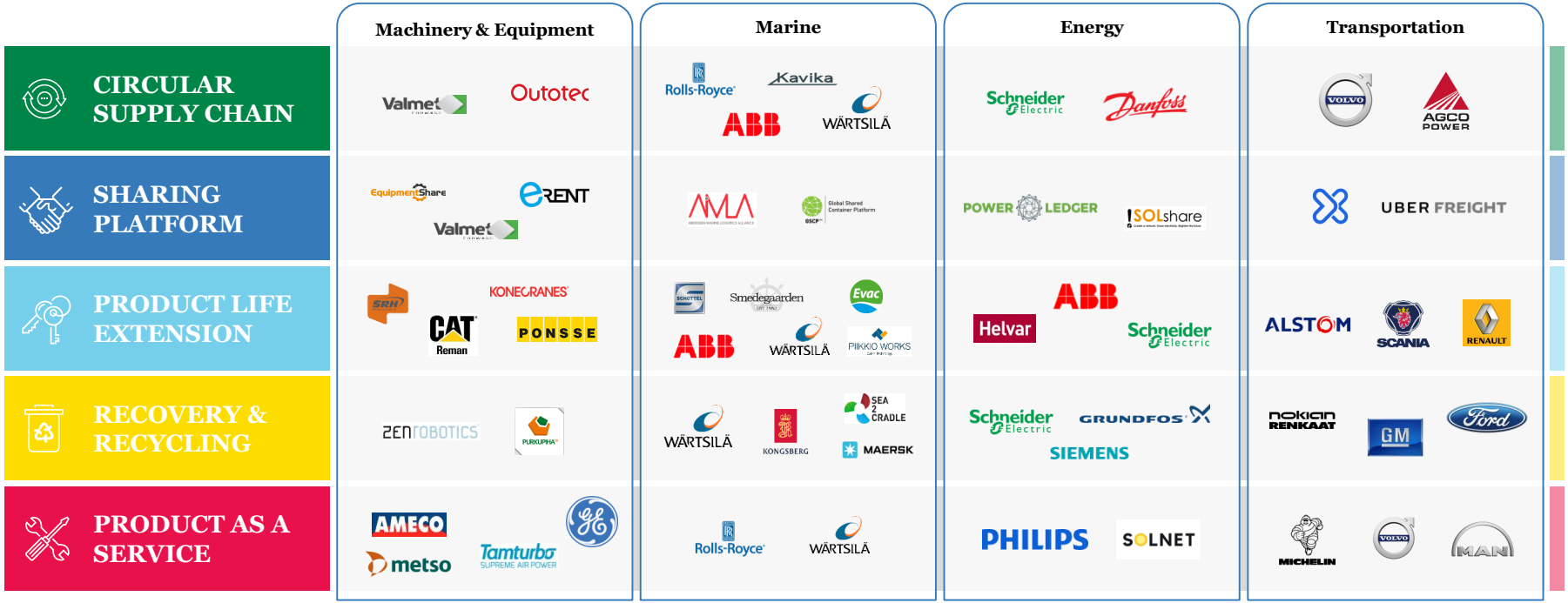
Current adoption level of circular business models within the Finnish manufacturing industry is limited[1]

Business model	Sub-model	Adoption level	Comment
Circular Supply Chain	Build to last	Not applied at all – Widely applied	Products are designed for long lifecycles – however, use of modular design principles is not very common yet.
	Circular supplies	Not applied at all – Widely applied	Input materials are mostly recyclable (e.g. steel), while use of sustainable indirect materials, such as renewable energy, varies a lot.
Sharing Platform	Share	Not applied at all – Widely applied	Sharing platforms are seen as challenging to implement for some products, e.g. those with fixed installation.
Product as a service	Product as a service	Not applied at all – Widely applied	Only a few companies have adopted the model, while many are currently exploring it.
	Performance as a service	Not applied at all – Widely applied	Many companies are currently exploring the model, and some have never heard of it.
Product Life-extension	Repair & Maintain	Not applied at all – Widely applied	Most companies provide at least some repair and maintenance services. However, some report that they are not leveraging their full potential.
	Upgrade	Not applied at all – Widely applied	Many companies are already applying the model, and most others are exploring how to apply it.
	Resell	Not applied at all – Widely applied	Companies are not seeing reselling as a relevant opportunity for products that have very long lifecycles.
	Remanufacture	Not applied at all – Widely applied	Remanufacturing is not seen as relevant for products with very long lifecycles.
Recovery & Recycling	Recycle / upcycle	Not applied at all – Widely applied	Companies find it challenging to ensure recycling of products, e.g. because products might be scattered around the world and companies do not have information on their final location. Furthermore, recycling is often seen as customers' responsibility.
	Return	Not applied at all – Widely applied	Most companies recycle some of their manufacturing waste.

[1] Analysis based on survey responses of 30 Finnish manufacturing SMEs, desktop research and interviews with industry experts. More detailed information on the survey in Appendix 1.

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can make the same analysis for your company.

Still, compelling examples from Finnish manufacturing companies and their competitors exist



Source: Company websites

Did you know?
In **Chapter 6**, there is a detailed description of all industry-specific leading circular economy examples mentioned above.

Relevant circular business models depend on the type of inefficiencies that need to be addressed

Inefficiencies		Level*	Business Models: CIRCULAR SUPPLIES – Build to last	CIRCULAR SUPPLIES – Circular supplies	SHARING PLATFORM – Share	PRODUCT AS A SERVICE – Product as a service	PRODUCT AS A SERVICE – Performance as a service	PRODUCT LIFE EXTENSION – Repair & Maintain	PRODUCT LIFE EXTENSION – Upgrade	PRODUCT LIFE EXTENSION – Resell	PRODUCT LIFE EXTENSION – Remanu-facture	RECOVERY & RECYCLING – Recycle/ Upcycle	RECOVERY & RECYCLING – Return
NON-REUSABLE MATERIALS	Direct materials	Medium	●	●				●	●		●	●	
	Indirect materials	High		●				●	●		●	●	
UNDER-UTILISED CAPACITY	Availability	Medium			●	●	●	●	●				
	Operational performance	Very low	●			●	●	●	●		●		
PREMATURE PRODUCT LIVES	Relevance	Low	●		●	●	●	●	●	●	●		
	Functionality	Very low	●		●	●	●	●	●		●		
WASTED END-OF-LIFE VALUE	Waste in production	Medium	●			●	●				●	●	●
	Take-back	Very high	●			●	●				●	●	●
	Recycling	Low	●			●	●				●	●	●
UNEXPLOITED CUSTOMER ENGAGEMENTS	After-sales	High	●		●	●	●	●	●	●	●	●	
	Add-on sales	Very high	●		●	●	●	●	●	●	●	●	

Example:
To address underutilised capacity, Share, Product as a Service, Performance as a Service, Repair & Maintain and Upgrade are relevant circular business models.

*Analysis based on survey responses of 30 Finnish manufacturing SMEs.
More detailed information on the survey replies in Appendix 1.

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, which helps you to assess inefficiencies in your value chain and identify relevant business models.

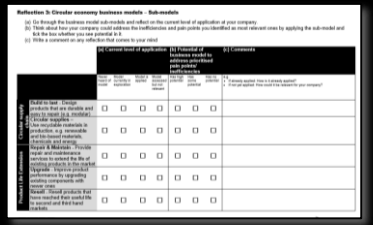
Circular Economy business models can boost bottom line results for manufacturing companies

CIRCULAR SUPPLY CHAIN	Build to last	Reduce production costs	Wärtsilä achieved **45% reduction in production development expenses**, 44% lower cost for ongoing product care and 50% reduction in assembly time using modular engine architecture
		Increase market share	DESSO **increased market share by 8%** and EBIT from 1% to 9.2% in four years by producing carpets that are easy to disassemble by eliminating toxics and number of materials in carpets
	Circular Supplies	Reduce utility costs	Ecovative **reduced energy costs by 75%** compared to industry averages by developing home compostable bio-plastics based on mycelium
SHARING PLATFORM	Share	Reduce warehousing costs	FLEXE helps companies **lower warehousing costs by 20-70%** by providing a sharing service that helps optimise usage
PRODUCT LIFE EXTENSION	Repair & Maintain	Reduce operating expenses	Nokia **reduced OPEX by 20%** by maximising value of aging equipment through modernisation of logistics, warehousing and dismantling
	Resell	Participate in secondary sales	**~50% revenue increase** from selling 2nd hand products
	Remanufacture	Increase gross profits	Caterpillar achieved **50% higher gross profits** from selling remanufactured products at a 20% discount rate
RECOVERY & RECYCLING	Recycle / upcycle	Generate revenue	GM's by-product recycling and reuse initiatives have not only saved money, but also **generated $1 billion in new revenue** for the automaker
	Return	Reduce input material costs	Ford is **cutting about 20% from the cost** of swapping aluminium for steel in F-150 body panels by sorting, cleaning and returning scrap to the same mills that supply it with metal sheet
PRODUCT AS A SERVICE	Product as a Service	Increase revenues	Michelin sells tires-as-a-service with **a revenue potential of 3bn€ in 10 years**

Source: Company websites

Did you know?
On the Circular Economy site, there is a **Value case tool**, with which you can calculate a high-level business case for circular economy business models for your company.

A set of tools support you in identifying the most relevant circular business model(s) for your company

Tool	Purpose	Required time	Illustration of the tool
Business model development toolkit	Set of exercises for identifying inefficiencies and customer pain points, assessing relevance of circular business models, and prioritising them.	30-60 min	
Value case tool	Tool for calculating high-level business case for circular business models.	~60 min	

Which capabilities are required?

Introduction to organisational requirements for circular business models

This chapter will help you to:

- Understand which capabilities are needed to operate your selected circular business model(s)
- Assess capability gaps and identify actions to bridge them
- Identify potential partners for whom to outsource non-strategic and underdeveloped capabilities

Supporting tools:

- Capability maturity assessment

CHAPTER SUMMARY

Which capabilities are required?

- When transforming from a linear to a circular value chain, new know-how regarding offerings, resource use, operations and organisation is required
- Nine capabilities enable companies to transform their value chain to increased circularity:
  - (1) Design solutions to deliver customer outcomes
  - (2) Design products for circularity
  - (3) Source recycled or recyclable material
  - (4) Produce, remanufacture and recycle products
  - (5) Sell outcomes and lifecycle services
  - (6) Take back products at end-of-life
  - (7) Deploy technologies and data for delivering outcomes
  - (8) Orchestrate ecosystem of partners
  - (9) Transform mindset and steering
- The capabilities need to be developed across the organisation in several functions, including for example R&D, procurement and sales

Moving from a linear to a circular value chain requires different capabilities

Linear chain

- Sourcing
- Manufacturing
- Logistics
- Marketing & Sales
- Product Use
- End-of-life Disposal

Differences in required know-how when going circular

A) Customer value delivery

- Customer engagement beyond point of sale will be required to support with product life cycle management services
- Improved understanding of customer and product requirements can be achieved through continuous interactions and data analytics

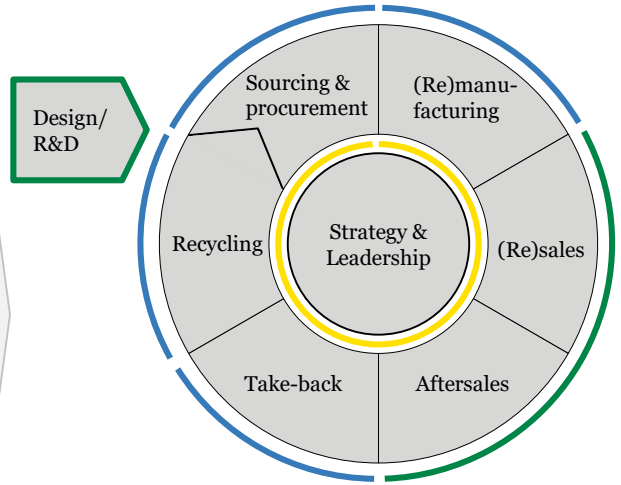
B) Resource handling

- Improved resource management is needed to do more with less
- New capabilities and mindsets are required for an improved understanding of how material selection, waste management and manufacturing services impact environmental footprint

C) Organisation and collaboration

- Use of IT and digital technologies is not enough, companies further need the ability to collect and derive valuable insights from data
- Collaboration is needed to optimise customer outcomes and value creation with partners aligned to end-to-end value creation

Circular value chain

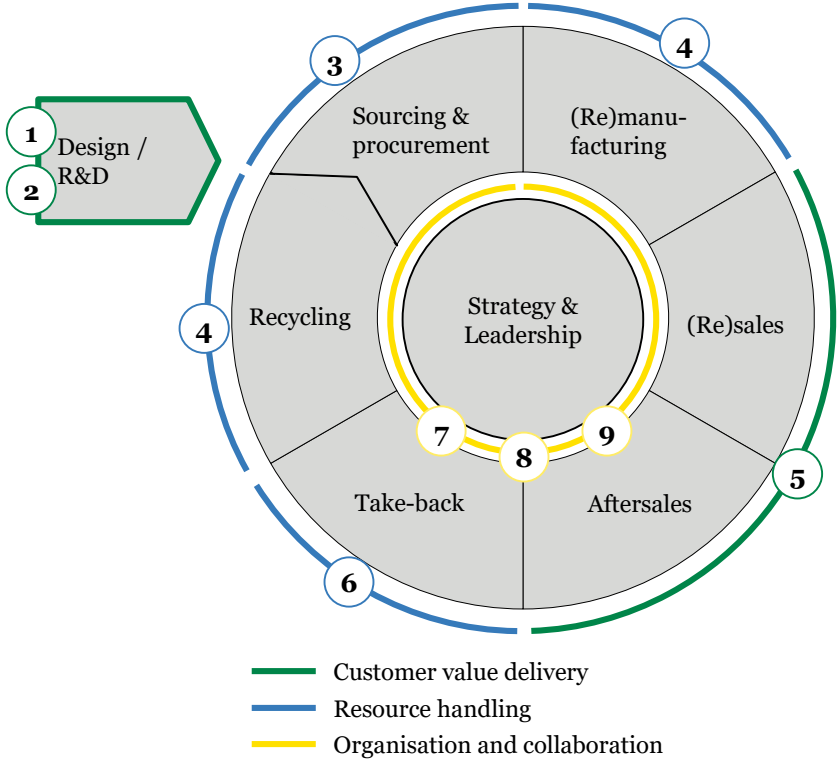


Source: Adapted from earlier Accenture publication, Appendix 2 for more details

Nine capabilities enable companies to transform their value chain to increased circularity

Capabilities

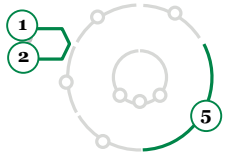
1. Design solutions to deliver customer outcomes
2. Design products for circularity
3. Source recycled or recyclable material
4. Produce, remanufacture and recycle products
5. Sell outcomes and lifecycle services
6. Take back products at end-of-life
7. Deploy technologies and data for delivering outcomes
8. Orchestrate ecosystem of partners
9. Transform culture and steering



Source: Adapted from earlier Accenture publication, Appendix 2 for more details

Did you know?
On the Circular Economy site, there is a **capability maturity assessment**, with which you can assess the capability gaps of your company and identify actions to bridge them.

Customer-centric design enables additional sales throughout the product lifecycle



A) Customer value delivery

	1 Design solutions to deliver customer outcomes	2 Design products for circularity	5 Sell outcomes and lifecycle services
	Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling Strategy & Leadership	Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling Strategy & Leadership	Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling Strategy & Leadership
Required know-how	**Ability to put customer needs and requirements at the centre of product design** • Understanding of user journeys and needs • Ability to integrate digital applications into product design • Development of complete product lifecycle solutions and services	**Ability to design products for long life cycles and sustainable material use** • Understanding of environmental impact throughout product life cycle • Ability to design products that are durable, easy to repair and upgrade, and use materials sustainably	**Ability to leverage customer insights in selling value-adding solutions** • Ability to engage customers and use customer insights for sales throughout product life cycles • Developing new offering and pricing models for outcome-oriented solutions • Understanding of customer demand and changing needs across product life cycles
Recommended approach	**Engage customers and partners in solution co-creation** • Perform iterative design and rapid prototyping to test, fail, learn and rebound quickly • Manage an open ecosystem of customers and partners, and engage in open innovation • Use big data and develop smart products	**Follow circular design principles in product design** • Perform life cycle assessment (LCA) to understand and avoid environmental impact in design • Use environmental databases and tools to model environmental impact of products • Develop product passports to give guidance on usage throughout product life cycle	**Centre sales around customer outcomes throughout the whole product life** • Allow customers to use a product against a fee or usage-based charges instead of owning it • Develop service and after-sales offerings for product life extension – e.g. maintenance and repair services with the help of IoT solutions • Leverage data insights for predictive support

Improved customer-centricity through more frequent interaction and more customised solutions

1. Design solutions to deliver customer outcomes

Customer-centric design, digital technologies and knowledge around DPLM[1] are core for solution design

Required know-how and activities

1. **Customer-centric design:** Centre development process around customer needs and the functional requirements, rather than the physical device. This way innovative solutions and product-as-a-service models are promoted
2. **Smart and connected solutions**: Consider how to develop smart products using new technologies such as sensors and big data that enable to deliver better outcomes for the customer through e.g. enhanced functionality
3. **Digital product or application life cycle management (DPLM/ALM[2]):** Include the design of the complete digital life cycle into the initial design phase. The DPLM enables to speed up processes and increase efficiencies throughout the life cycle by digitising and coordinating all relevant processes connected to the solution. Product life cycle management data becomes an important part for generating insights and detecting potential new revenue streams

Guidance on customer-centric design

Design Thinking is a methodology for customer-centric design. It is an iterative process using a broad set of design methods (e.g. accessible through this link). The aim is to frame opportunities and innovate in close collaboration with customers and other relevant stakeholders. Through the customer interaction, Design Thinking is especially relevant when designing customer experiences and user interfaces for new solutions.

Core to the methodology is to quickly move from prototypes to "minimum viable products" and reduce the lead time for development (see example approach on next page).

Example metrics

- # of external stakeholders (including customers) engaged
- # of days until minimum viable product is realised

Business model relevance

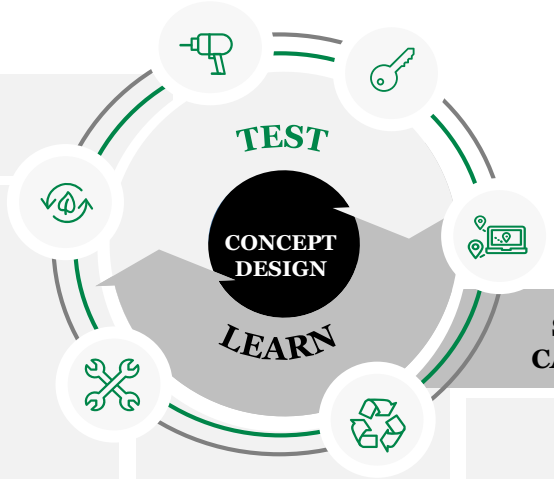
Circular supply chain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
✓	✓	✓	✓	✓

1: Digital Product Life cycle Management 2: Application Life cycle Management

1. Design solutions to deliver customer outcomes

Customers, partners and employees ensure proof-of-concept through iterative testing and learnings

Piloting approach

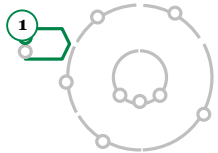


CUSTOMERS	NEEDS		SERVICES / CAPABILITIES	ECOSYSTEM PARTNERS
• Discover customer needs through market research (e.g. questionnaire) and customer workshop • Deploy design thinking methodology to create a prototype and minimum viable product for fast market testing and iterative refinement **1 week**	• Describe circular concept in relation to customer needs and preferences **1 week**	• Design concept together with customers, employees and partners through rapid prototyping • Iterate and test concept until desired state is reached **4 weeks**	• Test internal capabilities to deliver concept • Prepare required organisational changes, including capabilities, technologies and processes **4 weeks**	• Identify partners that can complement capabilities • Collaborate on solution development and corporate ventures and share experience to improve concept **2 weeks**

Improved user experience and enhanced ability to deliver solution

1. Design solutions to deliver customer outcomes

Changes in set-up and actors are required when moving from product to solution innovation



Changes from traditional to service innovation

	Product innovation	Solution innovation
What	Understand customer usage and expected product attributes	Design and live customer experience/ journey
How	Leverage traditional and robust processes	Perform iterative design and prototyping (to test, fail, learn and rebound quickly)
Who	Leverage companies distinctive forces and expertise around product/service	Manage an open ecosystem and perform open innovation – acquiring/partnering with new talents
Core skills	Draw on traditional product/service know-how	Apply design thinking and big data/analytics
Duration	Perform innovation cycle in years	Perform innovation cycle in weeks/months

1. Design solutions to deliver customer outcomes

Prototyping spaces, digital acceleration centres and digitally enabled solutions are good practices

Good practices and examples

Co-creation and prototyping space
Establish a space in which companies, students and future customers can jointly develop, test and prototype new ideas

Example: *Firstbuild, a GE Appliances backed co-creation space, offers access to the latest technology to design, prototype, or put the finishing touches to inventions. It also has a virtual community on a platform proposing challenges and ideating solutions*

Digital acceleration centres
Create distinct development programmes around how digital solutions can enhance customer value

Example: Wärtsilä established four digital acceleration centres that act as incubators for new digital ideas. The work is based on agile methodologies and involves close interaction with customers and stakeholders. In a six week "sprint" 106 different concepts were developed for the digital vessel project that then were evaluated in more detail

Digitally enabled solution
Reflect on areas a product has impact on and the data required to add value to the customer. Ideate what means might exist to access and use this data

Example: ZF Friedrichshafen developed a fuel-economic transmission system that knows in advance when to shift gears by analysing the topography on the basis of GPS data feed

Enabling technologies

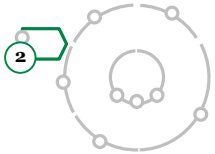
Internet of Things

Big data

Source: Company websites

2. Design products for circularity

Life cycle thinking and circular design criteria are key in developing circular products



Required know-how and activities

1. **Life cycle thinking:** Consider the whole life cycle in the design process from production to use phase to end-of-life as more than 80% of the environmental impact of a product is determined at the design stage (See guidance on the right)

2. **Circular design criteria**: Develop and apply circular design criteria such as
   - Design for a longer life through upgrading, reuse, refurbishment and remanufacture
   - Design based on sustainable and minimal resource use and enabling high-quality recycling of materials
   - Enabling cleaner material cycles though substitution of hazardous substances

See next page for more information and examples

Guidance on life cycle thinking

Minimising environmental impacts along the whole life cycle and comparing alternatives against each other are key for sustainable product design. **Life cycle assessment (LCA) is** a method that allows assessing products and services, and the process itself is described trough ISO 14040 and 14044.

After defining the scope and boundaries of the analysis, the inventory and impact of products can be modelled. For this, data from **environmental databases** is available (e.g. resource depletion, CO_2 emissions). Several tools from different providers exist on the market e.g. SimaPro, Umberto and GaBi

Example metrics

- % of renewable, recycled or reused material in product
- # of different components in product design

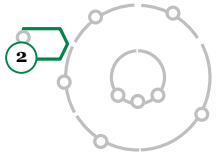
Business model relevance

Circular supply chain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
✓		✓		✓

Functions Design / R&D | Sourcing & Procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & Leadership

2. Design products for circularity

Seven aspects are relevant for circular design



Aspects	How to incorporate it in product	Example
1 Design out waste	Use less resources for producing the product	Ford investigates 3D printed parts to reduce material use and weight of components
2 Design for upgrading and modularity	Allow exchange of components for updates or upgrades (e.g. standardise connections)	PuzzlePhone is built from three modular components available in different sizes and materials
3 Design for reuse, repair, refurbishment, remanufacturing	Allow for disassembly through using e.g. reversible connections	Caterpillar designs parts for manufacturing e.g. an engine block with a removable sleeve in the cylinder bore
4 Design based on sustainable resources	Use renewable or recycled materials	Renault uses recycled material for 36% of the total mass of a new vehicle
5 Design for minimal resource use along life cycle	Make sure product is efficient in use phase (e.g. no resource intensive supplies)	Outotec dry tailings water treatment plant minimises fresh water intake during its operation
6 Design enabling high-quality recycling of materials	Limit number of different materials, use recyclable ones and make them separable	Philips constructs light bulbs in a sandwich construction that assures separation upon crushing
7 Design for cleaner material cycles	Substitute hazardous substances in products	Akzo Nobel created a new coating made from plant-based oils and recycled PET bottles instead of solvents

Source: Company websites

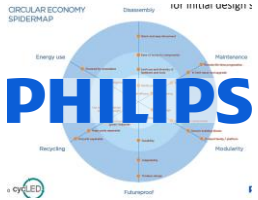
2. Design products for circularity

Several companies have good practices in circular product development, such as use of modular design

Good practices and examples

Modular design
Design your products in a modular way to improve reparability, upgrades and other benefits

Example: Wärtsilä developed a modular design for the medium speed engine product family as it allows standardisation and component commonality and flexibility for variances at the same time. The design enables updating technologies, improves serviceability and reduces the lead-time for product development



Design guide
Summarise all design criteria in line with company specific prioritisation in Design guide with tool kit for product developers

Example: Philips offers design guide for product development with CE Spider Web in which solutions are rated for Disassembly, Maintenance, Modularity, Futureproof, Recycling and Energy use (Link to tool description)

MAERSK

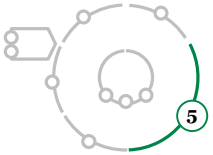
Product passport
Document the materials used in a product and give guidance how to extract valuable parts to enable recycling at the end of a product's life

Example: Maersk introduced a Cradle-to-Cradle Passport for vessels, a database listing the material composition of the main parts of the ship enabling better recycling of materials and parts. It requires input from all components' suppliers and documents approximately 95% (by weight) of the materials used to build the ships

Source: Company websites

5. Sell outcomes and lifecycle services

Centre sales around outcomes for customers and provide services throughout the whole product life



Required know-how and activities

1. **Customer-centric sales process:** Adopt customer perspective and knowledge on their industry to understand their needs, educate them on suitable existing or personalised solutions and invite them to joint solution development
2. **Offering and pricing models**: Develop new offering and pricing models for outcome-oriented solutions, such as performance-based models (see next page)
3. **Customer engagement throughout life cycle:** Continuously engage with customers to get deep insights on how the product is used, what issues arise and what improvement potential exists. Offer online platform for customer interaction
4. **Product life extension support:** Provide services for product life extension such as spare parts, (remote) maintenance and repair services. Leverage data from connected products for predictive services (see guidance on the right)
5. **Service delivery:** If know-how or reach for services does not exist (yet), partner with other companies to deliver value proposition

Guidance on product life extension support

To support extension of product life, several after-sales services can be provided:

- DIY guidance for maintenance and repair
- Maintenance services (remote, predictive)
- Repair support with VR
- Repair service on customer site
- Repair of sent-in products – using remanufacturing capabilities
- Upgrades of software and parts

Example metrics

- Level of customer satisfaction
- Average duration of customer relationships
- % of solutions sold (instead of product-only)

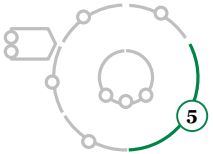
Business model relevance

Circular supply chain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
☐	✓	✓	☐	✓

Functions Design / R&D | Sourcing & Procurement | (Re)manufacturing | Sales | Aftersales | Take-back | Recycling | Strategy & Leadership

5. Sell outcomes and lifecycle services

Product as a service offering can be designed in different forms setting incentives for circularity



Offering models for product-service systems

Offering	Ownership	Offering design	Incentives for circularity
Product-as-a service models	Lies with producing company during useful life	**Operating lease**: Overarching concept, in which the lessor retains ownership of the asset, while the lessee pays for its use over a certain time	◔ Longevity
		Full service lease: Combines operating lease contract with additional services such as maintenance for the asset	◑ Longevity, reparability and easy maintenance
		Performance-based payment: Combines operating lease with periodical fees dependent on use or delivered performance of the asset	● Longevity, reparability, optimised use-phase consumption
		Rent: Differs from leasing in that it generally is for a shorter period. Maintenance and insurance are often included in the contract	◑ Longevity , reparability and easy maintenance
Other product-service systems (not considered as PaaS[1])	Transferred to customer some time during life cycle	**Finance lease**: All the risks and rewards connected to ownership of an asset is transferred to the lessee during time of lease (e.g. cost for maintenance, repair, resource use during use phase). At the end of the leasing contract, the ownership of the asset is passed over to lessee	○ No circularity incentives

Legend: Low ○ ◔ ◑ ● High

[1] Product as a Service

5. Sell outcomes and lifecycle services

Leading companies show how to use new pricing models and apply digital technologies

Good practices and examples

PHILIPS

New pricing models
Develop new pricing models that allow offering solutions based on the value and outcome they deliver to the customers

Example: Philips extends its offering and provides light as a service complementary to its offering of light bulbs. The pricing schemes used are either paying per lux or paying a fixed charge per month. The service delivers the value to the customer in a whole new way. To provide it as efficient as possible, equipment is tracked with sensors

Enabling technology
Internet of Things

Customer-centric sales process
Use e.g. virtual reality in marketing and offer an app in which customers can configure products, have it displayed in their environment and seamlessly place an order

Example: BMW developed a virtual reality marketing app in which customers can compile the car they would like to buy, see interior in a 360° view and have it shown in e.g. their own car park

Enabling technology
Virtual Reality

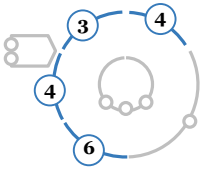
Product life extension support
Integrate sensors into product to monitor status and allow remote checks to prevent breakdowns

Example: Rolls Royce provides a suite of predictive maintenance and repair services for its jet engines, including monitoring engine health and modifying engines to increase reliability an durability

Enabling technology
Internet of Things

Source: Company websites

Appropriate resource handling ensures that materials and products are kept in a closed cycle



B) Resource handling

3 Source recycled or recyclable material

Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling
Strategy & Leadership

Required know-how

Ability to specify and source materials that can easily be regenerated and recycled

- Understanding of circular material properties and qualities
- Development of KPIs that promote circular thinking throughout procurement process
- Ability to engage suppliers and develop ecosystem partnerships

Recommended approach

Access circular materials from new sources:

- Collection infrastructure & external take-back
- Industrial symbiosis
- Source marketplace platform
- Waste company partnership
- Commodity market for secondary materials

4 Produce, remanufacture and recycle products

Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling
Strategy & Leadership

Required know-how

Ability to handle waste in production, incl. material flows and remanufacturing

- Material flow management
- Digital production for new levels of efficiency
- Repair and remanufacture returned products
- Treatment capabilities to recycle material

Recommended approach

Integrate technologies to monitor and track material and product flows

- Track production process and materials with RFID tags, Machine vision and AI
- Automatically sort materials (e.g. robotics)
- Assess performance and address only faulty functionality and components

6 Take back products at end-of-life

Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling
Strategy & Leadership

Required know-how

Ability to establish return systems that ease and facilitate disposal of end-of-life products

- Design and establish reverse logistic network
- Monitor and assess product performance
- Establish return incentives

Recommended approach

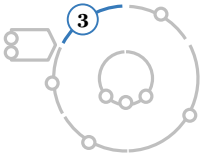
Adapt programmes and approach based on secondary values of products

- Define return specification based on economic value case
- Optimise returns, e.g. collaboration with dealers, workshops, stores and collection at premises

Improved management of resources to maximise returns on embedded values across product-life cycle

3. Source recycled or recyclable material

Circular sourcing reduces wasted value by matching required inputs with available circular material



Required know-how and activities

1. **Circular materials and equipment:** Make products/equipment that are produced following circular (design) criteria preferred choice for procurement. Source circular materials such as material for reuse or recycled material. To evaluate suitability of material as input, deep understanding of materials properties is required (e.g. quality requirements)

2. **Procurement process modification**: Integrate circular thinking into procurement process, e.g.
   - Consider total cost of ownership for goods
   - Include circular economy in Requests For Proposals and Supplier Code of Conduct
   - Use environmental KPIs such as carbon intensity as additional decision criteria in buying decision

3. **Supplier engagement:** Develop supplier network into ecosystem and e.g.
   - Establish a bidirectional dialogue on required materials and available by-products
   - Share knowledge on circular economy and other environmental practices

How to source circular materials?

- Establish collection infrastructure or draw on external take-back systems[1] and build or source treatment capabilities[2]
- Engage in industrial symbiosis
- Participate on resources marketplace platform
- Establish waste company partnership to source treated material
- Source resources on commodity market

Example metrics

- % of spend on circular materials
- % of key suppliers participating in supplier engagement programme
- % reduction in material cost

Business model relevance

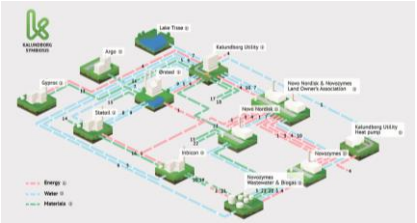
Circular supply chain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
✓		✓		✓

1 Please see capability 6 "Take back products at end-of-life" if done internally, 2: Please see capability 4 "Produce, remanufacture and recycle products" if done internally

3. Source recycled or recyclable material

Circular resource marketplace platforms and industrial symbiosis can transform material sourcing

Good practices and examples



Circular resource marketplace platform

Participate on a platform that facilitates matching of required and available materials for recycling or reuse of different companies or engage in its development

*Example: **Excess Materials Exchange** is a pilot of a digital facilitated marketplace run by a Dutch start-up. Companies from all industries can share information on the material they want to exchange, and receive information on the value, alternative uses for/ sources of secondary materials, and environmental impact. The platform uses an Artificial Intelligence engine connecting to data of thousands of scientific papers and patents*

Industrial symbiosis (IS)

Develop symbiotic partnerships with cross-industry actors designing "waste as input" streams

Example:
***Kalundborg** (Denmark) – Collaboration with 8 private and public partners started in 1970s. Has about 50 symbiotic exchanges such as steam, water, or specific flows. An example for a specific flow is Novo Gro30, biomass from pharmaceutical production that is then used as fertiliser, for wastewater treatment and biogas production*

Enabling technology

Artificial intelligence

Big data

Source: Company websites

3. Source recycled or recyclable material

Using shared services and asking suppliers to apply circular principles are good practices in sourcing

Good practices and examples

Shared services and equipment

Realise cost reduction by sharing production equipment and services

*Example: Instead of buying an own 3D printer, companies can use the platform **3Dhubs** for 3D printing and CNC machining (Link) or source the service from providers such as **UPS** (LINK)*

Circular economy in supplier code of conduct

Promote circular economy in your supplier relationships through stating its importance in the code of conduct

Example: HP includes circular economy aspects into its Supplier Code of Conduct with the following statement: "Suppliers shall implement a systematic approach to identify, manage, reduce, and responsibly dispose of or recycle solid waste (non-hazardous) and waste water."

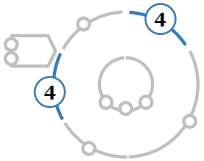
Enabling technology

3D printer

Source: Company websites

4. Produce, remanufacture and recycle products

Aim for material flow transparency in production and add remanufacturing know-how to skill-set



Required know-how and activities

1. **Material flow management:** Closely monitor and manage material flows on-site in production. Follow principles of prevent, reuse, recycle, recover and dispose. Try to keep materials separate to enable high-quality recycling
2. **Digital production technologies**: Unlock new levels of production efficiency through digital technologies such as sensors and big data that identify and predict maintenance issues. Facilitate tasks for workforce through wearables and improved machine-human interactions moving towards a digital plant
3. **Remanufacturing:** Develop skill and infrastructure required to sort, repair and remanufacture returned used products and components
4. **Reprocessing and recycling:** Build treatment capabilities to reprocess and recycle material from returned products or production waste

Guidance on remanufacturing process set-up

1) **Check-in:** Confirm that the returned part is valid for remanufacturing process through digitised quality analysis and the serial number and update status in system as "returned". This process can be supported by use of RFID tags, Machine vision and AI
2) **Sorting:** Sort the returned parts to identify whether they need to be refurbished, repaired, remanufactured or go into recycling. Define decision rules for process. Update data in inventory
3) **Remanufacturing:** Repair, refurbish and remanufacture the part. Conduct quality check in the end to guarantee function

Depending on the return scheme, Step 1 and 2 could take place offsite during the take-back phase by e.g. service provider or dealer

Example metrics

- % of waste recycled / % of waste sent to landfill
- % of wasted materials from production recovered
- # of parts remanufactured / % of returned parts remanufactured

Business model relevance

Circular supply chain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
☐	☐	☑	☑	☑

4. Produce, remanufacture and recycle products

To raise resource efficiency, use 3D printing, keep waste separated and introduce remanufacturing

Good practices and examples

3D printing

Boost product quality and help reduce the need for a spare parts inventory

Example: Volvo Trucks produces tough manufacturing and assembly tools in 94% less time with 3D printing

Production waste separation

Integrate waste management in production process and keep waste material flows separate to enable high quality recycling

Example: Ford engages with suppliers to recycle aluminium scraps from car production (e.g. stamping windows into body panels). To achieve the required level of purity, Ford invested in machinery to separate, clean and shred aluminium

Remanufacturing capabilities

Develop remanufacturing capabilities to sort and repair returned equipment to extend their life cycles

Example: Various models of Scania trucks are dismantled and remanufactured at Scania Vehicle Recycling. Parts such as engines, gear boxes and differentials are inspected and adjusted internally. They are sold through local Scania workshops and distributed via the daily spare parts routine of Scania Parts Logistics

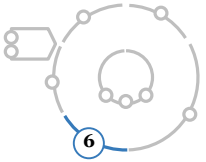
Enabling technology

3D printer

Source: Company websites

6. Take back products at end-of-life

Return flow management requires a take-back programme, product tracking and return incentives



Required know-how and activities

1. **Take-back programme:** Develop a programme that enables customers to return products at the end of their useful life. Design and establish a reverse logistics network for this. Criteria to consider for the design are e.g. price, size of product, and frequency of exchange (see guidance on the right).
2. **Tracking and monitoring**: Track and monitor condition of product in its life cycle by applying connected sensors and analytics
3. **Return incentives:** Incentivise product return through e.g. deposits, or establish a reverse logistics chain – either in-house or through partners

Guidance setting up a take-back programme

Take-back programmes are suitable for

- Products with high end-of-life value
- Companies with low costs for reversed logistics

To assess suitability…

- … estimate economic value of product that is to be returned as the difference between price on market and costs for remanufacturing. The remaining share of revenue needs to cover return and set-up costs for the programme
- … estimate cost of return by exploring different take-back options (through e.g. dealers, workshops, stores or direct collection at premises) operated internally or sourced from special providers

Example metrics

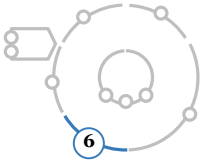
- % of sold items returned
- Cost per item returned
- Days required for return flow

Business model relevance

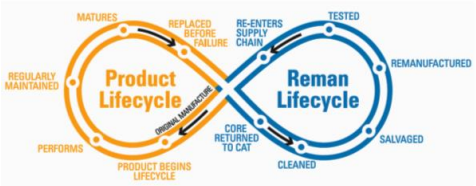
Circular supplychain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
☐	✓	✓	✓	✓

6. Take back products at end-of-life

Good practices inspire ways to incentivise product return, develop reverse logistics and manage waste



Good practices and examples



Incentivise product return
Provide incentives for customers to return products or components through e.g. refunds and discounts

Example: Caterpillar uses a proprietary core management system to globally manage core returns from dealers and Caterpillar inspection facilities and determine the core credit amounts that will be refunded

Reverse logistic channels
Develop own reverse logistic channels or partner with established companies to collect components and complete products

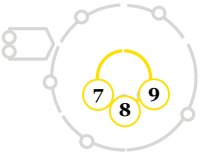
Example: CoremanNet, a subsidiary of Bosch, offers qualified core return solutions for the automotive spare parts market. The modular packages can be adapted to individual company requirements

Waste material management
Control waste material flows to secure high-quality material for recycling

Example: Renault tries to maintain control over the flow of automotive waste materials and parts through it subsidiary Renault Environnement that e.g. coordinates >300 demolishers in France

Source: Company websites

Technology, partners and leadership play a key role in the circular transformation



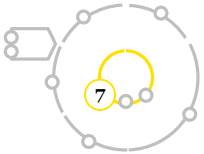
C) Organisation and collaboration

	7 Deploy technologies and data for delivering outcomes	8 Orchestrate ecosystem of partners	9 Transform culture and steering
	Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling Strategy & Leadership	Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling Strategy & Leadership	Design | S&P | (Re)manufacture | Re(sales) | Aftersales | Take-back | Recycling Strategy & Leadership
Required know-how	**Ability to collect, manage and derive valuable insights from technologies and real-time data** • Development and management of IT infrastructure and APIs • Data collection, analytics, visualisation and monetisation • Understanding of existing and new data and security regulations	**Ability to manage increasing number of ecosystem partners to jointly close the loop** • Understanding of how to maximise the strengths of each partner • Deriving new ideas through co-innovation and input from a variety of sources • Understanding of IPR[1] and legal compliance	**Ability to develop and motivate circular competences and outcomes** • Enablement of cultural shift and cross-functional collaborations • Development of targets and metrics to incentivise circular initiatives • Understanding of life cycle perspectives for accurate business valuation
Recommended approach	**Leverage tools to generate and visualise data** • Deploy sensors and other data collection tools, and develop smart products to generate data • Use data to reduce costs and generate revenues • Use visualisation tools to draw conclusions (e.g. Tableau, Microsoft Power BI and IBM Cognos)	**Harness existing network of partnerships and use digital platforms for interactions** • Join knowledge sharing platforms (e.g. WBCSD, CE100 from Ellen MacArthur foundation and DIMECC Ltd) • Build digital platforms to connect to stakeholders and to gain insights	**Integrate circular economy objectives and organise around products/services to drive cross-functional collaboration** • Define clear and measurable targets • Facilitate exchange of information and cross-functional collaborations • Motivate employees to change mindset

Successful transformation through full utilisation of internal and external strengths and resources

7. Deploy technologies and data for delivering outcomes

Know-how in IT is key for digitally enabled circular solutions and seamless integration with ecosystem



Required know-how and activities

1. **Data infrastructure set-up:** Develop the IT infrastructure of the company. A seamless integration of different technologies, databases and partners need to be in place for digitally enabled outcome-oriented offerings and resource efficient production. Management and integration of APIs (Application Programming Interfaces) is required for this
2. **Data collection, analytics and visualisation**: Draw insights from historic and real-time data from e.g. smart products through data analytics and visualisation to facilitate new offerings such as predictive maintenance. Use and develop tools for collecting data from customers, e.g. apps for reporting product malfunction.
3. **Monetising data:** Use data from business operations and smart products to reduce cost and develop new revenue streams (see guidance on the right)
4. **Data privacy and security:** Ensure compliance with data privacy regulation and secure all data transactions internally and in exchange with customers

Guidance on data monetisation

Manufacturing companies can monetise data by:

a) Reducing cost (focus on data from own operations)
- Analyse historic data to identify structural inefficiencies
- Analyse real-time data to detect incidents

b) Increasing revenue (focus on data from smart products):
- Draw insights from historic use phase data to develop new offerings and products (see example on next slide)
- Use real time use phase data to deliver services during the use phase, such as predictive maintenance
- Sell anonymised data to interested third parties supporting their services e.g. data on weather condition

Example metrics

- % of source data is accurate/ reliability level of source data
- Amount of historical data for analysis and algorithm reliability
- % increase in responsiveness to specified actions/ decisions

Business model relevance

Circular supply chain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
✓	✓	✓	✓	✓

7. Deploy technologies and data for delivering outcomes

Good practices include deploying technologies and drawing insights from generated data

Good practices and examples

Tech-enabled outcome orientation
Deploy sensors and develop smart products to generate data-enabled new business models

Example: Michelin introduced the first "Tire Monitoring Management System" for mining tires enabled through sensors in the tires recording and transmitting pressure and temperature

Enabling technology
Internet of Things

Data monetisation
Use data insights to reduce costs or generate revenue e.g. through predictive maintenance internally or provided as a service to customers

Example: Siemens models status of gas turbines with about 500 sensors in a turbine, and uses data to simulate operation while AI is simulating wear and tear of components to prompt maintenance measures to prevent downtime. Insights can be shared via cloud

Enabling technology
Internet of Things
Artificial intelligence

Data visualisation tools
Use data analytics and visualisation tools to extract insights from the pool of available data

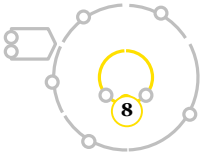
Example: Available plug-and-play tools are for example Tableau, Microsoft Power BI or IBM Cognos

Enabling technology
Big data

Source: Company websites

8. Orchestrate ecosystem of partners

To orchestrate the ecosystem, identifying and engaging stakeholders, and IPR management are key



Required know-how and activities

1. **Coordination of ecosystem partners:** Facilitate combining efforts to jointly generate circular value from closed loops, new services etc. Have oversight of different partnerships established in procurement, sales and support to identify synergies
2. **Engagement to co-innovate**: Harness ecosystem for co-innovation and obtain and develop ideas for new products or services from a wide variety of sources, both internal (employees) and external (customers, suppliers, market research) to the firm
3. **Intellectual property rights (IPR):** Secure own IPR and assure legal compliance in ecosystem collaboration and co-innovation (see guidance on the right)

Guidance on managing IPR in open innovation

1) Develop inventory of own IP assets and maintain it
2) Set-up non-disclosure agreements with partners to secure confidentiality in discussions and negotiations prior to an official collaboration, or embed it into a memorandum of understanding
3) Sign a jointly developed consortium agreement defining responsibilities, listing ownership of existing IPs and allocating ownership and access of newly generated IP

Helpful tools and resources are available at the European IPR helpdesk online (Link)

Example metrics

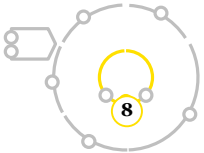
- # of ecosystem partners at each stage of product life cycle
- # of ideations with eco-system partners

Business model relevance

Circular supply chain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
✓	✓	✓	✓	✓

8. Orchestrate ecosystem of partners

Harness existing networks and partnerships and use digital platforms for interaction



Good practices and examples

Knowledge sharing networks

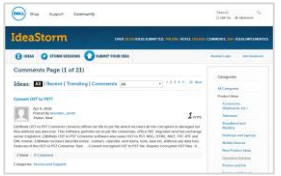
Join existing knowledge sharing platforms to leverage existing experiences and share own ones

Example: Factor 10 from WBCSD and CE100 from Ellen MacArthur foundation are initiatives that aim to accelerate the transition to a circular economy by bringing together companies from different sectors. Both organisations also publish CE content on their website, which is also available for non-member organisations

Cross-sector partnerships

Connect with stakeholders that have a similar mission and vision. To develop data-based solutions, cross-sector collaborations are required

Example: DIMECC Ltd launched the "Intelligent Industry Ecosystem" in December 2017, where Finnish companies create new data-based products and services. The ecosystem currently involves 10 companies, including e.g. Cargotec, Fastems, Konecranes, Nokia and Ponsse (Link)



Digital platforms

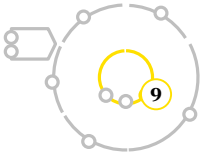
Build a platform to connect relevant stakeholders, collect ideas and find solutions

Example: Dell established the collaboration platform IdeaStorm for ideation and real-time product portfolio management

Source: Company websites

9. Transform mindset and steering

Build the capability to manage the transformation at the right pace



Required know-how and activities

1. **Circular economy competencies:** Build, maintain and expand circular economy know-how to train and support the organisation
2. **Culture and workforce**: Motivate employees and enable culture shift to embrace cross-functional collaboration, ecosystem thinking and customer-centricity. Show leadership commitment, have transparent and engaging communication and conduct trainings
3. **Steering mechanisms:** Develop targets and metrics to promote and incentivise circular capabilities and products. Set incentives for employees to drive circular initiatives. Develop process to account for metrics and track development over time
4. **Circular business case:** Adapt a life cycle perspective for business valuation and add qualitative indicators for intangible benefits

Guidance on steering mechanisms

Performance indicators and connected incentives need to be forward-looking and consider development over time, for example:

- **Design:** Life cycle emissions [e.g. CO_2 volume]
- **Sourcing:** % of input coming from virgin vs recycled materials
- **Manufacturing:** % of reused materials / components
- **Sales:** Customer lifetime value [€]
- **Take-back:** % of recovered assets

Example metrics

- # of trainings held
- % of variable salary connected to circular transformation

Business model relevance

Circular supply chain	Sharing platform	Product Life Extension	Recovery & Recycling	Product as a service
✓	✓	✓	✓	✓

9. Transform mindset and steering

The transformation requires new targets, cross functional collaboration and culture change

Good practices and examples

Target setting
Integrate circular economy objectives into company target(s) to demonstrate their importance and your company's commitment

Example: Siemens has a corporate zero-waste to landfill target.

Unilever sets multiple targets for different waste categories (Link to example targets).

Cross-functional collaboration
Facilitate exchange of information and joint solution development between different functional units of the business e.g. product development and sourcing

Example: Danone embraced circular economy in its organisational structure by developing cross-divisional, cross-functional internal units for its core materials used in production (i.e. milk, water and plastics)

Culture change
Acknowledge that a transformation is required and actively support the organisation to unfreeze its current status, trigger mindset shift and ensure employees internalise it for good

Example: Philips CEO Frans van Houte is guiding his company to redesigning its products and considering how to capture their residual value. At the same time it is shifting from a transaction- to a relationship-based business model – that entails closer cooperation with customers and suppliers.

Source: Company websites

The capabilities need to be developed from several functions – one function takes the lead for each capability

Capabilities	Design / R&D	Sourcing & Procurement	(Re)manufacturing	Sales	Aftersales	Take-back	Recycling	Strategy & Leadership
1 Design solutions to deliver customer outcomes	✓		✓	✓	✓			✓
2 Design products for circularity	✓	✓	✓			✓	✓	
3 Source recycled or recyclable material	✓	✓				✓	✓	
4 Produce, remanufacture and recycle products	✓		✓		✓	✓	✓	
5 Sell outcomes and lifecycle services	✓			✓	✓			
6 Take back products at end-of-life		✓	✓		✓	✓	✓	
7 Deploy technologies and data for delivering outcomes	✓	✓	✓	✓	✓	✓	✓	✓
8 Orchestrate ecosystem of partners	✓	✓		✓	✓	✓	✓	✓
9 Transform culture and steering	✓	✓	✓	✓	✓	✓	✓	✓

Legend: ✓ Function in lead ✓ Function contributing

The different business sub-models require different sets of capabilities

Capabilities

1. Design solutions to deliver customer outcomes
2. Design products for circularity
3. Source recycled or recyclable material
4. Produce, remanufacture and recycle products
5. Sell outcomes and lifecycle services
6. Take back products at end-of-life
7. Deploy technologies and data for delivering outcomes
8. Orchestrate ecosystem of partners
9. Transform culture and steering

Business sub-models

Not all capabilities have to be build internally, ecosystem partners can support

Illustrative examples

1 Design solutions to deliver customer outcomes
- Providers of digital technologies
- Companies supporting on digital product life cycle management
- Designers for customer centric and digital design

2 Design products for circularity
- Companies and universities with know-how on e.g. circular materials
- Designers assisting circular design

3 Source recycled or recyclable materials
- Raw material suppliers that already have circular economy initiatives
- Recycling companies
- Renewable energy companies

4 Produce, remanufacture and recycle products
- Providers of innovative production or remanufacturing technologies (e.g. robotics, 3D printing, artificial intelligence)

5 Sell outcomes and lifecycle services
- Partners that can assist in identifying customers (e.g. via Business Finland's search)
- Providers of sales intelligence and customer platforms

6 Take back products at end-of-life
- Logistic companies to jointly develop return scheme or draw on existing services
- Companies with specialised return logistics offering

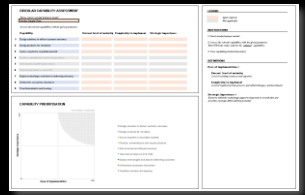
7 Deploy technologies and data for delivering outcomes
- Technology providers for e.g. IoT solutions
- Data-analytics companies and tools that help both gather and analyse data

8 Orchestrate ecosystem of partners
- Knowledge and experience sharing networks and platforms
- Public programs on circular economy

9 Transform mindset and steering
- Companies promoting transparency and reporting
- Networks offering guidance and good practices on transformation

Customer value delivery
Resource handling
Organisation and collaboration

A capability maturity assessment tool helps you to understand your starting point and areas to develop

Tool	Purpose	Required time	Illustration of the tool
Capability maturity assessment	Tool for assessing your company's maturity in the circular capabilities and identifying which capabilities to develop internally and which ones to outsource for external partners	15 min	

Which technologies can support?

Overview of enabling technologies

CHAPTER SUMMARY

Which technologies can support?

This chapter will help you to:

- Explore technologies that can enable your selected circular business model(s)
- Assess your technology maturity and identify actions to develop necessary applications and tools
- Identify potential technology partners and suppliers

Supporting tools:

- Technology maturity assessment

- The digital reinvention of industry (Industry X.0) can deliver tangible benefits and enable the move towards circular economy in the manufacturing industry
- Industry X.0 summarises the rapid development of digital, physical and biological technologies, providing levers for circularity
- Companies can draw on a set of 19 technologies that are applicable for different use cases and circular business models
- To assess the viability of technology implementation, price development, scope of application, comparability of technologies and their benefits need to be considered
- Finally, it is important to note that some new technologies come with risks that need to be balanced with their benefits

The availability and use of technology can enable the move towards circular economy in the manufacturing industry

"Information is at the heart of ensuring that businesses around the world can make the right decisions to eradicate waste and use resources effectively. **The internet of things**, with its smart sensors and connected technologies, can play a **key role in providing valuable data** about things like energy use, under-utilised assets, and material flows to help **make businesses more efficient**."
Kate Brand, Lead for Sustainability, Google Inc.[1]

Entries to The Circulars, the world's premier Circular Economy award, are all tech-enabled

100% of entries to "The circular" awards 2018 identified either a digital, physical or biological technology as part of their circular economy strategy – 51% were digital (e.g. Big Data and Machine Learning)[2]

"Truly circular economies arguably cannot exist without the Internet of Things. No amount of clever design ensures a complex system will remain useful and efficient over time. To be sustainable, **a system must be responsive**; actions and behaviours must be connected via data and knowledge."
Tim Brown, CEO of IDEO[1]

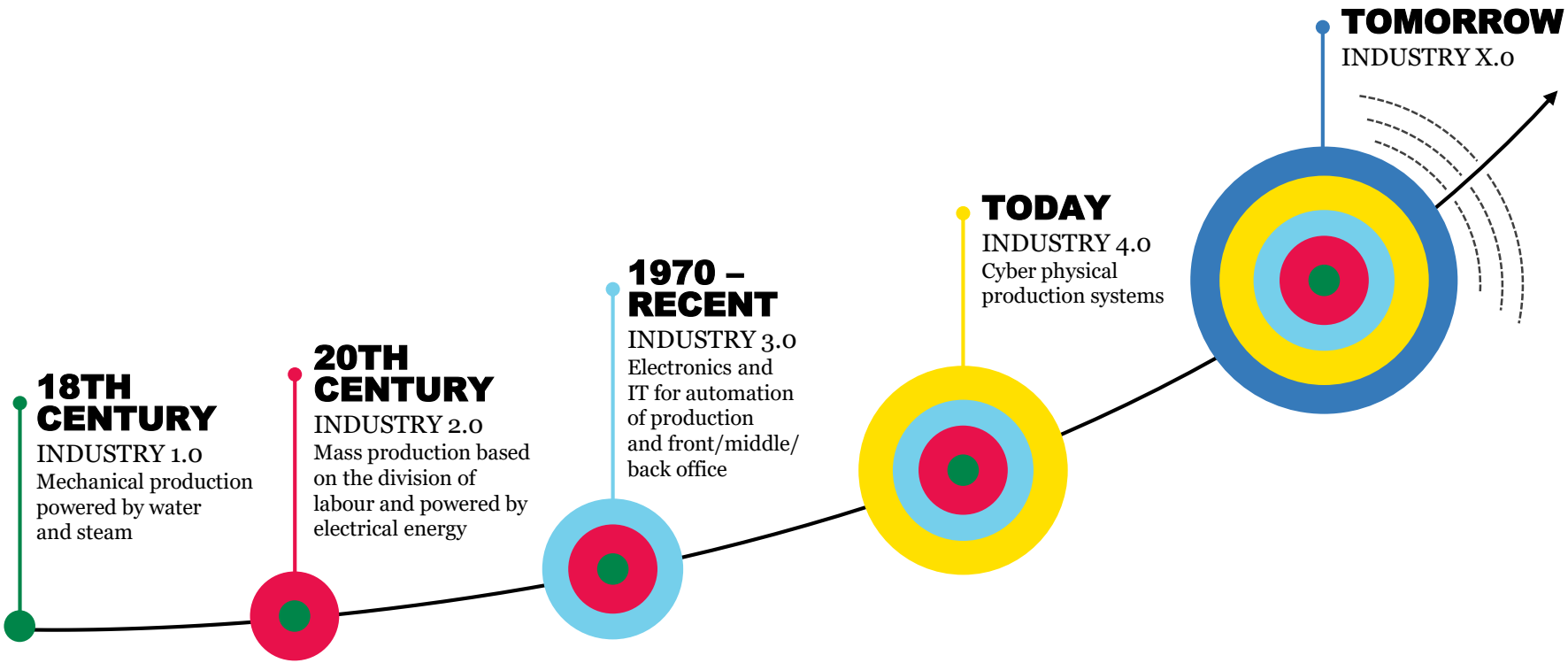
Price development makes technology accessible for SME

"Predictive maintenance in performance contracts is not a novel development at the enterprise level. However, recent technological development increasingly enables performance models to trickle down to small and medium-sized enterprise (SME) customers where previously the tracking and logistics were prohibitively costly" as a report of the World economic forum points out.[3]

"With the advent of the 4th industrial revolution, we have a suit of innovations and technologies that can enable resource decoupling, yet we still live in a world where natural resource demand is growing dramatically."
Dominic Waughra, Member of the Executive Committee, World Economic Forum[4]

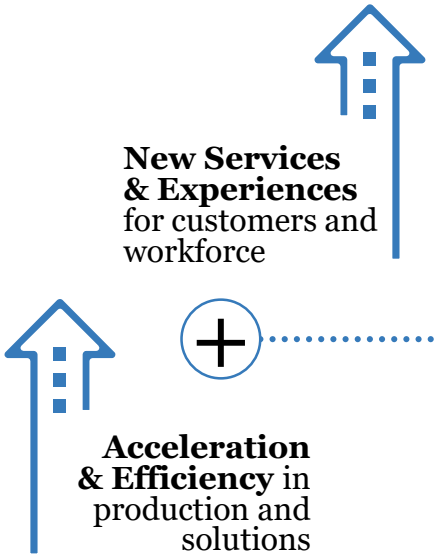
Sources: 1: Ellen Macarthur Foundation 2: Accenture analysis; 3: World Economic Forum; 4: Circle Economy

The increasing speed of technology development forms the term Industry X.0, referring to technologies used tomorrow



Source: Adapted from earlier Accenture publications, Appendix 2 for more details

Changes through Industry X.0 deliver tangible outcomes for companies



Industry X.0 changes

- Invent new **smart connected products and services**
- Transform business models and operations **from product to service to outcome-driven solutions**
- Enable companies to create and participate in **new ecosystems**
- Design the best **experiences for consumers and employees**

- **Automate** core processes of R&D, engineering, production and support
- Integrate systems and digital data footprint to create a **digital thread** through the product journey
- Apply **next generation production techniques -** 3D printing, robotics etc.
- Connect machines and sensors, and **extract data and derive intelligence** to improve performance

Outcome for companies

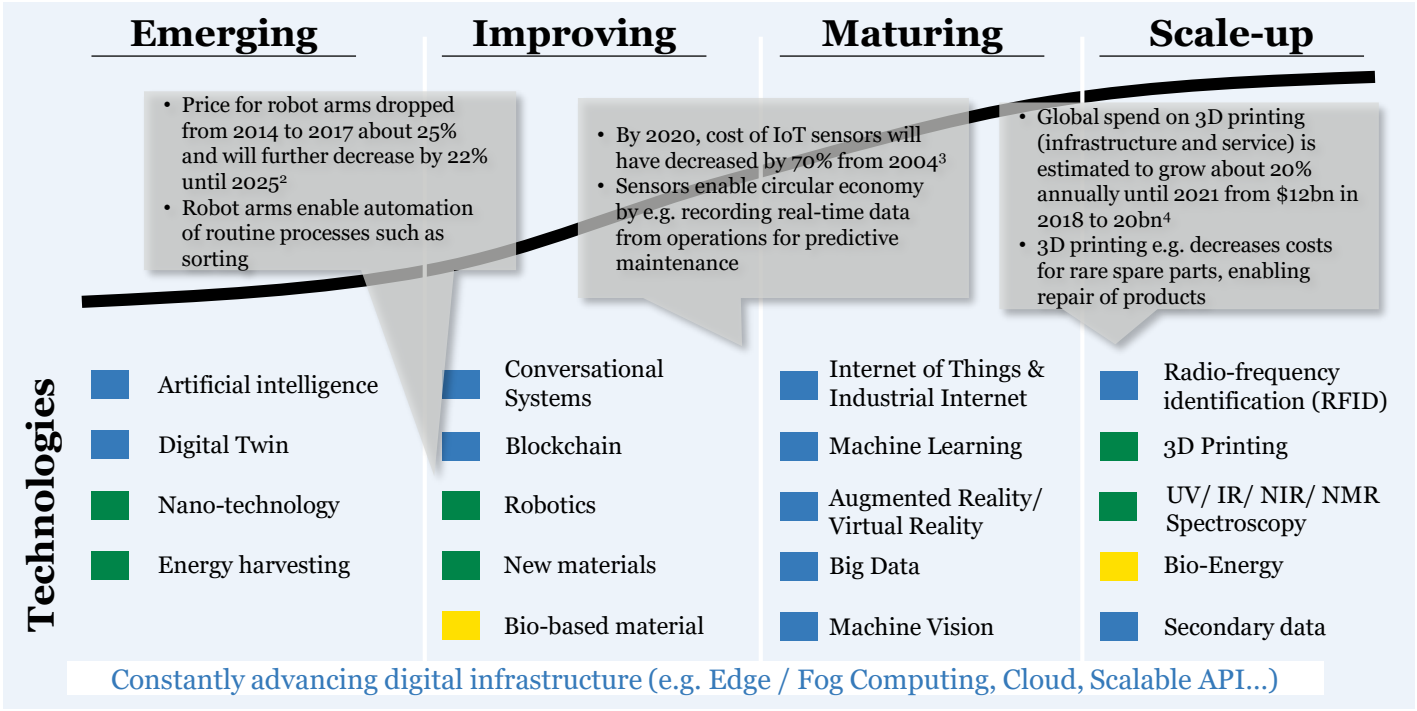
- **New revenue streams** from as a service and smart connected products
- **New product innovation & design**
- **Personalised customer experiences**
- Better **employee experiences** and productivity for both B2C and B2B

- **Faster time to market** from smarter processes and leading technologies
- Increased **R&D efficiency** by lean, agile methodologies
- Greater **agility and responsiveness** to demand
- Dramatically **reduced cost** with data driven insights

Source: Adapted from earlier Accenture publications, Appendix 2 for more details

Besides digital technologies, physical and biological technologies develop at rapid pace, enabling circularity

Level of technology development[1]



Digital:
Technologies based on computer sciences, electronics and communication which make use of increasing information intensity and connectedness of physical resources

Physical:
Technologies based on basic property of materials, energy, forces of nature and their interaction

Biological:
Technologies based on biology, aspects including but not limited to biological systems, living organisms, or derivatives thereof, to make products and processes for specific use

Sources: 1: Accenture, Appendix 2 for more details, 2: IEEE Engineering360; 3: Bank of America, Merrill Lynch; 4: International Data Corporation (IDC)

Legend Type of technology: Digital, Physical, Biological

Each circular business model is enabled by a different set of technologies

	Technologies	Circular supply chain	Sharing platform	Product life extension	Recovery & recycling	Product as a service
Scale-up	Radio-frequency identification (RFID)	✓		✓		✓
	3D Printing	✓		✓		
	UV / IR / NIR / NMR Spectroscopy				✓	
	Bio-Energy	✓			✓	
	Secondary data		✓	✓		✓
Maturing	Machine Learning	✓	✓	✓	✓	✓
	Internet of Things & Industrial Internet	✓		✓		
	Augmented Reality / Virtual Reality	✓		✓		
	Big data	✓	✓	✓	✓	✓
	Machine Vision	✓		✓	✓	
Improving	Conversational systems			✓		
	Blockchain		✓	✓	✓	✓
	Robotics			✓	✓	
	New materials	✓			✓	
	Bio-based materials	✓				
Emerging	Artificial Intelligence	✓		✓	✓	
	Digital Twin	✓		✓		✓
	Nano-technology	✓		✓		
	Energy harvesting	✓				

Legend: Circular supply chain | Sharing platform | Product life extension | Recovery & recycling | Product as a service

Type of technology: Digital | Physical | Biological

Did you know?
On the Circular Economy site, there is a **technology maturity assessment**, with which you can assess the maturity of your company in technologies enabling circularity, and identify actions to develop it.

RFID, Secondary data and Augmented reality are digital technologies enabling circular economy

Type of technology: Digital | Physical | Biological

	Technology	Description and circular economy example	Illustrative CE Value driver	Business model relevance
Scale-up	**Radio-frequency identification (RFID)**	Enables wireless communication of data between a network-connected reading device and a tag on which data is stored. Exchange is activated by the waves from the reading device *Example: HID offers RFID tags used for stock management, sorting and tracking applications*	Enables product identification throughout life cycle	✓ ✓ ✓
Maturing	**Secondary data**	Use of already existing data, such as social media comments, images, temperature measurements, and open data to draw insights on products and customer preferences *Example: SKF is measuring oil temperature to analyse bearing condition and performance, while Pandora's customers are posting pictures of second hand jewellery to assess their suitability for resale*	Saves time, efforts and costs related to data collection	✓ ✓ ✓
Maturing	**Augmented Reality/ Virtual Reality**	Provides interactive fully immersive digital reality in a computer generated or video enabled environment (VR) or superimposes real world with text, sounds, graphics on top of the physical world via wearables (AR) *Example: ThyssenKrupp enables the field service engineers repairing elevators with HoloLens displaying virtual models of the elevator, information on prior services and repair guidance*	Avoids or significantly reduces costly maintenance work	✓ ✓ ✓

Legend: Circular supply chain | Sharing platform | Product life extension | Recovery & recycling | Product as a service

Source, descriptions: WEF, Appendix 2 for more details
Source, examples: Company websites

Big data, IoT and Machine vision provide different value drivers for circular economy

Type of technology: Digital | Physical | Biological

	Technology	Description and circular economy example	Illustrative CE Value driver	Business model relevance
Maturing	**Big Data** 	Computationally analyses extremely large data sets to reveal patterns, trends, and dependencies *Example: Alstom uses big data to operate predictive maintenance tools that are able to monitor the health of trains and infrastructure*	Enables descriptive and predictive analytics	
Maturing	**Internet of Things/Industrial Internet** 	Deploys wireless devices with embedded sensors that interact and trigger actions *Example: SKF INSIGHT technology applied in railway and wind industry enables rotating machinery to communicate data on operating conditions to Cloud from which customers can extract information through a remote diagnostic service and receive reports and warnings*	Enables exchange of data generated in sensor network and triggering of action	
Maturing	**Machine learning** 	Enables machines to perform new tasks after being trained using historic data sets *Example: Siemens deploys machine learning in gas turbine control systems to optimise turbine emissions. The system is able to further reduce emissions by an additional 10-15% after experts' optimisation*	Enables predictive analytics through algorithms and optimisation	

Legend: Circular supply chain | Sharing platform | Product life extension | Recovery & recycling | Product as a service

Source, descriptions: WEF, Appendix 2 for more details
Source, examples: Company websites

Machine vision, Blockchain and Conversational systems are also enabling digital technologies

Type of technology: Digital | Physical | Biological

	Technology	Description and circular economy example	Illustrative CE Value driver	Business model relevance
Maturing	**Machine vision** 	Provides a computing device with the ability to acquire, process, analyse and understand digital images, and extract data from the real world *Example: A stamping technology manufacturer uses machine vision in quality control to prevent shipment of defective stampings*	Processes pictures for quality control or automated waste sorting	
Improving	**Blockchain** 	Uses transaction digital ledgers that are shared by all parties participating in an established, distributed network of computers to enhance transparency and secure information sharing as the data is auditable, unchangeable and open *Example: Provenance allows users to create and store a digital record of assets for anything of value to track it throughout supply chains*	Enables transparency and traceability in supply chain	
Improving	**Conversational System** 	Uses human voice and gesture recognition to trigger actions *Example: Boeing uses voice control in manufacturing processes to enable employees to receive data displayed on their virtual reality glasses without having to take hands off their work*	Facilitates assembly and remanufacturing process	

Legend: Circular supply chain | Sharing platform | Product life extension | Recovery & recycling | Product as a service

Source, descriptions: WEF, Appendix 2 for more details
Source, examples: Company websites

Artificial intelligence and Digital Twin also enable circular business models, not forgetting a solid infrastructure

Type of technology: Digital | Physical | Biological

	Technology	Description and circular economy example	Illustrative CE Value driver	Business model relevance
Emerging	**Artificial intelligence**	Enables machines to simulate human intelligence and act without explicit instructions *Example: Arago's general problem-solving AI HIRO™ manages and automates business and IT processes, and thus frees up company resources for other things. The AI increasingly learns about the environment it works in, becoming more capable over time*	Enables process to become more efficient over time	✓ ✓ ✓ ✓
Emerging	**Digital Twin**	A virtual model of a process, product or service, pairing virtual and physical worlds. This allows the analysis of data and monitoring of systems to develop new solutions or conduct predictive maintenance *Example: GE uses digital twins to simulate asset performance in different usage scenarios under varying conditions to develop maintenance solutions*	Supports development of maintenance solutions	✓ ✓ ✓ ✓
	Infrastructure	To apply and connect different digital technologies, a solid infrastructure is required with efficient networks, high-speed internet connection, etc. Technologies such as Edge / Fog Computing, Cloud and Scalable API should be considered and technological advancements followed to keep the infrastructure up-to-date		

Legend: Circular supply chain | Sharing platform | Product life extension | Recovery & recycling | Product as a service

Source, descriptions: WEF, Appendix 2 for more details
Source, examples: Company websites

3D printing, UV spectroscopy and Robotics are physical technologies supporting circular economy

Type of technology: Digital | **Physical** | Biological

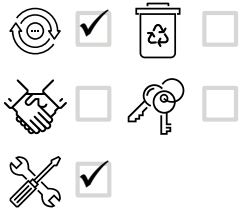
	Technology	Description and circular economy example	Illustrative CE Value driver	Business model relevance
Scale-up	**3D Printing** 	Creates 3D objects by forming successive layers of material under computer control *Example: Daimler Trucks North America pilots sales of on-demand 3D-printed plastic parts enabling delivery of parts which are traditionally difficult to provide e.g. due to low or intermittent demand*	Promotes repair by reducing inventory sizes and repair costs	
Scale-up	**UV/ IR/ NIR/ NMR Spectroscopy** 	Uses different spectrums of electromagnetic radiation to analyse material based on the molecular composition of the matter *Example: Trash-Sorting machine from TOMRA Sorting Recycling uses Near infrared sensors for sorting*	Detects particular type of material in mixed waste stream	
Maturing	**Robotics** 	Applies machines that are programmed to automatically carry out a complex series of actions. Especially suitable for repetitive and rule-based processes using structured data. If combined with machine learning, robots can train themselves *Example: Zenrobotics builds waste sorting robots that can sort and pick objects with various weight and shape and learn new sorting rules*	Automates waste sorting	

Legend: Circular supply chain | Sharing platform | Product life extension | Recovery & recycling | Product as a service

Source, descriptions: WEF, Appendix 2 for more details
Source, examples: Company websites

New materials, Nanotechnology and Energy harvesting are other enabling physical technologies

Type of technology: Digital | **Physical** | Biological

	Technology	Description and circular economy example	Illustrative CE Value driver	Business model relevance
Improving	**New materials** 	Advances in material sciences have led to development of polymers/ substances with modified molecular structure *Example: BMW uses carbon fiber-reinforced plastic in its electric vehicle, lowering the overall mass of the vehicle by over 100kg*	Increases product use efficiency	
Emerging	**Nanotechnology** 	Manipulates matter on an atomic, molecular, or supramolecular scale. Examples are fullerene, carbon nanotubes and quantum dots *Example: GloNaTech produces marine coatings containing carbon nanotubes that facilitate release of microorganisms responsible for biofouling. It reduces flow resistance between the ship's hull and the water in a environmentally friendly way*	Improves environmental performance of product	
Emerging	**Energy harvesting** 	Captures small amounts of energy that would otherwise be lost, such as heat, light, sound, vibration or movement *Example: EnOcean produces energy harvesting wireless switches using kinetic energy for switching application and energy harvesting wireless sensors using solar energy*	Enables data gathering at locations where cables and battery changes are not feasible	

Legend: Circular supply chain | Sharing platform | Product life extension | Recovery & recycling | Product as a service

Source, descriptions: WEF, Appendix 2 for more details
Source, examples: Company websites

Bioenergy and Bio-based materials support substitution of petrol-based materials

Type of technology: Digital | Physical | **Biological**

	Technology	Description and circular economy example	Illustrative CE Value driver	Business model relevance
Improving	**Bio energy**	Renewable energy derived from biomass which includes biological material such as plants and animals, wood, waste, (hydrogen) gas, and alcohol fuels *Example: BioGTS produces biogas from biodegradable waste, industrial residues and agricultural biomasses*	Substitution of petro-based materials and cascading of biomass	✓ ✓
Emerging	**Bio-based materials**	Composed out of biopolymers and other natural-fibre created partially or wholly by using pant feedstock *Example: Mazda uses bioplastic in the interior of its cars and also launched it as scratch and weather resistant material used as coating for cars*	Substitution of petro-based materials to renewable ones	✓

Legend: Circular supply chain | Sharing platform | Product life extension | Recovery & recycling | Product as a service

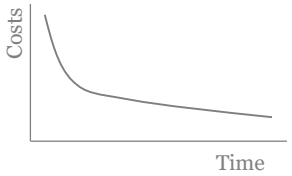
Source, descriptions: WEF, Appendix 2 for more details
Source, examples: Company websites

To assess the viability of implementing any technology, four aspects need to be considered

Price development

Price for digital technologies is decreasing over the years due to fast pace of technological development

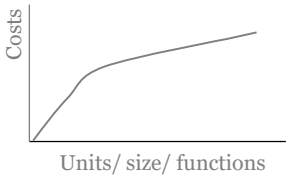
- By 2020, cost of IoT sensors will have decreased by 70% from 2004[1]
- Price for Robot arms dropped about 25% between 2014 and 2017 and will further decrease by 22% by 2025[2]



Scope dependency

Costs for implementation are highly dependent on the scope

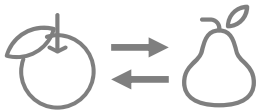
- Depending on the scope of technology application (size of operation facilities, complexity of products, number of processes), the required units/ the size of equipment will vary (e.g. robot arms: €20k-350k[2])



Comparability

Comparing costs of different technologies for prioritisation purposes is misleading as they come with different applications and benefits

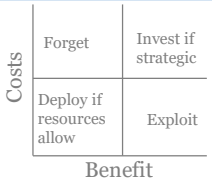
- Prices for technologies are only comparable if they deliver the same function
- Compare benefit of technologies to the company for prioritisation



Business case

Whether the price for a technology implementation makes economic sense or not, depends on the achievable revenues/cost savings potential

- Robotic process automation increases speed of process and can save 20-50% of costs[3]
- Combining technologies can increase benefits. Deploying Robotics, 3D printing, AI, Big data and Blockchain in industrial equipment can save e.g. €35k per employee[4]



Sources: 1: Bank of America; Merrill Lynch, 2: IEEE Engineering360, 3: Capgemini, 4: Accenture, Appendix 2 for more details

The new technologies come with risks that need to be balanced with their benefits

Illustrative

Environmental risks

Harmful production

Even tough beneficial in use phase, the **production** of environmentally friendly technologies can have severe negative environmental impacts (e.g. mining process of rare earth elements)[1]

Uncertainty of impact

The **(eco)toxicological risk and impact** of some innovative materials is **not clear upon first application** and regulations are missing – as is the case of nanotechnologies. Existing studies point to potential adverse effects on aquatic and possibly other organisms[2]

Recycling challenges

An inkjet 3D printer can waste up to **40% of its ink**. In addition, depending on the material used, this waste can not be easily recycled[3]

Additional consumption and waste

Around half a trillion connected devices by 2025 will result in **additional waste, emissions and resources** (including rare-earth elements) inherent in adding sensors, memory, and wireless[4]

Digital risks

Misuse of data

Data protection is of high public concern. The European General Data Protection Regulation now makes protection of EU residents' data for collector and processor mandatory. Sanctions of up **to €20mn/ 4% of global revenue** can be imposed[5]

Data breaches

The average size of data breaches is 24,000 records and **cost >$ 3mn** based on costs of $141 for each stolen or lost record containing sensitive and confidential information[6]

Cyber attacks

Over the last 5 years, average costs of cyber attacks have risen by 62%, mainly because of the **time it takes to resolve** them. While malware take about 6.4 days, malicious codes can take 55.2 days to resolve[7]

Intellectual property protection

Open collaboration and connecting with ecosystem partners e.g. through IoT makes handling **intellectual property protection more complex** – software is e.g. excluded from the scope of patents in EU (different to US)[8]

Source: 1: The Guardian, 2: OECD/ Alliance ; 3: Autodesk, 4: Sustainablebrands.com, 5: Openaccessgovernment.org, 6: IMB, 7: IT governance, 8: International bar association

A technology maturity assessment tool supports you in prioritising which technologies to focus on

Tool	Purpose	Required time	Illustration of the tool
Technology maturity assessment	Tool for assessing your company's maturity in the technologies enabling circular business models, and prioritising those for development.	20 min	

How to design the transformation journey?

Guidance on steps to take advantage of a circular economy and overcome barriers

This chapter will help you to:

- Understand the key steps, common barriers and success factors on the circular transformation journey
- Identify actions to be implemented in terms of culture, ecosystem partners and financing, to avoid typical pitfalls
- Design a transformation roadmap with concrete next steps, responsibilities and milestones

Supporting tools:

- Culture gap analysis
- Ecosystem partner identification
- Funding requirements analysis
- Roadmap development

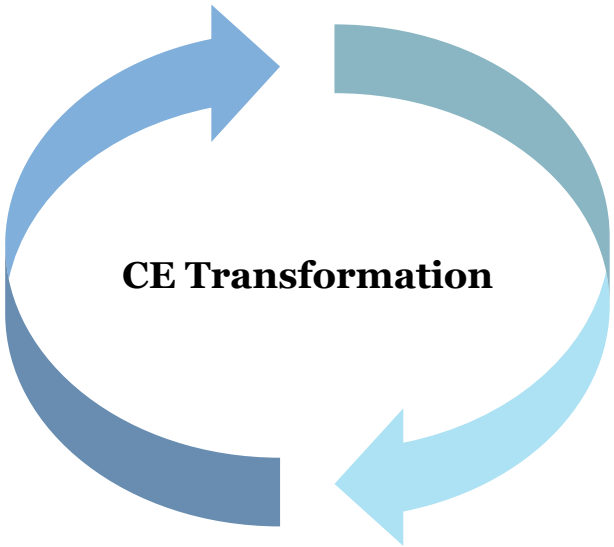
CHAPTER SUMMARY

How to design the transformation journey?

- The transformation journey required to leverage the circular advantage has two key elements: I) Envision and plan and II) Deliver and adapt
  I. Envision and plan describes the planning process in five steps from defining the vision, screening business opportunities, sizing value and assessing capability gaps to designing the roadmap
  II. Deliver and adapt focuses on the actual implementation. Circular transformation requires a fundamental shift across organisations, ecosystem of partners, and customers
- Typically, companies undergo three different stages where they first "Explore & shape" concepts for target business models, look for partners, design and test prototypes. They then "Attract & win" as they develop required processes and partnerships and pilot new solutions. Finally, they "Scale fast & keep growing" by adopting multiple circular business models across their operations and value chain
- Companies often face barriers along the transformation journey, typically related to (a) organisation & culture, (b) ecosystem and (c) finance
- To overcome barriers, companies need to promote a customer-centric, outcome-oriented and collaborative culture, understand funding requirements for circular initiatives and develop an ecosystem of partners

The transformation journey has two key elements: I) Envision and plan and II) Deliver and adapt

Envision and Plan
Develop a vision of how your company will exploit the circular economy opportunities and plan the required changes



Deliver and adapt
Implement changes to transform offering, modify processes, develop ecosystem and become a circular business. Evaluate results and adapt plan as required

Five steps are critical to envision and plan a successful transformation

Envision and Plan

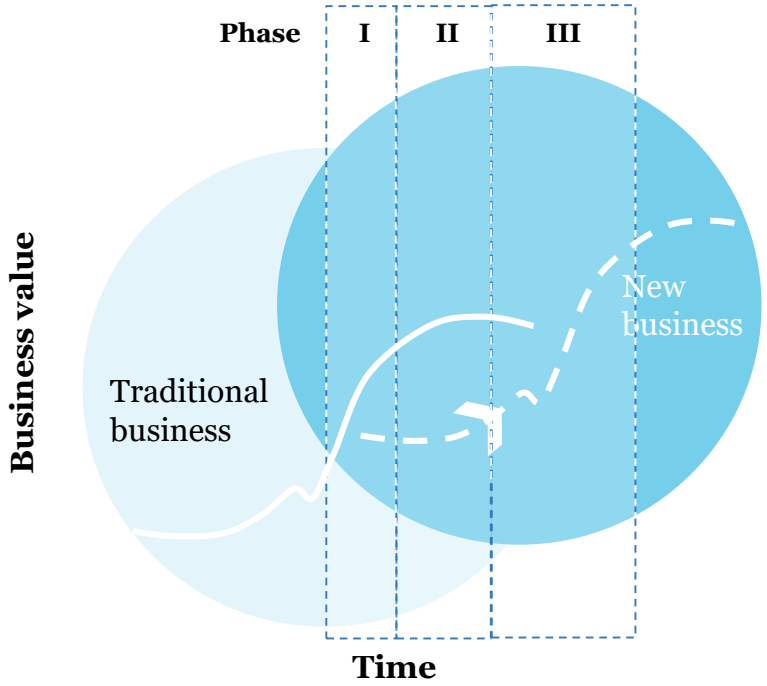
Key activities

1 Why: Define vision for circular economy	2 What: Screen opportunities and size value	3 Assess capability gaps	4 Assess technology gaps	5 How: Design roadmap
1 Vision Define aspirational description of achievements in mid- and long-term future	**2.1 Business models** Assess potential of circular business models to address inefficiencies	**3 Capability gap assessment** Understand and analyse internal capabilities	**4 Technology assessment** Evaluate opportunities of technologies	**5.1 Barriers** Identify potential internal and external implementation barriers and activities to mitigate them
	2.2 Value proposition Develop high level description of the value proposition for new products and services			**5.2 Implementation** Define the roadmap to implement target business model
	2.3 Value case Assess potential revenues, costs and investments for selected business models			
Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5

Start first pilot

The transition from the traditional to the new business model is gradual and has three phases

Deliver and Adapt

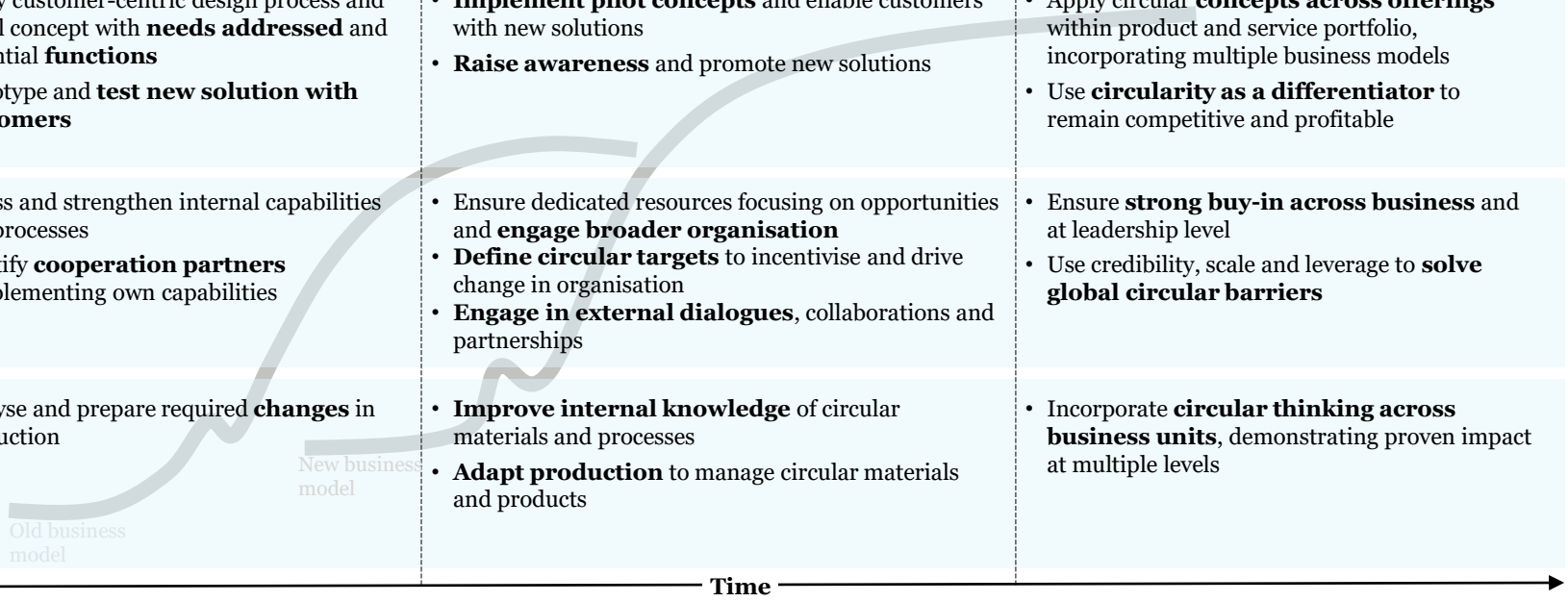


I	**Explore & Shape**	Develop concepts for target business models, look for partners, design and test prototype(s)
II	**Attract & Win**	Develop processes and partnerships and pilot new solution to convey benefits
III	**Scale fast & keep growing**	Adopt multiple circular business models across own operations and value chain

Source: Accenture, Appendix 2 for more details

In each phase, customer value delivery, collaboration and resource handling follow circular business logic

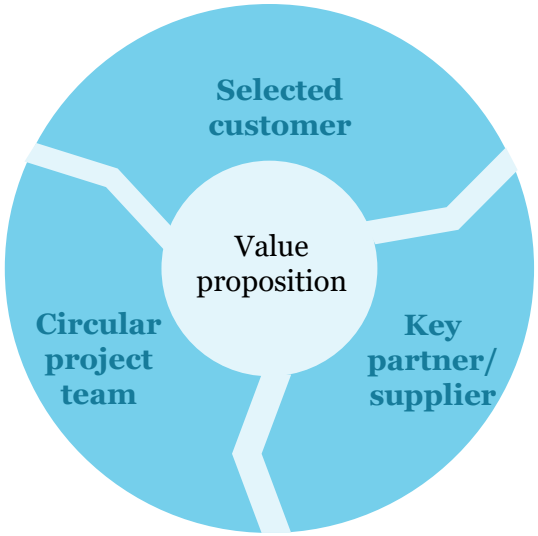
	I. Explore & Shape *Develop concepts for target business models, look for partners, design and test prototype(s)*	II. Attract & Win *Develop processes and partnerships and pilot new solution to convey benefits*	III. Scale fast & keep growing *Adopt multiple circular business models across own operations and value chain*
Customer value delivery	• Apply customer-centric design process and detail concept with **needs addressed** and potential **functions** • Prototype and **test new solution with customers**	• **Implement pilot concepts** and enable customers with new solutions • **Raise awareness** and promote new solutions	• Apply circular **concepts across offerings** within product and service portfolio, incorporating multiple business models • Use **circularity as a differentiator** to remain competitive and profitable
Organisation & collaboration	• Assess and strengthen internal capabilities and processes • Identify **cooperation partners** complementing own capabilities	• Ensure dedicated resources focusing on opportunities and **engage broader organisation** • **Define circular targets** to incentivise and drive change in organisation • **Engage in external dialogues**, collaborations and partnerships	• Ensure **strong buy-in across business** and at leadership level • Use credibility, scale and leverage to **solve global circular barriers**
Resource handling	• Analyse and prepare required **changes** in production	• **Improve internal knowledge** of circular materials and processes • **Adapt production** to manage circular materials and products	• Incorporate **circular thinking across business units**, demonstrating proven impact at multiple levels



Did you know?
On the Circular Economy site, there is a tool called **Roadmap development**, which supports you in planning your circular transformation journey.

First, a dedicated project team contributes to the pilot and stakeholders are engaged selectively

I. Explore & Shape



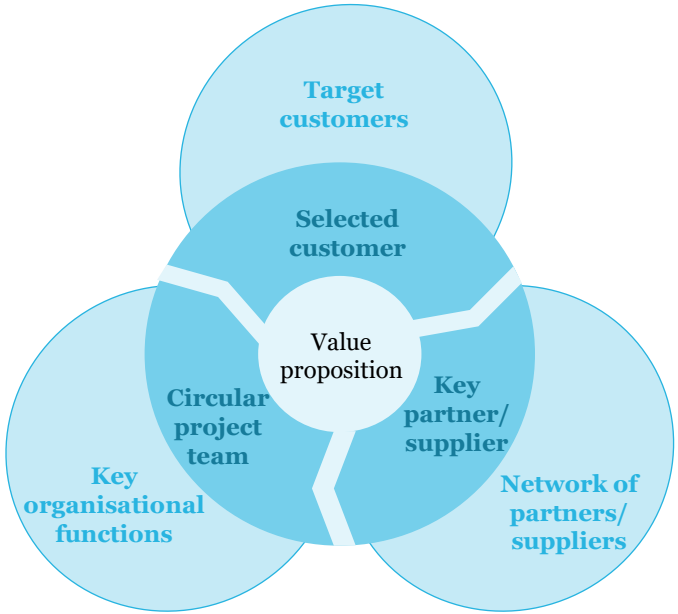
Description

- New solutions are developed in a customer-centric approach, analysing their needs and pain points and engaging them in the development process
- The solutions are prototyped and tested with the customers to assure fit
- The business model is not yet changed in this stage. A dedicated project team within the company contributes to the prototype
- Company boundaries are opened to selected stakeholders. Customers and potentially required partners are invited to contribute and take part in the development and take an active part. This way the developed prototype matches customer needs and demand as well as possible

Example: Michelin Case

- Michelin embarked on the journey to transform from a product-sales focused company towards a solution provider
- To achieve the goal to increase sales of one of its segments from €300mn to €3bn over a period of 10 years, innovative solutions to complement the portfolio were required
- In the first step, when developing a tire solution for mining tires, Michelin focused on understanding pain points in the value chain, and discussed who would be able to pay for a solution and who could be partners to deliver the solution

Later, stronger cross-functional collaboration and interaction with partners is required to bring concepts to market



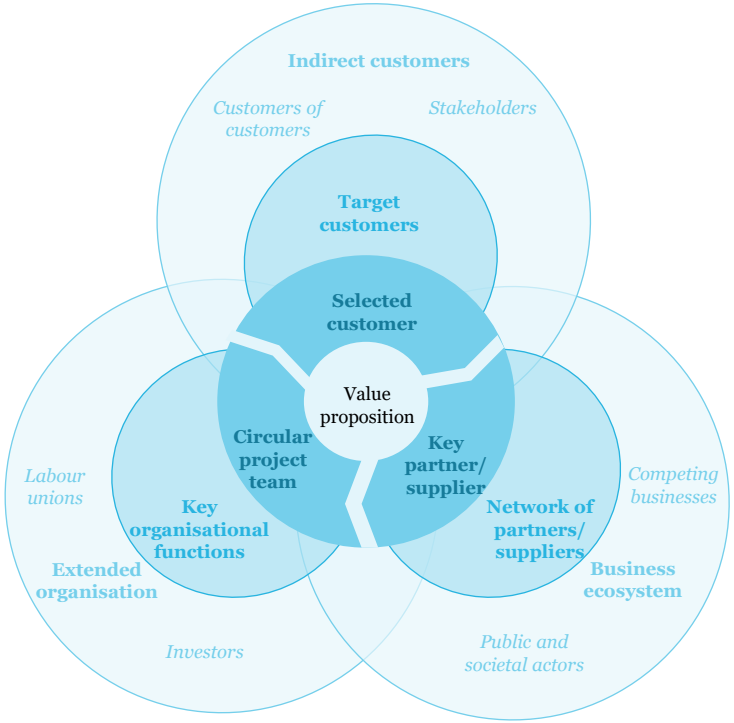
Description

- The new business model is piloted with target customers and runs parallel to the traditional business model
- Cross-functional collaborations are established by involving key functions in solution development
- A customer-centric culture is introduced throughout the company and customers play an integral part in solution development
- The company boundary gets more permeable as more and more stakeholders are engaged to form an ecosystem

Example: Michelin Case

- Michelin established an incubator programme office that is in charge of identifying client needs as well as internal processes that can be improved to respond to them
- The programme office provides guidance on agility and methods to involve external and internal stakeholders
- Michelin grows the identified projects as far as possible and tests them on the market to ensure their viability

Finally, to scale and adopt multiple circular initiatives, all stakeholders need to converge to an ecosystem



III. Scale & Grow

Description

- The new business models are scaled and the business is pivoted to the new, phasing out old business models
- Customer-centricity is fully established and applied throughout the organisation and integrated across the portfolio
- An ecosystem of partners has developed, and it is characterised by multilateral exchanges and interactions instead of one-to-one relationships

Example: Michelin Case

- Michelin leverages the overall ecosystem by drawing on
  - Strategic partners to jointly develop solutions to ensure credibility through a network of recognised partners (e.g. insurance company, telecom provider)
  - Business partners to benefit from their technical or commercial expertise to extend solution benefits with non-core services (e.g. automotive manufacturer)

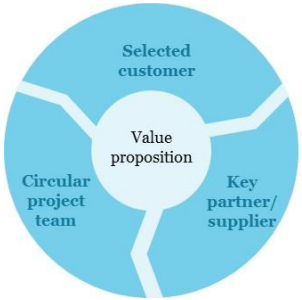
The business transforms over time, incorporating prototyping, customer-centricity and ecosystem engagement into its DNA

See next slides for details

I. Explore & Shape

Develop concepts for target business models, look for partners, design and test prototype(s)

Illustration of company state



Key characteristics

- Customer-centric approach to find minimal viable product through rapid prototyping
- Engage with key partners and customers through dedicated project team

II. Attract & Win

Develop processes and partnerships and pilot new solution to convey benefits

Illustration of company state

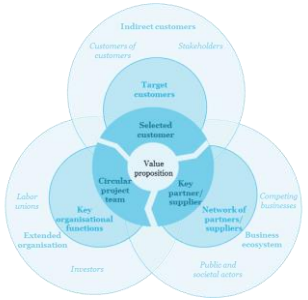
Key characteristics

- Pilot new business model with target customers in parallel to traditional business model
- Establish cross-functional collaborations by involving key functions in solution development
- Focus all processes around customer needs and open company boundary to engage with more and more stakeholders

III. Scale fast & keep growing

Adopt multiple circular business models across own operations and value chain

Illustration of company state



Key characteristics

- Phase out old business models
- Embrace and live a customer-centric culture
- Be connected with an ecosystem of partners in multilateral exchanges

Time

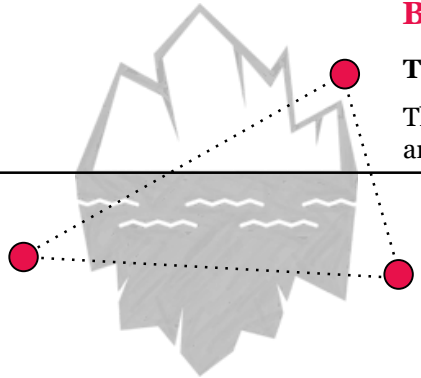
Companies typically face several barriers during their circular transformation journey

Recommendations will guide you through the section

	Type of Barrier	Challenges	Recommendations
Internal	**Organisational & Cultural**	• Change in culture requires changes in **behaviour, value and mindset** of employees • **Cross-functional collaboration and customer-centricity** required for the culture of circular business are often not yet well developed in linearly operating companies – neither on company or function-level • As the owner of customer relationships, the sales team needs to endorse the new circular culture • The transformation process needs to be well **managed** and embraced by leadership to support change in the long-term	1. Address all components of culture 2. Define company-wide and function-specific components 3. Put special focus on sales team 4. Manage culture change with a dedicated programme
External	**Ecosystem-related**	• Full **circular potential in value chains** from joint delivery of services and new configuration of value chains requires a diverse set of capabilities. Only big companies will be able to establish such an ecosystem themselves – others can **develop an ecosystem of partners** • To engage with ecosystem partners, actors that can provide the required capabilities and know-how need to be identified • **Framework conditions** form the prerequisite of how the ecosystem and business models can unfold. While some new business models face the challenge of operating without any legal guidance, others face hindering conditions	5. Understand full circular advantage from collaborative ecosystem opportunities 6. Identify partners to develop ecosystem 7. Be aware of framework conditions and actively engage to shape them
External	**Financial**	• Companies with a well running business model do not perceive a need to invest in circular business models that come with **different funding requirements**, risks and returns • With change in cash flow and asset structure, product as a service models change the overall business logic as compared to many other business models. This leads to **risks** that financiers and businesses often have difficulties to **assess and mitigate** • With e.g. changing cash flow structures, funding requirements vary for all business models, and therefore need to be well assessed and described • Funding sources are scarce, as **only few financiers** have circular economy experience	8. Holistically assess CE benefit 9. Understand business model specific funding requirements 10. Develop mitigation strategies for PaaS specific risks 11. Determine funding requirements 12. Identify funding partner and instrument

Behaviour, values and mindset changes are required to deliver outcome-oriented solutions

1. Address all components of culture



Behaviours

The outward signs of culture

They are informed by underlying values and mindsets

Values

The things we believe are most important

We have some awareness of our own values, but they are largely invisible to others

Mindsets

The assumptions we hold about the way the world is

These are often invisible to us and to others – the things we take for granted

Culture

"The way we do things around here"

Culture is the sum of how people in the organisation assume, believe, and act. This differentiates from competitors

The culture of circular business has company-level and function-specific components

2. Define company-wide and function-specific components

		Culture		
		Values	**Mindset**	**Behaviours**
Company-level		• Sustainability • Customer value creation • Collaboration/ Teamwork	• Minimising resource consumption and environmental impact is key for license to operate • Things that increase client value are prioritised • Sharing among colleagues is caring	• Voice new ideas • Use impact on client value as measure to prioritise activities • Share know-how and experience across functions
Function-specific	**Design/ R&D**		• The resource efficient way will be the better way in the long-run	• Apply circular design criteria • Consider the whole life cycle in design
	Sourcing & Procurement		• Recycled/ reused/ renewable material should be used where possible	• Explore new suppliers for material sources
	Manufacturing		• Repairing a product or component is better than producing a new one	• Support designers in design for repair
	Sales & Aftersales		• Every unmet request of a customer is a potential new solution	• Have dialogue with customers to explore unmet needs
	Take-back & Recycling		• Failing high recovery rates is failing value capturing	• Aim at recovering and recycling as much as possible of products
	Strategy & Leadership		• Leading by example is most effective	• Publicly praise employees for their contribution to the journey

Did you know?
On the Circular Economy site, there is a tool called **Culture gap analysis**, which helps you to understand how circular your company culture is, and identify actions to develop it further.

Shifting aspects of the sales operating model supports culture change towards outcome-orientation

3. Put special focus on sales team

Components of operating model in sales function	Required changes to enable outcome-orientation	Required changes to facilitate customer-centricity
Skills & Competences	Features → Financials Know-how on costs to deliver solutions and cost implications for modifications are needed when selling customised solutions with differing features	Production → Value-chain Highest customer value is achieved when use of capabilities throughout the value chain is optimised for why sales team needs to have close exchange with partners
Interaction	Silos → One-company The sales team needs to e.g. forward customer needs to design department and request input on feasibility of customer wishes	Inside-out → Outside-in The sales team needs to embrace external information to advance solutions instead of pushing product information and products out to the market
Processes & Tools	Stand-alone → Integrated Integrated databases are required to get easy access to information from the whole product life cycle	Internal → Collaborative Processes for continuous engagement along product life cycle are required and exchange of data needs to be enabled through e.g. platforms
Metrics	Snapshot → Longitudinal Performance indicators and connected incentives need to be forward-looking and consider development over time	Product → Customer Sales volume needs to be measured per customer instead of per product/ product family to optimise the value delivered to a customer

The culture transformation in a company can be facilitated by a dedicated change programme

Example change programme

A component manufacturer faced the challenge of below average ESG [1] performance, reputation of poor service quality and, connected with this, reduction in market share. This is their culture transformation journey:

- *They started the journey with a survey across all levels and some in-depth interviews with key internal and external stakeholders to get a holistic view of the situation and to develop a **vision** of where to transform to.*
- *They developed a **change story** describing how they got into the current position, where they want to be, how they plan to get there and what the change means for the individual employee.*
- *The transformation process started with **engagement workshops** in which employees were asked to select a number of initiatives in which they would have the opportunity to demonstrate their commitment to change – giving employees a long-list to decide from increases uptake of activities.*
- *Furthermore, "**Catalyst Projects**" aiming to demonstrate visible changes in values and behaviours were started. They were cross-functional, on top of the company agenda and highly visible.*
- *The transformation process was accompanied by several **communication tools** to constantly make employees aware of it. This included intranet posts, articles in corporate magazines, workshops and emails answering questions.*
- *For leadership, dedicated **peer-learning sessions** were conducted to exchange experiences and discuss challenges and opportunities.*
- *The first phase of the programme culminated in a **event** to celebrate the successes of the catalyst project and officially launch the new vision*

Overview of activities

Planning

1. Develop vision
2. Formulate change story

Engagement

3. Conduct engagement workshops
4. Kick-off catalyst projects
5. Release company-wide communications
6. Conduct regular leadership peer-learning sessions
7. Celebrate company event

1: Environmental, social and corporate governance

Taking an ecosystem approach opens new circular business opportunities

Illustrative examples

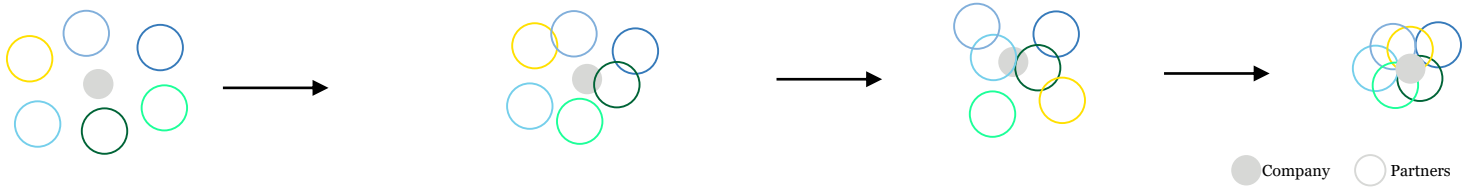
5. Understand full circular advantage from collaborative ecosystem

	Bundled offerings Make e.g. sharing concepts more attractive for customers	**Joint delivery of services** Increases service spectrum to deliver product life extension	**Value chain reconfiguration** Improves collection of material for reuse and recycling
Ecosystem design	• Partner with companies offering complementary services or products (e.g. insurance for shared products)	• Partner with companies delivering use phase services and technology companies enhancing own product e.g. for remote control	• Partner with companies throughout the whole value chain jointly working on recovery and recycling
Opportunity	• Enables to capture value from underutilised capacity of products by addressing potential customer pain points upfront	• Enables to operate business models that require capabilities currently not available at a company (e.g. onsite maintenance and repair services)	• Enable high quality recycling of large (mostly) uniform material that is currently not recoverable in a linear value chain
Challenges	• Identifying relevant product/service combinations • Potential cannibalisation of individual product / service sales	• Distribution of captured value among partners	• Exchange of information on material/ material composition • Work towards unification of input material (as required) • Purity of recovered material in collection
BM relevance	Circular supply chain ☐ · Sharing platform ✓ · Product Life Extension ✓ · Recovery & Recycling ☐ · Product as a service ✓	Circular supply chain ☐ · Sharing platform ✓ · Product Life Extension ✓ · Recovery & Recycling ☐ · Product as a service ✓	Circular supply chain ✓ · Sharing platform ☐ · Product Life Extension ☐ · Recovery & Recycling ✓ · Product as a service ☐

Indeed, achieving the full circular advantage often requires building an ecosystem of partners

5. Understand full circular advantage from collaborative ecosystem

Development of Ecosystem over time



From industry-specific value chains…

…to cross-industry value networks

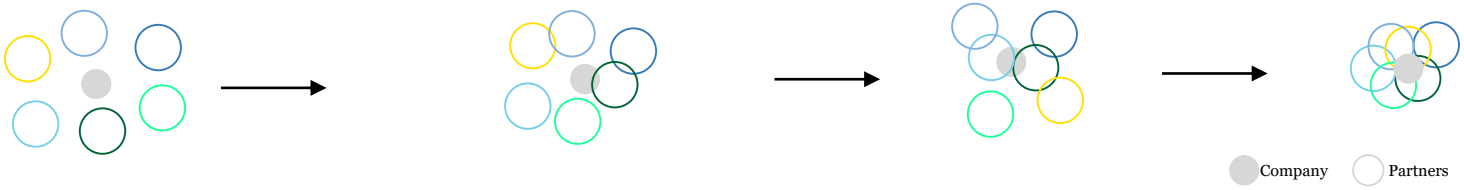
	Traditional approach	Ecosystem approach
Offering	Products and services	End-to-end solutions
Objective	Maximising profits	Maximising customer value
Interactions	Bilateral	Multilateral
Solution development	In-house R&D	Open innovation
Relationship strategy	Partner relationship management	Ecosystem orchestration

Enhanced capability to deliver extended value propositions and superior customer experiences

Ecosystem partners can help in bridging internal capability gaps

6. Identify partners to develop ecosystem

Development of Ecosystem over time



External ecosystem partners

Illustrative examples

Customers

- Current or potential new customers
- Reveal insights on needs and iteratively improve solution

Suppliers & delivery partners

- Goods and services providers for internal use and collaborative solution delivery (waste/ material management, logistics, insurance, payment solutions, …)
- Grant access to circular material, are partners for joint generation of circular material or partners for service delivery

Technology providers

- Providers of technologies and software enabling digital solutions or internal processes
- Engage in solution and production process design and supply required technology

CE Thought-leaders

- Universities, networks and peers with extensive CE knowhow
- Serve as source of inspiration, sounding board and (peer-) learning forum

Financiers

- Public institutions, banks, investment funds, supply chain partners
- Give access to funding required for offering the CE business model

Public and societal actors

- Governments, associations and other representatives
- Influence public perception and opinion and influence or set framework conditions

Did you know?
On the Circular Economy site, there is a tool called **Ecosystem partner identification**, which helps you in identifying ecosystem partners to support with your circular business idea.

Regulations around circular economy are evolving but do not give aspired level of support

7. Be aware of framework conditions and actively engage to shape them

Type of regulatory barrier	Effect for business	Example case
Missing regulations	• Uncertainty about legal status of operations or requirements to pursue the business • Risk of engaging in new model that then is prohibited by new regulations	• Sharing platforms such as Airbnb and Uber face difficulties of missing framework that provide required flexibility – e.g. missing appropriate tax collection laws
Current regulations promoting linear models	• Distortion of competition for circular businesses due to prices from linear models that do not show true costs (neglecting environmental costs/externalities)	• 6.5% of global GDP went to subsidising fossil fuels in 2013 • Tax payers pay more than 90% of the cost of recycling plastic
Current regulations hindering circular models	• Costs from increased administration • Hindrance to harness circular value opportunities	• Definition of material classifications (e.g. “secondary material” status vs. “waste” status) • WEEE is the only category where hazardous substances have been comprehensively restricted for by legislation

Engage in shaping regulations through

- Partnering with larger players
- Seeking for legal assistance
- Participating in political discourse

A clear value case helps companies to overcome hesitations towards engaging in the investment

8. Holistically assess CE benefit

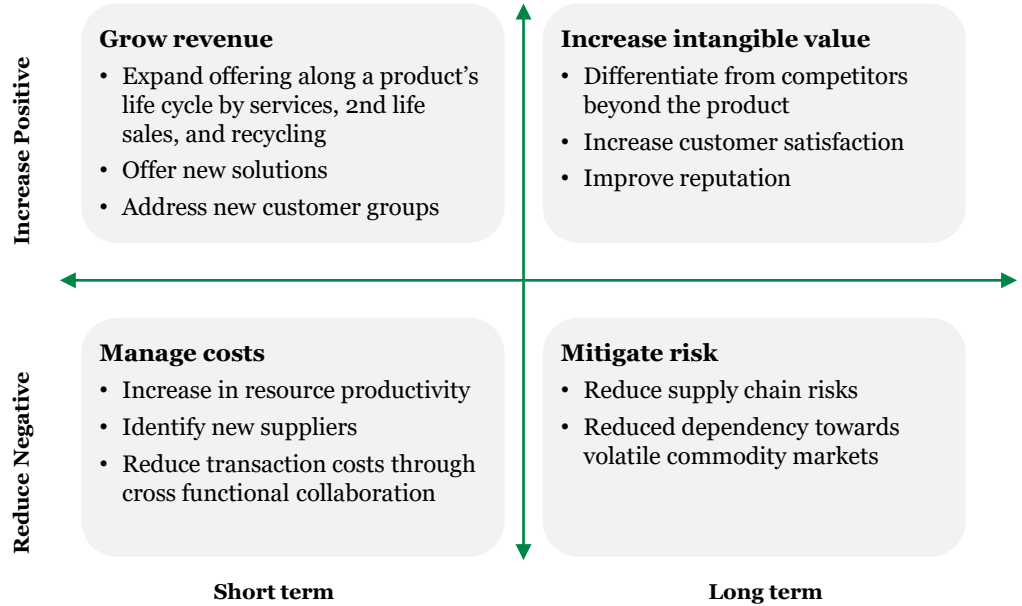
Common situation in business

"We have full books – why should we change something?"

"Our clients are not asking us – no need to change"

"All resources are tied-up, we have no capacity to change"

Holistic value of CE can outweigh rejections



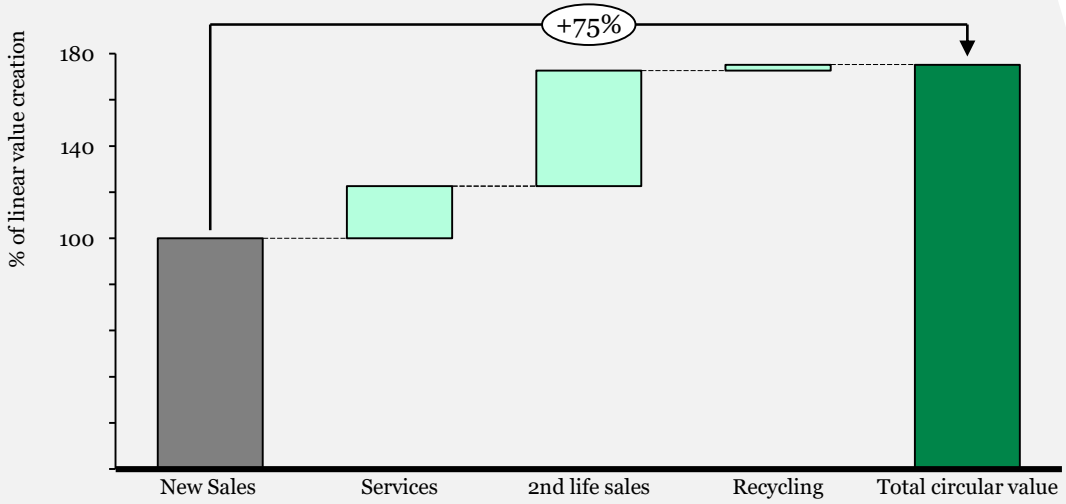
Did you know?
On the Circular Economy site, there is a **Value case tool**, with which you can calculate a high-level business case, including investment need, for circular economy business models for your company.

Income throughout a product life cycle can increase by 75% through circular business models

8. Holistically assess CE benefit

Illustrative

Illustrative financial benefits



Value captured in linear model

Additional value captured in circular supply chain from

- Business models extending product life such as repair and maintenance services
- Recovery and recycling business models

In this example, circular business models can **increase current revenues** as follows:

- Services 25%
- 2nd Life sales 50%
- Recycling 3%

Based on estimates for automatic and micro dive

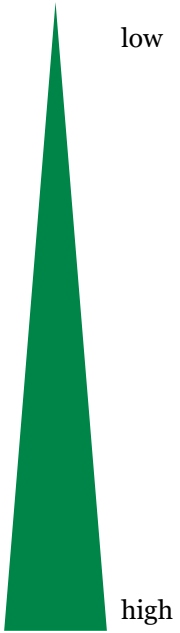
Legend: Current value captured | Additional value | Total value captured in CE value chain

Circular business models have three funding requirements that vary in level of risk and return

9. Understand BM specific funding requirements

Funding requirements	Applicability for Business models	Financial implications
Incremental investments to extend offering portfolio	Circular Supply Chain Product Life Extension Recovery & Recycling	• Investments to e.g. modify production equipment or set up reverse logistics processes are required • Incremental revenue and/ or cost reduction opportunity exists • If deposit system is introduced in take-back, additional cashflows are generated
Significant investment to finance balance sheet extension	Product as a service[1]	• Required working capital increases due to changes in cashflow and extension of balance sheet (assets offered to customer as-a-service need to be pre-financed) • Assets distributed to customers have limited value as collateral
Significant investment to finance new and potentially disruptive offering	Sharing Platform	• High investments are required for platform due to "winner takes it all" effect • Potential to disrupt industry exists but with uncertainty of success for this strategy and related return on investment

Level of Risk/ Return



[1] *Deep dive on following page*

Financial, legal and market-related risks need to be mitigated to convince financier to fund PaaS model

10. Develop mitigation strategies for PaaS specific risks

Risks of Product as a service model	Mitigation strategies
Financial • **Default of payback** due to longer payback periods for the required working capital • **Illiquidity** and costly collection of collateral due to assets being located at customer sites • **Decreasing value of collateral** over time due to depreciation • **Unknown residual value** of many products, due to small market of circular output companies	• Shorten payback period by changing pricing model to get higher cash flows in beginning • Show benefit of higher and more stable profit margins based on additional lifecycles and reduced dependence to volatile commodity prices • Leverage supply chain for securities i.e. supply chain finance/ reversed factoring
Legal • Discontinued payment of service in case of **client bankruptcy** by liquidator and limited ability to get product back (depending on products e.g. power-by-the-hour) • Legal **ownership of assets** might get lost due to legal accession (e.g. in real estate)	• Collect deposit do reduce risks connected to bankruptcy • Design service cut-off function (e.g. remotely disable engine in case of default of payment) to incentivise continued payment • Diversify contract and client portfolio
Market-related • **Lacking demand** of offered service as customers and companies are currently used to owning products • Lower **solvency of customers** attracted by PaaS due to reduced level of individual payments • Availability of stable **second hand market** required for valuing collateral	• Check creditworthiness of customers • Introduce risk premiums in pricing scheme

Mitigation strategies are important to convince internal or external financiers, depending on the individual funding requirements

Across all business models, funding requirements can be determined in four steps

11. Determine funding requirements

1) Model expected net cash flow

- Estimate price or monthly fee appropriate for product or service (depending on e.g. asset handling, insurance, services, operating costs)
- Model growth **scenario** taking into account the cyclic back-flow of assets in different conditions
- Calculate expected net **cash flow** based on fees and scenario

2) Define financing needs

To offer circular business models companies need to

- **Secure finance for upfront investments**: Development of product, set-up of infrastructure, training of workforce etc. need to be financed
- **Secure working capital during operations**: Especially relevant for PaaS – Products and spare parts delivered to customers but paid-back over a certain period of time need to be pre-financed. Capital needs to be flexibly available as new products need to be financed as soon as new contracts are signed

3) Asses risks and offer securities

The cashflow logic of all circular business models but PaaS is similar to linear value creation. Therefore, only for PaaS risks and collateral assessment varies. Following aspects are relevant:

- **Client quality**: Depends on solvency and a combination of number and diversity of clients. A strong portfolio offers security as it buffers the risk of default of payments
- **Asset quality**: Depends on the existence of a second hand market for the product and the condition of used products. A high resell price reduces risk as it gives high collateral. In the worst case, collateral is scrap value of a product
- **Contract robustness**: Depends on specifics of clauses such as termination fees or instalment fees that reduce risk of high fluctuation of customers and deposits reducing risks of default in payback in case of bankruptcy

4) Select funding sources

Companies can more easily use internal funding or approach external financiers. If external funding is required, the appropriate funding instrument and source is dependent on funding volume and risk. Factors influencing the risk are e.g.

- Availability of collateral in company
- Maturity of offering

The next pages give details on instruments and sources.

Source: 1: European commission (2016): Flash Eurobarometer 441 - European SMEs and the Circular Economy

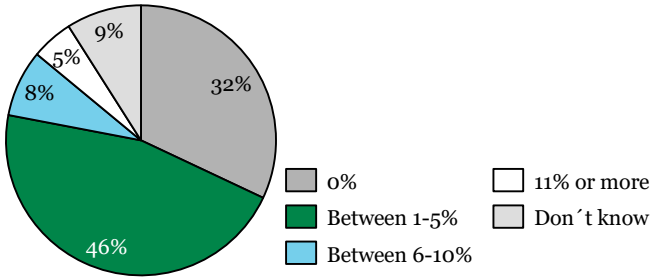
Did you know?
On the Circular Economy site, there is a tool called **Funding requirement analysis**, which helps you to reflect on your funding needs and sources.

Credit lines, leasing and bank loans can also be used to fund CE activities

12. Identify funding partner and instrument

Financing **CE activities** in SMEs **in EU**

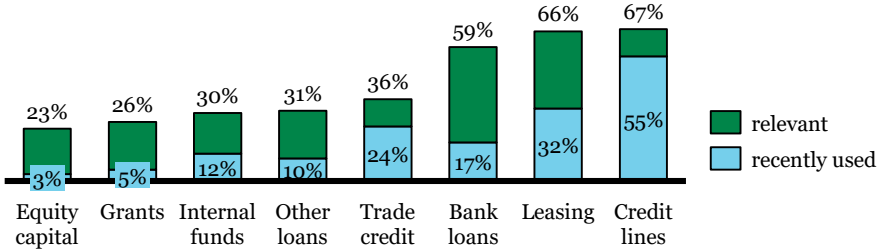
About 60% of SMEs engaging in circular economy invested some share of their turnover to conduct the initiatives[1]



- The most common external funding source for CE activities is a standard bank loan[1].
- Accessing external funding is perceived to be difficult – however, less companies actually encounter difficulties than expected before trying to secure funding (58% of companies that required external funding stated they had difficulties. Among companies that did not yet conduct circular activities but would require external resources, 78% expect it to be difficult).[1]

General SME financing **in Finland**

Credit lines, leasing and bank loans are the most relevant funding sources for SMEs in Finland[2]



- Only 6% of Finnish SMEs rate access to finance as their most important concern – for 69% this is availability of skilled staff or competition and regulation[2]
- 17% of SMEs applying for bank loans did not get the (full) bank loan they had planned for[2]
- 43% of SMEs used financing for fixed investments, 40% for inventory and working capital, and 26% for developing new products[2]

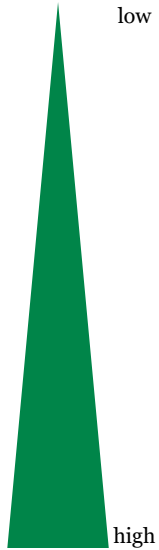
1: Answers to the question: "Over the last 3 years, what percentage of your company's turnover have you invested on average per year to undertake [Circular economy] activities?", n=7.771 European companies that stated to conduct circular economy activities, Source: European commission 2016 – European SMEs and the circular economy (Link); 2: European Commission 2017 -SME access to finance conditions 2017 SAFE results – Finland (Link);

Besides bank loans, other funding sources and instruments can be explored for CE funding

12. Identify funding partner and instrument

Funding source	Funding instrument	Application in circular businesses
Banks	**Corporate debt** (e.g. Bank loans, credit lines)	• Traditional lending that can finance circular investment needs • Requires guarantees from company
	Leasing	• Can enable Product as a service business models • Applicable for products with predictable residual value or creditworthy company
	Invoice factoring, Purchase order financing	• Can increase working capital and thus support PaaS business model • Applicable for companies with solid client or supplier base
	Warehouse financing	• Can enable e.g. product life extending businesses models that might lead to increase in inventory • Applicable for products with predictable residual value in mid- to high price range as storage fees need to be considered
Capital markets	**Equity finance**	• Only applicable for larger and mature circular businesses that meet the scale and requirements of the capital markets
	Debt finance (Green bonds)	
For-profit investors	**Crowd funding**	• Applicable for circular businesses that involve the (local) community or those based on ideas that appeal to the crowd
	Venture capital, private equity	• Only partly applicable for circular businesses as high growth and relatively fast payback horizons are required
Foundations & impact investors	**Grants, loans**	• Suitable for circular businesses that are at a pilot stage and not profitable yet or are lacking a track record

Indicative level of risk/return



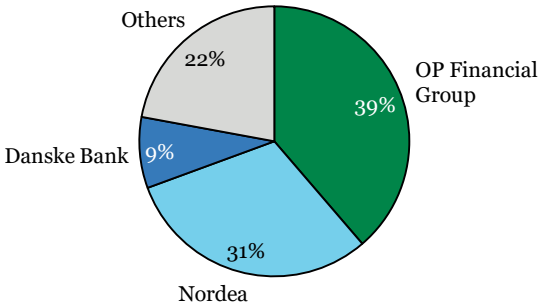
Depending on financier, high level of return is not expected

Source: Based on ING (2015): Rethinking finance in a circular economy

The three key Finnish banks are open for circular or sustainable businesses

12. Identify funding partner and instrument

Market shares of stock of loans to Finnish non-financial corporations
(December 2017)[1]



1

OP Financial Group

Example SME specific offerings:
- Loans with the European Investment Fund (EIF) InnovFin risk-sharing guarantee
- Factoring services to finance receivables
- Leasing of assets from a supplier of choice for a specific period

CE related expertise: OP is behind the DriveNow car sharing service in the Helsinki region. They rent out cars on a pay per minute basis according to the DriveNow concept. OP owns the cars and generates revenues through user fees and registering. They can thus draw on own experiences for the PaaS business model

2

Nordea

Example SME specific offerings:
- Asset life cycle management with leasing services and multiple options at the end of lease period
- Factoring services to finance receivables
- Wholesale financing and management offering a stock funding process

CE related expertise: Nordea positions itself as an enabler of sustainable business models and has experience with e.g. Product life extension as shown in the customer story of the Swedish company Inrego, an electronic device refurbisher

3

Danske Bank

Example SME specific offerings:
- Loans for different needs
- Factoring services to finance receivables
- Leasing services

CE related expertise: Danske Bank does not position circular economy as a focus area but concentrates on carbon reduction. It states to consider environmental, social and governance risks in lending practices in collaboration with customers. Furthermore, they claim to engage in knowledge sharing and stakeholder engagement from climate change

Source: Company websites; 1: Bank of Finland

Other public and private funding institutions can provide alternative funding sources

12. Identify funding partner and instrument

Public funding institutions

Finnish

- Finnish Ministry of Economic Affairs and Employment provides €2m funding for CE initiatives in 2019
- Business Finland offers funding programs for SMEs e.g. to support international expansion
- Finnvera gives guarantees against political or commercial risks associated with the financing of exports
- TESI offers funds and direct investments to support growth and has Circular economy as a new focus

European

- The EIB and European Commission finance the European Fund for Strategic Investments (EFSI) with €250bn available until 2020. OP Financial Institute can be approached to access the fund in Finland
- InnovFin provides guarantees and counter-guarantees on debt financing of up to €50m for companies with <3000 employees (grants from 7.5-25mn are directly delivered by the EIB)
- Under Horizon 2020, the European commission funds CE research between 2018 and 2020 with €1bn

Private funding

Illustrative examples

Finnish

- A financing company that operates the world's first Private Equity Circular Economy Fund
- An independent provider of financial solutions for growth companies, drawing on different sorts of funding solutions (equity, debt, EU and government funding
- Loudspring is an accelerator for companies that aim to save natural resources – generally in early stage.

International

- A specialised private equity firm investing in SMEs that operate in the circular economy (£1-5mn)
- A fund that invests in sustainable consumer goods companies, advanced recycling technologies and services related to the circular economy

Various tools help you to get started with your circular transformation journey

Tool	Purpose	Required time	Illustration of the tool
Culture gap analysis	Tool for analysing how circular your current company culture is and outlining activities to bridge identified culture gaps.	15 min	
Ecosystem partner identification	Tool for identifying external partners that can help in bridging internal capability and technology gaps.	15 min	
Funding requirement analysis	Tool for reflecting on funding requirements of your selected circular business model.	15 min	
Roadmap development	Tool for planning your circular transformation journey, including list of activities and key milestones.	30-45 min	

Concluding remarks

By now you should have a better understanding of…

- How circular economy and specific business models can create a competitive advantage and bottom line impact
- What will be required from your organisation and operations to deliver on the ambition
- What barriers you are likely to encounter and how to overcome those as you start to transform your business

As next steps, we encourage you to…

- Revise your first hypotheses together with selected business representatives
- Summarise insights (use circular business model canvas introduced on the next page)
- Gather a project team and get started!

The business model canvas helps you to summarise the key building blocks of your circular business model

Tool	Purpose	Required time	Illustration of the tool
Business model canvas	Tool for crystallising your circular business model by reflecting on its key building blocks, including your value proposition, infrastructure, customers and financing.	20-30 min	

Industry deep dives

Current state analysis and circular opportunities for Machinery & Equipment, Marine, Energy & Transportation

This chapter will help you to:

- Gain in-depth knowledge of the current state and leading circular economy examples of your industry
- Compare your starting point to others in your industry and identify most relevant circular business models for your company

Industry deep dives

- Machinery & Equipment, Marine, Energy and Transportation are important ecosystems within the Finnish manufacturing industry, representing almost 40% of Finland's manufacturing exports
- Therefore, these sub-sectors play a key role in driving wider adoption of circular business models across the Finnish business landscape
- This section takes a deep-dive into the current state of these four sub-sectors, looking at inefficiencies in the current value chains and showcasing leading circular economy examples
- Overall, inefficiencies occur in all parts of the linear value chains and the adoption of circular business models is limited in all studied sub-sectors
- Still, compelling circular business model examples from leading Finnish and international companies exist, and inspire others for action

The following sections take a deep dive into four important ecosystems within the Finnish manufacturing industry

Machinery & Equipment

Manufacture of machinery and equipment, including e.g. engines and turbines, pumps, compressors and valves, agriculture, forestry, mining and metallurgy machinery, and lifting and handling machinery.

Largest sector of the Finnish manufacturing industry, accounting for 13% of Finland's exports and employing 15% of the workforce.

Marine

Manufacture of ship parts and marine equipment, such as hull, propulsion and power engines, other systems and solutions and interior equipment.

Over 900 companies with a turnover of EUR 8 billion, of which approximately EUR 1 billion from shipbuilding.

Energy

Manufacture of electrical equipment, such as batteries, accumulators, wiring and wiring devices, electric lighting equipment, transformers and electricity control apparatus.

Employs over 15 000 people in Finland.

Transportation

Manufacture of motor vehicles, trailers and semi-trailers, and their parts and equipment.

Export value of EUR 3 billion with strong expertise in special vehicle manufacturing.

Sources: Statistics Finland, Finnish Customs, Finnish Marine Industries

Quotes from selected companies

"Workshops were great and had mentally both feet on the ground and head in the clouds. In workshops co-operation with other participants was good and I especially liked the Round Robin –method. We could develop our shy ideas into concrete plans and roadmaps. Now it is up to us to proceed according to the roadmap step by step. "

Pasi Aaltonen, Vice President, COO, Arvo Piiroinen Oy

"The circular economy will have an increased relevance for companies strategies and business models in the future. It was great to participate in the circular economy introduction programme. It was well managed, gave a structured approach to the topic and a good set of tools for continued work to find new possibilities to develop our and our customer's business."

Petri Paavolainen, Managing Director, Dinolift

"In Saxo Group we have been thinking for some years about the possibilities the circular economy can provide to us, and for the environment naturally. So we had a few ideas when we entered to the program as one of the pilot companies. The playbook worked for us as a systematic approach to further develop our ideas in a very concrete way. It is a tool which requires concentration and time to learn how to use it but we think it is absolutely worth the time spent for it. Like most of the similar tools it really helps to take different aspects into consideration and to build a business case where at least the most important factors have been thought."

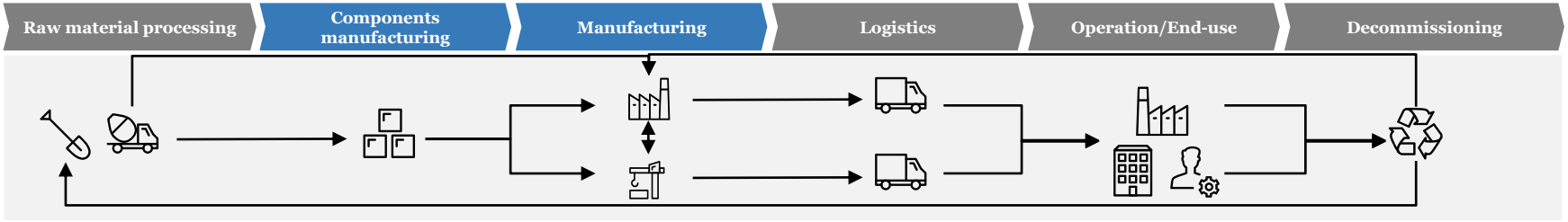
Jari Vuorinen, Managing Director, Plastone Oy (part of Saxo Group)

Machinery & Equipment

Current state analysis and circular opportunities

Currently, the Machinery & Equipment value chain is focused on building efficient, long-lasting products

In scope *Out of scope*



	Raw material processing	Components manufacturing	Manufacturing	Logistics	Operation/End-use	Decommissioning
EXAMPLE ACTORS	SSAB, ArcelorMittal, outokumpu	Levypyörä Oy, Stela Tube, Componenta, Nordic Aluminium, Suomen Muovituote Oy	metso, Cargotec, pema, Kone, Valmet, Junttan, Fastems, Konecranes	Havator, ILS, Varova, Jahnhunen	YIT, Boliden, Hkscan, UPM, fortum, Meyer Turku	Delete, Tana, Kuusakoski
KEY PRODUCTS /SERVICES	Production of raw materials including • Steel • Iron • Aluminium alloy	Manufacturing components, such as: • Simple metal components that mainly include be bending, moulding and casting (pipes, screws, hinges etc.) • Other components such as plastic support structures and electrical equipment	Manufacturing all types of machinery and equipment, such as • Engines and turbines • Pumps, compressors and valves • Agriculture, forestry, mining and metallurgy machinery • Lifting and handling machinery	Providing transportation services, such as: • Transportation of entire plants, large shipments of industrial equipment, production lines, large-scale systems and devices.	Creating products and services of industrial customers in various sectors such as • Logistics, automotive, general manufacturing, mining, agriculture, pulp & paper, construction and energy	Offering products and services such as • Recycling: including the demolishing, transportation and recycling of old industrial equipment • Providing raw materials extracted from the recycled products
EXAMPLE CE INITIATIVES*	• Circular supplies – using and creating materials with high recyclability	• Build to last – component technical life is a very important KPI for a manufacturing company	• Build to last: applying modular design • Product life extension services (repair & maintain, upgrade and remanufacture) are increasingly common	• *N/A*	• Build to last, circular supplies, repair & maintain and upgrade – the operators aim for a deep relationship with the end-user	• Recycle & return – the decommission companies make business from returning raw materials back to the start of the value chain

*Examples of circular economy initiatives pursued by some Finnish companies in the industry

However, inefficiencies occur in all parts of the Machinery & Equipment value chain

Inefficiency	Description of current state	Illustrative data points
UNSUSTAINABLE MATERIALS	• Most input materials are recyclable and durable (e.g. steel) and the use of recycled material is fairly common • Use of sustainable indirect materials is limited, and most efforts are focused on optimising energy efficiency during product operation or end-use	• The majority of companies spend 50% or more on sustainable direct and indirect materials of their total material spend
UNDERUTILISED CAPACITIES	• Industrial machinery is often not utilised to the maximum even if most machinery and equipment is customised to fully fit customer needs	• Many companies report that their products are idle for over 50% of the available time
PREMATURE PRODUCT LIVES	• Products are built to last for long lifecycles, but they are not necessarily designed for reparability or upgradeability • Full potential of repair, maintenance and upgrade services is not exploited e.g. through predictive and condition-based maintenance	• Typically, products last for more than 10 years, some even more than 30 years
WASTED END-OF-LIFE VALUE	• Many companies are recycling materials and products, even if high costs decrease incentives to do it • Still, few companies have dedicated take-back schemes for their products	• Most companies state that they recycle over 80% of both their manufacturing waste and end-of-life products
UNEXPLOITED CUSTOMER ENGAGEMENTS	• The full potential of after-sales and add on sales is not exploited, but many companies are exploring new service-based offerings	• The share of revenues from after-sales services for most companies is 5.1-10%, while industry leaders can get up to 60% depending on their strategy

Analysis based on desktop research, insights from workshops with SMEs and interviews with industry experts.

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can make the same analysis for your company.

To address these inefficiencies, Machinery & Equipment companies should explore the five circular business models

Reform use of resources

CIRCULAR SUPPLY CHAIN

Build to last – Design products that are durable and easy to repair (e.g. modular).

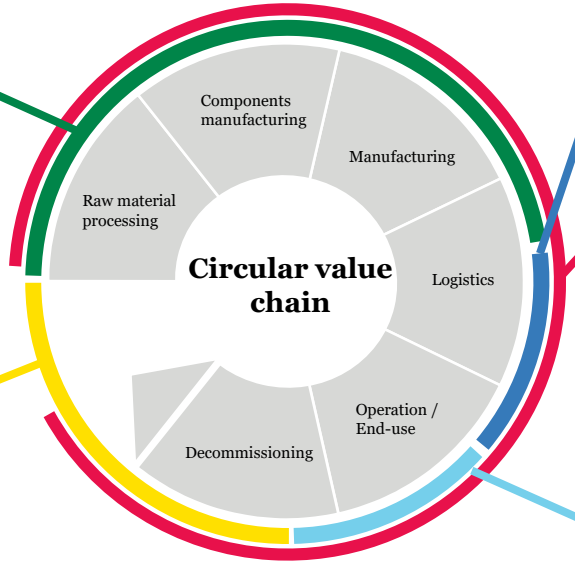
Circular supplies – use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates.

Recover value in waste

RECOVERY & RECYCLING

Recycle / upcycle – Collect and recover materials of end-of-life products and reuse them in own production.

Return – Return wasted parts and materials to the source (e.g. waste and by-products from own production).



Optimise capacity use

SHARING PLATFORM

Share – Develop solutions that enable increased use of capacity e.g. for machines that have high value and are easily transportable.

Offer outcome oriented solutions

PRODUCT AS A SERVICE

Product as a service – Offer customers to use a product against a subscription fee or usage based charges instead of owning it, e.g. crane-as-a-service.

Performance as a service – Offer customers to buy a pre-defined service and quality level and commit to guaranteeing a specific result, e.g. through a subscription-based service agreement.

Extend lifecycles

PRODUCT LIFE EXTENSION

Repair & Maintain – Deliver repair and maintenance services to extend the life of existing products in the market.

Upgrade – Improve product performance by upgrading existing components with newer ones.

Resell – Resell machinery, equipment and their parts that have reached their useful life to 2nd and 3rd hand markets.

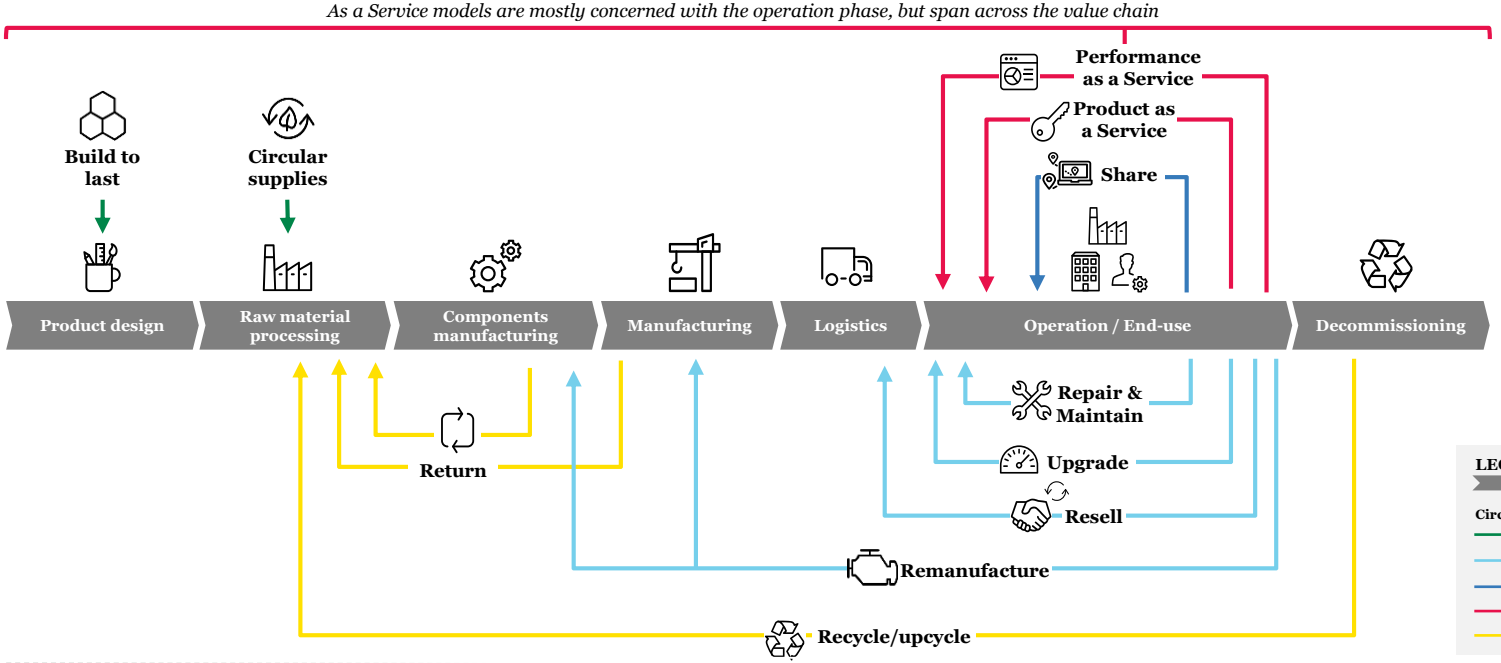
Remanufacture – Take back and perform industry-like restoration or improvement on original functionality of machinery, and parts and remarket them with lower price.

Source: Accenture, Appendix 2 for more details

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can analyse the relevance of each circular business model for your company.

The five business models can be broken down to sub-models to circulate products and materials along the value chain

The circular value chain for machinery & equipment



Additional circular business models

Circular supply chain
- Recycled direct materials
- Sustainable indirect materials

Sharing platform
- Virtual sharing platform
- Physical sharing platform

Recovery & Recycling
- Recover
- Downcycle

Product life extension
- Restore
- Repurpose
- Refresh

LEGEND
- Linear value chain

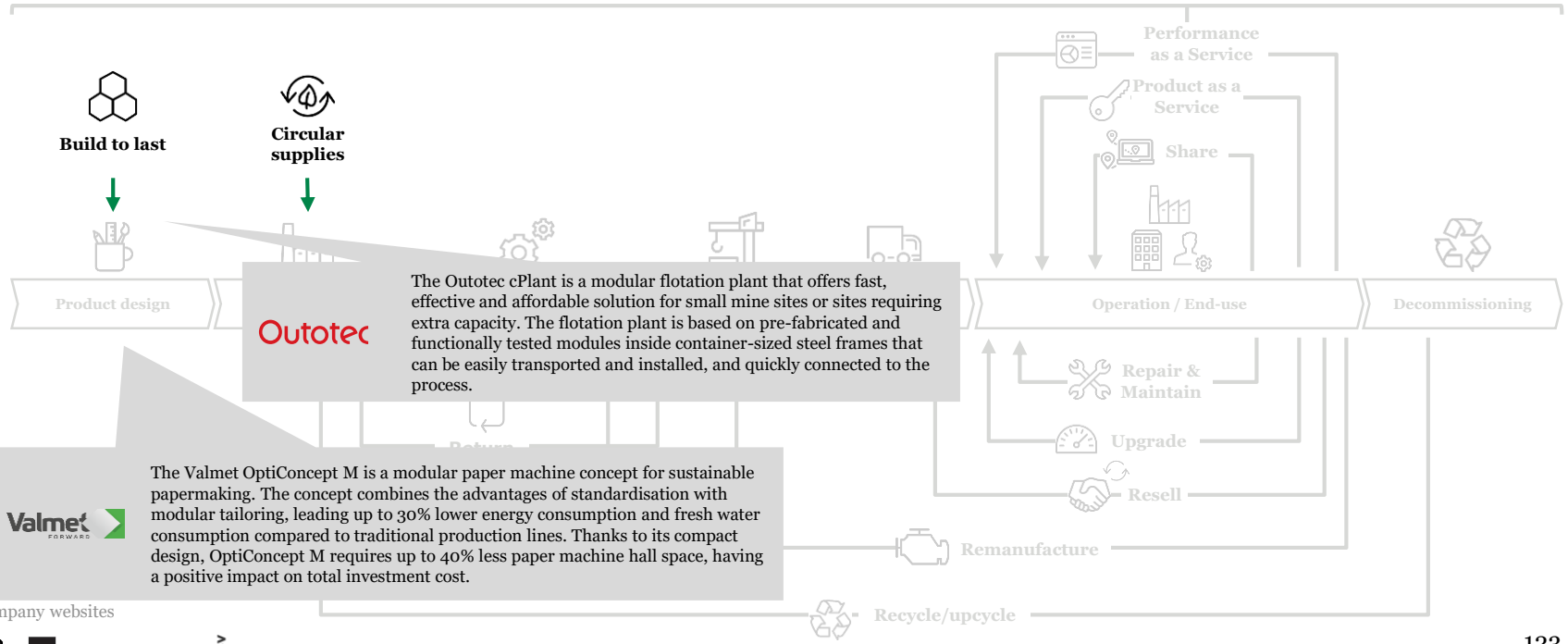
Circular Economy Value Chain
- Circular Supply Chain
- Product Life Extension
- Sharing platform
- Product as a service
- Recovery & Recycling

Most circular opportunities are in the product use phase, bringing companies closer to their customers.

Source: Accenture, Appendix 2 for more details

Modular product design can improve operational efficiency and enhance durability and reparability of products

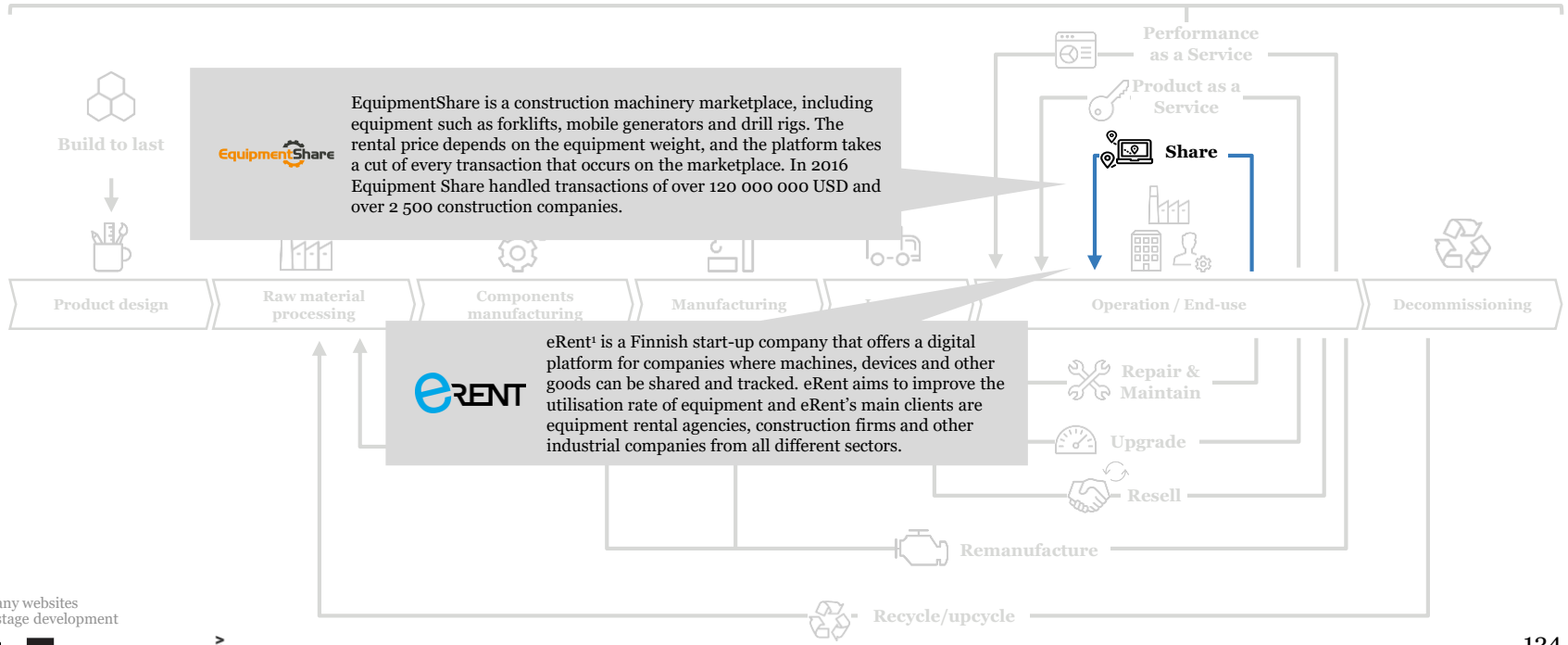
Leading examples: Circular Supply Chain



Source: Company websites

Sharing platforms increase utilisation rates and maximise value contribution of products

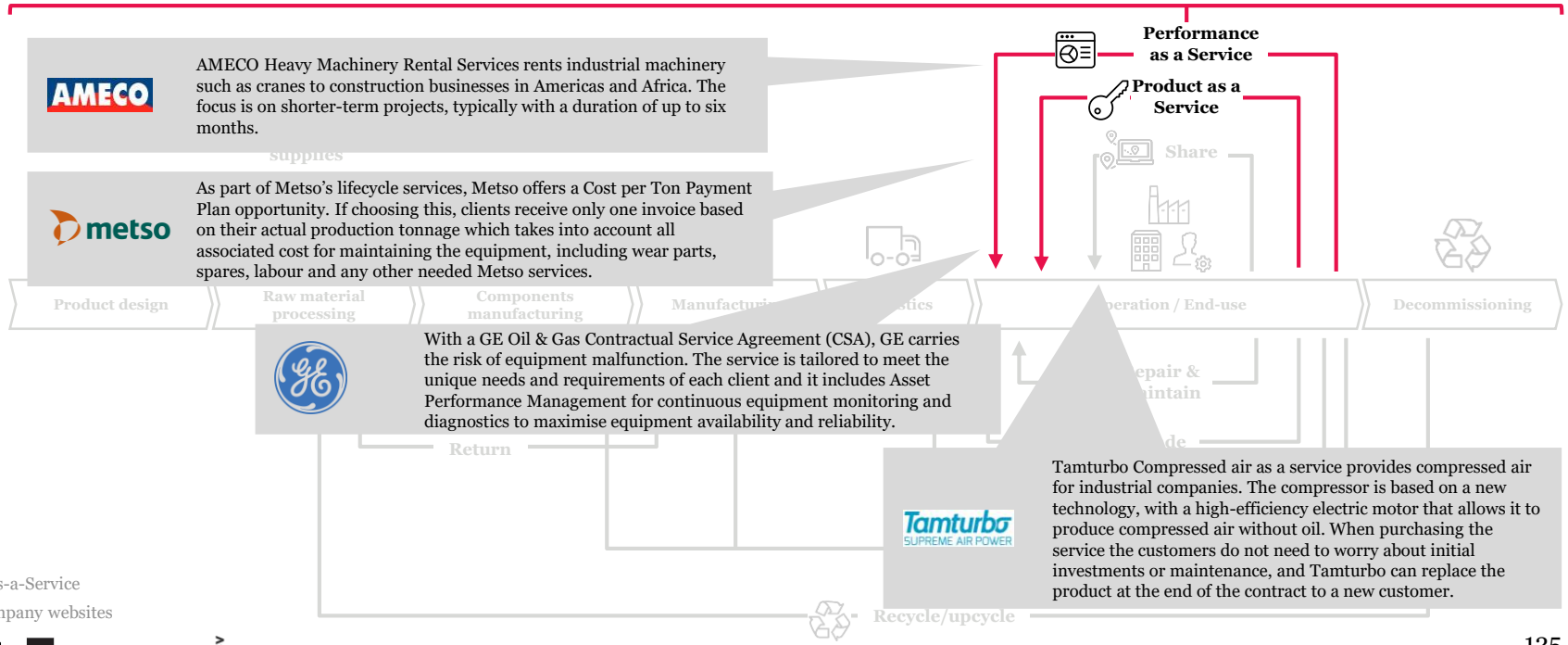
Leading examples: Sharing platform



Source: Company websites
[1] Still in early-stage development

PaaS[1] transfers cost-of-ownership to the producer which can incentivise more efficient use of resources

Leading examples: Product as a Service



AMECO Heavy Machinery Rental Services rents industrial machinery such as cranes to construction businesses in Americas and Africa. The focus is on shorter-term projects, typically with a duration of up to six months.

As part of Metso's lifecycle services, Metso offers a Cost per Ton Payment Plan opportunity. If choosing this, clients receive only one invoice based on their actual production tonnage which takes into account all associated cost for maintaining the equipment, including wear parts, spares, labour and any other needed Metso services.

With a GE Oil & Gas Contractual Service Agreement (CSA), GE carries the risk of equipment malfunction. The service is tailored to meet the unique needs and requirements of each client and it includes Asset Performance Management for continuous equipment monitoring and diagnostics to maximise equipment availability and reliability.

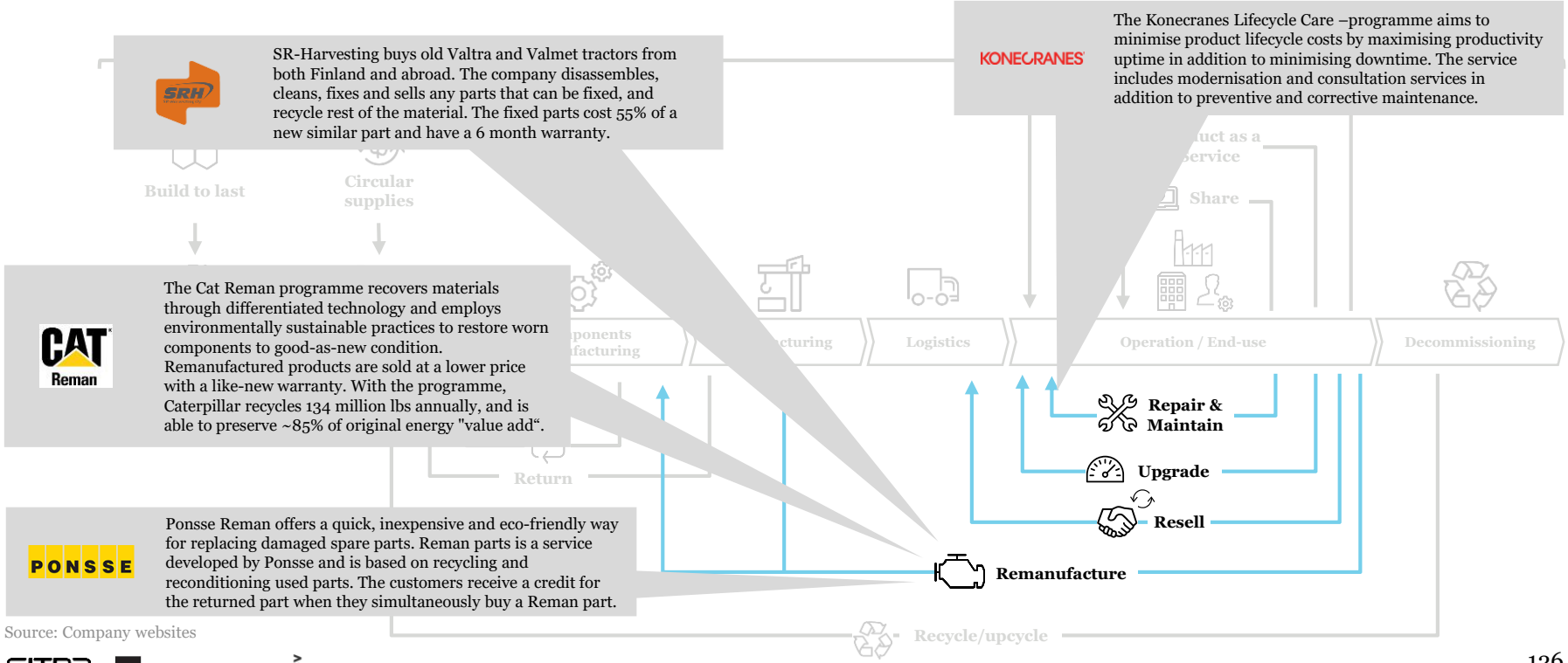
Tamturbo Compressed air as a service provides compressed air for industrial companies. The compressor is based on a new technology, with a high-efficiency electric motor that allows it to produce compressed air without oil. When purchasing the service the customers do not need to worry about initial investments or maintenance, and Tamturbo can replace the product at the end of the contract to a new customer.

1 Product-as-a-Service

Source: Company websites

Remanufacturing, upgrade, and maintenance can extend product lifecycles and release new sources of value

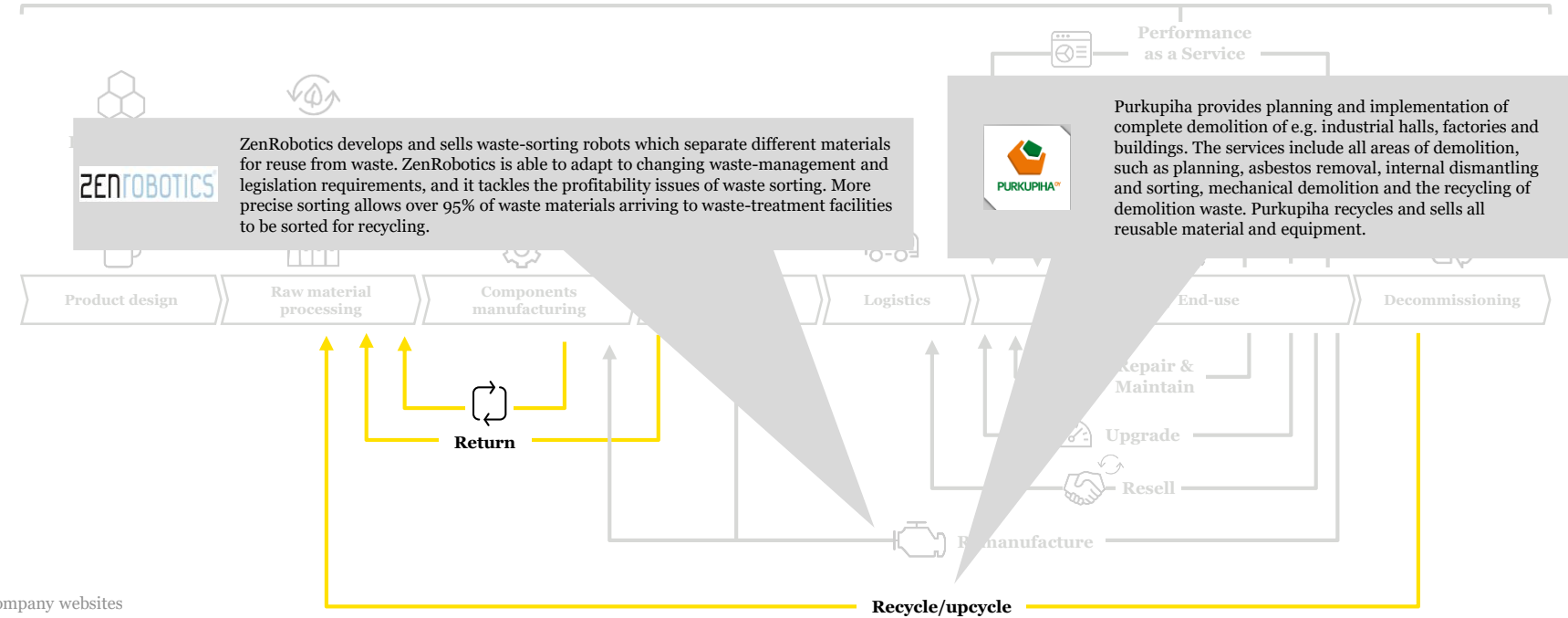
Leading examples: Product Life Extension



Source: Company websites

Decommissioning and recycling can offer a competitive cost advantage in raw material supply

Leading examples: Recovery & Recycling



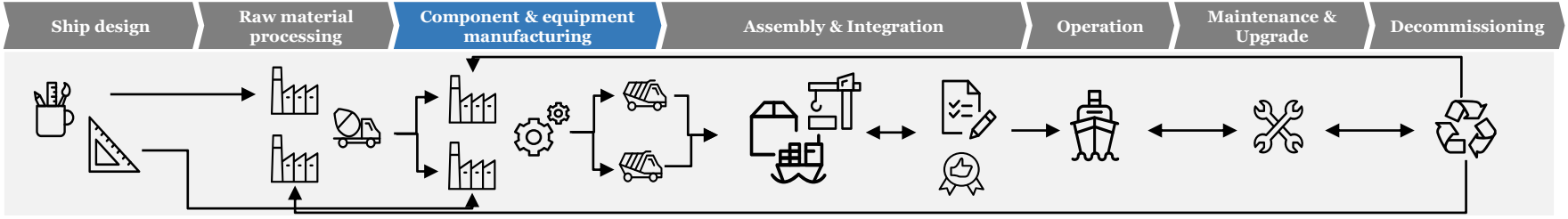
Source: Company websites

Marine

Current state analysis and circular opportunities

The marine value chain is complex with a large group of heterogeneous players with varying circular maturity levels

In scope *Out of scope*



	Ship design	Raw material processing	Component & equipment manufacturing	Assembly & Integration	Operation	Maintenance & Upgrade	Decommissioning
EXAMPLE ACTORS	DELTAMARIN, ELOMATIC, FORESHIP, ENGNO	SSAB, outokumpu	WÄRTSILÄ, Evac, ABLEMANN, Promeco, Malton, MOBIMAR, PIKKIO WORKS, Merima	MEYER TURKU, RAUMA MARINE CONSTRUCTIONS, SHIPBUILDING COMPLETION, arctech, KAEFER, ALMACO, FSP	VIKING LINE, TALLINK SILJA LINE, Finnlines, CONTAINERSHIPS	TURKU REPAIR YARD	Delete, MERIAURA, Hans Langh

KEY PRODUCTS /SERVICES	• Provides ship design, offshore engineering and construction support
	• Services span from concept development to project management. during shipbuilding
		• Produces raw materials including:
		  • Aluminium & stainless steel
		  • Composite material
		  • Syntactic foam
		  • Concrete
			• Creates main equipment and integrated solutions, incl.:
			  • Superstructure, rigging, etc
			  • Propulsion and power engines
			  • Other systems and solutions (e.g. HVAC, energy mgmt., navigation, safety etc.)
			  • Interior equipment (e.g. cabins, bathrooms, doors, etc)
				• Manufactures the hull of the ship and assembles the ship by cutting, forming, welding, fitting and joining the different parts of the ship together
				• Finalises the ship by:
				  • Painting & coating the ship
				  • Installing machinery & equipment
				  • Furnishing the interior
				• Conducts dock and sea trials to test the ship and make final fixes
				• Organises a celebratory launch for the ship
					• Equips the ship for transporting goods and/or passengers, and operates it	• Conducts repair, maintenance and conversion projects, incl. e.g. damage repairs, equipment replacements, refurbishing, and repainting	Provides various services for end-of-life vessels
							• Dismantling & cutting into blocks
							• Sorting out and processing materials
							• Washing & waste disposal

EXAMPLE CE INITIATIVES*	• Build to last –modular design principles	• Circular supplies – creates material with high recyclability	• Build to last – high use of modular design principles, some use of recycled materials • Return waste materials to source • Product-as-a-service – only some players have started providing these	• Build to last – use of durable, modular products • Increased use of innovative and environmentally friendly construction techniques	• Rental agreements – chartering	• Lifecycle services – repair, refurbishment, repainting, etc	• Recycle/upcycle • Return *** First initiatives started only in late 2017*

*Examples of circular economy initiatives pursued by some Finnish companies in the industry

Still, inefficiencies occur in all parts of the Marine value chain

Inefficiency	Description of current state	Illustrative data points
UNSUSTAINABLE MATERIALS	• Most input materials in ships are recyclable and durable (e.g. steel) • Use of sustainable indirect materials is limited, and most efforts are focused on optimising the safety and energy efficiency of the ship during its operation	• On average, 96% of ship materials can be recycled or reused • Spend on sustainable indirect materials of all indirect material spend for marine companies varies between less than 5% and 50%
UNDERUTILISED CAPACITIES	• Many ships are left unused for long periods of time or operated with limited use of available capacity, creating significant unnecessary costs and emissions • When it comes to operational fit, ships are typically custom-built, while for marine equipment both standardisation and customisation is used	• 10 % of global container fleet is idle, and over 60% of unused capacity comes from less than 10 year old ships • About 20 % of containers carried by ships are empty • Over 75 % of ships operating in the Baltic seas spend over 40% in ports waiting for cargo loading/unloading.
PREMATURE PRODUCT LIVES	• Ships are built to last for long lifecycles, but non-standardised equipment and components make remanufacturing of ships challenging • Ship operators are increasingly interested in refurbishment and upgrade projects to revitalise their aging fleet due to increased costs, stricter regulations and the lack of a 2nd hand market	• A typical lifecycle of a ship is 30-40 years
WASTED END-OF-LIFE VALUE	• Ship dismantling and recycling activities are very limited in Finland due to lack of binding regulations and incentives • There are also limitations to profitably recycling materials such as fabrics, small manufactured items, and motors that cost more to reduce to scrap than the scrap is worth	• Only 16% of materials used in ship cabins are recycled, while 90% of them could be recycled
UNEXPLOITED CUSTOMER ENGAGEMENTS	• After-sales and add-on sale efforts are limited for most marine industry players, but leading companies are exploring as-a-service business models to establish stronger customer relationships and increase their margins	• Marine companies report that their share of revenues from both after-sales and add-on sales is less than 5%

Analysis based on desktop research, insights from workshops with SMEs and interviews with industry experts.

Did you know?
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To address these inefficiencies, marine companies should explore the five circular business models

Reform use of resources

CIRCULAR SUPPLY CHAIN

Build to last – Design products that are durable and easy to repair (e.g. modular).

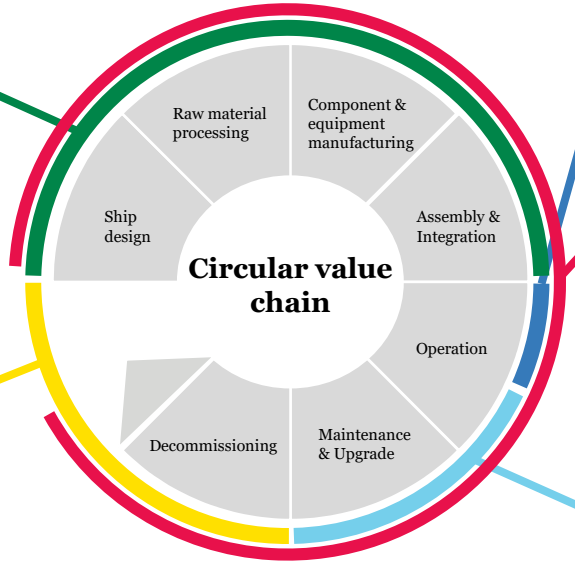
Circular supplies – use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates.

Recover value in waste

RECOVERY & RECYCLING

Recycle / upcycle – Collect and recover materials of end-of-life products and reuse them in own production.

Return – Return wasted parts and materials to the source (e.g. waste and by-products from own production).



Optimise capacity use

SHARING PLATFORM

Share – Develop solutions that enable increased use of vessel capacity.

Offer outcome oriented solutions

PRODUCT AS A SERVICE

Product as a service – Offer customers to use a product against a subscription fee or usage based charges instead of owning it, e.g. engine-as-a-service, equipment-as-a-service, vessel-as-a-service.

Performance as a service – Offer customers to buy a pre-defined service and quality level and commit to guaranteeing a specific result.

Extend lifecycles

PRODUCT LIFE EXTENSION

Repair & Maintain – Deliver repair and maintenance services to extend the life of existing products in the market.

Upgrade – Improve product performance by upgrading existing components with newer ones.

Resell – Resell ship parts and equipment that have reached their useful life to 2nd and 3rd hand markets

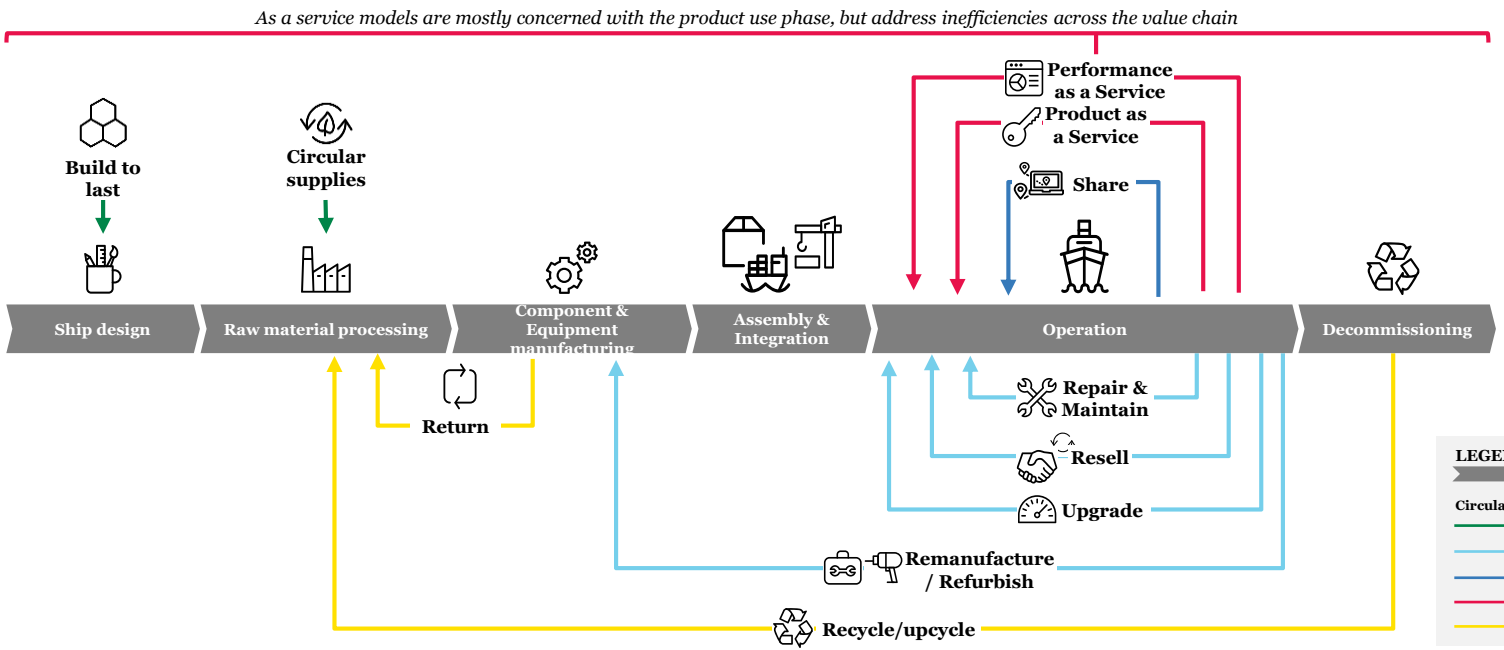
Remanufacture – Take back and perform industry-like restoration or improvement on original functionality of ship parts and equipment, and remarket them with lower price

Source: Accenture, Appendix 2 for more details

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can analyse the relevance of each circular business model for your company.

The five business models can be broken down to sub-models to circulate products and materials along the value chain

The circular value chain for marine



Additional circular business models

Circular supply chain
- Recycled direct materials
- Sustainable indirect materials

Sharing platform
- Virtual sharing platform
- Physical sharing platform

Recovery & Recycling
- Recover
- Downcycle

Product life extension
- Restore
- Repurpose
- Refresh

LEGEND
- Linear value chain

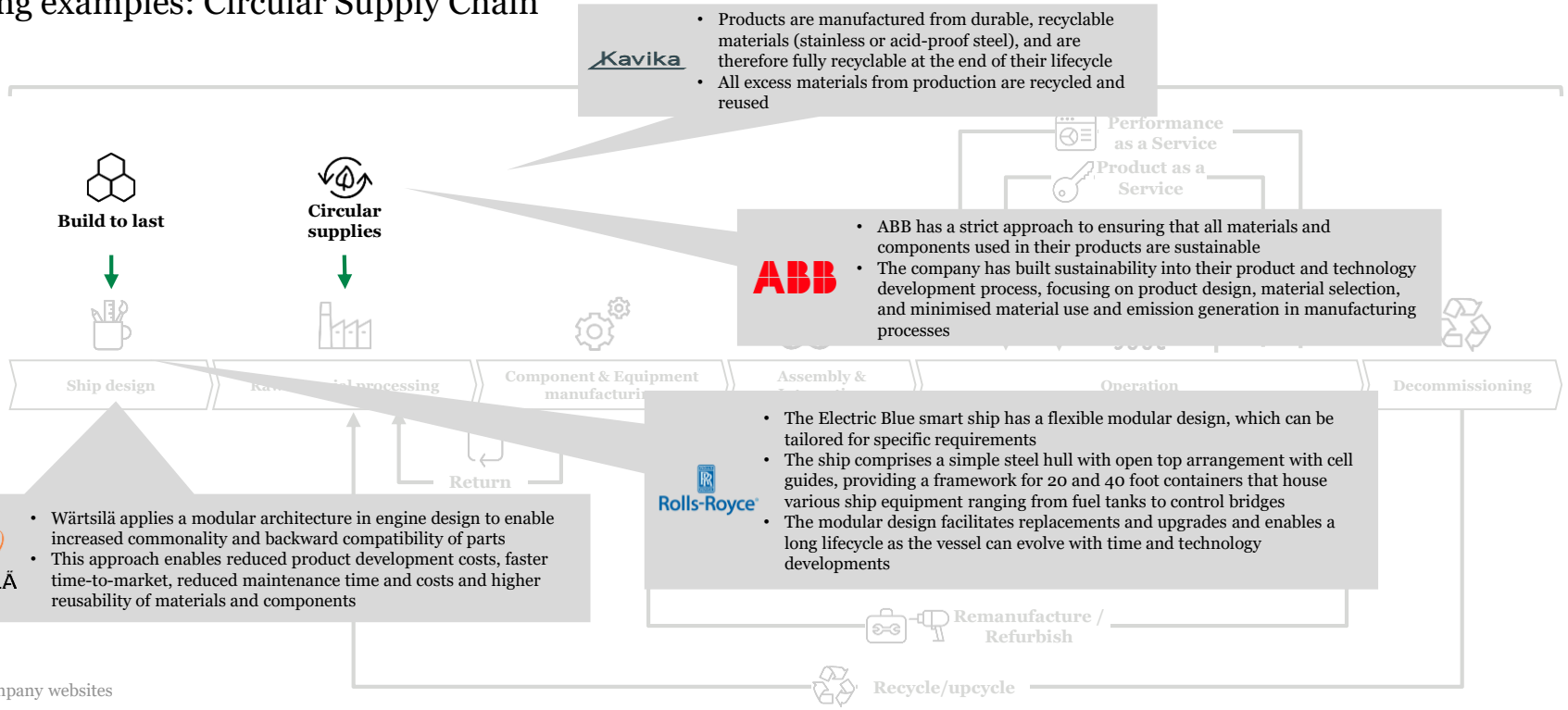
Circular Economy Value Chain
- Circular Supply Chain
- Product Life Extension
- Sharing platform
- Product as a service
- Recovery & Recycling

Most circular opportunities are in the product use phase, bringing companies closer to their customers.

Source: Accenture, Appendix 2 for more details

Modular design principles and use of recyclable materials facilitate lifecycle extension and resource recovery

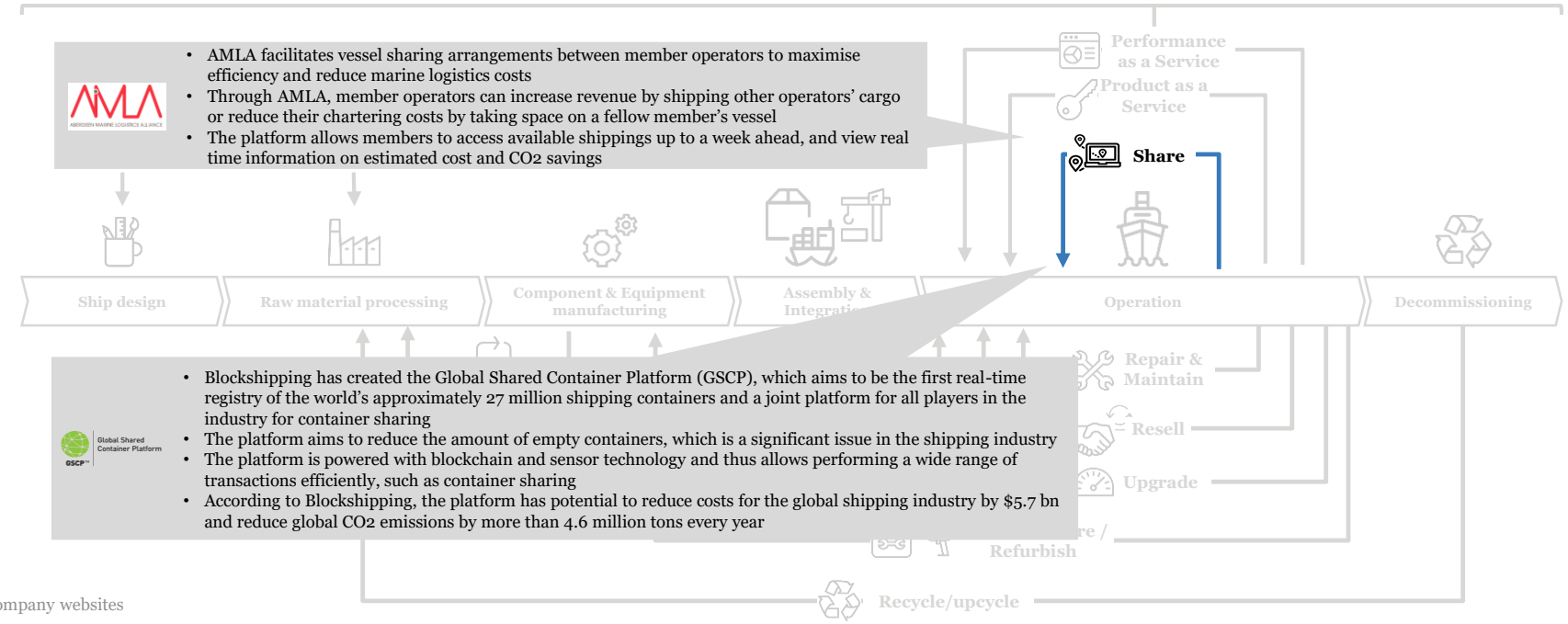
Leading examples: Circular Supply Chain



Source: Company websites

Sharing platforms are most relevant in the operation phase, and can increase use of vessel capacity

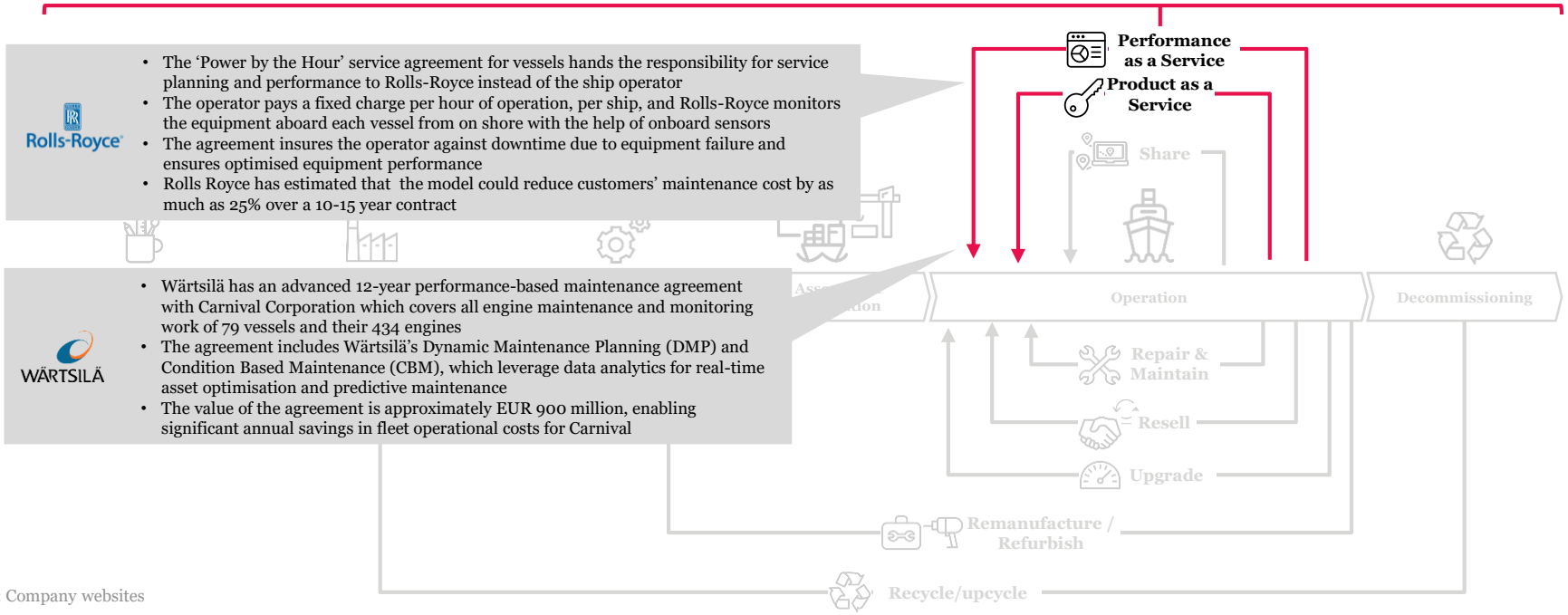
Leading examples: Sharing platform



Source: Company websites

Demand for as-a-service models for marine equipment is increasing, providing new opportunities to explore

Leading examples: Product as a Service



Rolls-Royce

- The 'Power by the Hour' service agreement for vessels hands the responsibility for service planning and performance to Rolls-Royce instead of the ship operator
- The operator pays a fixed charge per hour of operation, per ship, and Rolls-Royce monitors the equipment aboard each vessel from on shore with the help of onboard sensors
- The agreement insures the operator against downtime due to equipment failure and ensures optimised equipment performance
- Rolls Royce has estimated that the model could reduce customers' maintenance cost by as much as 25% over a 10-15 year contract

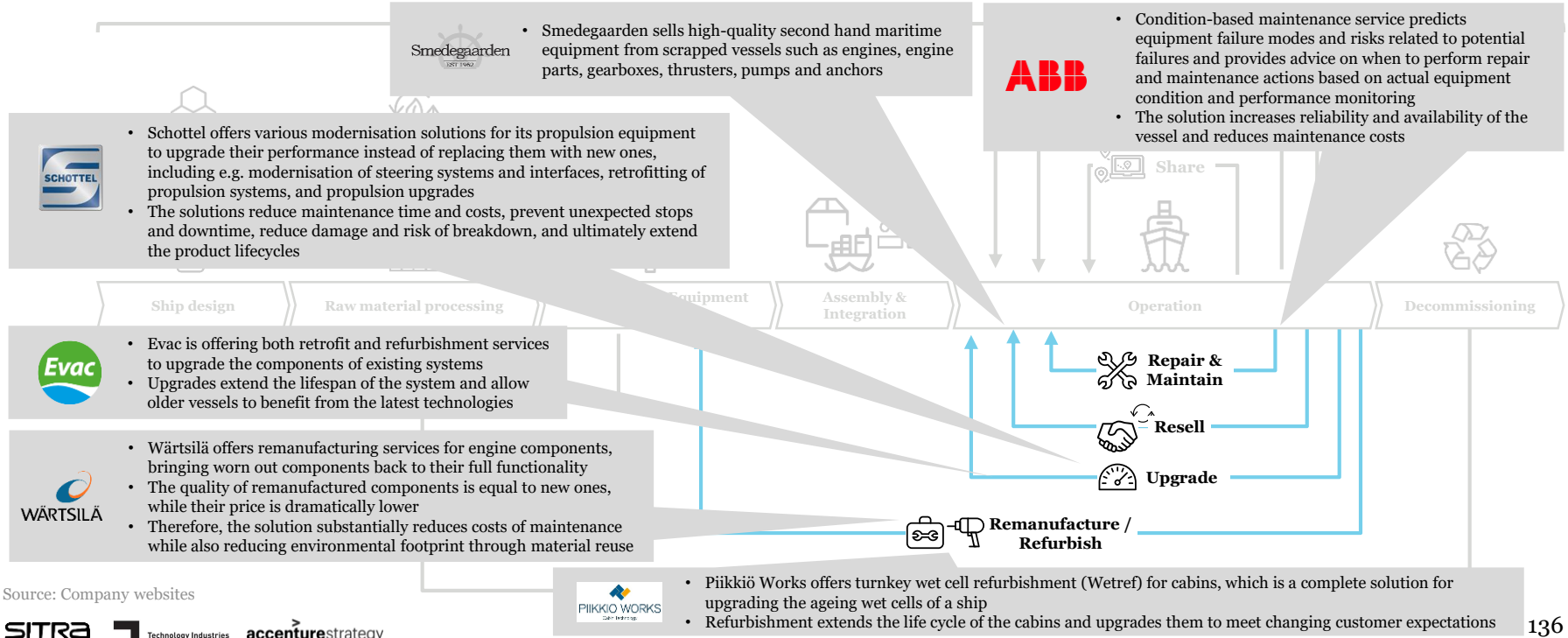
WÄRTSILÄ

- Wärtsilä has an advanced 12-year performance-based maintenance agreement with Carnival Corporation which covers all engine maintenance and monitoring work of 79 vessels and their 434 engines
- The agreement includes Wärtsilä's Dynamic Maintenance Planning (DMP) and Condition Based Maintenance (CBM), which leverage data analytics for real-time asset optimisation and predictive maintenance
- The value of the agreement is approximately EUR 900 million, enabling significant annual savings in fleet operational costs for Carnival

Source: Company websites

Lifecycle services provide significant revenue potential for equipment manufacturers

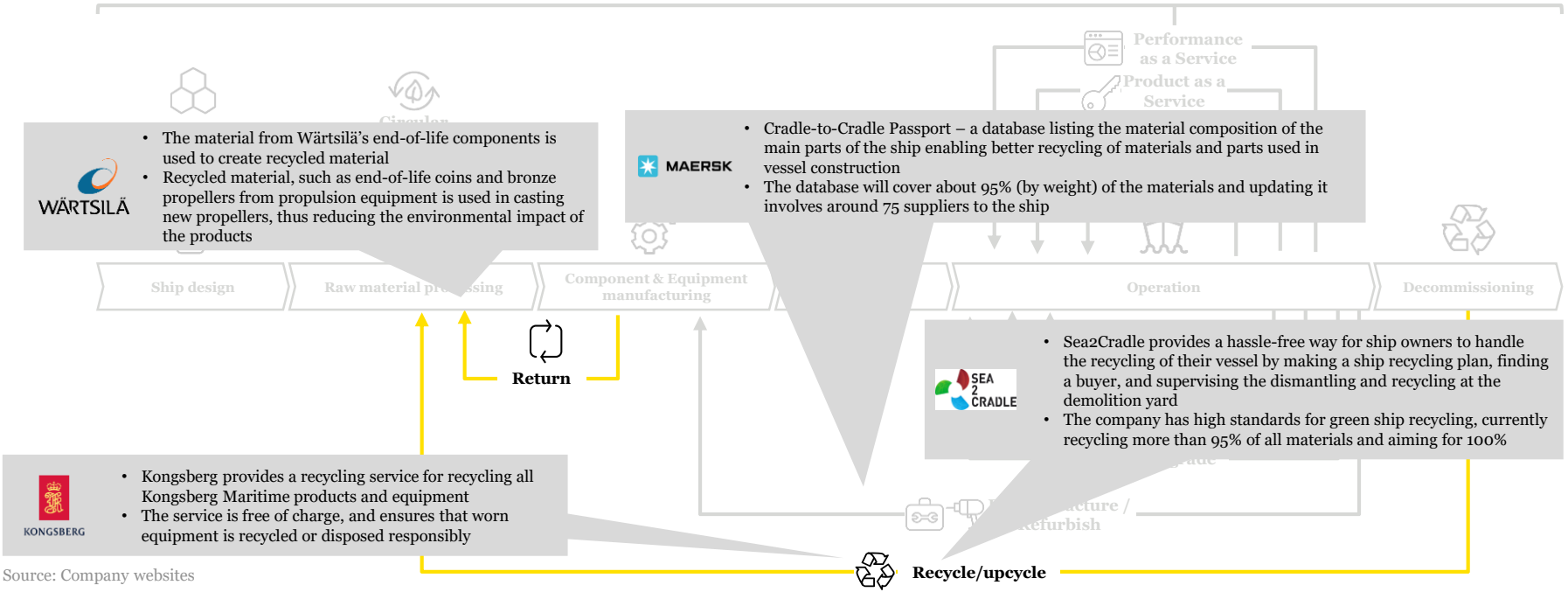
Leading examples: Product Life Extension



Source: Company websites

Recovery and recycling of ship parts, materials and equipment enables both cost and environmental efficiencies

Leading examples: Recovery & Recycling



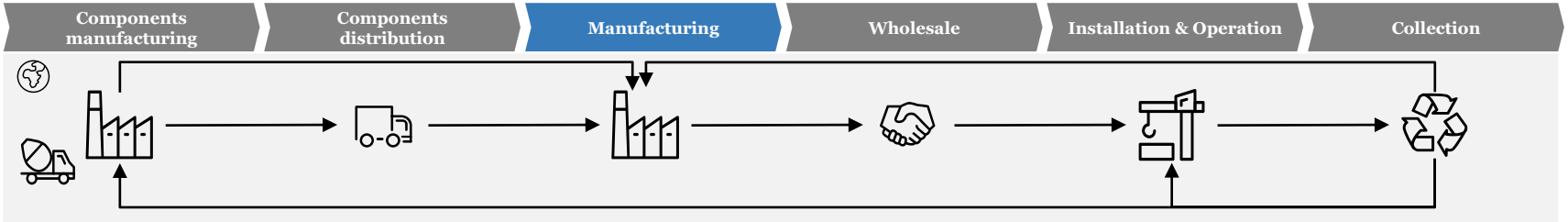
Source: Company websites

Energy

Current state analysis and circular opportunities

Currently, the electrical equipment value chain aims to build durable and energy-efficient products

In scope *Out of scope*



	Components manufacturing	Components distribution	Manufacturing	Wholesale	Installation & Operation	Collection
EXAMPLE ACTORS	SUMITOMO ELECTRIC, crydom, Amphenol, muRata	ARROW ELECTRONICS, INC., MOUSER ELECTRONICS	Danfoss, VACON, ABB, Helvar, VEXVE	SLO, ahlsell, onninen		ABB, L&T
KEY PRODUCTS /SERVICES	• Manufacturing electrical components such as diodes, transistors, hall and current sensors, thyristors, opto-electronics, displays, discharge devises and resistors	• Distributing electrical components, often with a large variety of products from numerous suppliers globally	• Manufacturing electrical equipment such as batteries, accumulators, wiring and wiring devices, electric lighting equipment, transformers and electricity control apparatus	• Distributing electrical equipment	• Producing power generation, distribution and other utilities • Key customers are in the sectors of, e.g. construction, energy, raw material producing or industrial equipment manufacturing	• Collecting and recycling electrical waste
EXAMPLE CE INITIATIVES*	• Build to last: products are planned to be durable and energy efficient at the product installation & operation - phases	• *N/A*	• Product life extension services and recovery and recycle services initiatives are increasing	• *N/A*	• Product and performance as a service: selling results instead of a product	• Recycle/upcycle and return: re-usage and remanufacturing is getting more common

*Examples of circular economy initiatives pursued by some Finnish companies in the industry

Still, inefficiencies occur in all parts of the electrical equipment manufacturing value chain

Inefficiency	Description of current state	Illustrative data points
UNSUSTAINABLE MATERIALS	• Electrical equipment manufacturers aim to produce components and products that are energy efficient during their use phase – but not necessarily having any focus on sustainability of the production • Indeed, use of both direct and indirect recyclable/renewable materials in production is limited	• Most energy companies report that their spend on recyclable/renewable materials is less than 5% of their material spend
UNDERUTILISED CAPACITIES	• Capacity use of energy equipment is not always optimised, even if they are often built to fully meet customer needs and requirements through customisation	• Some energy companies report that their products are idle for over 50% of the available time
PREMATURE PRODUCT LIVES	• Electrical equipment is often replaced due to limited opportunities for upgrades and customers opting for the products with the newest technologies • Due to challenging conditions and improper care not all electrical equipment reach their technical life targets • Equipment maintenance often happens according to schedule, not need, wasting resources	• Most energy companies report that at least 50% of their revenues come from products designed for a long life – however, products are not always designed for enhanced reparability or upgradeability e.g. through modular design
WASTED END-OF-LIFE VALUE	• Recycling of electrical equipment is very limited, as the process is costly and the value of recovered materials is low • Also, many products are sold outside Finland and Europe, making their take-back and recycling challenging	• Most energy companies report that they recycle less than 5%, if any, of end-of-life products
UNEXPLOITED CUSTOMER ENGAGEMENTS	• Providing outcome-oriented solutions is very rare in the industry	• Most energy companies report that their share of revenues from both after-sales and add-on sales is less than 5%

Analysis based on desktop research, insights from workshops with SMEs and interviews with industry experts.

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Therefore, electrical equipment manufacturing companies should explore the five circular business models

Reform use of resources

CIRCULAR SUPPLY CHAIN

Build to last – Design products that are durable and easy to repair (e.g. modular).

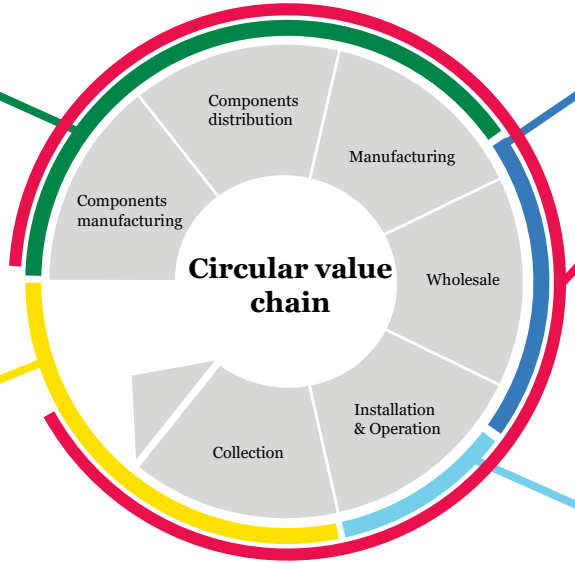
Circular supplies – use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates.

Recover value in waste

RECOVERY & RECYCLING

Recycle / upcycle – Collect and recover materials of end-of-life products and reuse them in own production.

Return – Return wasted parts and materials to the source (e.g. waste and by-products from own production).



Optimise capacity use

SHARING PLATFORM

Share – Develop solutions that enable increased use of capacity.

Offer outcome oriented solutions

PRODUCT AS A SERVICE

Product as a service – Offer customers to use a product against a subscription fee or usage based charges instead of owning it.

Performance as a service – Offer customers to buy a pre-defined service and quality level and commit to guaranteeing a specific result, e.g. through a subscription-based service agreement.

Extend lifecycles

PRODUCT LIFE EXTENSION

Repair & Maintain – Deliver repair and maintenance services to extend the life of existing products in the market.

Upgrade – Improve product performance by upgrading existing components with newer ones.

Resell – Resell products that have reached their useful life to 2nd and 3rd hand markets.

Remanufacture – Take back and perform industry-like restoration or improvement on original functionality of products and product parts and remarket them with lower price.

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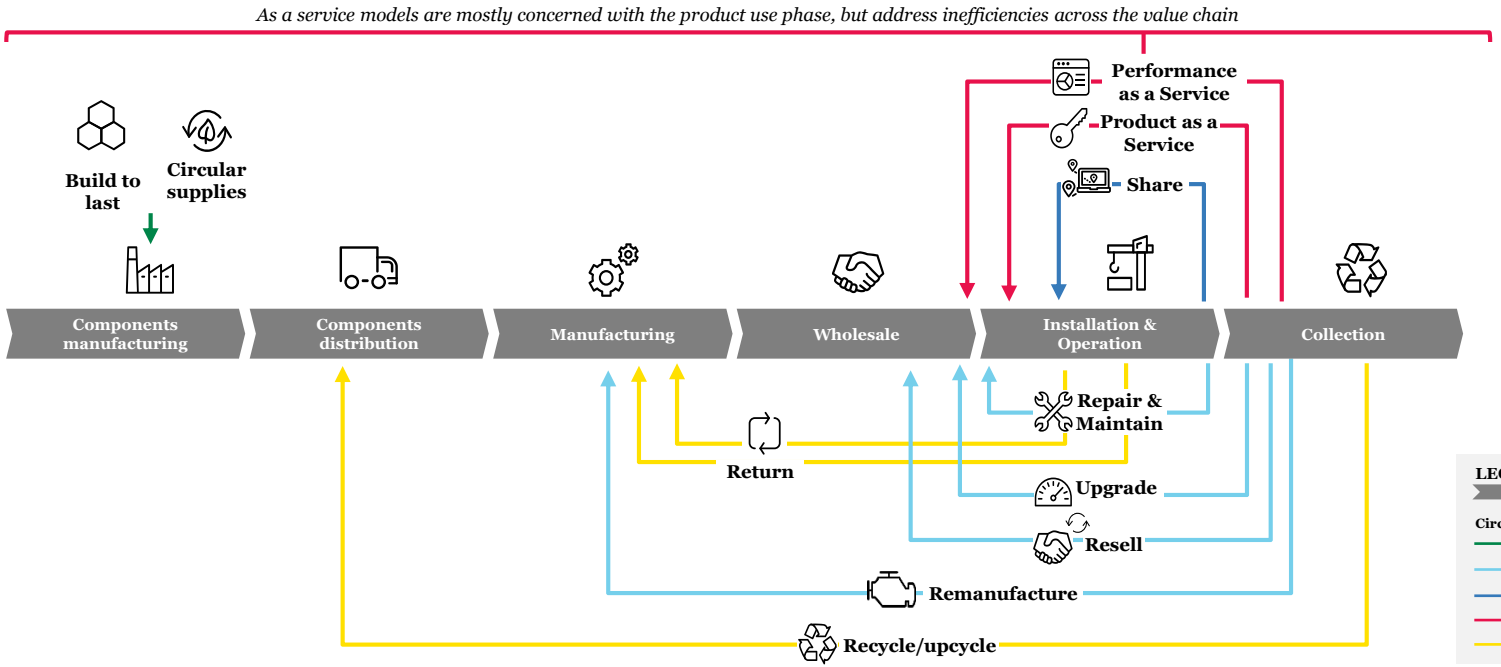
The circular value chain for energy



Additional circular business models

Circular supply chain
- Recycled direct materials
- Sustainable indirect materials

Sharing platform
- Virtual sharing platform
- Physical sharing platform

Recovery & Recycling
- Recover
- Downcycle

Product life extension
- Restore
- Repurpose
- Refresh

LEGEND
- Linear value chain

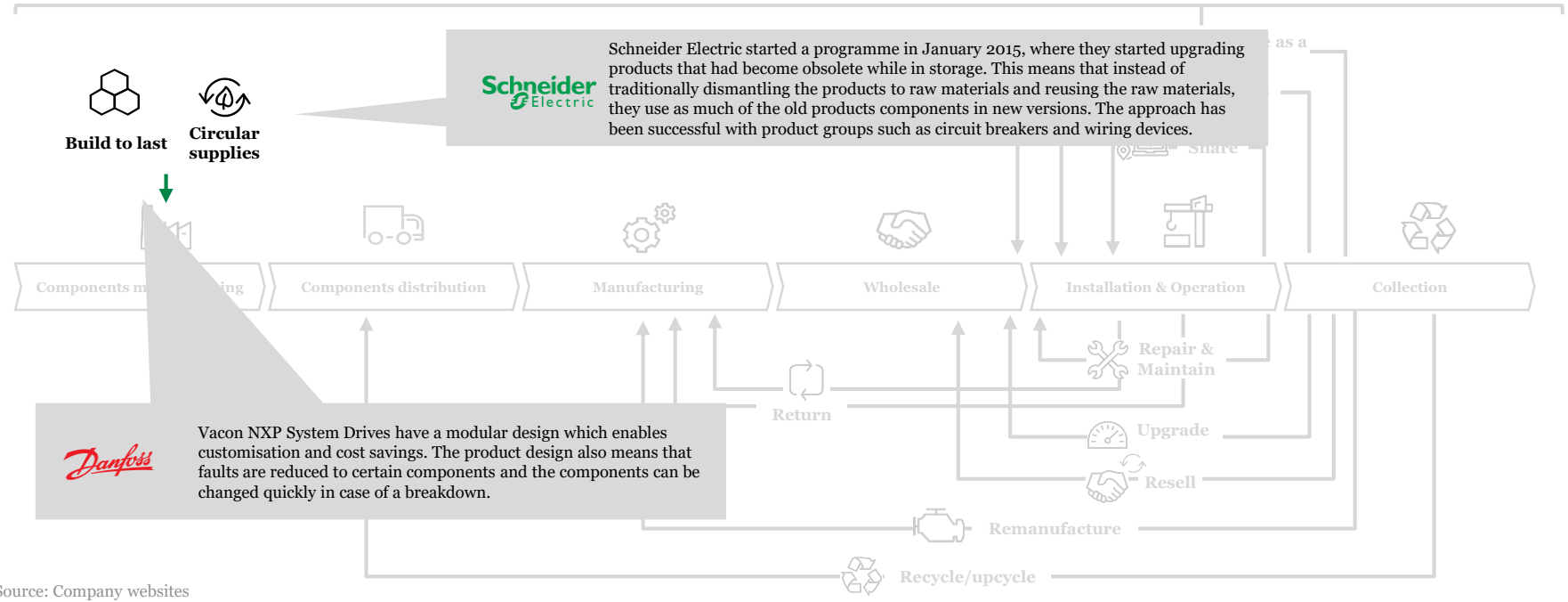
Circular Economy Value Chain
- Circular Supply Chain
- Product Life Extension
- Sharing platform
- Product as a service
- Recovery & Recycling

Most circular opportunities are in the product use phase, bringing companies closer to their customers.

Source: Accenture, Appendix 2 for more details

Modular design principles and use of recyclable materials facilitate lifecycle extension and resource recovery

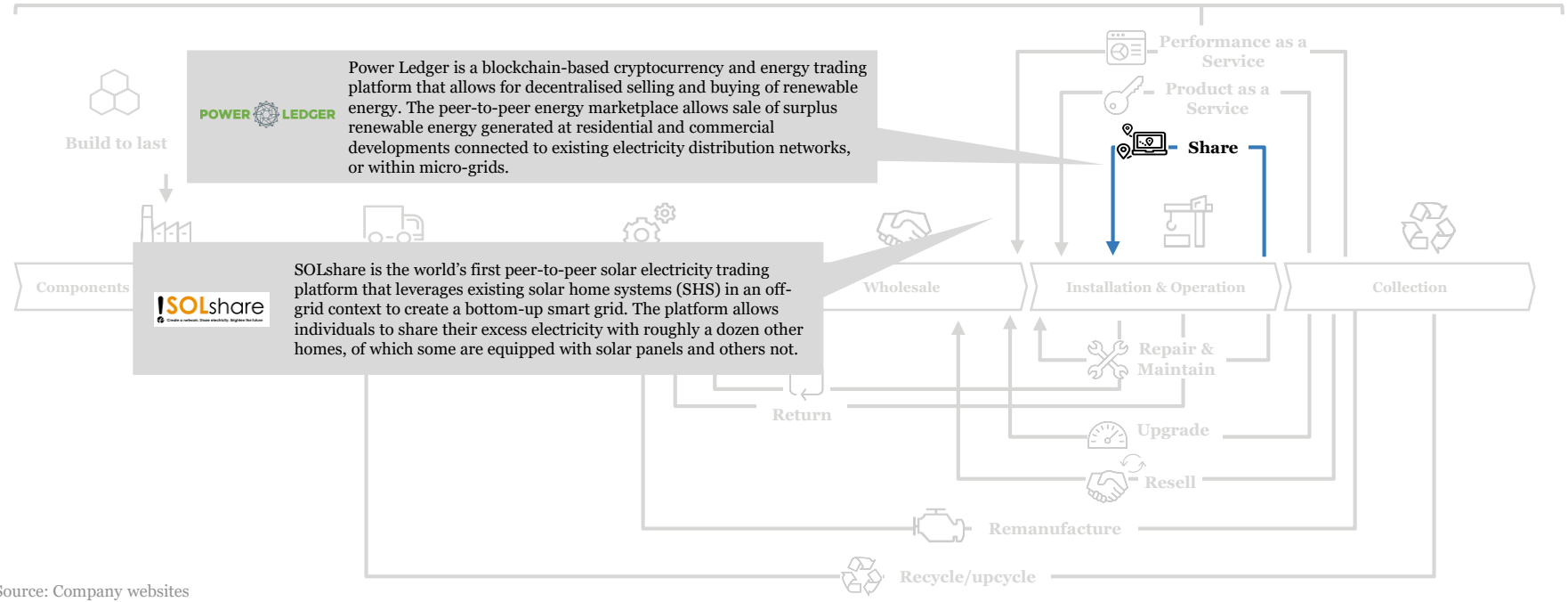
Leading examples: Circular Supply Chain



Source: Company websites

Sharing platform initiatives are mainly focused on the usage phase, allowing businesses and consumers to sell their excess energy

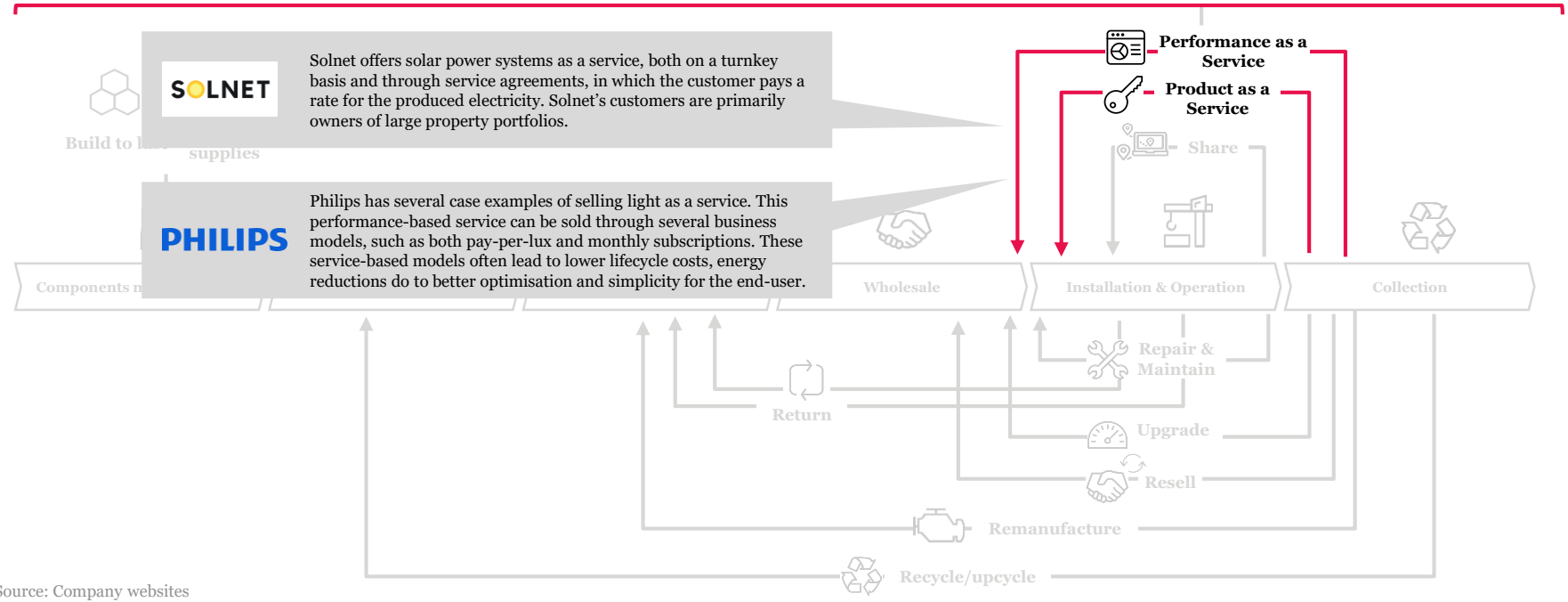
Leading examples: Sharing platform



Source: Company websites

Product as a service business models align customer and client objectives to minimise product lifecycle costs

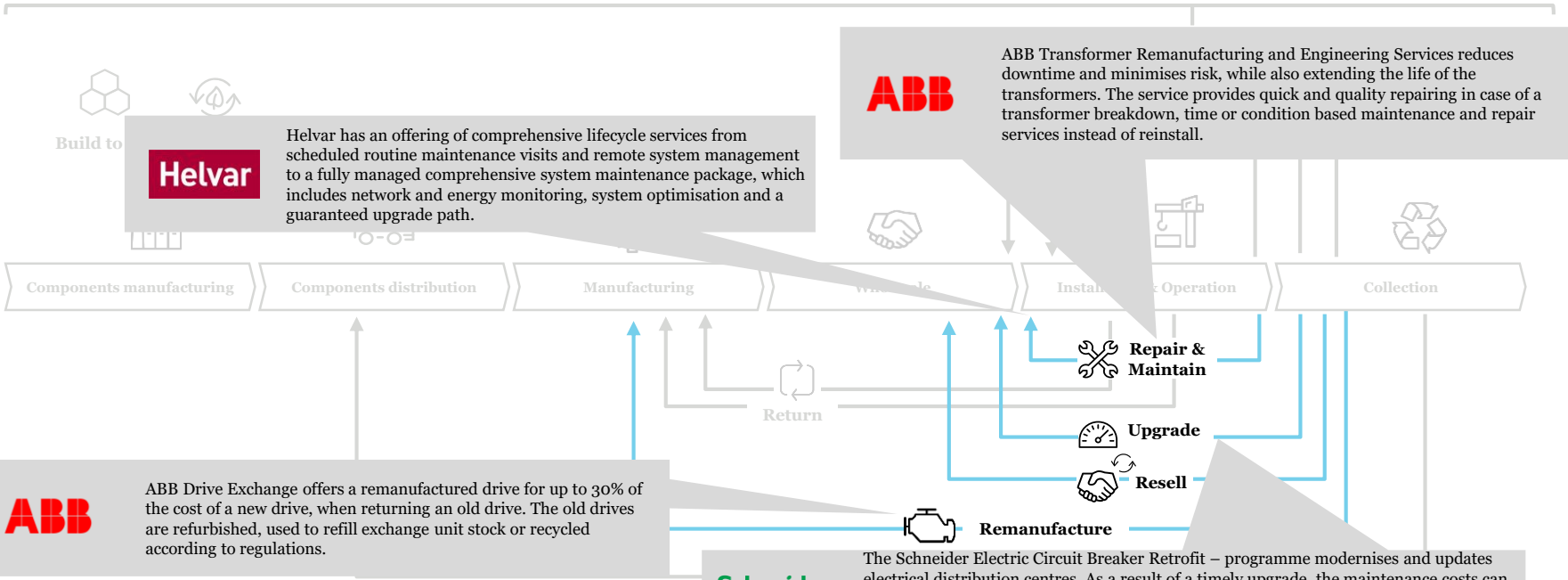
Leading examples: Product as a Service



Source: Company websites

Remanufacturing and maintenance services offer a deeper customer relationship and new business opportunities

Leading examples: Product Life Extension



Helvar Helvar has an offering of comprehensive lifecycle services from scheduled routine maintenance visits and remote system management to a fully managed comprehensive system maintenance package, which includes network and energy monitoring, system optimisation and a guaranteed upgrade path.

ABB ABB Transformer Remanufacturing and Engineering Services reduces downtime and minimises risk, while also extending the life of the transformers. The service provides quick and quality repairing in case of a transformer breakdown, time or condition based maintenance and repair services instead of reinstall.

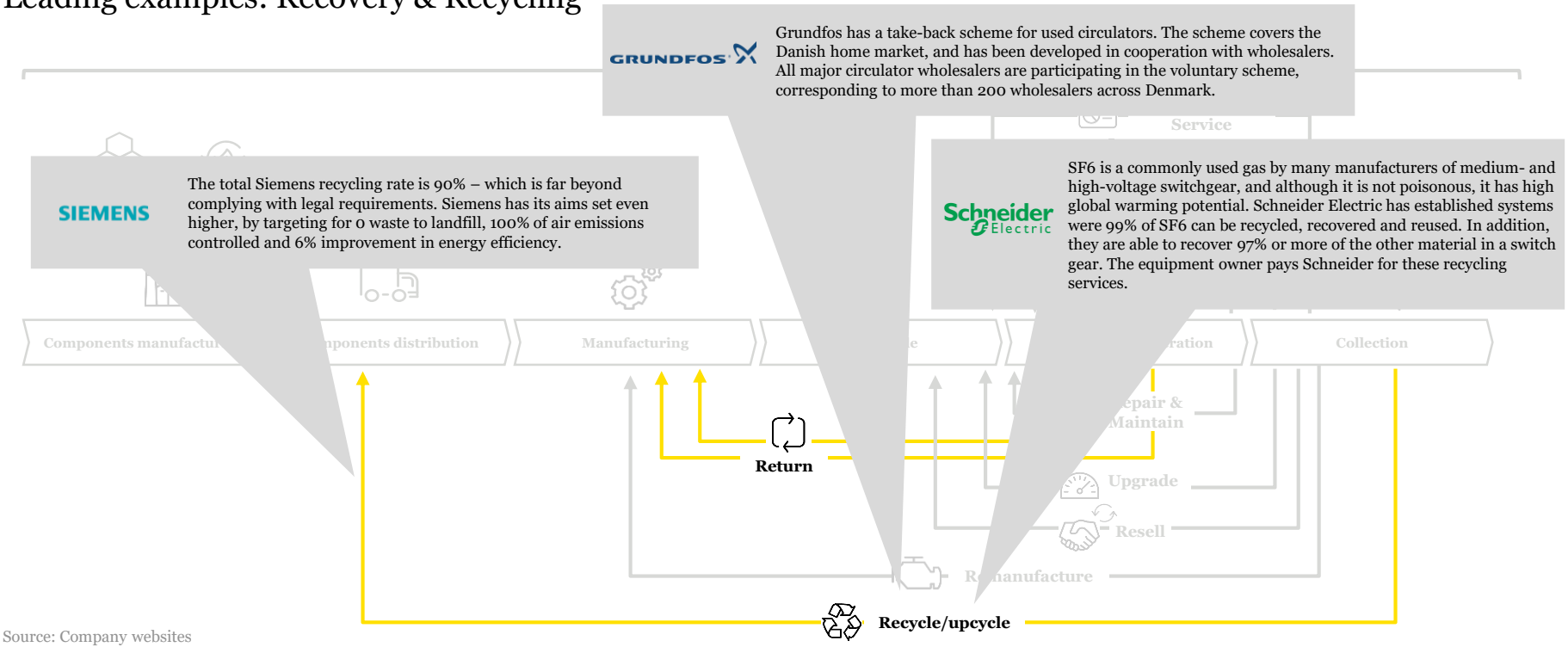
ABB ABB Drive Exchange offers a remanufactured drive for up to 30% of the cost of a new drive, when returning an old drive. The old drives are refurbished, used to refill exchange unit stock or recycled according to regulations.

Schneider Electric The Schneider Electric Circuit Breaker Retrofit – programme modernises and updates electrical distribution centres. As a result of a timely upgrade, the maintenance costs can be significantly reduced, the product life prolonged and the technical capabilities improved.

Source: Company websites

Collection and recycling can offer a competitive advantage to raw material supply, especially for scarce materials

Leading examples: Recovery & Recycling



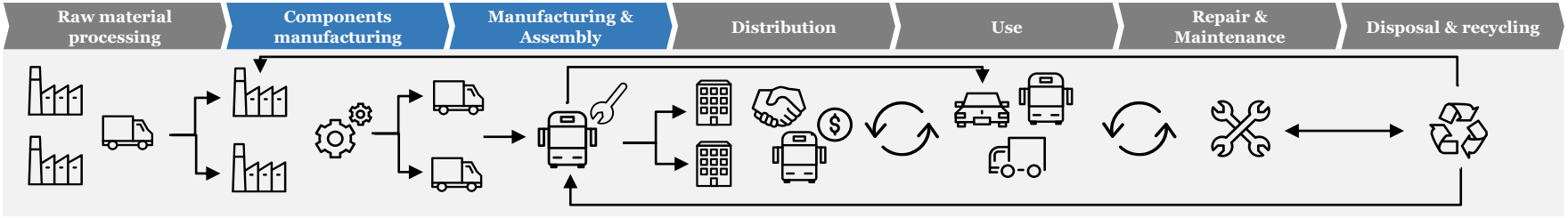
Source: Company websites

Transportation

Current state analysis and circular opportunities

The transportation value chain is fairly circular, but improvement areas still exist - especially in resource use

In scope *Out of scope*



	Raw material processing	Components manufacturing	Manufacturing & Assembly	Distribution	Use	Repair & Maintenance	Disposal & recycling
EXAMPLE ACTORS	SSAB, TEKNIKUM, outokumpu, REKA RUBBER	nokian RENKAAT, PARLOR, FENNO, MEFILTER, CARRUS, SISU AXLES, Eskeri	VOLVO, SCANIA, valmet automotive	LAAKKONEN, SCANIA, VEHO, VOLVO, NETTI KONE .com	DHL, Pohjolan Liikenne, DB SCHENKER, DSV, Nobina	AUTOKLINIKKA, ATOY, RASKONE, ASSISTOR	KUUSAKOSKI RECYCLING, STENA RECYCLING, Suomen Autokierrätys, Recycling EURAJOEN RÖMU OY
KEY PRODUCTS /SERVICES	Produces raw materials including: • Steel • Aluminium • Rubber • Plastic • Glass • Fabrics	Manufactures main parts and equipment of vehicles, incl. • Bodies, trailers, semi-trailers • Parts, accessories and systems (incl. engines, brakes, seats, wheels, tires, exhausts, windows, HVAC etc)	• Provides services such as manufacturing engineering, body welding, painting and final assembly of vehicles	• Distributes vehicles for sale • Sells both new and used vehicles and provides after sales support • Provides vehicle sharing & rental services	• Provides logistics services **OR** transports people from one place to another	• Provides repair & maintenance services (incl. damage repairs, repainting, reinstallation etc) • Sells spare parts and accessories	• Provides collection, treatment and recycling services for end-of-life vehicles, incl. separation of reusable components, crushing, and separation of materials to be reutilised
EXAMPLE CE INITIATIVES*	• Circular supplies – creates material with high recyclability	• Build to last – durable products that are easy to repair, somewhat modular design • Return	• Build to last – somewhat modular design principles • Return	• Rentals – renting, leasing • Resell – market for used vehicles	• *N/A*	• Lifecycle services – repair, maintenance, refurbishment • Remanufacturing	• Recycle / upcycle • Return

*Examples of circular economy initiatives pursued by some Finnish companies in the industry

Indeed, inefficiencies occur in all parts of the Transportation value chain

Inefficiency	Description of current state	Illustrative data points
UNSUSTAINABLE MATERIALS	• Most input materials are recyclable (e.g. metals) - however design of products is not optimised for continuous regeneration (materials are mixed together in components), increasing the use of virgin materials • The use of sustainable indirect material in production is also limited	• Companies report that their spend on sustainable direct materials varies between 20 to 80% of their direct material spend, while for indirect materials their spend remains below 50% of their total indirect material spend
UNDERUTILISED CAPACITIES	• Typically, vehicles are left unused for long periods of time and their full capacity is not used, creating significant unnecessary costs	• In Finland, average load rate of trucks is only 69%, and 23% of kilometers are driven without cargo. In rail transport, 47% of freight cars are transported empty
PREMATURE PRODUCT LIVES	• Most vehicles and vehicle components are durable and have long lifecycles • Still, vehicle maintenance mainly happens according to schedule, not according to need, wasting some lifecycle effects	• Most companies provide maintenance, repair and upgrade services for their products, and get more than 10% of their revenues from after-sales
WASTED END-OF-LIFE VALUE	• Most manufacturing waste and the majority of end-of life products are recycled. However, increased complexity e.g due to rise of customisation, use of glue in fixation and more advanced electronics makes recycling, repair and recovery of vehicles increasingly challenging • Dedicated product take-back schemes are rare	• Most companies report that they recycle over 80% of manufacturing waste, and at least 50% of end-of-life products
UNEXPLOITED CUSTOMER ENGAGEMENTS	• After-sales and add-on sales opportunities are relatively well exploited, compared to other manufacturing sub-sectors	• The share of both after-sales and add-on sales revenue is over 10% for most companies

Analysis based on desktop research, insights from workshops with SMEs and interviews with industry experts.

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can make the same analysis for your company.

To address these inefficiencies, transportation companies should explore the five circular business models

Reform use of resources

CIRCULAR SUPPLY CHAIN

Build to last – use modular design principles to facilitate repair, reuse and disassembly of vehicles and their parts.

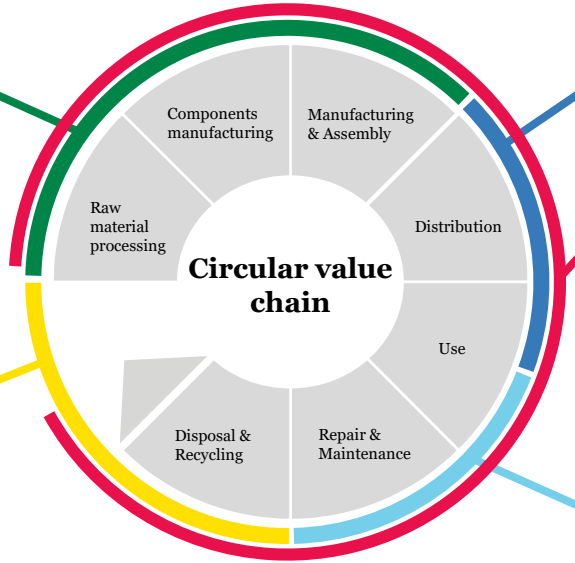
Circular supplies – use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates

Recover value in waste

RECOVERY & RECYCLING

Recycle / upcycle – Collect and recover materials of end-of-life products and reuse them in own production.

Return – Return wasted parts and materials to the source (e.g. waste and by-products from own production).



Optimise capacity use

SHARING PLATFORM

Share – Develop solutions that enable increased use of capacity

Offer outcome oriented solutions

PRODUCT AS A SERVICE

Product as a service – Offer customers to use a product against a subsricption fee or usage based charges instead of owning it, e.g. tire-as-a-service, truck-as-a-service

Performance as a service – Offer customers to buy a pre-defined service and quality level and commit to guaranteeing a specific result, e.g. through a subscription-based service agreement

Extend lifecycles

PRODUCT LIFE EXTENSION

Repair & Maintain – Deliver repair and maintenance services to extend the life of existing products in the market.

Upgrade – Improve product performance by upgrading existing components with newer ones.

Resell – Resell vehicle parts and components that have reached their useful life to 2nd and 3rd hand markets.

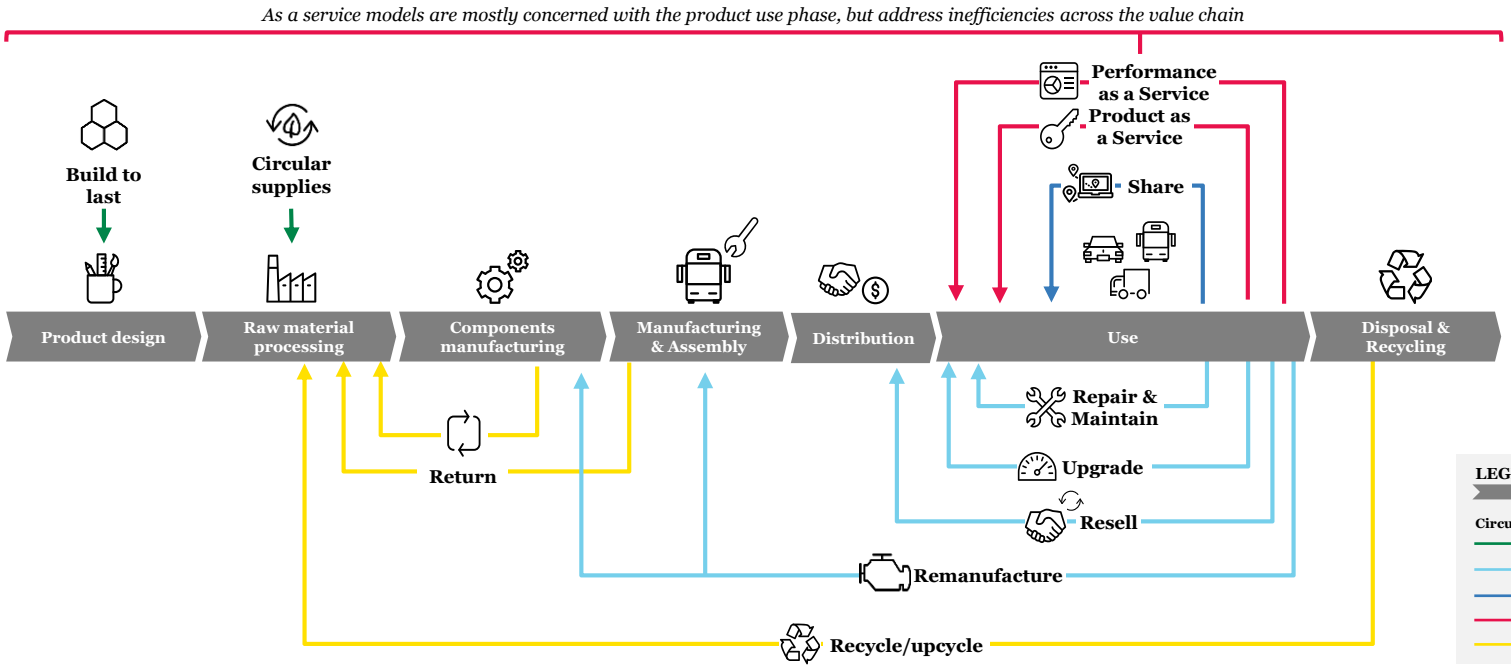
Remanufacture – Take back and perform industry-like restoration or improvement on original functionality of vehicle parts and remarket them with lower price

Source: Accenture, Appendix 2 for more details

Did you know?
On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can analyse the relevance of each circular business model for your company.

The five business models can be broken down to sub-models to circulate products and materials along the value chain

The circular value chain for transportation



Additional circular business models

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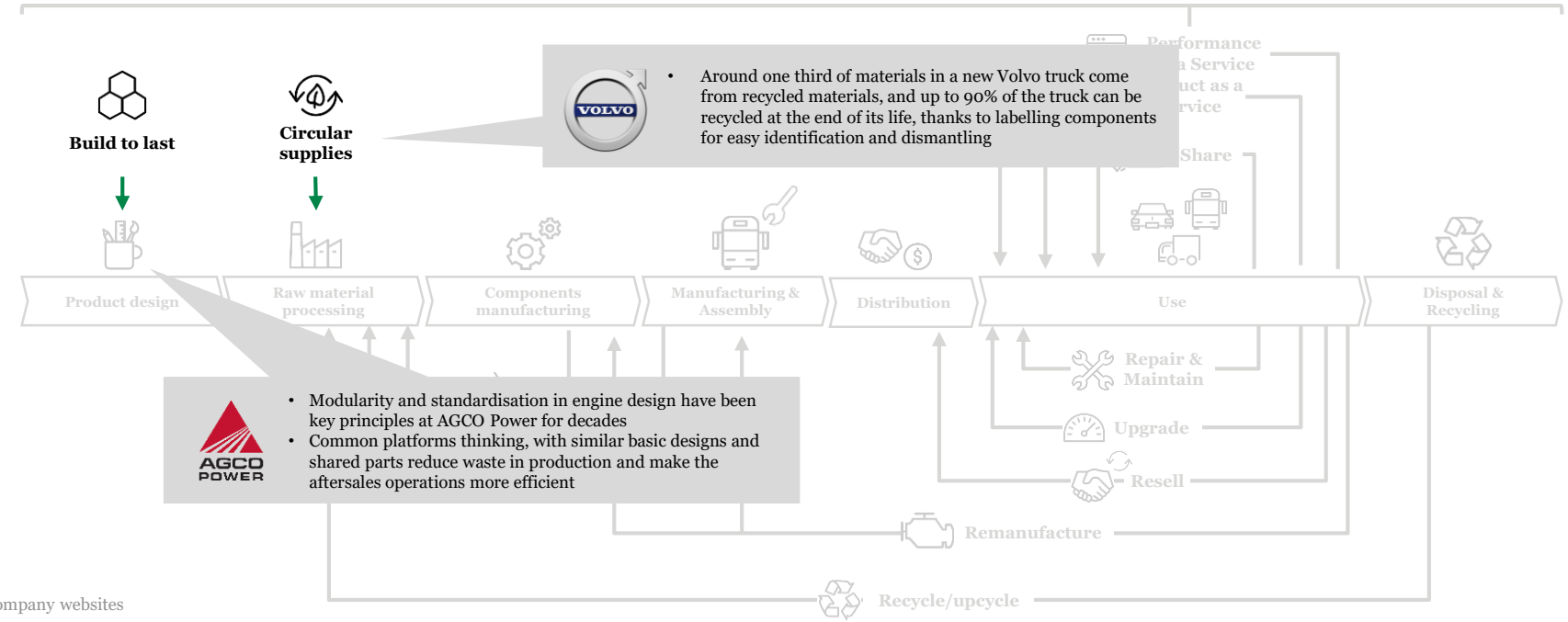
Most circular opportunities are in the product use phase, bringing companies closer to their customers.

Source: Accenture, Appendix 2 for more details

Modular design principles and use of recyclable materials facilitate recovery of parts and materials

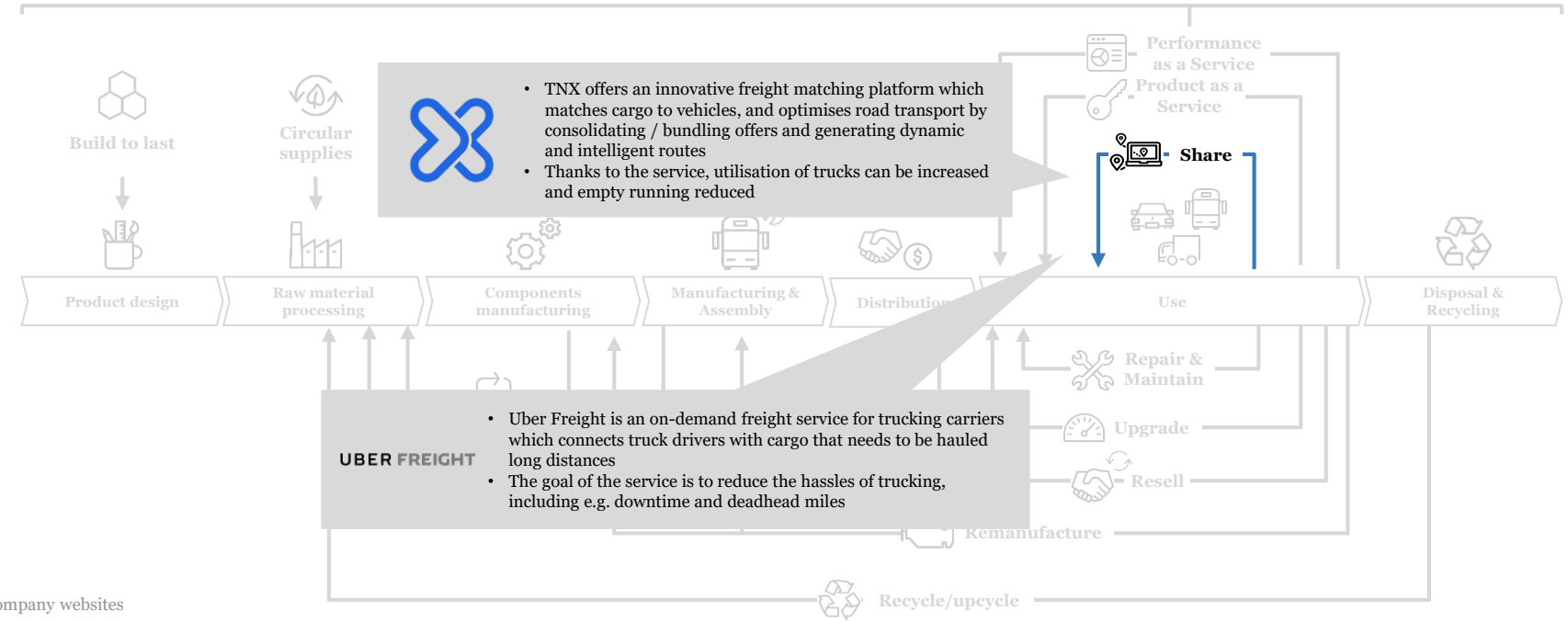
Leading examples: Circular Supply Chain



Source: Company websites

Sharing platforms are more relevant in the vehicle use phase, where they enable capacity optimisation

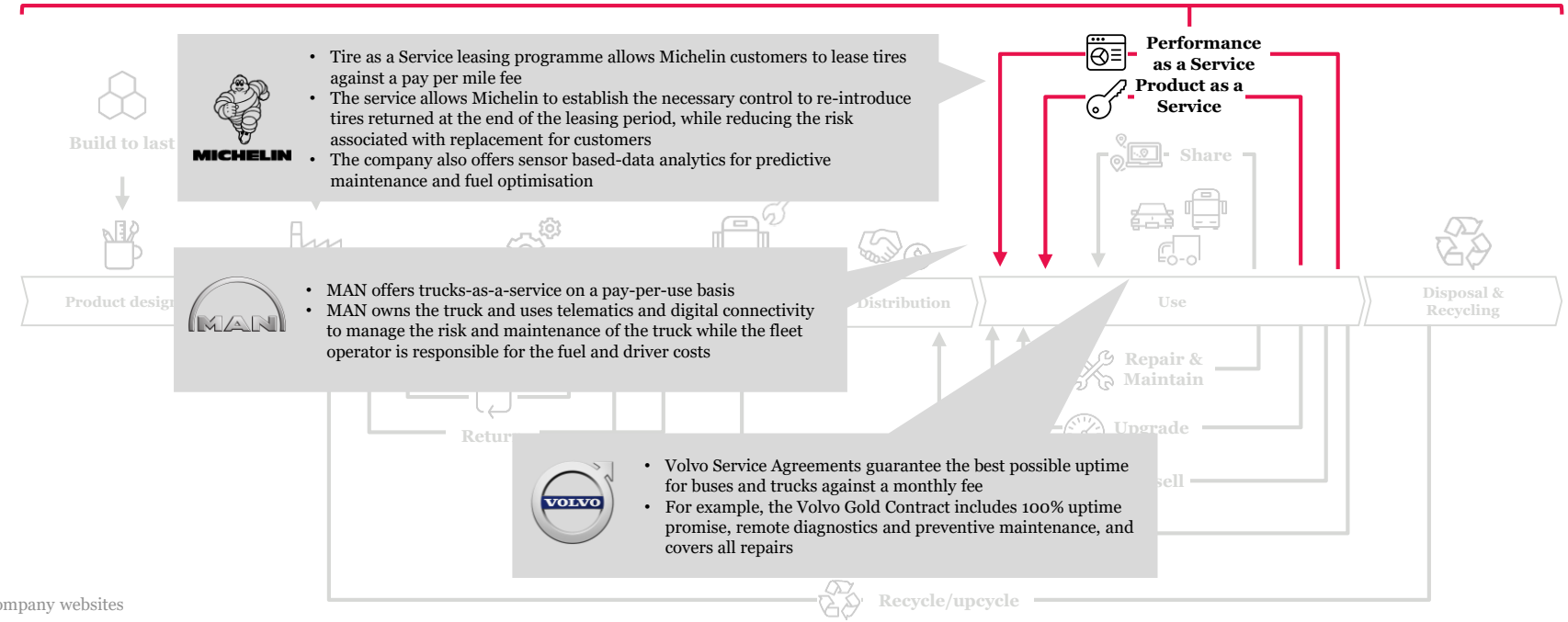
Leading examples: Sharing platform



Source: Company websites

Product as a Service models strengthen customer relationships through shared risk and frequent interaction

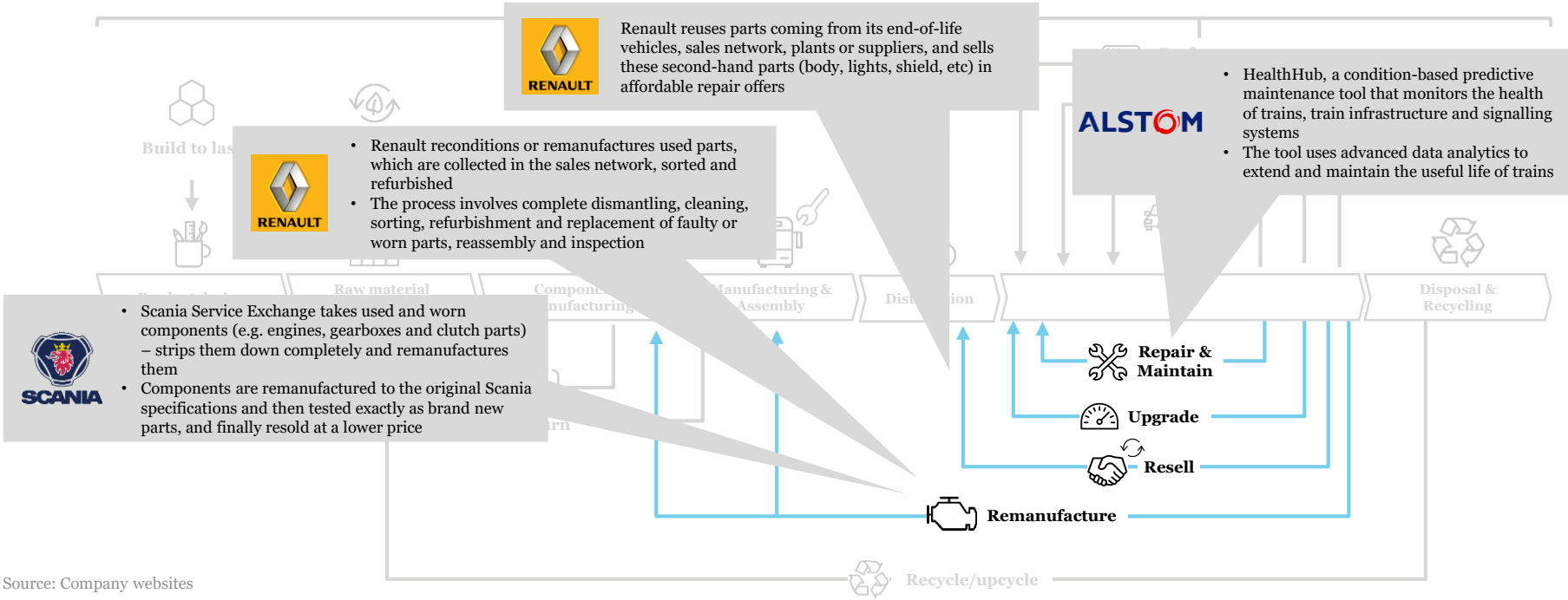
Leading examples: Product as a Service



Source: Company websites

Various services can significantly prolong the lifecycle of a vehicle while also generating additional revenues

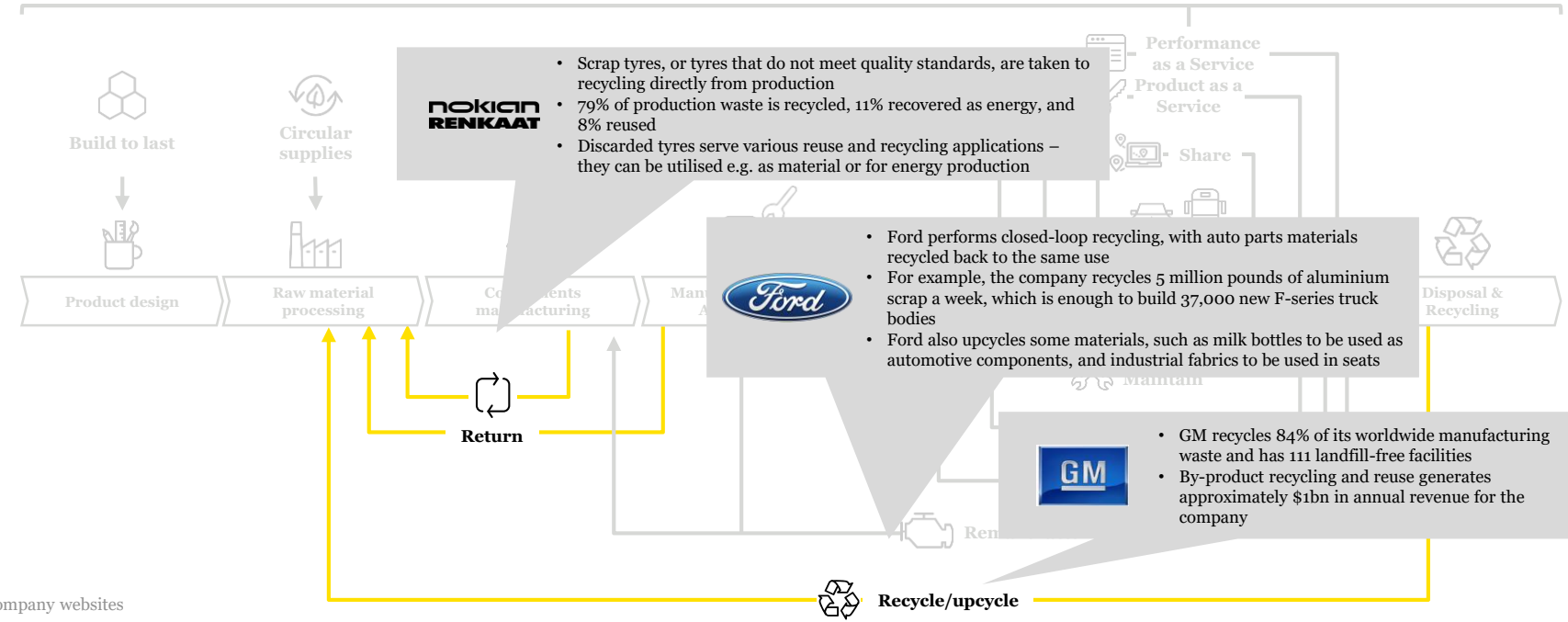
Leading examples: Product Life Extension



Source: Company websites

Thanks to legislative initiatives, the transportation industry is a forerunner in resource recycling

Leading examples: Recovery & Recycling



Source: Company websites

Key contacts

Would you like to know more about the circular economy opportunities?

Key contacts

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Technology Industries of Finland

accenturestrategy

APPENDIX 1 – Circular maturity survey

INTRODUCTION

Circular maturity survey

Purpose

The Circular maturity survey was conducted to understand the starting point of Finnish manufacturing SMEs in adopting circular economy principles.

Content

The survey included two reflections:
1) Inefficiency assessment
2) Current adoption of circular business models

The first reflection focused on understanding the occurrence and level of the five inefficiencies of the linear model:
- Unsustainable materials
- Underutilised capacities
- Premature product lives
- Wasted end-of-life value
- Unexploited customer engagements

In the second reflection, companies were asked to assess their current adoption level of the 11 circular sub-models.

Outcome

In total, 30 Finnish manufacturing SMEs replied to the survey. The responses were collected in industry-specific workshops and through an online survey in May-June 2018.

Detailed results of the survey are presented in the following pages.

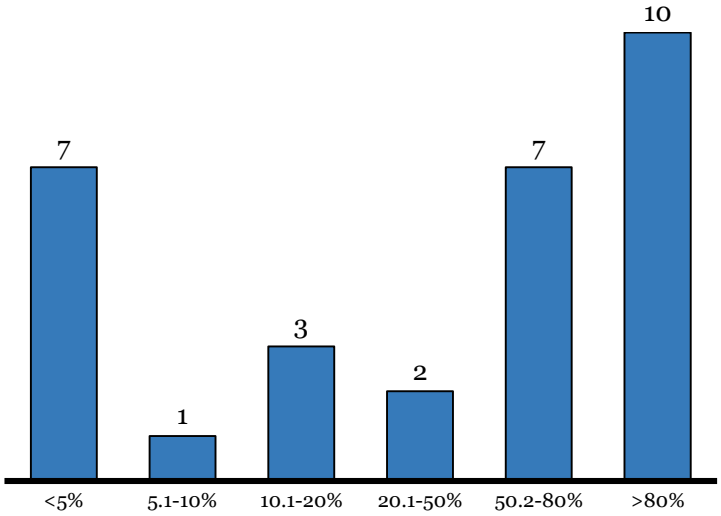
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (1/5)

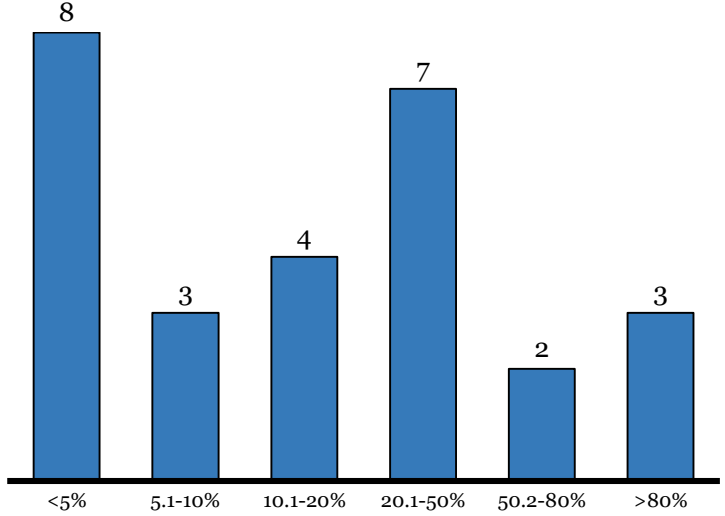
1) Unsustainable materials

Material and energy that cannot be continually regenerated (e.g. direct and indirect material is not renewable or bio-based)

Direct Material: What % of direct material spend is spent on circular material such as renewable, recycled or reused materials?



Indirect material: What % of indirect material spend (=not clearly allocated to a certain product) is spend on circular material such as renewable, recycled or reused materials?



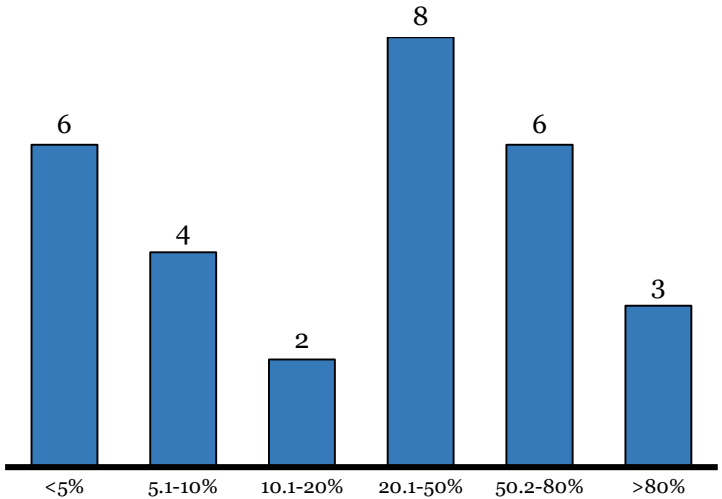
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (2/5)

2) Underutilised capacity

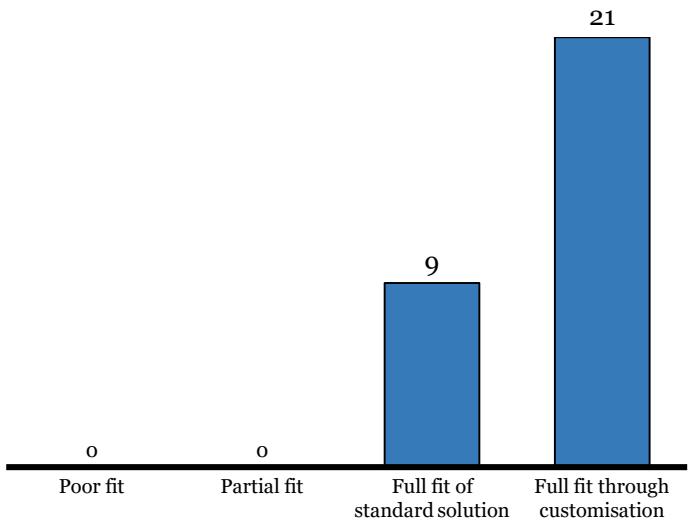
Underutilised or unused products and assets (e.g. products are not operating full hours or full functionality is not used)

Availability: What % of time is the product not used by the customer/end user? (e.g. if only used in summer, 1h a day)*



** % of 24hours x 365 days per year*

Operational fit: to what extent does the product fit the requirements of the customer e.g. regarding operating efficiency, product operations planning?



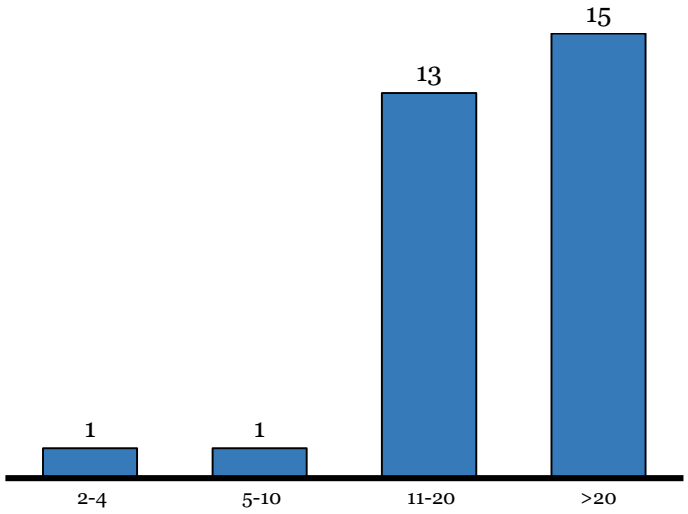
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (3/5)

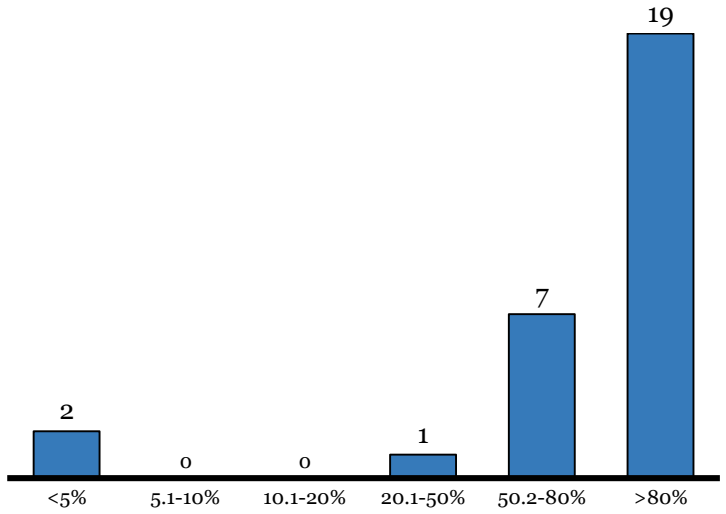
3) Premature product lives

Products are not used to the fullest possible working life (e.g. due to new models and features or lack of repair and maintenance)

Lifetime: What is the current average duration of a product life (in years)?



Functionality: % of revenue that comes from products that are designed for a long life e.g. through enhanced repairability, modularity, upgradeability



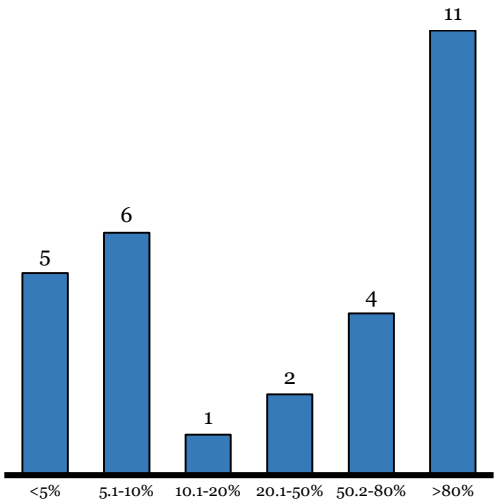
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (4/5)

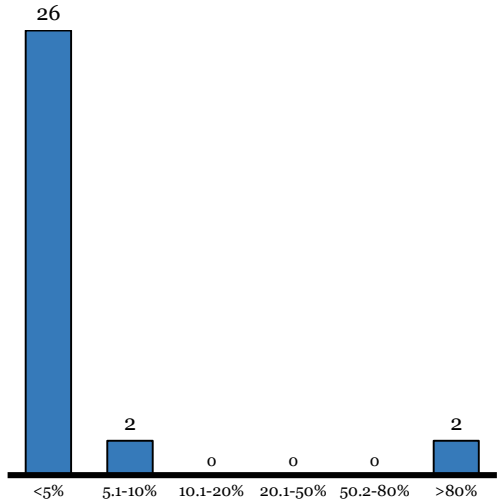
4) Wasted end-of-life value

Valuable components, materials and energy is not recovered at disposal (e.g. not recycled or recovered at end of life)

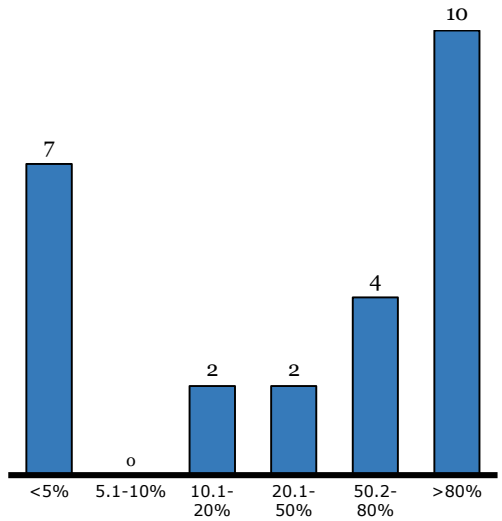
Waste in production: % of waste from production that is recycled (based on weight)



Take-back: % of products taken back from customer in dedicated return scheme at end-of-life



Recycling: % of products recycled at end-of-life



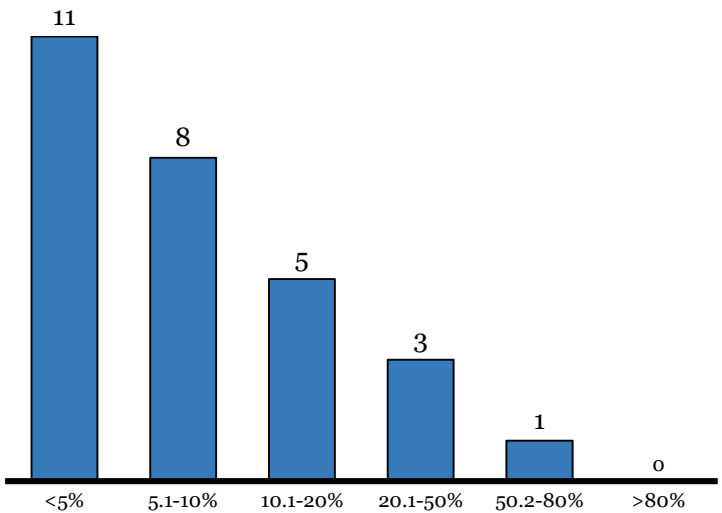
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (5/5)

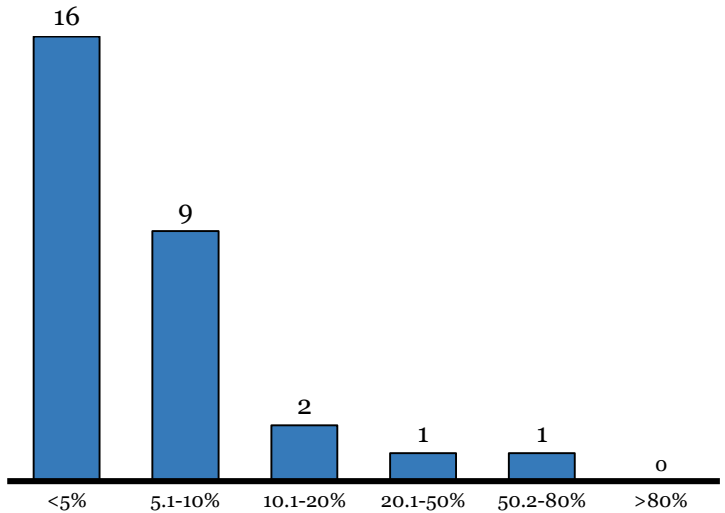
5) Unexploited customer engagements

Material and energy that cannot be continually regenerated (e.g. direct and indirect material is not renewable or bio-based)

After-sales: % of revenue from after sales services



Add-on sales: % of revenue from add-on sales

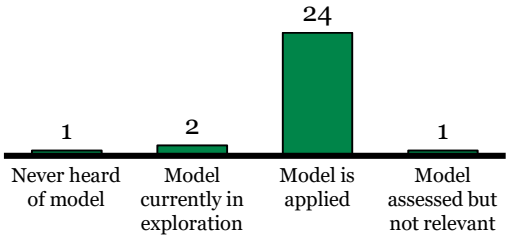


RESULTS – CIRCULAR MATURITY SURVEY

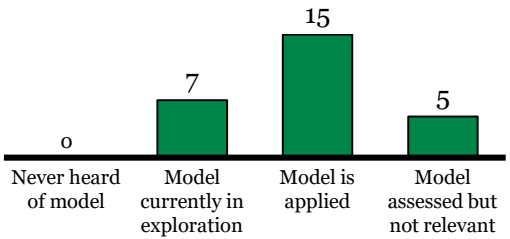
Business model adoption (1/2)

CIRCULAR SUPPLY CHAIN

Build to last

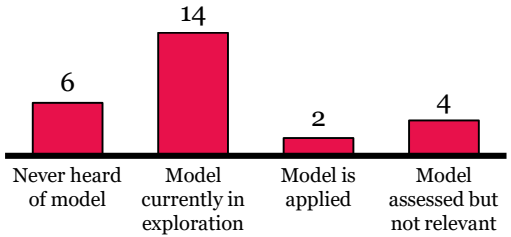


Circular supplies

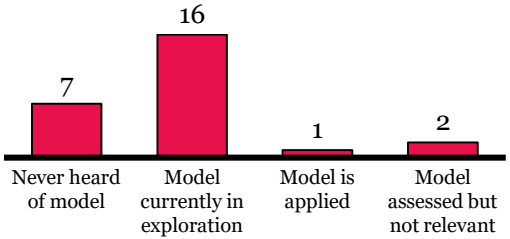


PRODUCT AS A SERVICE

Product as a Service

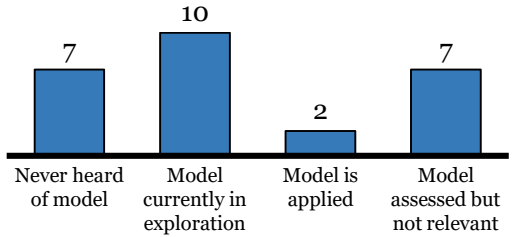


Performance as a Service



SHARING PLATFORM

Share

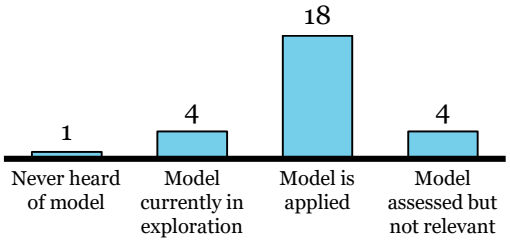


RESULTS – CIRCULAR MATURITY SURVEY

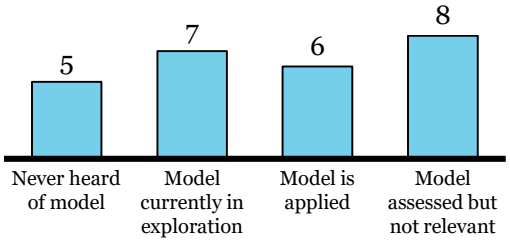
Business model adoption (2/2)

PRODUCT LIFE EXTENSION

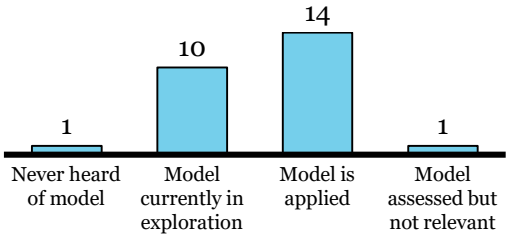
Repair & Maintain



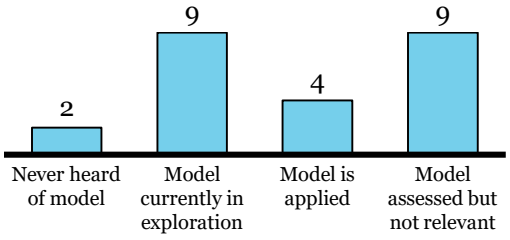
Resell



Upgrade

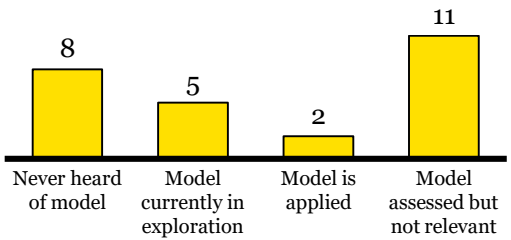


Remanufacture

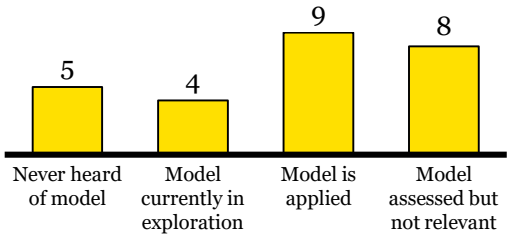


RECOVERY & RECYCLING

Recycle / upcycle



Return



APPENDIX 2 – Additional details on sources

Additional details on sources

Content	Playbook pages	Source
5 Circular business models	23, 119, 129, 139, 149	• Accenture – Lacy, P. & Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. 1st ed. English: Palgrave Macmillan.
3 drivers for Circular Economy	11	• Accenture presentation, Circular Materials Conference (2018): http://www.circularmaterialsconference.se/wp-content/uploads/2018/03/CMC-conference_CE-Introduction_20180308.pdf
4 types of inefficiencies in the linear value chain	10	• Accenture – Lacy, P. & Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. 1st ed. English: Palgrave Macmillan • Accenture presentation, Circular Materials Conference (2018): http://www.circularmaterialsconference.se/wp-content/uploads/2018/03/CMC-conference_CE-Introduction_20180308.pdf • Accenture – 3D Printing vs 3D-TV: https://www.accenture.com/no-en/insight-3d-printing-vs-3d-tv
Development of resource demand	13	• Accenture – Lacy, P. & Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. 1st ed. English: Palgrave Macmillan
Circular technology development	14, 70	• WBCSD - CEO Guide to the Circular Economy (2017): https://www.wbcsd.org/Clusters/Circular-Economy-Factor10/Resources/CEO-Guide-to-the-Circular-Economy • Accenture presentation, Circular Materials Conference (2018): http://www.circularmaterialsconference.se/wp-content/uploads/2018/03/CMC-conference_CE-Introduction_20180308.pdf
Circular technology descriptions	72-78	• World Economic Forum, in collaboration with Accenture – Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation (2018): http://www3.weforum.org/docs/WEF_39558_White_Paper_Driving_the_Sustainability_of_Production_Systems_4IR.pdf
Circular sub-models	24, 25, 120, 130, 140, 150	• Accenture Point of View – Automotive's latest model: Redefining competitiveness through the circular economy: https://www.accenture.com/t20161216T034331__w__/us-en/_acnmedia/PDF-27/Accenture-POV-CE-Automotive.pdf • Accenture study – Chancen der Kreislaufwirtschaft für Deutschland (2017): https://www.nachhaltigkeitsrat.de/wp-content/uploads/migration/documents/RNE-Accenture_Studie_Chancen_der_Kreislaufwirtschaft_04-07-2017.pdf • Accenture presentation, Circular Materials Conference (2018): http://www.circularmaterialsconference.se/wp-content/uploads/2018/03/CMC-conference_CE-Introduction_20180308.pdf
9 Circular capabilities	33, 34	• Adapted from: Accenture – Lacy, P. & Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. 1st ed. English: Palgrave Macmillan.
Industry X.0	68-69	• Accenture – Schaeffer, E. (2017). *Industry X.0: Realizing Digital Value in Industrial Sectors*. 1st ed. English: Kogan Page Publishers. • Accenture Research – Combine and Conquer: Unlocking the Power of Digital (2017): https://www.accenture.com/t20180112T093917Z__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_26/Accenture-Industry-XO-whitepaper.pdf
Incremental savings from combining technologies	79	• Accenture Research– Combine and Conquer: Unlocking the Power of Digital (2017): https://www.accenture.com/t20180112T093917Z__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_26/Accenture-Industry-XO-whitepaper.pdf
The wise pivot	86	• Accenture Point of View – Leading in the NEW: Harness the Power of Disruption (2017): https://www.accenture.com/t00010101T000000Z__w__/jp-ja/_acnmedia/PDF-62/Accenture-Leading-in-the-New-POV.pdf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